# REDLANDS
# PASSENGER RAIL PROJECT
## Existing Drainage Conditions Memo
### San Bernardino & Redlands, San Bernardino County, California

***DRAFT***

**July 2013**

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# 1.0 DRAINAGE SYSTEM

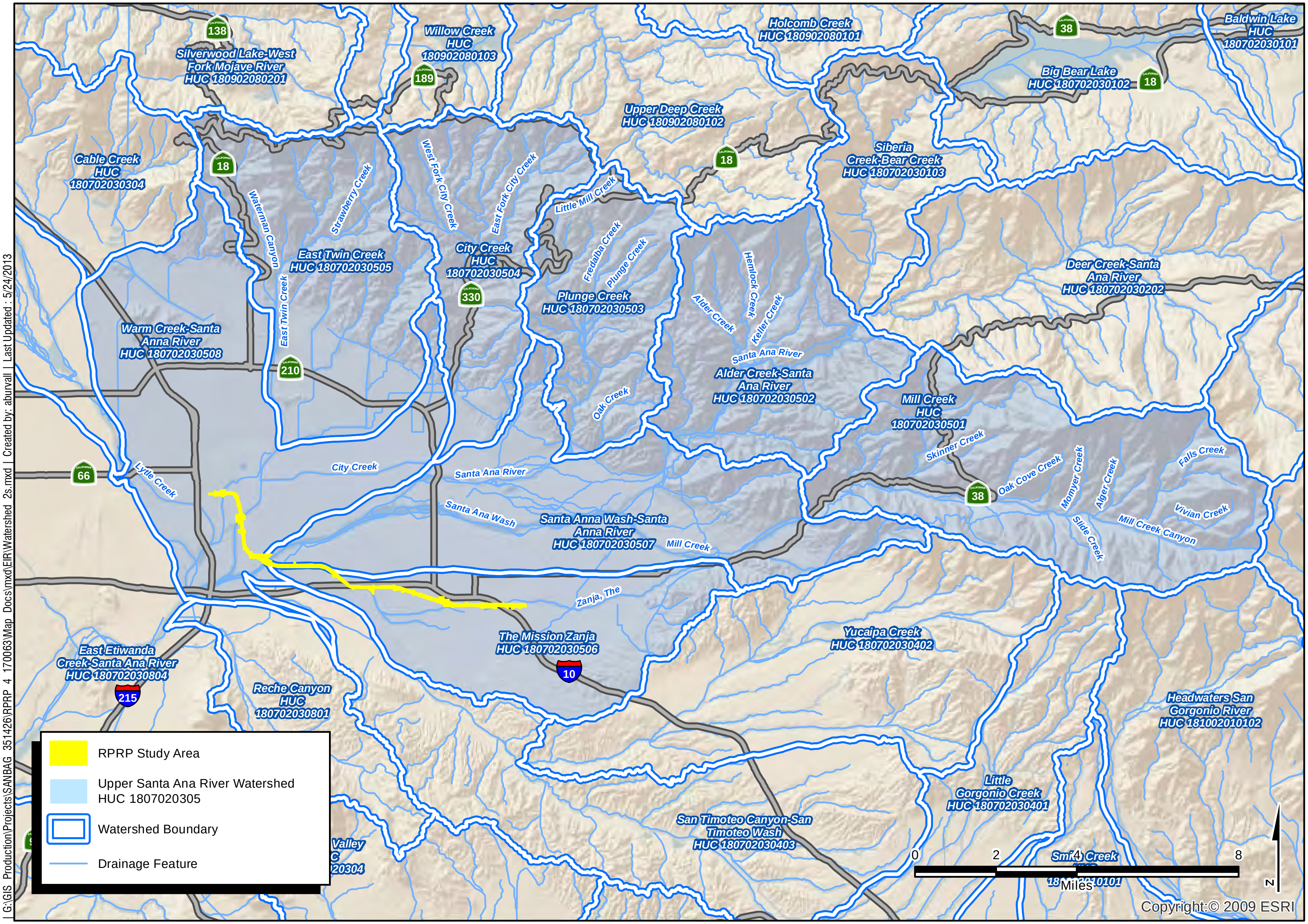
Drainage refers to surface water systems that convey stormwater runoff, including watersheds, floodplains, channels, and rivers. This section identifies the drainage setting and sets the tone for the subsequent discussion on the existing and proposed drainage facilities. See Figure 1.

## 1.1 WATERSHED BACKGROUND

Watersheds refer to areas of land, or basin, in which all waterways drain to one specific outlet, or body of water, such as a river, lake, ocean, or wetland. Watersheds have topographical divisions such as ridges, hills or mountains. All precipitation that falls within a given watershed, or basin, eventually drains into the same body of water.

The Santa Ana Watershed includes much of Orange County, the northwestern corner of Riverside County, the southwestern corner of San Bernardino County, and a small portion of Los Angeles County, draining a total of 2,650 square miles. The Study Area is located within the Upper Santa River Watershed, which is hydraulically disconnected from the lower watershed by San Prado Dam. The Study Area corresponds with the Santa Ana River Wash (HUC 18070203507), Mission Zanja (HUC 180702030506), and the Warm Creek (HUC 180702030508 sub-watershed units. The watershed is bounded on the south by the San Jacinto Watershed, on the east by the Salton Sea and Southern Mojave Watersheds, and on the north and west by the Mojave and San Gabriel Watersheds. The highest elevations in the Watershed occur in the San Bernardino Mountains at San Gorgonio Peak at 11,485 feet and the eastern San Gabriel Mountains at Mt. Baldy at 10,080 feet. The mainstem of the Santa Ana Watershed is the Santa Ana River (SAR) which is about 96 miles long. The headwaters of the SAR are in the San Bernardino Mountains with two of its major tributaries, Bear Creek and Mill Creek. Other tributaries include Lytle Creek originating in the San Gabriel Mountains and the San Jacinto River originating in the San Jacinto Mountains. These major tributaries confluence to form the SAR in the San Bernardino Valley located at the southern base of the Transverse Ranges of the San Bernardino Mountains. Surface waters start in this mountainous zone and flow northeast to southwest. The SAR traverses through the San Bernardino Valley before cutting through the Santa Ana Mountains and flowing to the Coastal Plain in Orange County. Eventually the river discharges to the Pacific Ocean in the City of Huntington Beach. Santa Ana Watershed is home to the most developed portion of Orange County and much of the built-up portions of Riverside and San Bernardino Counties.

The Project is located in the Santa Ana Watershed and is divided by the SAR, the mainstem, at approximate Mile Post (MP) 3.4. This corresponds to SAR River Mile 28.62 (approximate) and is part of System No. 2-701-1A (SBCFCD System Index, January 2010). Specifically located within the Upper Santa Ana Watershed, the SAR divides the project into the north/west segment (3.4 miles, 34 %) and the south/east segment (6.6 miles, 66 %), with each side draining tributary onsite and offsite areas into the SAR either by surface flow, local drainage facilities, or major stormwater conveyance systems. The project is tributary to Reach 4 (downstream - minority) and Reach 5 (upstream - majority) of the SAR.

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# Upper Santa Ana River Watersheds and Regional Hydrology

**Figure 3-1**

FTA/SANBAG | Redlands Passenger Rail Project | EIS/EIR

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San Bernardino County Flood Control District (SBCFCD), as established by the San Bernardino Flood Control Act of 1939, manages the major stormwater conveyance systems within San Bernardino County. The SBCFCD is subdivided into six flood control zones with interests, responsibilities or geographical divisions distinctive of the particular zone. Consequently, the project is located in Flood Control Zone 2 (318 square miles) and 3 (366 square miles) with the boundary between these zones lying along the SAR. Zones 2 and 3 lie west and east of the SAR and correspond to the north/west and south/east segment of the project, respectively. From this point forward in the document, the north/west and the south/east segment of the tributary drainage of the project will be referred to as the Zone 2 Drainage Area (Z2DA) and Zone 3 Drainage Area (Z3DA), respectively. Within the project, the major stormwater conveyance systems that cross or are adjacent to the project are Warm Creek (Historic), Twin Creek, SAR, Mission Zanja Creek, and Mill Creek Zanja (see Section 1.5 for more information). The Z2DA and the Z3DA are part of the Warm Creek/Twin Creek and Zanja basins, respectively. Portions of City of San Bernardino and City of Redlands are located in both zones. Beside SBCFCD, related drainage infrastructure tributary to the project is also under the jurisdiction of City of San Bernardino, City of Redlands, Caltrans and U.S. Army Corps of Engineers (USACE).

Within the Z2DA, the project is tributary to the Warm Creek and Twin Creek watershed (15.7 square miles) via two main channel facilities. First, the westerly drainage area flows to Warm Creek (Historic) [part of Subarea J which is part of the below report] and outlets to Warm Creek via the Warm Creek Bypass Channel. This part of Z2DA is tributary to Reach 4 of the SAR. Second, the easterly drainage area flows to the East Twin Creek and Warm Creek Channel (also known as Twin Creek Channel) [part of Subarea M which is part of the below report] and outlets to Reach 5 of the SAR. The small remainder of the Z2DA south of the above drainage area surface flows directly to Reach 5 of the SAR. The Z2DA lies entirely within the City of San Bernardino (USACE, Review Report, Lytle and Warm Creek). Refer to Appendix E.

Similarly, the drainage from the Z3DA is part of the Mission Zanja drainage basin. Located along the southern boundaries of San Bernardino County, the Mission Zanja drainage basin comprises approximately 26 square miles, as shown in Appendix E. Shaped like a half circle, the basin starts at the Zanja Peak in the Crafton Hills area and extends westward for about 12 miles until it confluences with Reach 5 of the SAR. In the north-south direction, the basin generally lies between State Route 38 and the San Bernardino/Riverside County line. The mainstem of the Mission Zanja drainage basin is the Zanja Creek which is the principal flood control facility for the City of Redlands. In various historical and technical documents, the Zanja Creek is also referred to as Mission Zanja Creek, Mission Channel, Mill Creek Zanja, and the Zanja. The Zanja Creek crosses the County of San Bernardino, City of Redlands, and City of San Bernardino.

The Zanja Creek used to convey excess flows from Mill Creek (a main tributary to the SAR), but now only conveys flows from within its drainage basin due to an existing levee constructed along Mill Creek at the SAR designed to prevent flood flows from entering the Mission Zanja drainage basin (no further consideration is given in this report to Mill Creek flows). The corresponding watershed originates in Crafton Hills east of Redlands and flows westerly through the City of Yucaipa, County of San Bernardino, City of Redlands (majority) and City of San Bernardino until it flows into the SAR (14 miles). It consists of three segments. The Creek is a partially improved open channel from the SAR to 1st Street (City of Redlands) and is referred to as the Mission Zanja Channel. The Creek continues upstream under downtown Redlands from 1st Street to 9th Street (City of Redlands) as the Mission Storm Drain. Finally, the Mill Creek Zanja is the upstream segment of the Creek system and extends from 9th Street to the Mill Creek confluence at the upstream (east) end (San Bernardino County). According to railroad documentation, Mill Creek Zanja is also referred to as Sylvan Creek.

## 1.2 MASTER PLAN OF DRAINAGE

Throughout SBCFCD, a number of Master Plans of Drainage (MPD) and Comprehensive Storm Drain Plans (CSDP) have been developed. These documents are prepared by SBCFCD, their consultants or the Cities. The purpose of these documents is as follows:

- A coordinated plan of flood control improvements for an area based on its future planned development;
- Identifies existing flood control facilities which are inadequate to convey the 100 year peak storm flows, existing facilities needing improvements and new facilities that need to be constructed;
- Provides construction priorities for facilities based on need and preliminary planning cost estimates.

As described above, the Project is included within CSDP No. 7 and 4, both documents of which cover Z2DA and Z3DA, respectively. As documents that address the future master drainage lines for the City of San Bernardino and City of Redlands, the Cities do not prepare their own Master Drainage Plan (MPD) but instead contract with the SBCFCD to prepare the related document on their behalf. CSDP No. 7 covers most of the City of San Bernardino and CSDP No. 4 covers the majority of City of Redlands.

CSDP No. 7 identifies the existing and proposed storm drain systems within Zone 2 of San Bernardino County and includes most of the City of San Bernardino (Z2DA). It should be recognized that this CSDP does not reflect the methodology in the current San Bernardino County Hydrology Manual (1986), and hence is overdue for an update. Z2DA is included as part of Area A which is tributary to Warm Creek (Historic) and as part of Area C which is tributary to Twin Creek Channel (CSDP No. 7, 1982).

CSDP No. 4 was prepared in May 1975 by Omer H. Brodie and Associates, for SBCFCD, to conceive a comprehensive system of storm drains within Zone 3 of San Bernardino County and covers the City of Redlands (as well as Z3DA). The plan presents preliminary hydrology, mainline storm drain sizes and alignments, and construction cost estimates. As of 1987, proposed storm drain projects not yet constructed have been identified (CSDP No. 4, May 1975, Figure 4-2). It should be noted that the updated methodology in hydrologic modeling techniques and data, as presented in the San Bernardino County Hydrology Manual (1986), would generate runoff flows that are approximately 25 to 50 percent higher than those generated in this 1975 study (Mission Zanja Creek Channel Improvement Study). Hence, this is one reason necessitates an update of this document and was not available from the City of Redlands or SBCFCD. However, the updated informal CSDP No. 4 was made available from SBCFCD. It is pending approval from City of Redlands and SBCFCD and only includes raw data, calculations and node exhibits, and does not include a narrative (CSDP No. 4, Pending Approval, January 22, 2010).

## 1.3 HYDROLOGIC SETTING

This Subsection sets the hydrologic setting such as climate, rainfall, topography, soil data, and vegetation.

### 1.3.1 Climate

The SAR Watershed has a Mediterranean climate with hot, dry summers and cooler wet and sometimes snowy winters. Rainfall ranges from 12 inches per year in the coastal plain, to 18 inches per year in the inland valleys, to 40 inches per year in the mountains. Due to the climate, there is little natural perennial surface water in the watershed. The upper part of the watershed in the mountains has the highest gradient and water quality is usually of high quality. Flows in the Upper Valley from the Seven Oaks Dam to the

City of San Bernardino consist of storm flows and rising groundwater. From the City of San Bernardino to the City of Riverside, the SAR flows perennially and includes publicly owned treatment works discharge.

The Santa Ana winds blow into the valley from the Cajon Pass, which exits the valley's north end between the San Gabriel and San Bernardino Mountains. The seasonal Santa Ana winds are felt particularly strongly in the San Bernardino area as warm and dry air is channeled through nearby Cajon Pass at times during the autumn months.

### 1.3.2 Rainfall

Rainfall season is from October 1 to May 1 with average rainfall depths of 14.5 inches to 25.1 inches.

Little streamflow occurs along Mission Zanja Creek except during and immediately after precipitation because climate and drainage area characteristics are not conducive to continuous runoff. During large storms, streamflow increases rapidly in response to effective precipitation.

### 1.3.3 Topography

The project's topography is typical of low land valley areas with gentle slopes. The general slope of the area is towards the SAR with slopes ranging from 1 percent to 3 percent. Specifically, the project ranges from elevation 1022 to 1020 for Z2DA and from elevation 1020 to 1040 for Z3DA.

The average slope of the Mission Zanja Creek is approximately 3.8 percent. Within downtown Redlands, it is about 1.9 percent.

### 1.3.4 Soil Data

Soils within the project survey boundary were mapped using the Natural Resources Conservation Service (NRCS) Web Soil Survey (USDA 2003). The proposed project crosses eight different soil types that include Grangeville Fine Sandy Loam, Tujunga Gravelly Loamy Sand, Hanford Coarse Sandy Loam, Psamments and Fluvents, Tujunga Loamy Sand, Hanford Sandy Loam, and Ramona Sandy Loam (Jurisdictional Wetland Delineation Report). The tributary drainage areas also consist of urbanized alluvial fan areas emanating from the San Bernardino Mountain ranges. According to the San Bernardino County Hydrology Manual, the project area is located in Hydrologic Soil Groups A (minority) and B (majority) with moderate runoff potential.

### 1.3.5 Vegetation

The sporadic vegetation varies throughout the project. Onsite, the existing rail alignment is already disturbed and absent of most vegetation. The project consists of pockets of unmaintained vegetation which consist of weeds. Offsite, the survey area supports 14 distinct vegetation communities; however, the predominant land cover was identified as being urban/developed. The majority of the survey area is made up of paved roadways, man-made structures, adjacent lands that are un-vegetated, and landscaped parcels.

## 1.4 Local Drainage

Onsite drainage is storm runoff generated within the project's existing ROW limits. In contrast, offsite drainage is storm runoff that originates outside of the existing railroad ROW, but tributary to the project site either by way of surface and/or subsurface conveyance. However, once onsite and offsite drainage is collected in an onsite system, it will discharge to either an existing or proposed local storm drain system, or modification thereof, or an existing major flood control facility. Local drainage consists of either public water or private water and may comingle depending on its location. Local storm drain systems are under the jurisdiction of City of San Bernardino, City of Redlands or Caltrans. Drainage along I-10, from the West I-10 Overpass to the East I-10 Overpass, is part of the offsite drainage tributary to the project at various locations. Caltrans has jurisdiction of the I-10 drainage. See Section 2, Existing Conditions for more information; also see Appendix B for Hydrology Maps.

## 1.5 MAJOR FLOOD CONTROL FACILITIES

A total of five major flood control facilities either cross or are located longitudinally to the project. The crossings from west to east are known as Warm Creek (Historic) [Bridge 1.1], Twin Creek [Bridge 2.2], Santa Ana River [Bridge 3.4], and Mill Creek Zanja [Bridge 9.4]. Mission Zanja Creek is the one major offsite facility located adjacent to a segment of the project. The numbers associated with the bridge designations correspond to the railroad Mile Post. See EIR and Floodplain Technical Memorandum.

These facilities are either owned or maintained by the local agency or the SBCFCD. This information along with identifying which agency constructed the facility, and other related rights and responsibilities of the facilities is described below. A short description of these facilities follows. For additional information, refer to the Floodplain Evaluation Technical Memorandum.

**Warm Creek (Historic), Bridge 1.1**

Warm Creek extends from north of the City of Highland downstream to its confluence with the SAR at the southwest quadrant of the I-10/I-215 separation. However, the East Twin and Warm Creek improvements by the USACE in 1961 delivered most of the Warm Creek flows to the SAR at a point 1.4 miles upstream of its original confluence, resulting in a rerouting of the portion of Warm Creek from about 5th Street south to Central Avenue. The Warm Creek Bypass Channel today connects the Twin Creek Channel to the downstream Warm Creek Channel. Consequently, the remaining portion of Warm Creek no longer serves as a regional flood control facility, but only conveys tributary local drainage (about 18 square miles) from the City of San Bernardino (USACE, Review Report, Lytle and Warm Creeks). From this point forward, this remaining portion of the channel will be referred to as Warm Creek (Historic). After the rerouting of Warm Creek occurred, Warm Creek (Historic) itself and all related studies and record drawings have since been relinquished from SBCFCD to the City of San Bernardino (per conversation with Steve Gibson, SBCFCD, 2011). However, none of the Warm Creek (Historic) documentation was available from the City. Currently, the City of San Bernardino owns, operates and maintains Warm Creek (Historic). At the point where Warm Creek (Historic) crosses the project, the facility is a rectangular concrete channel (RCC) (17 feet wide by 9 feet high – as surveyed) with a chain link fence on top that crosses underneath the railroad trestle bridge. The railroad has prior rights at this location.

**Twin Creek, Bridge 2.2**

Twin Creek (also known as “East Twin Creek and Warm Creek Channel”) is a major channel that conveys flows from the Twin Creek Spreading Grounds in northern San Bernardino to its confluence with the SAR at the northeast quadrant of I-10/I-215 separation. Twin Creek was constructed by USACE, and is owned, operated and maintained by the SBCFCD. According to USACE record drawings, Twin Creek was confirmed to be a 60-foot wide by 14-foot high RCC through the project. Further downstream, the channel transitions to an unimproved 202-foot wide base trapezoidal channel (with 2:1 side slopes). The portion crossing the project was constructed in 1958. The Standard Project Flood (SPF) is 22,000 cfs (FEMA Levee Certification Report). The railroad has prior rights at this location.

**Santa Ana River, Bridge 3.4**

The SAR bridge crossing is located between Waterman Avenue and Tippecanoe Avenue in the City of San Bernardino. The project location corresponds to SAR River Mile 28.6. The SAR is operated and maintained by the SBCFCD where it has ROW to do so. Adjacent to and upstream of the railroad crossing (at Mission Zanja Creek) on the south side of the SAR, a private entity owns a 500-foot long frontage along the SAR which extends out to the center of the SAR. Surrounding that, the SBCFCD owns the rest of the SAR in that area. During a recent field visit, the project team confirmed that the SAR is unimproved though the project area with no dry weather flows evident in the channel (at least not during the field visit). According to the SAR Mainstem Project, Feature Design Memorandum No. 2, Seven Oaks Dam, Floodway Delineation Report, prepared by USACE, dated August 1991, the existing and future 100-year recurrence frequency flows (near and downstream of the project site at E Street) are estimated to be 67,000 and 70,000 cfs, respectively. The railroad has prior rights at this location.

**Mill Creek Zanja, Bridge 9.4**

The Mill Creek Zanja bridge crossing is located just west of the East I-10 Overpass (Caltrans BR 54.0472, PM 31.52, Redlands OH) and east of Church Street in the City of Redlands. The Mill Creek Zanja is part of the overall Mission Zanja Creek system, the principal flood control facility for the City of Redlands. This bridge is part of the Creek's designation as a State and Federal Historic Structure. The bridge is located at the intersection with the abandoned Southern Pacific Railroad within railroad ROW (50 feet wide). As referenced in related USACE documentation, this bridge is also referred to as Santa Fe Railroad bridge.

BNSF railroad records designate that the bridge crossing Mill Creek Zanja as Sylvan Creek. (Note: local Redlands historian Tom Atchley mentioned that Mill Creek Zanja has never been called Sylvan Creek, so for purposes of this report, Mill Creek Zanja will be used to designate this wash crossing).

SBCFCD owns the portion of the Creek upstream and downstream of the project. During a recent field visit, the Creek was confirmed to be unimproved (with no consistent geometry) though the project area with no dry weather flows evident (at least not during the field visit). Just upstream in Caltrans ROW, the Creek is covered with grouted rip rap as it conveys flows under East I-10 Overpass (east crossing).Where the Creek intersects 9th Street in the City of Redlands, the SPF and 100-year flows are determined to be 6,400 cfs and 3,600 cfs, respectively (USACE, Reconnaissance Study for Mission Zanja Creek).

The railroad has prior rights at this location; however, the SBCFCD has operation and maintenance responsibilities of the Creek.

**Mission Zanja Channel (MP 3.4 to MP 6.1)**

The Mission Zanja Channel parallels the project along the south side from the SAR confluence to approximately 1,000 feet west of California Street. Owned and maintained by SBCFCD, it is mostly improved as a trapezoidal earthen channel with some segments including wire revetment. The Channel is vegetated from the SAR outlet to Gage Canal. The capacity of the channel ranges from 3,000 to 4,000 cfs. During field visits in 2011, the project team identified pockets of scouring that resulted in encroaching onto the railroad property (SANBAG, Redlands First Mile, Draft Existing Conditions Report).

Mission Zanja Channel is an open channel downstream from California Street to the SAR except where some local road bridges cross the channel (Tippecanoe Avenue, Richardson Street, Mountain View Avenue, and Bryn Mawr Avenue). According to discussions with David Lovell (SBCFCD), the local road culverts are undersized and most likely exacerbate the flooding conditions along the Channel. The road bridges limit the flow-carrying capacity to about 2,200 cfs in several places (USACE, Reconnaissance Study for Mission Zanja Creek). Between the Mountain View Avenue and Bryn Mawr Avenue bridges, the Channel also crosses under the West I-10 Overpass (Caltrans BR 54.0570, PM 27.64, West Redlands OH) at MP 5.61.

It is uncertain what maintenance obligations SBCFCD has to the north bank of the Mission Zanja Channel between the SAR and just west of California Street. A portion of this north bank is within SANBAG and SBCFCD ROW. The project data does not reflect a ROW line south of the Channel from the SAR to Richardson Street. However, the project data does reflect a south ROW line for the Channel from Richardson Street to Bryn Mawr bridge that varies from 75 feet to 100 feet. This ROW is located south and adjacent to the SANBAG ROW. There are agreements in place that SBCFCD is responsible for operating and maintaining the Channel including the north channel bank which is located partially in SANBAG and SBCFCD ROW. There is history of the north channel bank eroding into the SANBAG ROW after heavy seasonal storm events.

The following table summarizes the existing major flood control facilities discussed above.

**Table 2-1. Existing Major Flood Control Facilities**

| Name | Mile Post | Jurisdiction | Q100 (cfs) | Description |
|---|---|---|---|---|
| Warm Creek (Historic) | 1.1 | City of San Bernardino | 2,525 cfs | 17 ft wide by 9 ft high RCC |
| Twin Creek | 2.2 | SBCFCD, Zone 2 | 22,000 cfs SPF | 60 ft wide by 14 ft high RCC |
| Santa Ana River | 3.4 | SBCFCD, Zone 2 & 3 | 67,000 cfs | Unimproved trapezoidal channel |
| Mill Creek Zanja (aka Sylvan Creek) | 9.4 | City of Redlands | 3,000 – 4,000 cfs | Unimproved channel, no fixed geometry |
| Mission Zanja Channel | 3.4 to 6.1 | SBCFCD, Zone 3 | 1,000 – 6,000 cfs | Unimproved trapezoidal channel |

Gage Canal (Bridge 3.9) crosses the project and the Mission Zanja Creek between the SAR and Tippecanoe Avenue, near the extension of Gage Street. Gage Canal is a potable water conveyance system (owned by the City of Riverside) that transports water from the San Bernardino area to the City of Riverside for domestic use. Along the Mission Zanja Channel is a stair-stepped drop structure just downstream of Gage Canal. Gage Canal used to be an open concrete-lined channel but in 1970 was rerouted underground as a 48-inch pipe.

## 1.6 Review of Key Documents

Many documents were reviewed for the tributary drainage systems, and policies and programs that may be impacted by the project. Of these documents, only certain key documents are summarized in Appendix E and include applicable exhibits and figures from these documents.

## 1.7 Coordination with Impacted Planned/Designed/Constructed Projects

There are certain projects that are planned, designed or constructed that are impacted by RPRP and require coordination. These projects are described in this Subsection below with emphasis on related drainage issues.

**Arrowhead Parking Lot (MP 1.3)**

Ludwig Engineering is contracted with the City of San Bernardino to provide final engineering plans for a proposed temporary parking lot at the southeast corner of Rialto Avenue and Arrowhead Avenue, which is adjacent to the north side of the RPRP in the City of San Bernardino. The purpose of the lot is to provide temporary parking for the construction workers of the new Justice Center at 3rd Street and Arrowhead Avenue. The Justice Center construction is scheduled to last approximately 2 years and should be constructed by March 2014. Once the Justice Center is completed, the temporary parking lot will be removed and the parcel will be restored to its original condition (City of San Bernardino, March/May, 2012).

The proposed parking lot will be paved and will consist of a 351-foot long by 62-foot wide by 0.5-foot (minimum) high detention basin located in the northwest portion of the temporary parking lot to which the entire lot will drain. The basin will outlet to an existing 12-inch diameter storm drain at the southeast corner of Rialto Avenue and Arrowhead Avenue. A proposed 2:1 slope embankment will be constructed along the north railroad ROW to separate the railroad offsite flows from the project flows. In the existing condition, the parcel drains to a low point just north of the south property line and about 150 feet east of the west property line. The north side of RPRP also drains to this low point.

**Central Avenue Corridor Storm Drain Improvements and Utility Master Plan (MP 2.85)**

The Inland Valley Development Agency (IVDA) desires to improve the existing roads and infrastructure of the North and South Gateway area of City of San Bernardino as part of the master planned development of the Inland Empire Goods Movement Bill. To accomplish this, IVDA, the lead agency in the development of this project, will provide preliminary engineering and environmental documentation for the proposed improvements. Thiesen Engineering is the consultant responsible for preparing these documents. The project is bounded by Mill Street on the north, Orange Show Road and SAR on the south, Waterman Avenue to the west, and Tippecanoe Avenue to the east.

The purpose of this project is to identify the core infrastructure that may be required to help facilitate future development in the project area. The scope includes topographic survey, research of existing utilities and storm drains, storm drain hydrology and hydraulics, sewer layout and analysis, water network analysis and layout, storm drain, sewer, and water master plan, cost estimates, traffic impact analysis, ROW delineation and data sheets, alternative analysis, preliminary plans and profiles, geotechnical investigation, and environmental document.

Related to drainage, the exhibit in the RFP identifies proposed storm drains. These proposed storm drains include a line along Central Avenue which drains east into a line along Waterman Avenue which drains south. Adding a proposed storm drain along Lena Road which drains south, both of these lines will convey flows to a proposed storm drain along Orange Show Road which will continue west, crossing the Project, at MP 2.85, until it discharges to Twin Creek. This project will determine tributary areas, associated discharge, and the size and location of the proposed storm drain along Orange Show Road.

**I-10 High Occupancy Vehicle (HOV) Project (MP 5.61/9.45)**

http://www.sanbag.ca.gov/projects/mi_fwy_I-10-HOV.html

SANBAG is working with Caltrans to prepare a project report and environmental document to add a carpool lane, also known as an express lane or HOV lane, in each direction of I-10 between Haven Avenue (PM 8.20) in Ontario and Ford Street (PM 33.43) in Redlands, a 25-mile span. The I-10 HOV project will extend the carpool lanes east from where the existing carpool lanes end. In addition to the carpool lanes, the project proposes to widen outside existing lanes, pave medians, widen several existing under-crossings, rebuild over-crossings where needed, construct a concrete median barrier, improve drainage and add auxiliary lanes to improve weaving between on-ramps and off-ramps. The Caltrans project number is EA 08-0C2500.

As part of the Project Approval and Environmental Documentation (PA&ED) phase, Parsons Transportation Group (PTG) is evaluating several alternatives for the project under contract with SANBAG. SANBAG estimates that the PA&ED will be approved by 2017. Final design and acquisition of ROW is tentatively set to be approved and certified by 2014. If funds are available, construction could start by 2015, and portions of the project could be completed by 2020. This schedule is based on funding availability and subject to change.

The drainage scope of this phase is a high level hydrologic analysis that does not include hydrologic discharges or delineate offsite and onsite drainage areas. Additionally, detailed hydraulic analysis is not part of the drainage scope. However, the associated Concept Drainage Report provides a general overview of the existing drainage conditions and facilities of the project for this phase. Ultimately, a comprehensive and detailed drainage report will be prepared, including hydrologic and hydraulic analysis, during the PS&E phase of this project. To the extent possible, this project will be considered as existing conditions for the RPRP.

**Mill Creek Zanja Expanded Inlet (MP 9.15)**

In 2005, the SBCFCD, in coordination with the City of Redlands, completed construction of the Mill Creek Zanja Expanded Inlet and the 9th Street Culvert. The SBCFCD and City of Redlands had an agreement to administer the design the construction of the project. The purpose of the project was to address frequent flooding in Redlands by implementing one of the recommendations in the USACE Reconnaissance Study prepared in 1994. This implementation included constructing a 6-foot high by 11-foot wide RCB from 425 feet west of 9th Street to just east of 9th Street.

Reconstruction of the project was made possible after the stakeholders received required funding from the federal government. Under terms of the required agreement, the City reviewed and approved the project's plans and specifications, prepared required environmental documentation, and provided funding to the county in an amount not to exceed $1 million, less any environmental costs. The county prepared all plans, specifications and cost estimates, advertised, awarded and administered the construction contract, and paid all project costs exceeding $1 million, less any environmental costs.

This project is identified as Project No. 7 and was driven by a Disaster Initiative Grant (City of Redlands Local Hazard Mitigation Plan). SBCFCD owns, operates and maintains the project, except for that portion within the ROW for 9th Street which City of Redlands maintains.

**Mission Storm Drain Bypass (MP 8.17/9.74)**

This future storm drain is expected to alleviate the flooding in downtown Redlands (Lead Agency) by adding capacity to the existing inadequate Mission Storm Drain. This future storm drain is also referred to as the Recommended Plan, Downtown Storm Drain Project, Mill Creek Zanja By-Pass Storm Drain, or proposed culvert in related documentation. The Mission Storm Drain Bypass will provide a drainage conveyance system for the downtown area and will include the construction of an approximately 4,500 feet of 10-foot diameter RCP storm drain system constructed in City-owned ROW. Starting between 9th Street and I-10, the proposed project will run west and parallel to (and south of) Redlands Boulevard for approximately one mile to the confluence with the existing Mission Zanja Channel west of Texas Street. The system will include construction of storm drain related appurtenances, including junction structures and manholes with connections to the existing system at both the upstream and downstream ends.

The project will provide approximately 25-year flood protection to the project area upon completion (for Phase 1) and 100-year flood protection once all program facilities (and all phases) are completed. Funding in the amount of $5.2 million is being sought by the City to construct the project. It is assumed this amount includes both capital and soft costs. Annual O&M costs are estimated to be around $5,000.

Recently, the City of Redlands is competing to fund this project via the One Water One Watershed (OWOW) 2.0 Project Solicitation process which is part of the voter-approved Proposition 84. OWOW is a new and innovative Integrated Regional Water Management Plan (IRWMP) planning process being developed within the Santa Ana Watershed by the Santa Ana Watershed Project Authority (SAWPA).

This storm drain will cross the project at two locations: (1) just east of the East I-10 Overpass via a 9-foot RCP (rerouting of the Oriental Drain), and (2) just west of the East I-10 Overpass via a 13.5-foot high by 14-foot wide RCB. See Appendix E for additional information.

The Carrot Drain will be connected to the Mission Storm Drain Bypass at 9th Street by joining a collar structure over a connection to the existing pipe. This additional flow would amount to 300 cfs.

**Mission Zanja Creek Feasibility Study (MP 3.4 to beyond eastern terminus of Project)**

SBCFCD (Lead Agency) has plans to perform this study to determine the most feasible solution to the existing flooding issues along Mission Zanja Channel from the SAR upstream through Redlands. The objective of the study will be to build upon the previous watershed planning efforts and provide viable alternatives, and implement water quality and water supply aspects on a regional scale for the next generation. The goals of the study focus on solving the flooding issues, groundwater recharge, and implementing economic and environmentally viable alternatives for the long-term vision.

Without success, SBCFCD has been trying for years to obtain funding at the local, state and federal level to pay for the study and associated capital improvements ($2 million in total costs; it's assumed this includes both capital and soft costs). Annual O&M costs are estimated to be around $20,000. Recently, the SBCFCD is competing to fund this project via the OWOW 2.0 Project Solicitation process which is part of the voter-approved Proposition 84. OWOW is a new and innovative Integrated Regional Water Management Plan (IRWMP) planning process being developed within the Santa Ana Watershed by the Santa Ana Watershed Project Authority (SAWPA).

**Mountain View Avenue Street Improvements (MP 5.2)**

In 2006, IVDA awarded a contract to T.Y. Lin for professional services to design improvements for Mountain View Avenue from Palm Meadows Drive/Central Avenue to Interstate 10 (I-10). The project is currently designed to be constructed in two phases. The first phase (design completed) will consist of the bridge structure over the SAR and includes road and infrastructure improvements southbound to Riverview Avenue/San Bernardino Avenue. The second phase of the project (design 95 percent complete) will complete the road improvements from Riverview Avenue/San Bernardino Avenue southbound to the I-10 interchange and includes a second, smaller bridge structure at the Mission Zanja Creek crossing (culvert to convey Creek flows). Phase 1 construction began in October 2012 with Phase 2 planned to commence construction shortly thereafter. Both phases are scheduled to be completed by 2013.

The project drains from south to north along the street; specifically, from I-10 to Mission Zanja Creek, and from Mission Zanja Creek north to SAR. Drainage from the southern portion will be intercepted at a sump by a proposed catch basin just south of Mission Zanja Creek, then will be intercepted by an existing 69-inch RCP before it is discharged to Mission Zanja Creek.

This project will not impact local drainage related to RPRP. The proposed grade crossing for RPRP will perpetuate drainage patterns along the street and the Creek.

**Opal Detention Basin (beyond east terminus of Project)**

In July 2012, the City of Redlands approved a contract with TKE Engineering for professional services to design improvements for Opal Detention Basin, including environmental services. To expand on previous related studies completed by USACE, the SBCFCD, and City of Redlands, the purpose of the project is to provide added flood protection to the area, and downtown Redlands, when combined with the City's future Mission Storm Drain Bypass project. In April 2012 the City received written confirmation of being conditionally selected for a grant of $5 million for the project. The project estimated delivery budget is set at $5.7 million. The start and end construction dates are slated for February 2014 and November 2014, respectively. For additional discussion on the Opal Detention Basin, see Section 1.6; refer to the Mission Storm Drain Bypass discussion in this Subsection.

**Redlands Boulevard/Alabama Street Intersection Improvements (MP 7.3)**

http://www.cityofredlands.org/redlandsalabamaintersection

The City of Redlands is currently coordinating improvements to the intersection of Redlands Boulevard, Alabama Street, and Colton Avenue to improve the level of service. Parsons Brinckerhoff (PB) is the City's contracted consultant and is in the final design phase. Currently, the capital budget is around $10 million and is slated to begin construction in 2014 at the earliest. The project will require concurrence from SANBAG on the proposed Colton Avenue crossing before approval and construction is granted.

Based on preliminary information from PB, proposed drainage improvements include an 18-inch and 36-inch diameter RCP along Redlands Boulevard, joining to the existing 48-inch diameter RCP along Alabama Boulevard, and other laterals and catch basins. The project will cross RPRP with a proposed storm drain along a redesigned Colton Avenue and will have to be coordinated with tributary drainage areas east of the project that drain along Colton Avenue and Redlands Boulevard. As of the date of this RPRP report, requested hydrology study and associated drainage computations/maps for the City project was not made available to HDR.

**University of Redlands, A Center for the Arts (MP 9.8)**

The improvements associated with this project were constructed in 2008 and one of the elements constructed was a basin, owned by the University. Bounded by Park Avenue to the south, Sylvan Boulevard to the north, the Arts buildings to the west and vacant land to the east, the basin only has a pipe inlet structure and does not have a pipe outlet system. During an emergency, the basin will spill over the parking lot and Sylvan Boulevard until it drains into the Mill Creek Zanja. Based on a review of the documents, it appears that the basin serves for both flood control and water quality. About 3.46 acres of the Arts building site is tributary to the basin and it is designed to treat 3,745 cubic feet of runoff volume for water quality. Hydrology based on the storm event discharge associated with a 10 and 100 year frequency recurrence interval (Q10 and Q100, respectively) was the basis of design for flood control. There may be an opportunity to coordinate use of this basin for the proposed RPRP improvements such as the platform/station fronting Park Avenue.

## 1.8 Drainage/Flooding History and Perspective

To appreciate the drainage issues related to the project, it is important to understand the flooding history surrounding the region. As such, this Subsection will describe the related history.

### 1.8.1 Flood History

Historical records of floods along Mission Zanja Creek and adjoining streams date back to 1819 when missionaries settled in the area. However, most historical data is qualitative; very little quantitative data is available. Records since 1900 indicate that medium to large floods occurred in the area in 1910, 1916, 1929, 1935, 1937, 1938, 1943, 1965, 1969, 1976, and 1980. A stream gaging station was established on Mission Zanja Creek at Tippecanoe Avenue near its mouth in 1942; at Iowa Street, about 1 mile downstream from the lower end of the proposed project in 1969; and at 9th Street, within the project area, in 1970. The lower two gages are affected by urbanization and inadequate channel capacity upstream which allows flow to divert around one gage while the other gage has a relatively short period of record.

Prior to 1961, major flows from Mill Creek, a much larger watercourse than Mission Zanja Creek, escaped the Mill Creek channel and flooded the community of Mentone and the City of Redlands. Construction of the Mill Creek levees has provided protection to the City of Redlands from Mill Creek flows since that date. Therefore, an examination of major floods prior to 1961 is not relevant.

The following are descriptions of known major storm events since 1961. These descriptions are based on streamgage records, newspaper accounts, and field investigations (USACE, Mission Zanja Creek, Detailed Project Report and Environmental Assessment).

1. Flood of August 11, 1965: During the afternoon of the 11th, an intense local thunderstorm occurred in the Redlands-Mentone area. Intense precipitation occurred for about a 45 minute period in the afternoon resulting in a high rate of runoff and causing overflow from Mission Zanja Creek. Approximately 76 structures received flood damages which included apartment complexes and mobile homes. Damages also occurred to local storm drains, bridges, and utilities. Flood depths averaged a foot causing extensive damage to the downtown business district. Total damages related to the flood reached an estimated $120,000.
2. Flood of January 18-27, 1969: A series of storms began on January 18 and ended January 27. Except for a lull occurring on January 22 and 23, heavy precipitation occurred during most of the period from January 18-26 and was climaxed by an intense downpour on January 25. The storm churned muddy water through the city upstream of the project area with the creek jumping its banks near Judson Street and Sylvan Boulevard and at Dearborn Street. The creek overflow was minor and damage was confined to levees, dip crossings, and agricultural land. Total damage was estimated at $51,000.
3. Flood of February 22-25, 1969: The late February 1969 storm series was the climax of more than a month of extremely heavy, recurring rainfall in southern California. The 4-day storm totals ranged from less than 5 inches in the Redlands area to over 17 inches in the higher surrounding mountains, with the bulk of these totals occurring on February 24 and 25. The following discharges were recorded in the project area: Mission Zanja at Iowa Street, 1,228 cfs; and Mission Zanja Creek at Tippecanoe, 976 cfs. The following break-down of damages (in dollars) occurred along Mission Zanja Creek: Residential; 6,000, Business; 1,000, Industrial; 25,000, agricultural; 20,000, Highways and roads; 40,000, Flood control; 166,000, business loss and emergency cost; 42,000. Total damages amounted to $400,000.
4. Flood of September 24, 1976: A flood with peak discharges along Mission Zanja Creek at 9th Street, Iowa Street, and Tippecanoe Avenue of 3000 cfs, 1,952 cfs, and 1,024 cfs, respectively, caused major damages in the City of Redlands. The existing channel and storm drains were inadequate and major flooding occurred in the downtown area. Depths of water and mud ranged from 1 to 3 feet. The flood caused damages totaling about $2,000,000, including $590,000 to residential property, $362,000 to business property, $133,000 to public properties, $150,000 to

highways, roads and streets, and $84,000 to flood control channels and drains. Approximately 250 homes were damaged in the flood. The flood was estimated to have been a 40 year event. No breakdown is available of damages along the project reach.

5. Flood of February 13-22, 1980: During a one week period in mid-February, a series of 6 storms moved through the Redlands area causing flooding conditions in Mission Zanja Creek. The maximum peak discharge along the creek at the Iowa Street gage was 1,255 cfs, and the 9th Street gage recorded a flow of 105 cfs. Reported damages caused by this flood, reached $49,000.

Additional Flood History: In September 1976, Redlands experienced water flows of up to three feet deep that caused flooding of the downtown business area and more than 200 homes. There was an estimated $1,750,000 worth of damage; $1 million to private and public property; and $750,000 to SBCFCD Facilities. Information on additional storms is available (SBCFCD General Information Book).

Additional information is provided for historical floods more recent than 1980 (City of Redlands Local Hazard Mitigation Plan) as follows.

1. Flood of February 1992: In February 1992, significant flooding occurred as a result of major storm systems moving through Southern California. The three-day storm system produced most of the 14.96 inches in rainfall for 1991-92.

   Historically, the SAR and Mission Zanja were the cause of the most significant damages, and due to extensive build out of the southeast area, storm runoff produced increased flooding of the Country Club area. Most significantly, water run-off from the populated Country Club area traversed a private elementary school as well as Ford Street and developed subdivisions to the north. School property was damaged as a result of flood waters flowing through the school's parking lot and only street entrance, resulting in a lawsuit against the City. In 1993-94 the City constructed the Ford Street Storm Drain at a cost of $450,000, and future flooding in that area has been nonexistent. The Bear Valley Pipeline, generally located in Mill Creek near Greenspot Road and Florida Street, sustained $92,000 in damage to approximately 400 feet of steel pipe and supports. The Mill Creek Zanja at Sylvan Blvd. at Judson Street eroded significantly, threatening flooding of neighborhood homes as floodwaters spilled over into the public ROW, and causing $12,000 in damage. Public safety, spillway erosions, landfill tipping fees, and debris removal alone resulted in $160,000 in damages for a 3-day period of time. There was no loss of life or public property.

2. Flood of January 1993: The Winter Floods of 1993 produced the most significant damage to the City of Redlands in recent history. Recurrent flooding during the months of December through March resulted in an over saturation of soil which promoted long-term effects of storm waters in the City and region. Tropical rains melted a heavy snow pack at the higher elevations, producing increased flood activity.

   With approximately $6.5 Million in damages, but no loss of life, these storms finally claimed both the Alabama Street and Orange Street bridges. Demolition of the old Orange Street Bridge, and construction of temporary replacement dip crossings resulted in costs of $570,000 and both crossings were opened in July 1993; replacement of the bridges is estimated to cost approximately $5.0 million by 1995. The Mission Zanja again produced flooding along its banks at Sylvan Blvd. and Judson Street, resulting in channel improvements at that intersection in excess of $27,000. Partial collapse of the Zanja occurred again in Sylvan Park. Landslides crushed the Monkey Face Falls waterline, which provides water to residents of Mountain Home Village. One additional water line, serving sparse residences north of the SAR, was washed out. Repair was affected in October 1993, following subsidence of the SAR. Tipping fees to the County landfill exceeded $185,000. Several city-owned buildings sustained water damage, including the Smiley Library, which is on the National Register of Historic Places. Fire and Police Department emergency services topped $95,000, with no loss of life. Emergency Protective Measures and Debris Removal accounted for another $125,000 in emergency services. Landslides occurred in the San Timoteo/Live Oak Canyon area, resulting in road closures for a portion of the three-month Declaration period. Final clean up efforts were accomplished in April 1993 at a cost of $30,000.

3. Flood of March 1995: The second storm series resulted in more than $12,000 in damage costs associated with Emergency Protective Measures and Debris Removal. A small storm drain collapse at Church and State Streets created another $4,000 in damage, and another mudslide in San Timoteo Canyon created damages associated with debris removal of approximately $20,000. Additionally, severe ditch and shoulder erosion and culvert damage occurred between Pilgrim Road and Rancho Caballo, at an approximate cost of $200,000. The water line, which supplies potable water from Monkey Face Falls to the residents of Mountain Home Village, was further buried after damage from two previous disasters. Due to a potential $500,000 cost for debris removal, the water line was relocated at a cost of less than $50,000. The most significant damage, however, was the loss of the temporary emergency crossings at Orange and Alabama Streets. Warm tropical rain, coupled with an extreme snowmelt, created severe flooding conditions in the SAR. Mud, debris, and boulders swept away both roads, which were replaced in 1993 (FEMA 979) at a cost of $570,000. New replacement costs were incurred for $529,000.
4. Flood of February 1998: Redlands experienced a continuing series of storms. On February 27&28, 1998 the strongest storm created a 2-day event that resulted in considerable damage and private property loss.

### 1.8.2 Mill Creek Levees

A flood control survey report of the entire SAR Basin was prepared by the USACE Los Angeles District dated November 1, 1946 (House Document 135, 81st Congress, 1st Session). This report considered the flood problem along Mission Zanja Creek resulting from flood flows escaping Mill Creek and flooding the City of Redlands. The report recommended the construction of levees on Mill Creek. The Mill Creek levee project was authorized by Congress in 1950 as a part of the Santa Ana flood control project. The Mill Creek levees were constructed in 1961 to protect property in and around Redlands, Crafton and Mentone against floods and debris overflowing from Mill Creek. The principal features of the project include (a) about 2.6 miles of levee improvements, including a side-drainage inlet levee, along the south bank of Mill Creek and (b) protection for existing masonry walls, which were utilized without modification. The levees end near the confluence of Mill Creek and the SAR. The Mill Creek Levees are designed to confine flows up to the SPFlevel, but are not designed to control floods originating in the Mission Zanja Creek drainage area.

### 1.8.3 Zanja Creek

Use of the Zanja for flood control began as early as 1892 when the portion through downtown Redlands was first channelized. Further improvements that placed the Zanja in a large underground culvert were made in 1935, when Redlands Boulevard was constructed as U.S. Highway 60, 70, and 99, one of the principal U.S. highways from Los Angeles to the east in the 1930's.

The segment of the Zanja within and adjacent to the project area has been completely changed from its original alignment due to previous flood control activities spanning the time period from 1892 to 1962.

### 1.8.4 Mill Creek Zanja

Mill Creek Zanja was originally built by Native Americans as a ditch for water supply in 1819. The water diverted from Mill Creek supported the San Bernardino Assistencia and surrounding farms and ranches. As the area has developed, the use of the Creek transformed from water supply to a flood control and drainage channel, and is manifested in pockets being owned by the SBCFCD. The Mill Creek Zanja, from 9th Street to Mill Creek, is designated as a State and Federal Historic Structure.

One of the constraints downstream of the crossing is the inlet capacity to the storm drain system at 9th Street, which is limited to 300 cfs. Current efforts (with the County and City of Redlands as stakeholders) to update CSDP No. 4, the County's master drainage plan that covers this area, are currently on hold. One of the critical components of this update is a viable flood control solution to Mill Creek Zanja. Similarly, the Redlands Conservancy is currently planning for preparation of a Mill Creek Zanja Master Plan (only from upstream of 9th Street) that may incorporate flood control solutions to the Creek. Given the City's flooding history and its association with the Mill Creek Zanja, further study is recommended to determine feasible options for this project.

### 1.8.5 Downtown Redlands

For a number of years, the City of Redlands has been concerned about the severe flooding of Mission Zanja Creek in the downtown area. Recent floods have caused over $4.3 million of damage in the area. As a result of this flooding problem, the downtown area is currently in a depressed state of development: vacant and condemned areas abound and existing land utilization is not at an optimum. Any new development in the floodplain is restricted by local ordinances. The City has prepared a Redevelopment Plan, but cannot fully implement the plan without effectively eliminating the flood hazard. However, given the current dissolution of Redevelopment agencies in the state, this plan is in a state of uncertainty. In the end, complete implementation is dependent upon elimination of the flooding problem. Flood control is essential to the City of Redlands for eliminating potential flood damages as well as stimulating economic growth. More recently, the City of Redlands has initiated work on a Flood Control Master Plan to develop a program for implementing flood control improvements for the entire city, including downtown.

**Mission Storm Drain**

Use of the Zanja for flood control purposes began as early as 1892 when the portion through downtwown Redlands was first channelized. Further improvements that placed the Zanja in a large underground box culvert were made in 1935 when Redlands Boulevard was constructed as U.S. 99 (USACE, Mission Zanja Creek, Detailed Project Report and Environmental Assessment).

The existing RCB under Redlands Boulevard is of inadequate capacity to convey runoff during a major storm event. In order to mitigate the severe flooding problem in downtown Redlands, a number of storm drain projects have been proposed by way of various studies.

The results indicate that the upper reach of the Zanja is listed on the National Register of Historic Places, but the upper portion of the Zanja is not included within the currently proposed project. The segment of the Zanja within and adjacent to the current study area has been completely changed from its original configuration and, in many areas, from its original alignment due to previous flood control projects spanning the time from 1892 to 1962.

# 2.0 EXISTING CONDITIONS

This section covers existing conditions for the Project such as land use, onsite/offsite hydrology, floodplain, storm drains, grade crossings, ditches and stormwater quality.

## 2.1 LAND USE

Land use has a direct nexus to the runoff coefficient (or runoff curve number), an important parameter for determining the runoff discharge for drainage areas. Part of the research included correlating the agency land use components to the appropriate hydrology program land use code or development type (AES). For existing land use, HDR based existing development type on existing land use conditions from land use maps.

**Table 2-1. City of Redlands Existing Land Use Category Matching vs. AES Software**

| City Land Use Categories | AES Code Number | AES Land Use or Development Type |
|---|---|---|
| A-1, Agricultural District (5 acre minimum lots) | 11 | 0.4 DU/Ac |
| A-1-20, Agricultural District (20 acre minimum lots) | 11 | 0.4 DU/Ac |
| A-2, Estate Agricultural (11/2 acre lots) | 10 | 1 DU/Ac |
| R-R, Residential Rural District (1 acre lots) | 10 | 1 DU/Ac |
| R-R-A, Residential Rural - Animal District (1 acre lots) | 10 | 1 DU/Ac |
| R-A, Residential Estate (20,000 SF lots) | 9 | 2 DU/Ac |
| R-A-A, Residential Estate –Animals (20,000 SF lots) | 9 | 2 DU/Ac |
| R-E, Residential Estate (14,000 SF lots) | 8 | 3-4 DU/Ac |
| R-S, Suburban Residential (10,000 SF lots) | 8 | 3-4 DU/Ac |
| R-1, Single Family Residential (7,200 SF lots) | 7 | 5-7 DU/Ac |
| R-1D, Single Family Residential (8,100 SF lots) | 7 | 5-7 DU/Ac |
| R-2, Multiple Family Residential (8,000 SF lots) | 7 | 5-7 DU/Ac |
| R-2,2000, Multiple Family Residential (12,000 SF lots) | 4 | Condominiums |
| R-3, Multiple Family Residential (10,000 SF lots) | 3 | Apartments |
| Table notes | | |

## 2.2 HYDROLOGY

This section describes the existing hydrology for both onsite and offsite drainage. It is organized in drainage area segments along the RPRP alignment from west to east (mostly between streets, but also between major flood control facilities and freeways). Refer to Appendix B for applicable drainage area designations identified in the hydrology maps. Unless noted otherwise, quoted discharge rates in cfs are for 100-year storm events (Q100) and the referenced stationing is to the existing track alignment.

Unless noted otherwise, the referenced stations below relate to the existing track stations. Existing stations increase towards Redlands. Left and right sides of the tracks are relative to looking upstation towards Redlands. Stations are identified in the format xxx+xx (e.g., 280+32). The existing stations do not match the proposed stations.

**E Street to Sierra Way**

This section of track extends approximately from station 83+00 to 121+00 and travels from east to west. The area is divided into three separate drainage systems with the flow of each system eventually draining into Warm Creek (Historic). This segment interfaces with the Downtown San Bernardino Passenger Rail Project (DSBPRP) at E Street. As part of the DSBPRP, SANBAG is proposing to extend Metrolink regional passenger rail service approximately one mile east from its current terminus at the existing San Bernardino Metrolink Station/Santa Fe Depot at 1170 West 3rd Street to new Metrolink commuter rail platforms near Downtown San Bernardino at the intersection of Rialto Avenue and E Street. The primary features of the Project include: construction of a second track, rail platforms, parking lots, a pedestrian overpass at the Depot, Omnitrans Bus Facility; grade crossing improvements; railroad signalization; and roadway closures. The proposed Project's secondary features include: construction of drainage improvements, utility accommodation, and implementation of safety controls. Related to the DSBPRP, the improvements for the San Bernardino Transit Center (SBTC) at E Street and Rialto Avenue are currently ongoing. Limited coordination of drainage improvements is taking place with the SBTC project as well.

Drainage Area 1000

Drainage Area 1000 is comprised of runoff collected from the DSBPRP located west of the RPRP. This drainage area includes commercial properties located as far north as 2nd Street and as far west as G Street (see Sheet 1, Appendix B). The runoff from these offsite developments are conveyed along curb and gutter improvements at Rialto Avenue, crossing Rialto Avenue through an existing culvert at the intersection of Rialto Avenue and E Street, continues southward on E Street where a 30-foot long catch basin collects a majority of the runoff prior to reaching the rail ROW (see Sheet 1, Appendix B). It is assumed the uncollected flow drains onto the rail ROW and is discharged into the rail ROW on either side of the E Street at-grade crossing. The existing 42-inch RCP storm drain system is also used to collect the runoff from the DSBPRP west of the RPRP. The total flow within the 42-inch RCP storm drain prior to the RPRP is 59 cfs.

The existing 42-inch RCP continues eastward along the rail ROW, north of the main track (see Sheet 1, Appendix B). The existing drainage improvements east of E Street are comprised of earthen ditch improvements located on both sides of the tracks, with the flow collected within drop inlet structures at Stoddard Avenue and D Street. In addition to the onsite flow, the existing drainage ditches also collect offsite flow from the developed commercial properties north of the rail ROW. The total flow collected prior to Stoddard Avenue is 64 cfs. The storm drain increases to a 48-inch RCP east of Stoddard Avenue and the collected flow is increased to 65 cfs prior to D Street and is discharged into Warm Creek (Historic).

Drainage Areas 1100, 1300 and 1400

Drainage Area 1100 models runoff conveyed within an offsite storm drain system north of the rail ROW that includes surface runoff from D Street, south of Rialto Avenue, to the rail ROW and the properties adjacent to the street (see Sheet 1, Appendix B). The flow is discharged into an asphalt swale north of the tracks and discharged into Warm Creek (Historic). The total flow conveyed within this drainage area is 10 cfs.

Drainage Area 1300 models the portion of the rail ROW between D Street and Warm Creek (Historic) (see Sheet 1, Appendix B). The flow within this area surface drains along the rail ROW towards Warm Creek (Historic); the tributary area is approximately 0.3 acres and generates less than 1 cfs of flow.

Drainage Area 1400 is comprised of the onsite area between Warm Creek (Historic) and Arrowhead Avenue. Based on a review of available topographic information, the adjacent properties drain away from the rail ROW (see Sheet 1, Appendix B). The area tributary to Drainage Area 1400 is 0.3 acres and generates less than 1 cfs of flow.

Drainage Area 2000

Drainage Area 2000 extends from Sierra Avenue to Arrowhead Avenue. It is comprised of unimproved open space parcels, identified as a former superfund site, north of the rail ROW and are graded to drain towards the rail ROW (see Sheet 1, Appendix B). The area does not have an improved drainage swale adjacent to the track, however the existing ground is generally sloped from east to west towards Sierra Avenue. Original surface topographical data obtained for the project indicated the existence of a localized sump within the open space parcel north of the tracks and it appears the flow drains into the open space parcel where the runoff either infiltrated into the ground and/or discharged onto the adjacent roadway. However, recent improvements for the Arrowhead Parking Lot discussed in Section 1.7 raised the surface grades within this area. It appears that the runoff now drains through the ballast and onto Hilda Street and/or Sierra Avenue.

The area tributary to the northern portion of the rail ROW is 5.0 acres and generates a discharge of 8 cfs. The area tributary to the southern portion of the rail ROW is 0.8 acres and generates a discharge of 2 cfs.

**Sierra Way to Mill Street**

The track alignment from station 122+00 to 134+00 is sloped from north to south with the track grades varying but averages 0.3 percent. The track ROW is bounded by Dorothy Street to the east and a mixture of developed and undeveloped parcels to the west. Onsite runoff west of the tracks appears to drain onto the adjacent offsite properties while the onsite runoff east of the tracks is collected within a drainage swale (unimproved earthen ditch) (see Sheet 2, Appendix B).

Dorothy Street, a local street with a curb-to-curb width of 27 feet, intersects with Julia Street, Cluster Street and Valley Street to the east and drain east to west towards Dorothy Street. Dorothy Street has a crowned section without curb and gutter improvements on either side, runoff is conveyed via drainage swales. The street is relatively flat with an average gradient of 0.1 percent. Dorothy Street terminates at the intersection with Valley Street near existing track station 134+00 (see Sheet 2, Appendix B). The runoff from the east leg of Dorothy Street crosses the street via an asphalt cross gutter and confluences with the runoff from west of Dorothy Street and continues south along the track alignment (see Sheet 2, Appendix B).

South of station 134+00, the track continues southward towards Mill Street, near station 152+00. The track is bounded by unimproved earthen swales located on both sides of the track (see Sheet 2, Appendix B). The track gradient increases to an average of 0.5 percent. The drainage swale west of the tracks eventually discharges into the adjacent offsite property near station 144+00 and does not appear to directly drain onto Mill Street. The drainage swale east of the track discharges onto Mill Street where an offsite curb inlet located 150 feet from the tracks conveys the runoff via a storm drain into Twin Creek (see Sheet 2, Appendix B).

The Mill Street storm drain system is a 42-inch CMP collecting runoff from two existing sump catch basins along Allen Street and two existing sump catch basins along Mill Street. The system also conveys the runoff from a private catch basin within the commercial property just north of Mill Street (see Sheet 2, Appendix B).

The hydrology for the track ditches are modeled in Drainage Areas 5000, 5100 and 7000. Drainage Areas 5000 and 5100 include the offsite runoff beginning from the eastern half-street portion of Sierra Way, north of Dorothy Street, and include properties east of Dorothy Street from the high point, estimated to be midblock between Dorothy Street and Waterman Avenue. These drainage areas also include the onsite runoff generated from the eastern half of the track ROW (see Sheet 2, Appendix B). The drainage areas extend southward to the discharge point at Mill Street. The combined tributary area for these basins is 26.9 acres with 40 cfs entering Mill Street.

Drainage Area 7000 analyzes the onsite runoff conveyed within the drainage swale west of the track, beginning near station 146+00 southward to its point of discharge onto the adjacent properties west of the track near station 150+00 (see Sheet 2, Appendix B). The overall tributary drainage area is 0.2 acres with a total flow of 1 cfs discharged into the adjacent parcels.

Drainage Area 5500 analyzes the offsite portion tributary to the Mill Street storm drain system. The drainage area has 58 acres tributary to two catch basins on Allen Street and generates a discharge of 96 cfs. The combined offsite tributary area for the inlets on Mill Street is less than an acre (excludes the rail ROW). Inlet calculations indicate the existing catch basins on Allen Street and the 42-inch storm drain are not adequately sized to collect and convey the 100-year storm flows, resulting in ponding along the street frontages near the intersection. The emergency overflow from these ponded areas would expand onto Mill Street and into the parking lot of the commercial property just north and east of the Mill Street at-grade crossing prior to extending onto the at-grade crossing, impacting the track. Future analysis is needed to determine the extent of the ponding (see Sheet 2, Appendix B).

**Mill Street to Twin Creek**

This reach begins just south of the Mill Street at-grade crossing. The track alignment from station 147+75 to 152+00 is sloped from north to south with the track grades varying, but averaging 0.3 percent to the south. The track ROW is bound by existing commercial properties on either side of the tracks and does not drain directly onto the rail ROW (see Sheet 3, Appendix B). The onsite runoff west of the tracks drains southward and onto the existing access road leading to Twin Creek. The onsite runoff east of the track drains onto the existing access road and onto the concrete swale at the top of Twin Creek channel wall where it comingles with offsite runoff east of the rail ROW prior to draining into the channel (see Sheet 3, Appendix B).

The hydrology for this portion of the rail ROW is modeled in Drainage Areas 8000 and 8100. Drainage Area 8000 has a tributary of 0.4 acres and a discharge of 2 cfs. Drainage Area 8100 has a tributary area of 0.7 acres and a discharge of 2 cfs (see Sheet 3, Appendix B).

**Twin Creek to Central Avenue**

This section of track extends from station 159+00 to 174+50. There does not appear to be graded ditch improvements on either side of the track (see Sheet 3, Appendix B). The area west of the track centerline is graded to drain offsite onto adjacent properties at different points. The area east of the track is graded to drain towards a low point near track station 166+30 where a culvert conveys the flow across the tracks and onto the adjacent property west of the rail ROW (see Sheet 3, Appendix B). The rail ROW is bounded by developed commercial properties on both sides of the rail ROW with a majority of the properties east of the rail ROW draining onto the rail ROW (see Sheet 3, Appendix B).

An existing 36-inch CMP pipe is located at the low point near existing station 166+30 and conveys the flow west of the existing track towards an improved swale located offsite (see Sheet 3, Appendix B). The downstream flowline of the existing 36-inch CMP storm drain is at elevation 1002.8 feet with the adjacent asphalt swale at elevation 1004 feet. The runoff within the rail ROW ponds up to the 1004-foot elevation prior to discharging to the improved offsite swale. The existing swale improvement drains at a 0.5 percent gradient towards Lugo Avenue located west of the rail ROW; the runoff is then discharged onto the curb and gutter improvements on Lugo Avenue and ultimately to Twin Creek (see Sheet 3, Appendix B). Based on a review of available topographic information, ponding resulting from blockage of the existing culvert would build up behind the track ballast, but would discharge onto Allen Street prior to overtopping the track. The hydrology for the track ditches are modeled in Drainage Areas 8300 and 9000. Drainage Area 8300 models the portion west of the existing track centerline from existing station 159+00 to 166+00. The onsite flow comingles with offsite runoff west of the rail ROW before discharging to Twin Creek (see Sheet 3, Appendix B). The drainage area consists of 0.8 acres with a discharge of 2 cfs. Drainage Area 9000 models the remaining portion of onsite runoff leading to the culvert. The tributary area leading to the culvert is 4.2 acres with a discharge of 9.3 cfs. The drainage area continues downstream and includes the offsite flow draining onto Lugo Avenue and ultimately into Twin Creek (see Sheet 3, Appendix B). The total tributary area of the catch basin at Lugo Avenue is 14 acres and generates a discharge of 31 cfs.

Central Avenue is a four-lane collector street with a 65-foot curb-to-curb street width. The street has curb and gutter improvements just east of the rail at-grade crossing. West of the at-grade crossing, the curb and gutter improvements are only located on the north side. Inlets structures are located on both sides of the street just east of the at-grade crossing (see Sheet 3, Appendix B). The inlet on the south has a 6-foot opening and an 18-foot wide depression. The inlet on the north side has an 8-foot opening with a 21-foot wide depression. The height of the inlet opening is not available.

The hydrology for Central Avenue is modeled in Drainage Area 11000. Based on a review of the available topography and a field walk, the tributary area extends from the Central Avenue at-grade crossing eastward to Lena Road. The tributary area is calculated to be 36.1 acres, with a majority being undeveloped mixed use properties north of and including Central Avenue. The flow is primarily conveyed along curb and gutter improvements along Central Avenue. Catch basins are located at the intersection of Central Avenue and Waterman Avenue where the runoff is collected. The flow is then discharged onto the Central Avenue curb and gutter improvements approximately 100 feet west of the intersection. The flow continues westward towards the at-grade crossing and is collected in sump catch basins. The captured runoff is conveyed within a 22-inch x 38-inch arch pipe through the grade crossing and discharged onto the north side of Central Avenue. The runoff eventually drains into the Twin Creek channel (see Sheet 3, Appendix B).

**Central Avenue to Orange Show Road**

This section of track extends from track station 175+00 to 192+50. There does not appear to be graded ditch improvements on either side of the track. The area west of the track centerline along this section is graded to drain westward onto the adjacent properties and it does not appear the flow is concentrated at any point along this stretch. The area east of the track is graded to drain towards a low point near track station 181+00. The track ROW is bounded by mixed use properties, a majority of which remain undeveloped. A majority of the properties east of the rail ROW drain towards the rail ROW, however a review of the topographical information indicates existence of a sump area within the properties east of the rail ROW near station 179+50 (see Sheet 4, Appendix B). The sump is approximately 1.5 feet below the rail ROW and collects runoff from properties near station 178+50 to 181+00.  The properties west of the rail ROW drain away from the rail ROW (see Sheet 4, Appendix B).

An existing 4-foot wide x 3-foot high wooden culvert is located at the low point near existing station 186+50 and is used to convey the flow west of the track towards the offsite properties west of the rail ROW (see Sheet 4, Appendix B). The wooden culvert is practically buried and a small opening exists where flow is allowed to drain.

The hydrology for the onsite flow is modeled in the 12000, 12100 and 12200 drainage areas. Drainage Areas 12100 and 12200 model the flow generated west of the rail ROW. The tributary area in each drainage area is less than 1 acre each and directly drains onto the properties west of the rail ROW (see Sheet 4, Appendix B). It does not appear the flows are concentrated prior to discharging onto the adjacent properties. Drainage Area 12000 models the runoff currently draining into the wooden box culvert. The area tributary to the wooden culvert is 13.8 acres, generating a discharge of 25 cfs. Due to the inability of the buried wooden culvert to convey this flow, the runoff most likely ponds east of the rail ROW until the runoff is conveyed through the culvert or percolates into the ground. With the track ballast 3 feet higher than the adjacent grades and the flat terrain adjacent to the rail ROW, it does not appear likely that the runoff would overtop the tracks during an intense storm. Site photos of the track ballast adjacent to existing culvert do not show evidence of erosion related to runoff overtopping the track ballast.

**Orange Show Road to Waterman Avenue**

This section of track extends from station 199+00 to 208+00 and travels north to south. There does not appear to be graded ditch improvements on either side of the track within the rail ROW. The adjacent property east of the track is a fully developed commercial site. The site is graded to drain westward and towards the track ROW. The area west of the track appears to be residentially zoned with a mixture of open space and developed properties. The site surface is graded to drain away from the rail ROW. The existing rail ROW west of the track is sloped westward and drains onto the adjacent properties west of the rail ROW. The existing rail ROW east of the track is graded to drain from south to north, and flattens out near existing station 200+00 (see Sheet 4, Appendix B). It appears that the runoff ponds at this point and percolates into the ground as there does not appear to be a point of discharge. Based on a review of available topographic information, the runoff would overtop the track centerline prior to draining onto Orange Show Road.

The hydrology for the flow within this section is modeled in Drainage Area 14000. The total tributary area is 4.2 acres and generates a discharge of 10 cfs.

**Waterman Avenue to SAR**

This section of track extends from station 209+00 to 228+00 and travels west to east. There does not appear to be graded ditch improvements on either side of the track within the rail ROW. The adjacent property north of the track is open space zoned for commercial. The offsite area north of the tracks is graded to drain north and west away from the track ROW (see Sheet 4, Appendix B). The offsite area south of the track is a developed commercial site with curb and gutter improvements and a combination wall/tube steel fence separating it from the rail ROW. The site surface improvements convey the runoff away from the rail ROW. The existing rail ROW is graded to drain from east to west towards the concrete drainage structures at the Waterman Avenue at-grade crossing (see Sheet 4, Appendix B). The drainage structures discharge the flow into a 30-inch RCP storm drain (per available record documents).

The hydrology for the onsite flow is modeled in Drainage Areas 16500 and 16600. Drainage Area 16500 models the onsite runoff north of the track. The total tributary is 1.8 acres and generates a discharge of 3 cfs. Drainage Area 16600 models the runoff south of the existing track (see Sheet 4, Appendix B). The total tributary area in this drainage area is 1.6 acres and generates a discharge of 2 cfs. Drainage flow within the existing 30-inch RCP storm drain has not been determined as additional information regarding the detention basins upstream, near Norman Road is required to determine the flow tributary to the storm drain.

**SAR to Tippecanoe Avenue**

This section of track extends from station 237+00 to 269+00 and travels west to east. The offsite properties north of the track are primarily developed commercial properties. The existing ground drains away from the rail ROW, except for the property located adjacent to Tippecanoe Avenue (see Sheet 5, Appendix B). The track is bounded by the Mission Zanja Channel to the south. The existing rail ROW is graded to drain from east to west and discharges onto the SAR (see Sheet 5, Appendix B).

The hydrology for the onsite flow is modeled in Drainage Area 18000 which focuses on the runoff north of the track. The total tributary is 5.0 acres and generates a discharge of 7 cfs which drains to the SAR.

**Tippecanoe Avenue to Richardson Street**

This section of track extends from station 270+00 to 291+00 and travels west to east. The adjacent properties north of the track are developed commercial properties. A majority of the adjacent properties drain towards the rail ROW except for the parcels immediately adjacent to Tippecanoe Avenue and Richardson Street which are surrounded by a concrete swale (see Sheet 6, Appendix B). The track is bounded by the Mission Zanja Channel to the south. The existing rail ROW is graded to drain from east to west and is tributary to the SAR (see Sheet 6, Appendix B).

The area just south of the track is modeled in Drainage Area 19000. The drainage area has a tributary area of 1.2 acres with a total runoff of 1.8 cfs which drains directly into the Mission Zanja Channel. The hydrology for the area north of the track is modeled in Drainage Area 20000. The total tributary is 7.8 acres with a total runoff of 10 cfs. The runoff drains into a concrete ditch along the existing parking lot of the parcel just east of Tippecanoe Avenue (see Sheet 6, Appendix B). The concrete ditch drains onto Tippecanoe Avenue and northward towards the SAR.

**Richardson Street to Mountain View Avenue**

This section of track extends from station 292+00 to 320+50 and travels west to east. The adjacent properties north of the track are comprised of residential properties, except for the parcels adjacent to Richardson Street and Mountain View Avenue which appear to be mixed use (see Sheet 6 and Sheet 7, Appendix B). A majority of the properties drain towards the rail ROW except for the parcels immediately adjacent to Richardson Street (see Sheet 7, Appendix B). The track is bounded by the Mission Zanja Channel to the south. The existing rail ROW is graded to drain from east to west and discharges onto Richardson Street (see Sheet 6 and Sheet 7, Appendix B).

The hydrology for the onsite flow north of the track is modeled in Drainage Area 21000. The total tributary is 28.6 acres and generates a flow of 53 cfs. The runoff sheet flows onto the existing curb and gutter improvements at Richardson Street, which eventually drains west onto Tippecanoe Avenue and northward towards the SAR. The tracks are very close to the Mission Zanja Channel embankment resulting in a very small area that is collected within a drainage swale, the majority directly drains towards the channel embankment (see Sheet 6 and Sheet 7, Appendix B). Drainage Area 22000 models this area, having a tributary area of 0.6 acres and generates a flow of 1.1 cfs. This runoff drains into the channel.

**Mountain View Avenue to West I-10 Overpass**

This section of the track extends from station 321+00 to 345+00 and travels from northeast to southwest. The adjacent properties north of the track are primarily commercial with a few residential properties, as well as some open fields. There is also a detention basin at the northeast intersection of Mountain View

Avenue and Lugonia Avenue. A majority of the offsite properties drain toward the rail ROW except for the parcels north of Lugonia Avenue (including the detention basin). The track is bounded by the Mission Zanja Channel to the south. The existing rail ROW is graded to drain from east to west and drains towards the SAR by way of Mission Zanja Channel (see Sheet 7, Appendix B).

The hydrology for the onsite flow is modeled in Drainage Areas 23000, 24100 and 26000. Drainage Area 23000 models onsite runoff east of the track and north of Lugonia Avenue (see Sheet 7, Appendix B). The drainage area has a tributary area of 0.6 acres and generates a total flow less than 2 cfs. The onsite runoff drains into the detention basin east of Mountain View Avenue. Drainage Area 24100 models the runoff north of the track (see Sheet 7, Appendix B). The total tributary area is 24.8 acres and generates a discharge of 31 cfs. The onsite runoff drains into a concrete channel with a 3-foot x 2-foot drop inlet and into 72-inch storm drain where it confluences with offsite flow from Lugonia Avenue and drains into the Mission Zanja Channel. The ditch uses a 3-foot wide x 4-foot high wooden culvert crossing the tracks as an emergency overflow spillway. The total flow entering the Mission Zanja Channel from this system, including the runoff from Lugonia Avenue is approximately 450 cfs. Drainage Area 26000 models the runoff west of the tracks, which is primarily onsite runoff (see Sheet 7, Appendix B). The tributary area is 1.2 acres and generates a runoff of 2.0 cfs.

**West I-10 Overpass to Alabama Street**

This section of the track extends from station 347+50 to 433+00 and travels from east to west. The tributary parcels north of the track consist of open space parcels from 347+50 to 406+00 and commercial properties from 407+00 to 433+50. The track is bounded by the Mission Zanja Channel to the south from 347+50 to 370+00 and a mixture of commercial and open space properties for the remainder. These parcels drain away from the rail ROW. The existing rail ROW is graded to drain from east to west with the flow eventually discharging into the Mission Zanja Channel (see Sheet 7 through Sheet 9, Appendix B).

<u>West I-10 Overpass to California Street</u>

The tributary area within this section drains from east to west and begins at California Street and includes the area offsite north of the track ROW, as the area south of the tracks drains southward into the Mission Zanja Channel (see Sheet 7 and Sheet 8, Appendix B). The offsite area north of the tracks consists primarily of open space. The offsite area drains east to west with only a portion draining onto the rail ROW, near station 349+00 and the remainder draining directly into the Caltrans trapezoidal concrete-lined ditch adjacent to the toe of the south I-10 slope. The onsite flow is collected and conveyed in an earthen swale located north of the tracks and drains into the Caltrans ditch at station 350+00 and is conveyed into a 42-inch RCP storm drain prior to being discharged into the Mission Zanja Channel (see Sheet 7 and Sheet 8, Appendix B). The flow collected within the earthen channel is modeled as part of Drainage Area 50000. This portion of the drainage area has a tributary area of 8.7 acres and has a discharge of 13 cfs. The total flow draining into the Caltrans ditch prior to discharging into the Mission Zanja Channel is 330 cfs. The onsite area south of the track is modeled in Drainage Area 27000 and has a tributary drainage area of 1.9 acres with a flow of 3 cfs, draining directly into the Mission Zanja Channel.

<u>California Street to Nevada Street</u>

The tributary area within this stretch drains from east to west and begins at Nevada Street and north of the track ROW, as the area south of the tracks drains southward and away from the project. The offsite area north of the tracks consists of open space with a majority consisting of an orange grove. A portion of this offsite area drains into the Caltrans ditch adjacent to the I-10 and the remainder drains onto the rail ROW. The runoff within the rail ROW is collected and conveyed in an earthen swale which drains into the Caltrans ditch which conveys the flow westward beyond California Street (see Sheet 8, Appendix B). The Caltrans ditch also collects and conveys the runoff from the I-10.

The tributary area to the earthen ditch within the rail ROW is 5.8 acres generating less than 9 cfs. The runoff confluences with 3.8 acres from the orange grove parcel which does not drain towards the rail ROW (see Sheet 8, Appendix B). An additional 20 acres drain directly into the Caltrans ditch from the portion of I-10 within this section. Assuming all flows are able to enter the ditch during the 100-year event, the total flow in the Caltrans ditch at California Street is 310 cfs.

<u>Nevada Street to Alabama Street</u>

The tributary area for the track runoff begins at Alabama Avenue and is modeled as part of Drainage Area 50000. The track runoff is collected and conveyed in an irregular earthen ditch north of the track. The earthen ditch also collects and conveys offsite flows from a portion of the commercial properties immediately north of the tracks and conveys the flow west towards Nevada Street (see Sheet 9, Appendix B). The runoff is drained onto the street and confluences with runoff from Industrial Park Avenue. In addition, there is flow from the area north of the I-10 which consists primarily of commercial properties extending as far north as Plum Lane. The offsite runoff flows east and south towards the I-10 overpass at Nevada Avenue. Eventually all the runoff at the I-10 overpass drains into the Caltrans concrete ditch immediately south of the I-10 and drains westward where it confluences with Mission Zanja Channel.

The total tributary area from the rail ROW and the commercial properties draining onto the rail ROW is 10 acres and generates a discharge of 22 cfs (see Sheet 9, Appendix B). The offsite flow from Industrial Park Avenue is 16.9 acres and generates a discharge of 33 cfs. When the flows confluence, the total runoff is 51 cfs. The total flow within the Caltrans ditch upstream of Nevada Street is 100 cfs and the runoff from the area north of the I-10 is 149 cfs and has a tributary area of 69.3 acres. Assuming all flows are able to enter the ditch during the 100-year event, the total flow within the Caltrans ditch downstream of Nevada Street is 295 cfs.

**Alabama Street to Texas Street**

This section of track extends from station 434+00 to 489+00 and travels east to west. The adjacent properties north of the track are comprised of commercial and industrial properties, except for the parcels adjacent to Stuart Avenue which is a school and a park. The offsite flow from the school, park, and the industrial properties drain to a storm drain system at the corner of New York Street and Stuart Avenue, and then outlets into a ditch in the rail ROW (see Sheet 10 and Sheet 11, Appendix B). It then continues west towards Tennessee Street. The heavy flow has eroded the subgrade and crossed under the tracks. The auto body shop drains through the ROW and onto Redlands Boulevard (see Sheet 10 and Sheet 11, Appendix B). The flow traveling west in the ditch crosses through a culvert at Tennessee Street. The commercial properties north of the tracks from Tennessee Street to Colton Avenue drain south onto the tracks and enter the ditch (see Sheet 10 and Sheet 11, Appendix B). The ditch then enters a culvert at Colton Avenue. The flow then continues to Alabama Street where it enters into the storm drain system north of the grade crossing.

The hydrology for the onsite flow is modeled in Drainage Area 60000. The Drainage Area 60000 models the onsite runoff and offsite runoff north of the track (see Sheet 10 and Sheet 11, Appendix B). The total tributary is 100 acres and generates a discharge of 138 cfs. The runoff outlets at a culvert on Colton Avenue and flows along existing curb and gutter improvements along Redlands Boulevard, which eventually flow into the Mission Zanja Channel.

**Texas Street to Church Street**

This section of track extends from station 489+50 to 542+00 and slopes from east to west. Based on a review of the available topography, it appears that the offsite properties adjacent to the tracks drain away from rail ROW. As a result, the existing rail ROW only accommodates the runoff generated onsite (see Sheet 11 through Sheet 13, Appendix B). West of Eureka Street, the rail ROW begins to accept offsite flows from properties adjacent on both sides. These properties consist primarily of commercial and open space properties.

Existing storm drain infrastructure along this stretch consists primarily of the storm drain which begins at Texas Street and branches off into Stuart Avenue and Eureka Avenue. Other systems are found at Orange Avenue, 9th Street and Church Street.

<u>Texas Street to Eureka Street</u>

The tributary area begins at Eureka Street and is modeled in Drainage Area 70000. A majority of the adjacent properties north of the rail ROW drain onto the tracks, with only the undeveloped properties draining onto the track from the south (see Sheet 11 and Sheet 12, Appendix B). The runoff is collected and conveyed in unimproved drainage ditches located on either side of the tracks and is discharged onto the curb and gutter improvements on Texas Street before it continues flowing into the existing catch basin improvements near the intersections.

The total flow within the unimproved drainage swales is 9 cfs along the northern swale prior to being discharged onto Texas Street and 5 cfs along the swale south of the rail ROW.

<u>Eureka Street to Orange Street</u>

The tributary area begins at 6th Street and is modeled in Drainage Area 70000. There is no offsite areas tributary to the rail ROW in this stretch. Instead, runoff within the rail ROW drains onto the adjacent open space property north of the tracks (see Sheet 12, Appendix B). The flow is conveyed towards the existing catch basin located at the intersection of Stuart Avenue and Eureka Street. The flow south of the track drains towards the existing catch basin improvements on Eureka Street.

<u>Orange Street to 6th Street</u>

The tributary area for the drainage area begins at 6th Street and is modeled in Drainage Area 80000. There is no offsite area tributary to the rail ROW in this section. The runoff within the rail ROW is conveyed primarily within unimproved swales on both sides of the track and drains onto Orange Street on either side of the track (see Sheet 12, Appendix B). The runoff is then collected in the catch basin inlets on either side of the tracks.

The onsite drainage areas are 0.3 acres on either side of the track and generate a total flow of 1.5 cfs.

<u>6th Street to 7th Street</u>

6th Street is located approximately 250 feet west of 7th Street. There are no offsite properties tributary to the rail ROW within this section. The onsite flows are conveyed in unimproved drainage swales on either side of the track and drain onto 6th Street on either side of the track (see Sheet 12, Appendix B). The runoff south of the tracks drains towards Redlands Boulevard and the runoff north of the tracks drains northward along 6th Street.

The area tributary to 6th Street is less than 0.2 acres on either side and the flow would be less than 1 cfs.

7th Street to 9th Street

The tributary area for the drainage area begins at 9th Street and is modeled in Drainage Area 70000. There is no offsite areas tributary to the rail ROW in this stretch. The runoff within the rail ROW is conveyed primarily within unimproved ditches on both sides of the track and drain onto 7th Street on either side of the track (see Sheet 12, Appendix B). This flow drains onto Stuart Avenue where it continues to flow westward. The runoff south of the track drains onto Redlands Boulevard and the flow north of the tracks drains onto Stuart Avenue.

The area tributary to 7th Street is less than 0.2 acres on either side of the tracks and the total flow would be less than 1 cfs. For the purposes of this study, the flows have been calculated to continue along the track ROW to 6th Street.

9th Street to Church Street

The tributary area for the drainage area begins north of Church Street and includes the commercial property immediately north of the at-grade crossing. The flows drain into the rail ROW via an asphalt swale. The flows drain along the rail ROW in an unimproved drainage swale north of the tracks and discharge onto the 9th Street surface improvements. This flow drains onto Stuart Avenue where it continues to flow westward (see Sheet 12 and Sheet 13, Appendix B).

The drainage is modeled in Drainage Area 70000. Based on calculations, the unimproved swale discharges 5 cfs from 1.3 acres onto 9th Street. The total flow on Stuart Avenue is 60 cfs.

**Church Street to Cook Street**

This section of track extends approximately from existing track station 545+00 to 575+00 and travels from east to west. Based on a review of the available topography, the drainage tributary includes offsite improvements, up to 2,000 feet from Cook Street at-grade crossing (see Sheet 13 and Sheet 14, Appendix B). These improvements include a 5-acre mobile home park north of the rail ROW and fronting Judson Street, and a portion of a single residential subdivision west of Judson Street. The runoff sheet flows westward across Grove Street along an unimproved ditch north of the rail ROW (see Sheet 13 and Sheet 14, Appendix B). A 24-inch Corrugated Steel Pipe (CSP) culvert conveys the flow under Cook Street where an unlined ditch continues the flow west towards University Street. The total flow conveyed through the culvert is 27 cfs. Based on a review of the existing contours, it appears the concentrated flow dissipates due to a lack of drainage improvements near University Street, and it is possible the flow could either drain south or north along University Street, or continue westward along Park Avenue. For the purposes of this study, it is assumed the flow continues westward across University Street and along Park Avenue. The total flow at University Street is 32 cfs and flows westward along Park Avenue and eventually drains into the Mill Creek Zanja; the total flow draining into the channel is 32 cfs.

The second area within this section is between Church Street and Mill Creek Zanja, from existing track station 537+00 to 540+00. The portion from 541+00 to 542+00 drains into Mill Creek Zanja and the track from 542+00 to 545+00 is under the East I-10 Overpass.

In summary, for existing conditions, the average discharge per area ratio west and east of the SAR is 1 and 2.4 cfs per acre, respectively.

### 2.2.1 Caltrans

Drainage along certain sections of I-10 (Caltrans ROW) flow along Caltrans ditches and eventually discharges into culverts that outlet to Mission Zanja Channel. This is identified in the applicable subsections of Section 2.2. Tributary drainage along I-10 was taken into account in determining existing drainage areas and discharges. Existing H&H reports describing the tributary drainage areas to I-10 were requested from Caltrans but are not available.

## 2.3 Floodplain

Regional flooding has an impact on local drainage especially in the floodplain. Additional information is available in the Floodplain Evaluation Technical Memorandum prepared by HDR Engineering. Based on this information, downtown Redlands area presents the greatest flooding risk to the project. Flood control projects implemented by the USACE, SBCFCD, and the City of Redlands have greatly reduced potential flood hazards. However, the potential for flooding during moderate (i.e., not unusually heavy) storm events still exists and is of primary concern for the Project.

## 2.4 Storm Drains

The existing major and minor storm drains within the project area or affecting the project are identified in this section.

### *2.4.1 Onsite*

The only onsite storm drain system is located at the west end of the project from E Street to Historic Warm Creek and was constructed in August 20, 2001, as part of the Metrolink Commuter Rail System Project and covered most of the area for DSBPRP (Contract C3056). It was designed for Southern California Regional Rail Authority (SCRRA) by the Commuter Rail Engineering Team (CRET). An existing 48-inch RCP drains the area from the high point between F Street and E Street of DSBPRP and is located within railroad ROW. The existing storm drain begins along the north side of the tracks, conveys flows easterly, crosses to the south side of the tracks just east of D Street, and continues east until it outlets through the west wall of Historic Warm Creek.

The remaining onsite systems consist of culverts as identified on Table 2-2. These culverts drain runoff outside of grade crossings. See Appendix D for related photos. Culverts located at grade crossings and that are part of local drainage systems under the jurisdiction of local agencies basically convey offsite flows. Refer to Table 2-3 for additional information.

**Table 2-2. Existing Culverts**

| MP | Location | Size / Geometry / Material | Documentation Source | Notes |
|---|---|---|---|---|
| 2.0 | Mill Street | 8-foot wide x 4.5-foot high x 34.8-foot CAP | Redlands District Track Chart, Sept 1981 | Not found in the field. |
| 2.25 | | 36-inch CMP | | Found culvert in field investigation. See Sheet 3 in Appendix B. |
| 2.4 | Central Avenue | 22-inch x 13-inch Squashed CMP | Plan 69-231, sheet 4263 | It has been verified in the field. See Sheet 3 in Appendix B. |
| 2.6 | Between Central Avenue and Ennis Street | 4-foot wide x 3-foot high x 32-foot Wood Box | Redlands District Track Chart, Sept 1981 | Confirmed in field investigation. Culvert has been buried and has a smaller opening to allow flow to seep through. See Sheet 3 in Appendix B. |
| 2.9 | Between Ennis Street & Orange Show Road | 1-foot wide x 1-foot high x 6.6-foot Wood Box | Redlands District Track Chart, Sept 1981 | Not found in field. |

| MP | Location | Size / Geometry / Material | Documentation Source | Notes |
|---|---|---|---|---|
| 3.9 | West of Tippecanoe Avenue | Unknown | | Found in field. Culvert under industrial spur track for UPS building. Size/material needs to be confirmed. The pipe runs parallel to the main track and is about 120 feet long. See Sheet 5 in Appendix B. |
| 4.2 | East of Tippecanoe Avenue | 2 – 36-inch x 22-inch Squashed CSP<br>1 – 24-inch x 36-inch Squashed CSP | Redlands District Track Chart, Sept 1981 | All three pipe locations were verified in the field investigation. They serve as culverts under industrial spur tracks and run parallel to the main track. See Sheet 6 in Appendix B. |
| 5.1 | | Size Undetermined, Concrete Encased | Redlands District Track Chart, Sept 1981 | Confirmed in field investigation. The pipe has been plugged and is not in use. The size of the pipe could not be verified. |
| 5.2 | Mountain View Avenue | 1 – 72-inch RCP<br>1 – 3-foot x 4-foot squash CMP<br>1 - 24-inch RCP at Lugonia Avenue extension | Storm Drain Improvements Lugonia Avenue RR Xing & Channel Connection. Plan 1097-7-B<br><br>Redlands District Track Chart, Sept 1981 | Confirmed storm drains in field investigation. 72-inch RCP comes from Lugonia Avenue, where it is joined by 24-inch RCP which picks up flow from the 3-foot x 2-foot drop inlet. There is also an older 3-foot x 4-foot squashed pipe culvert, which picks up whatever flow that doesn't make it into the 3-foot x 2-foot drop inlet. See Sheet 7 in Appendix B. |
| 5.7 | North of west I-10 overpass | 2 culverts<br><br>48-inch RCP | Redlands District Track Chart, Sept 1981<br><br>Storm Drain Improvement Plans for Line 'C' | Two culverts from track charts were not found in field investigation. It seems that 2 culverts have been replaced by Line 'C,' which is a 48-inch RCP. There is also a second culvert south of the I-10 that is under the storm drain crossings. See Sheet 7 in Appendix B. |
| 6.05 | Between Bryn Mawr Avenue and California Street | 15-inch RCP | Redlands District Track Chart, Sept 1981 | Verified a 14-inch CMP from field investigation. See Sheet 8 in Appendix B. |
| 6.8 | Nevada Street | 22-inch wide x 16-inch high Wood Box | Redlands District Track Chart, Sept 1981 | Could not field verify. |
| 7.4 | Colton Avenue | 2 – 24-inch x 18-inch Wood Box | Redlands District Track Chart, Sept 1981 | Both boxes were verified in field investigation. See Sheet 10 in Appendix B. |
| 7.8 | Tennessee Street | 18-inch RCP and 24-inch RCP | Redlands District Track Chart, Sept 1981 | In field investigation, HDR found an 18-inch RCP which carries flow from Tennessee Avenue onto the railroad ROW. HDR also found a 24-inch RCP which carries flow parallel to the tracks across Tennessee Avenue. See Sheet 11 in Appendix B. |
| 7.8 | Tennessee Street | 6-inch RCP | | Private crossing has culvert which runs parallel to the tracks. |

| MP | Location | Size / Geometry / Material | Documentation Source | Notes |
|---|---|---|---|---|
| 8.2 | Stuart Avenue | 18-inch RCP<br><br>12-inch CMP (longitudinal – north side) | | In field investigation, the 18-inch RCP was found to take flow from New York Street and Stuart Avenue and discharges flow into onsite ditch. There is also a 12-inch CMP parallel to the tracks on the north side that conveys flow from the ditch under the pedestrian walkway. See Sheet 11 in Appendix B. |
| 8.36 | Texas Street | 24-inch CMP | Redlands District Track Chart, Sept 1981 | Could not field verify. |
| 8.43 | Texas Street | 2-foot wide x 1-foot high x 30.2-foot CWB | Redlands District Track Chart, Sept 1981 | Could not field verify. |
| 8.85 | Orange Street | 18-inch wide x 18-inch high x 47.6-foot CWB | Redlands District Track Chart, Sept 1981 | Could not field verify. |
| 9.2 | 9th Street | 60-inch x 44.3-foot long CIP | Redlands District Track Chart, Sept 1981 | Could not field verify. Survey of area is required. |
| Notes: CAP, Concrete Arched Pipe; CIP, Cast Iron Pipe; CMP, Corrugated Metal Pipe; CSP, Corrugated Steel Pipe; CWB, Creosote Wood Box; RCP, Reinforced Concrete Pipe | | | | |

### 2.4.2 Offsite

Culverts located at grade crossings and that are part of local drainage systems under the jurisdiction of local agencies basically convey offsite flows. These crossings are identified in Table 2-3.

**Table 2-3. Existing Local Storm Drain Crossings**

| MP | Location | Size / Geometry / Material | Notes |
|---|---|---|---|
| 2.05 | Along north side of Twin Creek south of Mill Street | 78-inch RCP | See Sheet 3 in Appendix B. |
| 2.4 | Central Avenue | 22-inch x 36-inch Squashed CMP | Storm drain discharges into curb and gutter west of crossing. Future analysis should include review of the condition of system as it appears storm drain may be breached by existing palm trees west of tracks. See Sheet 3 in Appendix B. |
| 2.8 | Orange Show Road | 36-inch RCP | See Sheet 4 in Appendix B. |
| 3.0 | Waterman Avenue and Dumas Street | 30-inch RCP (Estimated) | Need a site visit to access existing manhole and verify size of storm drain. See Sheet 4 in Appendix B. |
| 5.2 | Mountain View Avenue | Unknown | There is a storm drain system on Mountain View Avenue, but plans for storm drain system were not found at the City. See Sheet 7 in Appendix B. |
| 5.25 | Lugonia Avenue | 72-inch RCP<br><br>3-foot x 4-foot Squashed CMP | The 3-foot x 4-foot squashed pipe CMP is used as a back up for the flow that cannot be accommodated into the 72-inch RCP. See Sheet 7 in Appendix B. |
| 5.6 | North of I-10 west overpass | 48-inch RCP | See Sheet 7 in Appendix B. |
| 5.6 | Concrete channel south of I-10 | 42-inch RCP | See Sheet 7 in Appendix B. |
| 7.3 | Alabama Street | 39-inch RCP | Coordination required with PB to see if any changes will be made to the storm drain in Colton realignment. We will have to see if we can join the existing pipe and discharge RPRP onsite drainage. See Sheet 10 in Appendix B. |
| 7.4 | Colton Avenue | 36-inch RCP | Proposed project by PB which will be constructed by the time RPRP is constructed. Need to coordinate with PB to possibly upsize storm drain pipes. See Sheet 10 in Appendix B. |
| 8.4 | Texas Street | 66-inch RCP | See Sheet 11 in Appendix B. |
| 8.8 | Orange Street | 24-inch RCP | 36-inch steel casing around pipe at track crossing. See Sheet 12 in Appendix B. |
| 9.0 | 6$^{th}$ Street | 24-inch RCP | 32-inch steel casing pipe at crossing. See Sheet 12 in Appendix B. |
| 9.2 | 9$^{th}$ Street | 48-inch x 30-inch Rock and Concrete Arch | Per conversations with the City of Redlands, the culvert used to be an open channel and has since been covered through the development process. HDR was notified that records were burned in a fire at the City. Records of the Mission Zanja Channel identifies a 4-foot x 5-foot box outlet from the north, presumably the system at 9$^{th}$ Street. See Sheet 12 in Appendix B. |
| Notes: CMP, Corrugated Metal Pipe; RCP, Reinforced Concrete Pipe | | | |

## 2.5 GRADE CROSSINGS

Grade crossings occur where the railroad crosses street intersections. There are two scenarios to convey drainage onsite (rail ROW) and across grade crossings to perpetuate the drainage pattern. Drainage towards grade-crossings is either directed parallel to the railroad and across the street via culverts or is directed to drain into the intersected street (by turning left or right) via the curb and gutter and/or the local storm drain system located within the street. The intersected street at most existing grade-crossings create a high point instead of a sump condition, and none of the grade crossings includes a median. The agency requirement used to design the existing grade-crossings is not known at this time but was probably based on BNSF requirements.

## 2.6 WAYSIDE DITCHES

As discussed in Section 2.2, most ditches are functioning as intended to convey drainage away from the railroad ballast. However, there are some sections whereby sedimentation has compromised the ballast section or has resulted in very flat ditches to the point where they longer convey flow in a concentrated manner. The ballast in these areas are saturated with fines and could probably be cleaned, screened and reused.

## 2.7 STORMWATER QUALITY

This document does not address stormwater quality or applicable mitigation for the project. Please refer to the project Preliminary Water Quality Management Plan for additional information.

# 3.0 REGULATORY SETTING

This section establishes the drainage regulatory setting of the Project from a federal, state, regional and local perspective.

## 3.1 FEDERAL

### 3.1.1 Flood Insurance Rate Maps

FIRMs are prepared after a risk study for a community has been completed and the risk premium rates have been established. The maps indicate the risk premium zones applicable in the community and when those rates are effective. They are used in making floodplain determinations and to determine if a proposed action is located in the base or critical action flood plain, as appropriate. The base floodplain is defined as "the area subject to flooding by the flood or tide having a one percent chance of being exceeded in any given year." An encroachment is defined as "an action within the limits of the base floodplain."

## 3.2 STATE

### 3.2.1 California Drainage Law

California Drainage Law is essentially case law. Therefore, it is complex, but the courts have established the following general principles that apply to development projects:

- The downstream property owner is obligated to accept and make provisions for those waters that are the natural flow from the land above.
- The upstream property owner shall not concentrate water where it was not concentrated before without making proper provision for its disposal without damage to the downstream property owner.
- The upstream property owner may reasonably increase drainage runoff by paving or construction of other impervious surfaces, including buildings without liability. The upstream property owner may not further increase drainage runoff by diversion of water that previously drained to another area. Reasonableness is often based on prevailing standards of practice in the community or region.
- No property owner shall block, or permit to be blocked, any drainage channel, ditch, or pipe. No property owner shall divert drainage water without properly providing for its disposal.

## 3.3 REGIONAL

There are no regional regulatory requirements that dictate local drainage design.

## 3.4 LOCAL

### 3.4.1 City of Redlands Municipal Code

The Redlands Municipal Code (RMC), Title 13 Public Services, Chapter 13.54 Storm Drains, was modified to include a comprehensive stormwater ordinance that prohibits illicit discharges to the storm drain system. It is prohibited to:

- Discharge directly or indirectly into the storm drain system any stormwater or other solid, liquid or gaseous matter in violation of any law, rule, regulation, permit, order or other requirement of any federal, state, county, municipal or other governmental entity or agency;
- Discharge nonstormwater directly or indirectly to the storm drain system or any street, or lined or unlined drainage ditch which leads to a public storm drain, unless such discharge is permitted by an NPDES permit or a city permit. If such discharge is permitted by an NPDES permit, but causes the city to violate any portion of its NPDES permit for stormwater discharges, such discharge is also prohibited;
- Throw, deposit, leave, maintain, keep or permit to be thrown, deposited, placed, left or maintained, any refuse, rubbish, garbage, or other discarded or abandoned objects, articles, and accumulations, in or upon any street, alley, sidewalk, storm drain, inlet, catch basin, conduit or other drainage structures, business place, or upon any public or private lot of land in the city, so that the same might be or become a pollutant; or
- Throw or deposit litter in any fountain, pond, lake, stream or any other body of water in any park, or elsewhere within the city. (Ord. 2274 § 1, 1995)

### *3.4.2 City of Redlands General Plan*

The City of Redlands' General Plan contains several policies regarding the risks associated with flooding in the Health and Safety Element. Specifically, it provides assessment of natural and manmade hazards associated with flooding and dam inundation, as well as providing a framework and guiding policies to guide future development and strengthen existing regulations within the City. The guiding policies in regards to flooding are as follows:

- Policy 8.20c: Where feasible given flood control requirements, maintain the natural condition of waterways and flood plains to ensure adequate groundwater recharge and water quality. This policy is a restatement of a part of Policy 8.40d in Section 8.40, Drainage and Flooding. An increase in impervious surfaces works to diminish percolation of water into the aquifer. The flushing action of adequate flows is necessary to preserve water quality. Preservation of soft or natural-bottom channels aids in percolation and recharge, maintaining water quality.
- Policy 8.40a: Protect lives and property and ensure that structures proposed for sites located on floodplains subject to the 100-year flood are provided adequate protection from floods.
- Policy 8.40b: Preserve as open space those areas which cannot be mitigated for flood hazard.
- Policy 8.40d: Where feasible given flood control requirements, maintain the natural condition of waterways and floodplains to ensure adequate groundwater recharge and water quality, preservation of habitat, and access to mineral resources.
- Policy 8.40f: Support the intent of the County of San Bernardino's flood control policies as specified in the County General Plan.
- Policy 8.40e: Coordinate with the U.S. Army Corps of Engineers and San Bernardino throughout construction, mitigation, and operation of the various components/projects that make up the "Santa Ana River Mainstem Project" that will directly affect the Planning area. These projects includes, but not limited to, improvements along Mission Zanja Creek. In addition, the City of Redlands Public Works Department must be actively included in the development of any/all proposed flood control facilities along the reaches of the Mission Zanja Creek system.

### 3.4.3 City of San Bernardino Municipal Code

The San Bernardino Municipal Code (SBMC), Title 19 Development Code, Chapter 19.16 Flood Plain Overlay District includes a comprehensive floodplain management ordinance that protects public health, safety, and general welfare, and to minimize hazards due to flooding in specific areas as identified by the latest adopted Flood Insurance Rate Maps. In order to accomplish its purposes, this Chapter includes methods and provisions for:

1. Restricting or prohibiting uses which are dangerous to health, safety, and property due to water or erosion hazards, or which result in damaging increases in erosion of flood heights or velocities;
2. Requiring that uses vulnerable to floods, including facilities which serve such uses, be protected against flood damage at the time of initial construction;
3. Controlling the alteration of natural floodplains, stream channels, and natural protective barriers, which help accommodate or channel flood waters;
4. Controlling filling, grading, dredging, and other development which may increase flood damage; and
5. Preventing or regulating the construction of flood barriers which will unnaturally divert flood waters or which may increase flood hazards in other areas.

Similarly, Title 8 Health and Safety, Chapter 8.80 Storm Water Drainage System of the SBMC focuses on water quality but mentions basic information on local drainage issues. Some of the basic drainage objectives include:

1. Control discharges from spills, dumping or disposal of materials other than storm water;
2. Establish penalties for violations of the provisions of this chapter; and
3. Provide for the equitable distribution of the cost of the storm water drainage system and storm water pollution abatement programs, and all related services through the establishment of fair and equitable fees and charges.

### 3.4.4 City of San Bernardino General Plan

The City of San Bernardino's General Plan contains several policies regarding the risks associated with storm drains and flood control facilities in the Utilities Element (Chapter 9). Specifically, it provides assessment of natural and manmade hazards associated with storm drains and flooding, as well as providing a framework and guiding policies to guide future development and strengthen existing regulations within the City. It also addresses water quality; however, those related items are not included in this summary. See the PWQMP for more information.

To prevent flooding of the City, the capacity of the storm drain system must consistently be evaluated and improved as needed. Storm drains and flood control facilities within the City include: channels, storm drains, street waterways, natural drainage courses, dams, basins, and levees. Storm drain and flood control facilities (natural and man-made components) in the planning area are administered by four different entities:

- City of San Bernardino (Public Works and Public Services Departments);
- San Bernardino County Flood Control District;
- Army Corps of Engineers; and
- San Bernardino International Airport and Trade Center.

Design and construction of storm drain and flood control facilities are the responsibility of the City Public Works Department. The Public Services Department is responsible for the operation and maintenance of storm drain and flood control facilities. The guiding policies in regards to storm drains and flooding are as follows:

Goal 9.4 Provide appropriate storm drain and flood control facilities where necessary.

Policies:

- 9.4.1 Ensure that adequate storm drain and flood control facilities are provided in a timely manner to protect life and property from flood hazards.
- 9.4.2 Upgrade and expand storm drain and flood control facilities to eliminate deficiencies and protect existing and new development.
- 9.4.3 Maintain existing storm drain and flood control facilities.
- 9.4.4 Require that adequate storm drain and flood control facilities are in place prior to the issuance of certificates of occupancy. Where construction of master planned facilities is not feasible, the Mayor and Common Council may permit the construction of interim facilities sufficient to protect present and short-term future needs. (LU-1)
- 9.4.5 Implement flood control improvements that maintain the integrity of significant riparian and other environmental habitats.
- 9.4.6 Minimize the disturbance of natural water bodies and natural drainage systems. (LU-1)
- 9.4.7 Develop San Bernardino's flood control system for multipurpose uses, whenever practical and financially feasible.
- 9.4.8 Minimize the amount of impervious surfaces in conjunction with new development. (LU-1)

### 3.4.5 San Bernardino County Flood Control Act of 1939

The SBCFCD was created by the California Legislature by the San Bernardino County Flood Control Act (Act), Chapter 73, Statutes of 1939, adopted and effective April 20, 1939.

SBCFCD was formed as an urgency and progressive measure for the preservation and promotion of public peace, health and safety as the direct aftermath of the disastrous floods of March 1938, which caused loss of lives and millions of dollars of property damage within the County. The SBCFCD is countywide, the external boundaries coinciding with those of the County of San Bernardino.

Some of the objectives and purposes of SBCFCD as they related to floods and storm drains are

1. To provide for the control of flood and storm waters of SBCFCD;
2. To protect from flood and storm waters the water courses, watersheds, public highways, life and property in SBCFCD;
3. To obtain, retain, and reclaim drainage, storm, flood and other waters for beneficial use in the District.

SBCFCD has the following program as it relates to storm drain construction:

1. Comprehensive storm drain planning
2. Construction and operation of main trunk storm drains
3. Cooperative storm drain project with incorporated cities

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# Appendix A

# Existing Conditions H&H Calculations

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****************************************************************************
              RATIONAL METHOD HYDROLOGY COMPUTER PROGRAM PACKAGE
           (Reference: 1986 SAN BERNARDINO CO. HYDROLOGY CRITERION)
          (c) Copyright 1983-2008 Advanced Engineering Software (aes)
              Ver. 15.0  Release Date: 04/01/2008  License ID 1555

                            Analysis prepared by:




 ************************* DESCRIPTION OF STUDY *************************
* REDLANDS PASSENGER RAIL PROJECT                                          *
* EXISTING 100 YEAR ANALYSIS                                               *
* BASIN 1000                                                               *
 **************************************************************************

  FILE NAME: C:\RPRP\1000.DAT
  TIME/DATE OF STUDY: 17:14 05/22/2012
============================================================================
  USER SPECIFIED HYDROLOGY AND HYDRAULIC MODEL INFORMATION:
============================================================================
                    --*TIME-OF-CONCENTRATION MODEL*--

  USER SPECIFIED STORM EVENT(YEAR) =  100.00
  SPECIFIED MINIMUM PIPE SIZE(INCH) =  12.00
  SPECIFIED PERCENT OF GRADIENTS(DECIMAL) TO USE FOR FRICTION SLOPE = 0.90
  *USER-DEFINED LOGARITHMIC INTERPOLATION USED FOR RAINFALL*

  SLOPE OF INTENSITY DURATION CURVE(LOG(I;IN/HR) vs. LOG(Tc;MIN)) = 0.6000
  USER SPECIFIED 1-HOUR INTENSITY(INCH/HOUR) = 1.2500

  *ANTECEDENT MOISTURE CONDITION (AMC) III ASSUMED FOR RATIONAL METHOD*

  *USER-DEFINED STREET-SECTIONS FOR COUPLED PIPEFLOW AND STREETFLOW MODEL*
     HALF-  CROWN TO   STREET-CROSSFALL:   CURB  GUTTER-GEOMETRIES:  MANNING
     WIDTH  CROSSFALL  IN-  / OUT-/PARK-  HEIGHT  WIDTH  LIP   HIKE  FACTOR
NO.   (FT)     (FT)    SIDE / SIDE/ WAY    (FT)    (FT)  (FT)  (FT)    (n)
===  =====  =========  =================  ======  ===== ====== ===== =======
  1   30.0     20.0    0.018/0.018/0.020   0.67    2.00 0.0313 0.167 0.0150
  2   13.0      8.0    0.018/0.018/0.020   0.67    2.00 0.0313 0.167 0.0150
  3   25.0     15.0    0.018/0.018/0.020   0.67    2.00 0.0313 0.167 0.0150
  4   35.0     25.0    0.018/0.018/0.020   0.67    2.00 0.0313 0.167 0.0150
  5   20.0     15.0    0.018/0.018/0.020   0.67    2.00 0.0313 0.167 0.0150

  GLOBAL STREET FLOW-DEPTH CONSTRAINTS:
    1. Relative Flow-Depth =  0.20 FEET
       as (Maximum Allowable Street Flow Depth) - (Top-of-Curb)
    2. (Depth)*(Velocity) Constraint = 10.0 (FT*FT/S)
  *SIZE PIPE WITH A FLOW CAPACITY GREATER THAN
   OR EQUAL TO THE UPSTREAM TRIBUTARY PIPE.*
  *USER-SPECIFIED MINIMUM TOPOGRAPHIC SLOPE ADJUSTMENT NOT SELECTED

****************************************************************************
  FLOW PROCESS FROM NODE   1000.00 TO NODE   1001.00 IS CODE =  21
----------------------------------------------------------------------------
  >>>>>RATIONAL METHOD INITIAL SUBAREA ANALYSIS<<<<<
  >>USE TIME-OF-CONCENTRATION NOMOGRAPH FOR INITIAL SUBAREA<<
============================================================================
  INITIAL SUBAREA FLOW-LENGTH(FEET) =   640.00
  ELEVATION DATA: UPSTREAM(FEET) =   1047.70  DOWNSTREAM(FEET) =   1043.50

  Tc = K*[(LENGTH** 3.00)/(ELEVATION CHANGE)]**0.20
  SUBAREA ANALYSIS USED MINIMUM Tc(MIN.) =   11.014
  * 100 YEAR RAINFALL INTENSITY(INCH/HR) =  3.457
  SUBAREA Tc AND LOSS RATE DATA(AMC III):
   DEVELOPMENT TYPE/      SCS SOIL   AREA      Fp         Ap     SCS   Tc
       LAND USE             GROUP   (ACRES)  (INCH/HR)  (DECIMAL)  CN  (MIN.)
```

```
  COMMERCIAL                  B        0.70      0.42     0.100    76   11.01
  SUBAREA AVERAGE PERVIOUS LOSS RATE, Fp(INCH/HR) =  0.42
  SUBAREA AVERAGE PERVIOUS AREA FRACTION, Ap =  0.100
  SUBAREA RUNOFF(CFS) =      2.15
  TOTAL AREA(ACRES) =      0.70   PEAK FLOW RATE(CFS) =      2.15

****************************************************************************
  FLOW PROCESS FROM NODE   1001.00 TO NODE   1002.00 IS CODE =  62
----------------------------------------------------------------------------
  >>>>>COMPUTE STREET FLOW TRAVEL TIME THRU SUBAREA<<<<<
  >>>>>(STREET TABLE SECTION #  4 USED)<<<<<
============================================================================
  UPSTREAM ELEVATION(FEET) = 1043.50  DOWNSTREAM ELEVATION(FEET) = 1037.70
  STREET LENGTH(FEET) =   590.00   CURB HEIGHT(INCHES) =  8.0
  STREET HALFWIDTH(FEET) = 35.00

  DISTANCE FROM CROWN TO CROSSFALL GRADEBREAK(FEET) =  25.00
  INSIDE STREET CROSSFALL(DECIMAL) =  0.018
  OUTSIDE STREET CROSSFALL(DECIMAL)  =  0.018

  SPECIFIED NUMBER OF HALFSTREETS CARRYING RUNOFF =  1
  STREET PARKWAY CROSSFALL(DECIMAL)  =  0.020
  Manning's FRICTION FACTOR for Streetflow Section(curb-to-curb) =   0.0150
  Manning's FRICTION FACTOR for Back-of-Walk Flow Section =   0.0150

    **TRAVEL TIME COMPUTED USING ESTIMATED FLOW(CFS) =       2.78
    STREETFLOW MODEL RESULTS USING ESTIMATED FLOW:
    STREET FLOW DEPTH(FEET) =  0.36
    HALFSTREET FLOOD WIDTH(FEET) =   10.73
    AVERAGE FLOW VELOCITY(FEET/SEC.) =    2.26
    PRODUCT OF DEPTH&VELOCITY(FT*FT/SEC.) =    0.80
  STREET FLOW TRAVEL TIME(MIN.) =   4.35   Tc(MIN.) =   15.36
  * 100 YEAR RAINFALL INTENSITY(INCH/HR) =  2.831
  SUBAREA LOSS RATE DATA(AMC III):
   DEVELOPMENT TYPE/      SCS SOIL   AREA      Fp         Ap     SCS
       LAND USE            GROUP   (ACRES)  (INCH/HR)  (DECIMAL)  CN
  COMMERCIAL                  B        0.50      0.42     0.100    76
  SUBAREA AVERAGE PERVIOUS LOSS RATE, Fp(INCH/HR) =  0.42
  SUBAREA AVERAGE PERVIOUS AREA FRACTION, Ap =  0.100
  SUBAREA AREA(ACRES) =    0.50      SUBAREA RUNOFF(CFS) =    1.25
  EFFECTIVE AREA(ACRES) =      1.20    AREA-AVERAGED Fm(INCH/HR) =  0.04
  AREA-AVERAGED Fp(INCH/HR) =  0.42  AREA-AVERAGED Ap =  0.10
  TOTAL AREA(ACRES) =        1.2        PEAK FLOW RATE(CFS) =       3.01

  END OF SUBAREA STREET FLOW HYDRAULICS:
  DEPTH(FEET) = 0.36   HALFSTREET FLOOD WIDTH(FEET) =  11.12
  FLOW VELOCITY(FEET/SEC.) =  2.30   DEPTH*VELOCITY(FT*FT/SEC.) =   0.84
  LONGEST FLOWPATH FROM NODE   1000.00 TO NODE   1002.00 =    1230.00 FEET.

****************************************************************************
  FLOW PROCESS FROM NODE   1002.00 TO NODE   1002.00 IS CODE =  81
----------------------------------------------------------------------------
  >>>>>ADDITION OF SUBAREA TO MAINLINE PEAK FLOW<<<<<
============================================================================
  MAINLINE Tc(MIN.) =   15.36
  * 100 YEAR RAINFALL INTENSITY(INCH/HR) =  2.831
  SUBAREA LOSS RATE DATA(AMC III):
   DEVELOPMENT TYPE/      SCS SOIL   AREA      Fp         Ap     SCS
       LAND USE            GROUP   (ACRES)  (INCH/HR)  (DECIMAL)  CN
  COMMERCIAL                  B        9.60      0.42     0.100    76
  SUBAREA AVERAGE PERVIOUS LOSS RATE, Fp(INCH/HR) =  0.42
  SUBAREA AVERAGE PERVIOUS AREA FRACTION, Ap =  0.100
  SUBAREA AREA(ACRES) =    9.60      SUBAREA RUNOFF(CFS) =   24.09
  EFFECTIVE AREA(ACRES) =     10.80   AREA-AVERAGED Fm(INCH/HR) =  0.04
  AREA-AVERAGED Fp(INCH/HR) =  0.42  AREA-AVERAGED Ap =  0.10
  TOTAL AREA(ACRES) =       10.8       PEAK FLOW RATE(CFS) =      27.10

****************************************************************************
  FLOW PROCESS FROM NODE   1002.00 TO NODE   1003.00 IS CODE =  37
----------------------------------------------------------------------------
  >>>>>COMPUTE CULVERT TRAVEL TIME THRU SUBAREA<<<<<
```

```
  >>>>>USING COMPUTER-ESTIMATED CULVERT SIZE<<<<<
==============================================================================
  ELEVATION DATA: UPSTREAM(FEET) =  1037.70  DOWNSTREAM(FEET) =  1035.50
  FLOW LENGTH(FEET) =   100.00   MANNING'S N =  0.014
  Notes:
    1. Reference: "Hydraulic Charts for the Selection of
       Highway Culverts", Hydraulic Engineering Circular No. 5,
       December 1965, Federal Highway Administration.
    2. INLET control for all Culvert Analysis.
    3. Headwater depth is ASSUMED to be 3 FEET above the culvert soffit.
  GIVEN BOX CULVERT HEIGHT(FEET) =   1.00
  ESTIMATED BOX CULVERT BASEWIDTH(FEET) =    2.85
  CULVERT-FLOW VELOCITY(FEET/SEC.) =   9.50
  CULVERT-FLOW(CFS) =      27.10
  CULVERT-FLOW TRAVEL TIME(MIN.) =   0.18    Tc(MIN.) =   15.54
  LONGEST FLOWPATH FROM NODE   1000.00 TO NODE   1003.00 =    1330.00 FEET.

******************************************************************************
  FLOW PROCESS FROM NODE   1003.00 TO NODE   1003.00 IS CODE =  81
------------------------------------------------------------------------------
  >>>>>ADDITION OF SUBAREA TO MAINLINE PEAK FLOW<<<<<
==============================================================================
  MAINLINE Tc(MIN.) =   15.54
  * 100 YEAR RAINFALL INTENSITY(INCH/HR) =  2.811
  SUBAREA LOSS RATE DATA(AMC III):
   DEVELOPMENT TYPE/      SCS SOIL   AREA      Fp         Ap     SCS
       LAND USE            GROUP   (ACRES)  (INCH/HR)  (DECIMAL)  CN
  COMMERCIAL                 B        1.40      0.42     0.100    76
  SUBAREA AVERAGE PERVIOUS LOSS RATE, Fp(INCH/HR) =  0.42
  SUBAREA AVERAGE PERVIOUS AREA FRACTION, Ap =  0.100
  SUBAREA AREA(ACRES) =    1.40      SUBAREA RUNOFF(CFS) =    3.49
  EFFECTIVE AREA(ACRES) =     12.20   AREA-AVERAGED Fm(INCH/HR) =  0.04
  AREA-AVERAGED Fp(INCH/HR) =  0.42  AREA-AVERAGED Ap =  0.10
  TOTAL AREA(ACRES) =       12.2       PEAK FLOW RATE(CFS) =      30.41

******************************************************************************
  FLOW PROCESS FROM NODE   1003.00 TO NODE   1004.00 IS CODE =  62
------------------------------------------------------------------------------
  >>>>>COMPUTE STREET FLOW TRAVEL TIME THRU SUBAREA<<<<<
  >>>>>(STREET TABLE SECTION #  4 USED)<<<<<
==============================================================================
  UPSTREAM ELEVATION(FEET) = 1035.50  DOWNSTREAM ELEVATION(FEET) = 1030.80
  STREET LENGTH(FEET) =   560.00   CURB HEIGHT(INCHES) =  8.0
  STREET HALFWIDTH(FEET) = 35.00

  DISTANCE FROM CROWN TO CROSSFALL GRADEBREAK(FEET) =  25.00
  INSIDE STREET CROSSFALL(DECIMAL) =  0.018
  OUTSIDE STREET CROSSFALL(DECIMAL)  =  0.018

  SPECIFIED NUMBER OF HALFSTREETS CARRYING RUNOFF =  1
  STREET PARKWAY CROSSFALL(DECIMAL)  =  0.020
  Manning's FRICTION FACTOR for Streetflow Section(curb-to-curb) =   0.0150
  Manning's FRICTION FACTOR for Back-of-Walk Flow Section =   0.0150

    **TRAVEL TIME COMPUTED USING ESTIMATED FLOW(CFS) =      31.54
    STREETFLOW MODEL RESULTS USING ESTIMATED FLOW:
    STREET FLOW DEPTH(FEET) =  0.70
    HALFSTREET FLOOD WIDTH(FEET) =   31.91
    AVERAGE FLOW VELOCITY(FEET/SEC.) =    3.77
    PRODUCT OF DEPTH&VELOCITY(FT*FT/SEC.) =    2.65
  STREET FLOW TRAVEL TIME(MIN.) =   2.47   Tc(MIN.) =   18.01
  * 100 YEAR RAINFALL INTENSITY(INCH/HR) =  2.573
  SUBAREA LOSS RATE DATA(AMC III):
   DEVELOPMENT TYPE/      SCS SOIL   AREA      Fp         Ap     SCS
       LAND USE            GROUP   (ACRES)  (INCH/HR)  (DECIMAL)  CN
  COMMERCIAL                 B        1.00      0.42     0.100    76
  SUBAREA AVERAGE PERVIOUS LOSS RATE, Fp(INCH/HR) =  0.42
  SUBAREA AVERAGE PERVIOUS AREA FRACTION, Ap =  0.100
  SUBAREA AREA(ACRES) =    1.00      SUBAREA RUNOFF(CFS) =    2.28
  EFFECTIVE AREA(ACRES) =     13.20    AREA-AVERAGED Fm(INCH/HR) =  0.04
  AREA-AVERAGED Fp(INCH/HR) =  0.42  AREA-AVERAGED Ap =  0.10
```

```
  TOTAL AREA(ACRES) =       13.2        PEAK FLOW RATE(CFS) =      30.41
  NOTE: PEAK FLOW RATE DEFAULTED TO UPSTREAM VALUE

  END OF SUBAREA STREET FLOW HYDRAULICS:
  DEPTH(FEET) = 0.69   HALFSTREET FLOOD WIDTH(FEET) =  30.98
  FLOW VELOCITY(FEET/SEC.) =  3.76   DEPTH*VELOCITY(FT*FT/SEC.) =   2.61
  LONGEST FLOWPATH FROM NODE   1000.00 TO NODE   1004.00 =    1890.00 FEET.

****************************************************************************
  FLOW PROCESS FROM NODE   1004.00 TO NODE   1004.00 IS CODE =  81
----------------------------------------------------------------------------
  >>>>>ADDITION OF SUBAREA TO MAINLINE PEAK FLOW<<<<<
============================================================================
  MAINLINE Tc(MIN.) =   18.01
  * 100 YEAR RAINFALL INTENSITY(INCH/HR) =  2.573
  SUBAREA LOSS RATE DATA(AMC III):
   DEVELOPMENT TYPE/      SCS SOIL   AREA      Fp         Ap     SCS
       LAND USE             GROUP   (ACRES)  (INCH/HR)  (DECIMAL)  CN
  COMMERCIAL                  B        8.40      0.42     0.100    76
  SUBAREA AVERAGE PERVIOUS LOSS RATE, Fp(INCH/HR) =  0.42
  SUBAREA AVERAGE PERVIOUS AREA FRACTION, Ap =  0.100
  SUBAREA AREA(ACRES) =    8.40      SUBAREA RUNOFF(CFS) =   19.13
  EFFECTIVE AREA(ACRES) =     21.60   AREA-AVERAGED Fm(INCH/HR) =  0.04
  AREA-AVERAGED Fp(INCH/HR) =  0.42  AREA-AVERAGED Ap =  0.10
  TOTAL AREA(ACRES) =       21.6       PEAK FLOW RATE(CFS) =      49.20

****************************************************************************
  FLOW PROCESS FROM NODE   1004.00 TO NODE   1005.00 IS CODE =  31
----------------------------------------------------------------------------
  >>>>>COMPUTE PIPE-FLOW TRAVEL TIME THRU SUBAREA<<<<<
  >>>>>USING COMPUTER-ESTIMATED PIPESIZE (NON-PRESSURE FLOW)<<<<<
============================================================================
  ELEVATION DATA: UPSTREAM(FEET) =  1030.80  DOWNSTREAM(FEET) =  1030.00
  FLOW LENGTH(FEET) =   100.00   MANNING'S N =  0.013
  DEPTH OF FLOW IN  36.0 INCH PIPE IS  26.0 INCHES
  PIPE-FLOW VELOCITY(FEET/SEC.) =   9.02
  ESTIMATED PIPE DIAMETER(INCH) =  36.00    NUMBER OF PIPES =   1
  PIPE-FLOW(CFS) =      49.20
  PIPE TRAVEL TIME(MIN.) =   0.18    Tc(MIN.) =   18.20
  LONGEST FLOWPATH FROM NODE   1000.00 TO NODE   1005.00 =    1990.00 FEET.

****************************************************************************
  FLOW PROCESS FROM NODE   1005.00 TO NODE   1005.00 IS CODE =  81
----------------------------------------------------------------------------
  >>>>>ADDITION OF SUBAREA TO MAINLINE PEAK FLOW<<<<<
============================================================================
  MAINLINE Tc(MIN.) =   18.20
  * 100 YEAR RAINFALL INTENSITY(INCH/HR) =  2.557
  SUBAREA LOSS RATE DATA(AMC III):
   DEVELOPMENT TYPE/      SCS SOIL   AREA      Fp         Ap     SCS
       LAND USE             GROUP   (ACRES)  (INCH/HR)  (DECIMAL)  CN
  COMMERCIAL                  B        2.80      0.42     0.100    76
  SUBAREA AVERAGE PERVIOUS LOSS RATE, Fp(INCH/HR) =  0.42
  SUBAREA AVERAGE PERVIOUS AREA FRACTION, Ap =  0.100
  SUBAREA AREA(ACRES) =    2.80      SUBAREA RUNOFF(CFS) =    6.34
  EFFECTIVE AREA(ACRES) =     24.40   AREA-AVERAGED Fm(INCH/HR) =  0.04
  AREA-AVERAGED Fp(INCH/HR) =  0.42  AREA-AVERAGED Ap =  0.10
  TOTAL AREA(ACRES) =       24.4       PEAK FLOW RATE(CFS) =      55.23

****************************************************************************
  FLOW PROCESS FROM NODE   1005.00 TO NODE   1006.00 IS CODE =  62
----------------------------------------------------------------------------
  >>>>>COMPUTE STREET FLOW TRAVEL TIME THRU SUBAREA<<<<<
  >>>>>(STREET TABLE SECTION #  4 USED)<<<<<
============================================================================
  UPSTREAM ELEVATION(FEET) = 1030.00  DOWNSTREAM ELEVATION(FEET) = 1025.20
  STREET LENGTH(FEET) =   250.00   CURB HEIGHT(INCHES) =  8.0
  STREET HALFWIDTH(FEET) = 35.00

  DISTANCE FROM CROWN TO CROSSFALL GRADEBREAK(FEET) =  25.00
  INSIDE STREET CROSSFALL(DECIMAL) =  0.018
```

```
  OUTSIDE STREET CROSSFALL(DECIMAL)  =  0.018

  SPECIFIED NUMBER OF HALFSTREETS CARRYING RUNOFF =  1
  STREET PARKWAY CROSSFALL(DECIMAL)  =  0.020
  Manning's FRICTION FACTOR for Streetflow Section(curb-to-curb) =   0.0150
  Manning's FRICTION FACTOR for Back-of-Walk Flow Section =   0.0150

    **TRAVEL TIME COMPUTED USING ESTIMATED FLOW(CFS) =      55.67
    STREETFLOW MODEL RESULTS USING ESTIMATED FLOW:
    STREET FLOW DEPTH(FEET) =  0.74
    HALFSTREET FLOOD WIDTH(FEET) =   35.25
    AVERAGE FLOW VELOCITY(FEET/SEC.) =    5.91
    PRODUCT OF DEPTH&VELOCITY(FT*FT/SEC.) =    4.34
  STREET FLOW TRAVEL TIME(MIN.) =   0.71   Tc(MIN.) =   18.91
  * 100 YEAR RAINFALL INTENSITY(INCH/HR) =  2.500
  SUBAREA LOSS RATE DATA(AMC III):
   DEVELOPMENT TYPE/      SCS SOIL   AREA      Fp         Ap     SCS
       LAND USE            GROUP   (ACRES)  (INCH/HR)  (DECIMAL)  CN
  COMMERCIAL                 B        0.40      0.42     0.100    76
  SUBAREA AVERAGE PERVIOUS LOSS RATE, Fp(INCH/HR) =  0.42
  SUBAREA AVERAGE PERVIOUS AREA FRACTION, Ap =  0.100
  SUBAREA AREA(ACRES) =    0.40      SUBAREA RUNOFF(CFS) =    0.88
  EFFECTIVE AREA(ACRES) =     24.80    AREA-AVERAGED Fm(INCH/HR) =  0.04
  AREA-AVERAGED Fp(INCH/HR) =  0.42  AREA-AVERAGED Ap =  0.10
  TOTAL AREA(ACRES) =       24.8        PEAK FLOW RATE(CFS) =      55.23
  NOTE: PEAK FLOW RATE DEFAULTED TO UPSTREAM VALUE

  END OF SUBAREA STREET FLOW HYDRAULICS:
  DEPTH(FEET) = 0.73   HALFSTREET FLOOD WIDTH(FEET) =  35.06
  FLOW VELOCITY(FEET/SEC.) =  5.90   DEPTH*VELOCITY(FT*FT/SEC.) =   4.32
  LONGEST FLOWPATH FROM NODE   1000.00 TO NODE   1006.00 =    2240.00 FEET.

****************************************************************************
  FLOW PROCESS FROM NODE   1006.00 TO NODE   1007.00 IS CODE =  41
----------------------------------------------------------------------------
  >>>>>COMPUTE PIPE-FLOW TRAVEL TIME THRU SUBAREA<<<<<
  >>>>>USING USER-SPECIFIED PIPESIZE (EXISTING ELEMENT)<<<<<
============================================================================
  ELEVATION DATA: UPSTREAM(FEET) =  1018.20  DOWNSTREAM(FEET) =  1011.30
  FLOW LENGTH(FEET) =    95.00   MANNING'S N =  0.013
  DEPTH OF FLOW IN  36.0 INCH PIPE IS  14.1 INCHES
  PIPE-FLOW VELOCITY(FEET/SEC.) =  21.53
  GIVEN PIPE DIAMETER(INCH) =  36.00    NUMBER OF PIPES =   1
  PIPE-FLOW(CFS) =      55.23
  PIPE TRAVEL TIME(MIN.) =   0.07    Tc(MIN.) =   18.98
  LONGEST FLOWPATH FROM NODE   1000.00 TO NODE   1007.00 =    2335.00 FEET.

****************************************************************************
  FLOW PROCESS FROM NODE   1007.00 TO NODE   1007.00 IS CODE =  81
----------------------------------------------------------------------------
  >>>>>ADDITION OF SUBAREA TO MAINLINE PEAK FLOW<<<<<
============================================================================
  MAINLINE Tc(MIN.) =   18.98
  * 100 YEAR RAINFALL INTENSITY(INCH/HR) =  2.494
  SUBAREA LOSS RATE DATA(AMC III):
   DEVELOPMENT TYPE/      SCS SOIL   AREA      Fp         Ap     SCS
       LAND USE            GROUP   (ACRES)  (INCH/HR)  (DECIMAL)  CN
  COMMERCIAL                 B        0.80      0.42     0.100    76
  RESIDENTIAL
  "3-4 DWELLINGS/ACRE"       B        3.60      0.42     0.600    76
  SUBAREA AVERAGE PERVIOUS LOSS RATE, Fp(INCH/HR) =  0.42
  SUBAREA AVERAGE PERVIOUS AREA FRACTION, Ap =  0.509
  SUBAREA AREA(ACRES) =    4.40      SUBAREA RUNOFF(CFS) =    9.02
  EFFECTIVE AREA(ACRES) =     29.20   AREA-AVERAGED Fm(INCH/HR) =  0.07
  AREA-AVERAGED Fp(INCH/HR) =  0.42  AREA-AVERAGED Ap =  0.16
  TOTAL AREA(ACRES) =       29.2       PEAK FLOW RATE(CFS) =      63.74

****************************************************************************
  FLOW PROCESS FROM NODE   1007.00 TO NODE   1010.00 IS CODE =  41
----------------------------------------------------------------------------
  >>>>>COMPUTE PIPE-FLOW TRAVEL TIME THRU SUBAREA<<<<<
```

```
  >>>>>USING USER-SPECIFIED PIPESIZE (EXISTING ELEMENT)<<<<<
==============================================================================
  ELEVATION DATA: UPSTREAM(FEET) =  1010.50  DOWNSTREAM(FEET) =  1006.47
  FLOW LENGTH(FEET) =   250.00   MANNING'S N =  0.013
  DEPTH OF FLOW IN  42.0 INCH PIPE IS  21.6 INCHES
  PIPE-FLOW VELOCITY(FEET/SEC.) =  12.75
  GIVEN PIPE DIAMETER(INCH) =  42.00    NUMBER OF PIPES =   1
  PIPE-FLOW(CFS) =      63.74
  PIPE TRAVEL TIME(MIN.) =   0.33    Tc(MIN.) =   19.31
  LONGEST FLOWPATH FROM NODE   1000.00 TO NODE   1010.00 =    2585.00 FEET.

****************************************************************************
  FLOW PROCESS FROM NODE   1010.00 TO NODE   1010.00 IS CODE =  81
----------------------------------------------------------------------------
  >>>>>ADDITION OF SUBAREA TO MAINLINE PEAK FLOW<<<<<
==============================================================================
  MAINLINE Tc(MIN.) =   19.31
  * 100 YEAR RAINFALL INTENSITY(INCH/HR) =  2.468
  SUBAREA LOSS RATE DATA(AMC III):
   DEVELOPMENT TYPE/      SCS SOIL   AREA      Fp         Ap     SCS
       LAND USE            GROUP   (ACRES)  (INCH/HR)  (DECIMAL)  CN
  COMMERCIAL                 B       2.40      0.42     0.100    76
  RESIDENTIAL
  "3-4 DWELLINGS/ACRE"       B       0.30      0.42     0.600    76
  SUBAREA AVERAGE PERVIOUS LOSS RATE, Fp(INCH/HR) =  0.42
  SUBAREA AVERAGE PERVIOUS AREA FRACTION, Ap =  0.156
  SUBAREA AREA(ACRES) =    2.70      SUBAREA RUNOFF(CFS) =    5.84
  EFFECTIVE AREA(ACRES) =     31.90   AREA-AVERAGED Fm(INCH/HR) =  0.07
  AREA-AVERAGED Fp(INCH/HR) =  0.42  AREA-AVERAGED Ap =  0.16
  TOTAL AREA(ACRES) =       31.9       PEAK FLOW RATE(CFS) =      68.91

****************************************************************************
  FLOW PROCESS FROM NODE   1010.00 TO NODE   1020.00 IS CODE =  41
----------------------------------------------------------------------------
  >>>>>COMPUTE PIPE-FLOW TRAVEL TIME THRU SUBAREA<<<<<
  >>>>>USING USER-SPECIFIED PIPESIZE (EXISTING ELEMENT)<<<<<
==============================================================================
  ELEVATION DATA: UPSTREAM(FEET) =  1006.47  DOWNSTREAM(FEET) =  1003.30
  FLOW LENGTH(FEET) =   400.00   MANNING'S N =  0.013
  DEPTH OF FLOW IN  48.0 INCH PIPE IS  25.9 INCHES
  PIPE-FLOW VELOCITY(FEET/SEC.) =   9.96
  GIVEN PIPE DIAMETER(INCH) =  48.00    NUMBER OF PIPES =   1
  PIPE-FLOW(CFS) =      68.91
  PIPE TRAVEL TIME(MIN.) =   0.67    Tc(MIN.) =   19.97
  LONGEST FLOWPATH FROM NODE   1000.00 TO NODE   1020.00 =    2985.00 FEET.

****************************************************************************
  FLOW PROCESS FROM NODE   1020.00 TO NODE   1020.00 IS CODE =  81
----------------------------------------------------------------------------
  >>>>>ADDITION OF SUBAREA TO MAINLINE PEAK FLOW<<<<<
==============================================================================
  MAINLINE Tc(MIN.) =   19.97
  * 100 YEAR RAINFALL INTENSITY(INCH/HR) =  2.418
  SUBAREA LOSS RATE DATA(AMC III):
   DEVELOPMENT TYPE/      SCS SOIL   AREA      Fp         Ap     SCS
       LAND USE            GROUP   (ACRES)  (INCH/HR)  (DECIMAL)  CN
  COMMERCIAL                 B       0.70      0.42     0.100    76
  RESIDENTIAL
  "3-4 DWELLINGS/ACRE"       B       0.30      0.42     0.600    76
  SUBAREA AVERAGE PERVIOUS LOSS RATE, Fp(INCH/HR) =  0.42
  SUBAREA AVERAGE PERVIOUS AREA FRACTION, Ap =  0.250
  SUBAREA AREA(ACRES) =    1.00      SUBAREA RUNOFF(CFS) =    2.08
  EFFECTIVE AREA(ACRES) =     32.90   AREA-AVERAGED Fm(INCH/HR) =  0.07
  AREA-AVERAGED Fp(INCH/HR) =  0.42  AREA-AVERAGED Ap =  0.16
  TOTAL AREA(ACRES) =       32.9       PEAK FLOW RATE(CFS) =      69.55

****************************************************************************
  FLOW PROCESS FROM NODE   1020.00 TO NODE   1030.00 IS CODE =  41
----------------------------------------------------------------------------
  >>>>>COMPUTE PIPE-FLOW TRAVEL TIME THRU SUBAREA<<<<<
  >>>>>USING USER-SPECIFIED PIPESIZE (EXISTING ELEMENT)<<<<<
```

```
============================================================================
  ELEVATION DATA: UPSTREAM(FEET) =  1003.30  DOWNSTREAM(FEET) =   999.50
  FLOW LENGTH(FEET) =   350.00   MANNING'S N =  0.013
  DEPTH OF FLOW IN  48.0 INCH PIPE IS  23.7 INCHES
  PIPE-FLOW VELOCITY(FEET/SEC.) =  11.24
  GIVEN PIPE DIAMETER(INCH) =  48.00    NUMBER OF PIPES =   1
  PIPE-FLOW(CFS) =      69.55
  PIPE TRAVEL TIME(MIN.) =   0.52    Tc(MIN.) =   20.49
  LONGEST FLOWPATH FROM NODE   1000.00 TO NODE   1030.00 =    3335.00 FEET.
============================================================================
  END OF STUDY SUMMARY:
  TOTAL AREA(ACRES)     =       32.9  TC(MIN.) =     20.49
  EFFECTIVE AREA(ACRES) =     32.90  AREA-AVERAGED Fm(INCH/HR)=  0.07
  AREA-AVERAGED Fp(INCH/HR) =  0.42  AREA-AVERAGED Ap = 0.164
  PEAK FLOW RATE(CFS)   =      69.55
============================================================================
============================================================================
  END OF RATIONAL METHOD ANALYSIS
```

```
****************************************************************************
              RATIONAL METHOD HYDROLOGY COMPUTER PROGRAM PACKAGE
           (Reference: 1986 SAN BERNARDINO CO. HYDROLOGY CRITERION)
          (c) Copyright 1983-2008 Advanced Engineering Software (aes)
              Ver. 15.0  Release Date: 04/01/2008  License ID 1555

                            Analysis prepared by:




 ************************** DESCRIPTION OF STUDY **************************
 * REDLANDS PASSENGER RAIL PROJECT                                          *
 * EXISTING 100 YEAR ANALYSIS                                               *
 * BASIN 1100                                                               *
 **************************************************************************

  FILE NAME: C:\RPRP\1100.DAT
  TIME/DATE OF STUDY: 07:51 05/23/2012
============================================================================
  USER SPECIFIED HYDROLOGY AND HYDRAULIC MODEL INFORMATION:
============================================================================
                    --*TIME-OF-CONCENTRATION MODEL*--

  USER SPECIFIED STORM EVENT(YEAR) =  100.00
  SPECIFIED MINIMUM PIPE SIZE(INCH) =  12.00
  SPECIFIED PERCENT OF GRADIENTS(DECIMAL) TO USE FOR FRICTION SLOPE = 0.90
  *USER-DEFINED LOGARITHMIC INTERPOLATION USED FOR RAINFALL*

  SLOPE OF INTENSITY DURATION CURVE(LOG(I;IN/HR) vs. LOG(Tc;MIN)) = 0.6000
  USER SPECIFIED 1-HOUR INTENSITY(INCH/HOUR) = 1.2500

  *ANTECEDENT MOISTURE CONDITION (AMC) III ASSUMED FOR RATIONAL METHOD*

  *USER-DEFINED STREET-SECTIONS FOR COUPLED PIPEFLOW AND STREETFLOW MODEL*
     HALF-  CROWN TO   STREET-CROSSFALL:   CURB  GUTTER-GEOMETRIES:  MANNING
     WIDTH  CROSSFALL  IN-  / OUT-/PARK-  HEIGHT  WIDTH  LIP   HIKE  FACTOR
NO.  (FT)     (FT)     SIDE / SIDE/ WAY    (FT)    (FT)  (FT)  (FT)    (n)
===  =====  =========  =================  ======   ===== ====== ===== =======
  1   30.0     20.0    0.018/0.018/0.020   0.67    2.00 0.0313 0.167 0.0150
  2   13.0      8.0    0.018/0.018/0.020   0.67    2.00 0.0313 0.167 0.0150
  3   25.0     15.0    0.018/0.018/0.020   0.67    2.00 0.0313 0.167 0.0150
  4   35.0     25.0    0.018/0.018/0.020   0.67    2.00 0.0313 0.167 0.0150
  5   20.0     15.0    0.018/0.018/0.020   0.67    2.00 0.0313 0.167 0.0150

  GLOBAL STREET FLOW-DEPTH CONSTRAINTS:
    1. Relative Flow-Depth =  0.20 FEET
       as (Maximum Allowable Street Flow Depth) - (Top-of-Curb)
    2. (Depth)*(Velocity) Constraint = 10.0 (FT*FT/S)
  *SIZE PIPE WITH A FLOW CAPACITY GREATER THAN
   OR EQUAL TO THE UPSTREAM TRIBUTARY PIPE.*
  *USER-SPECIFIED MINIMUM TOPOGRAPHIC SLOPE ADJUSTMENT NOT SELECTED

****************************************************************************
  FLOW PROCESS FROM NODE   1100.00 TO NODE   1110.00 IS CODE =  21
----------------------------------------------------------------------------
  >>>>>RATIONAL METHOD INITIAL SUBAREA ANALYSIS<<<<<
  >>USE TIME-OF-CONCENTRATION NOMOGRAPH FOR INITIAL SUBAREA<<
============================================================================
  INITIAL SUBAREA FLOW-LENGTH(FEET) =   190.00
  ELEVATION DATA: UPSTREAM(FEET) =   1027.60  DOWNSTREAM(FEET) =   1020.00

  Tc = K*[(LENGTH** 3.00)/(ELEVATION CHANGE)]**0.20
  SUBAREA ANALYSIS USED MINIMUM Tc(MIN.) =    5.000
  * 100 YEAR RAINFALL INTENSITY(INCH/HR) =  5.552
  SUBAREA Tc AND LOSS RATE DATA(AMC III):
   DEVELOPMENT TYPE/      SCS SOIL   AREA      Fp         Ap     SCS   Tc
       LAND USE             GROUP   (ACRES)  (INCH/HR)  (DECIMAL)  CN  (MIN.)
```

```
  COMMERCIAL                 B        0.40      0.42     0.100    76    5.00
  SUBAREA AVERAGE PERVIOUS LOSS RATE, Fp(INCH/HR) =  0.42
  SUBAREA AVERAGE PERVIOUS AREA FRACTION, Ap =  0.100
  SUBAREA RUNOFF(CFS) =      1.98
  TOTAL AREA(ACRES) =      0.40   PEAK FLOW RATE(CFS) =      1.98

****************************************************************************
  FLOW PROCESS FROM NODE   1110.00 TO NODE   1120.00 IS CODE =  51
----------------------------------------------------------------------------
  >>>>>COMPUTE TRAPEZOIDAL CHANNEL FLOW<<<<<
  >>>>>TRAVELTIME THRU SUBAREA (EXISTING ELEMENT)<<<<<
============================================================================
  ELEVATION DATA: UPSTREAM(FEET) =   1020.00  DOWNSTREAM(FEET) =   1014.50
  CHANNEL LENGTH THRU SUBAREA(FEET) =   347.00   CHANNEL SLOPE =  0.0159
  CHANNEL BASE(FEET) =    4.00   "Z" FACTOR =  13.000
  MANNING'S FACTOR = 0.015   MAXIMUM DEPTH(FEET) =   0.50
  * 100 YEAR RAINFALL INTENSITY(INCH/HR) =  4.619
  SUBAREA LOSS RATE DATA(AMC III):
   DEVELOPMENT TYPE/      SCS SOIL   AREA      Fp         Ap     SCS
       LAND USE            GROUP   (ACRES)  (INCH/HR)  (DECIMAL)  CN
  COMMERCIAL                 B        0.80      0.42     0.100    76
  SUBAREA AVERAGE PERVIOUS LOSS RATE, Fp(INCH/HR) =  0.42
  SUBAREA AVERAGE PERVIOUS AREA FRACTION, Ap =  0.100
  TRAVEL TIME COMPUTED USING ESTIMATED FLOW(CFS) =       3.64
  TRAVEL TIME THRU SUBAREA BASED ON VELOCITY(FEET/SEC.) =   3.23
  AVERAGE FLOW DEPTH(FEET) =   0.18   TRAVEL TIME(MIN.) =   1.79
  Tc(MIN.) =    6.79
  SUBAREA AREA(ACRES) =     0.80       SUBAREA RUNOFF(CFS) =    3.30
  EFFECTIVE AREA(ACRES) =      1.20     AREA-AVERAGED Fm(INCH/HR) =   0.04
  AREA-AVERAGED Fp(INCH/HR) =   0.42  AREA-AVERAGED Ap =  0.10
  TOTAL AREA(ACRES) =        1.2         PEAK FLOW RATE(CFS) =       4.94

  END OF SUBAREA CHANNEL FLOW HYDRAULICS:
  DEPTH(FEET) =  0.21   FLOW VELOCITY(FEET/SEC.) =   3.52
  LONGEST FLOWPATH FROM NODE   1100.00 TO NODE   1120.00 =     537.00 FEET.

****************************************************************************
  FLOW PROCESS FROM NODE   1120.00 TO NODE   1130.00 IS CODE =  41
----------------------------------------------------------------------------
  >>>>>COMPUTE PIPE-FLOW TRAVEL TIME THRU SUBAREA<<<<<
  >>>>>USING USER-SPECIFIED PIPESIZE (EXISTING ELEMENT)<<<<<
============================================================================
  ELEVATION DATA: UPSTREAM(FEET) =  1014.50  DOWNSTREAM(FEET) =  1012.00
  FLOW LENGTH(FEET) =   106.00   MANNING'S N =  0.013
  DEPTH OF FLOW IN  36.0 INCH PIPE IS   5.5 INCHES
  PIPE-FLOW VELOCITY(FEET/SEC.) =   7.20
  GIVEN PIPE DIAMETER(INCH) =  36.00    NUMBER OF PIPES =   1
  PIPE-FLOW(CFS) =       4.94
  PIPE TRAVEL TIME(MIN.) =   0.25    Tc(MIN.) =    7.04
  LONGEST FLOWPATH FROM NODE   1100.00 TO NODE   1130.00 =     643.00 FEET.

****************************************************************************
  FLOW PROCESS FROM NODE   1130.00 TO NODE   1130.00 IS CODE =   1
----------------------------------------------------------------------------
  >>>>>DESIGNATE INDEPENDENT STREAM FOR CONFLUENCE<<<<<
============================================================================
  TOTAL NUMBER OF STREAMS =  2
  CONFLUENCE VALUES USED FOR INDEPENDENT STREAM  1 ARE:
  TIME OF CONCENTRATION(MIN.) =    7.04
  RAINFALL INTENSITY(INCH/HR) =   4.52
  AREA-AVERAGED Fm(INCH/HR) =  0.04
  AREA-AVERAGED Fp(INCH/HR) =  0.42
  AREA-AVERAGED Ap =  0.10
  EFFECTIVE STREAM AREA(ACRES) =       1.20
  TOTAL STREAM AREA(ACRES) =       1.20
  PEAK FLOW RATE(CFS) AT CONFLUENCE =       4.94

****************************************************************************
  FLOW PROCESS FROM NODE   1140.00 TO NODE   1145.00 IS CODE =  21
----------------------------------------------------------------------------
  >>>>>RATIONAL METHOD INITIAL SUBAREA ANALYSIS<<<<<
```

```
  >>USE TIME-OF-CONCENTRATION NOMOGRAPH FOR INITIAL SUBAREA<<
============================================================================
  INITIAL SUBAREA FLOW-LENGTH(FEET) =   250.00
  ELEVATION DATA: UPSTREAM(FEET) =   1027.40  DOWNSTREAM(FEET) =   1017.00

  Tc = K*[(LENGTH** 3.00)/(ELEVATION CHANGE)]**0.20
  SUBAREA ANALYSIS USED MINIMUM Tc(MIN.) =    5.227
  * 100 YEAR RAINFALL INTENSITY(INCH/HR) =  5.406
  SUBAREA Tc AND LOSS RATE DATA(AMC III):
   DEVELOPMENT TYPE/      SCS SOIL   AREA      Fp         Ap     SCS   Tc
       LAND USE            GROUP   (ACRES)  (INCH/HR)  (DECIMAL)  CN  (MIN.)
  COMMERCIAL                 B        0.30      0.42     0.100    76    5.23
  SUBAREA AVERAGE PERVIOUS LOSS RATE, Fp(INCH/HR) =  0.42
  SUBAREA AVERAGE PERVIOUS AREA FRACTION, Ap =  0.100
  SUBAREA RUNOFF(CFS) =      1.45
  TOTAL AREA(ACRES) =      0.30   PEAK FLOW RATE(CFS) =      1.45

****************************************************************************
  FLOW PROCESS FROM NODE   1145.00 TO NODE   1135.00 IS CODE =  41
----------------------------------------------------------------------------
  >>>>>COMPUTE PIPE-FLOW TRAVEL TIME THRU SUBAREA<<<<<
  >>>>>USING USER-SPECIFIED PIPESIZE (EXISTING ELEMENT)<<<<<
============================================================================
  ELEVATION DATA: UPSTREAM(FEET) =  1017.00  DOWNSTREAM(FEET) =  1016.50
  FLOW LENGTH(FEET) =    69.00   MANNING'S N =  0.024
  DEPTH OF FLOW IN  18.0 INCH PIPE IS   6.9 INCHES
  PIPE-FLOW VELOCITY(FEET/SEC.) =   2.30
  GIVEN PIPE DIAMETER(INCH) =  18.00    NUMBER OF PIPES =   1
  PIPE-FLOW(CFS) =       1.45
  PIPE TRAVEL TIME(MIN.) =   0.50    Tc(MIN.) =    5.73
  LONGEST FLOWPATH FROM NODE   1140.00 TO NODE   1135.00 =     319.00 FEET.

****************************************************************************
  FLOW PROCESS FROM NODE   1135.00 TO NODE   1135.00 IS CODE =  81
----------------------------------------------------------------------------
  >>>>>ADDITION OF SUBAREA TO MAINLINE PEAK FLOW<<<<<
============================================================================
  MAINLINE Tc(MIN.) =    5.73
  * 100 YEAR RAINFALL INTENSITY(INCH/HR) =  5.118
  SUBAREA LOSS RATE DATA(AMC III):
   DEVELOPMENT TYPE/      SCS SOIL   AREA      Fp         Ap     SCS
       LAND USE            GROUP   (ACRES)  (INCH/HR)  (DECIMAL)  CN
  COMMERCIAL                 B        0.80      0.42     0.100    76
  SUBAREA AVERAGE PERVIOUS LOSS RATE, Fp(INCH/HR) =  0.42
  SUBAREA AVERAGE PERVIOUS AREA FRACTION, Ap =  0.100
  SUBAREA AREA(ACRES) =    0.80      SUBAREA RUNOFF(CFS) =    3.65
  EFFECTIVE AREA(ACRES) =      1.10   AREA-AVERAGED Fm(INCH/HR) =  0.04
  AREA-AVERAGED Fp(INCH/HR) =  0.42  AREA-AVERAGED Ap =  0.10
  TOTAL AREA(ACRES) =        1.1       PEAK FLOW RATE(CFS) =       5.02

****************************************************************************
  FLOW PROCESS FROM NODE   1135.00 TO NODE   1130.00 IS CODE =  41
----------------------------------------------------------------------------
  >>>>>COMPUTE PIPE-FLOW TRAVEL TIME THRU SUBAREA<<<<<
  >>>>>USING USER-SPECIFIED PIPESIZE (EXISTING ELEMENT)<<<<<
============================================================================
  ELEVATION DATA: UPSTREAM(FEET) =  1016.50  DOWNSTREAM(FEET) =  1012.70
  FLOW LENGTH(FEET) =   154.00   MANNING'S N =  0.024
  DEPTH OF FLOW IN  24.0 INCH PIPE IS   8.6 INCHES
  PIPE-FLOW VELOCITY(FEET/SEC.) =   4.97
  GIVEN PIPE DIAMETER(INCH) =  24.00    NUMBER OF PIPES =   1
  PIPE-FLOW(CFS) =       5.02
  PIPE TRAVEL TIME(MIN.) =   0.52    Tc(MIN.) =    6.24
  LONGEST FLOWPATH FROM NODE   1140.00 TO NODE   1130.00 =     473.00 FEET.

****************************************************************************
  FLOW PROCESS FROM NODE   1130.00 TO NODE   1130.00 IS CODE =   1
----------------------------------------------------------------------------
  >>>>>DESIGNATE INDEPENDENT STREAM FOR CONFLUENCE<<<<<
  >>>>>AND COMPUTE VARIOUS CONFLUENCED STREAM VALUES<<<<<
============================================================================
```

```
  TOTAL NUMBER OF STREAMS =  2
  CONFLUENCE VALUES USED FOR INDEPENDENT STREAM  2 ARE:
  TIME OF CONCENTRATION(MIN.) =    6.24
  RAINFALL INTENSITY(INCH/HR) =   4.86
  AREA-AVERAGED Fm(INCH/HR) =  0.04
  AREA-AVERAGED Fp(INCH/HR) =  0.42
  AREA-AVERAGED Ap =  0.10
  EFFECTIVE STREAM AREA(ACRES) =       1.10
  TOTAL STREAM AREA(ACRES) =       1.10
  PEAK FLOW RATE(CFS) AT CONFLUENCE =       5.02

  ** CONFLUENCE DATA **
   STREAM       Q      Tc   Intensity   Fp(Fm)     Ap     Ae     HEADWATER
   NUMBER     (CFS)  (MIN.) (INCH/HR) (INCH/HR)         (ACRES)    NODE
      1        4.94    7.04    4.522  0.42( 0.04) 0.10       1.2    1100.00
      2        5.02    6.24    4.859  0.42( 0.04) 0.10       1.1    1140.00

  RAINFALL INTENSITY AND TIME OF CONCENTRATION RATIO
  CONFLUENCE FORMULA USED FOR  2 STREAMS.

  ** PEAK FLOW RATE TABLE **
   STREAM       Q      Tc   Intensity   Fp(Fm)     Ap     Ae     HEADWATER
   NUMBER     (CFS)  (MIN.) (INCH/HR) (INCH/HR)         (ACRES)    NODE
      1        9.74    6.24    4.859  0.42( 0.04) 0.10       2.2    1140.00
      2        9.62    7.04    4.522  0.42( 0.04) 0.10       2.3    1100.00

  COMPUTED CONFLUENCE ESTIMATES ARE AS FOLLOWS:
  PEAK FLOW RATE(CFS) =       9.74    Tc(MIN.) =     6.24
  EFFECTIVE AREA(ACRES) =       2.16   AREA-AVERAGED Fm(INCH/HR) =  0.04
  AREA-AVERAGED Fp(INCH/HR) =  0.42  AREA-AVERAGED Ap =  0.10
  TOTAL AREA(ACRES) =        2.3
  LONGEST FLOWPATH FROM NODE   1100.00 TO NODE   1130.00 =     643.00 FEET.

****************************************************************************
  FLOW PROCESS FROM NODE   1130.00 TO NODE   1160.00 IS CODE =  41
----------------------------------------------------------------------------
  >>>>>COMPUTE PIPE-FLOW TRAVEL TIME THRU SUBAREA<<<<<
  >>>>>USING USER-SPECIFIED PIPESIZE (EXISTING ELEMENT)<<<<<
============================================================================
  ELEVATION DATA: UPSTREAM(FEET) =  1012.70  DOWNSTREAM(FEET) =  1012.00
  FLOW LENGTH(FEET) =    81.00   MANNING'S N =  0.024
  DEPTH OF FLOW IN  36.0 INCH PIPE IS  13.7 INCHES
  PIPE-FLOW VELOCITY(FEET/SEC.) =   3.96
  GIVEN PIPE DIAMETER(INCH) =  36.00    NUMBER OF PIPES =   1
  PIPE-FLOW(CFS) =       9.74
  PIPE TRAVEL TIME(MIN.) =   0.34    Tc(MIN.) =    6.58
  LONGEST FLOWPATH FROM NODE   1100.00 TO NODE   1160.00 =     724.00 FEET.

****************************************************************************
  FLOW PROCESS FROM NODE   1160.00 TO NODE   1170.00 IS CODE =  51
----------------------------------------------------------------------------
  >>>>>COMPUTE TRAPEZOIDAL CHANNEL FLOW<<<<<
  >>>>>TRAVELTIME THRU SUBAREA (EXISTING ELEMENT)<<<<<
============================================================================
  ELEVATION DATA: UPSTREAM(FEET) =   1012.00  DOWNSTREAM(FEET) =   1007.00
  CHANNEL LENGTH THRU SUBAREA(FEET) =   140.00   CHANNEL SLOPE =  0.0357
  CHANNEL BASE(FEET) =    2.00   "Z" FACTOR =   2.000
  MANNING'S FACTOR = 0.030   MAXIMUM DEPTH(FEET) =   1.00
  * 100 YEAR RAINFALL INTENSITY(INCH/HR) =  4.537
  SUBAREA LOSS RATE DATA(AMC III):
   DEVELOPMENT TYPE/      SCS SOIL   AREA      Fp         Ap     SCS
       LAND USE            GROUP   (ACRES)  (INCH/HR)  (DECIMAL)  CN
  PUBLIC PARK                B        2.00      0.42     0.850    76
  SUBAREA AVERAGE PERVIOUS LOSS RATE, Fp(INCH/HR) =  0.42
  SUBAREA AVERAGE PERVIOUS AREA FRACTION, Ap =  0.850
  TRAVEL TIME COMPUTED USING ESTIMATED FLOW(CFS) =      13.50
  TRAVEL TIME THRU SUBAREA BASED ON VELOCITY(FEET/SEC.) =   5.62
  AVERAGE FLOW DEPTH(FEET) =   0.70   TRAVEL TIME(MIN.) =   0.42
  Tc(MIN.) =    7.00
  SUBAREA AREA(ACRES) =     2.00       SUBAREA RUNOFF(CFS) =    7.52
  EFFECTIVE AREA(ACRES) =      4.16     AREA-AVERAGED Fm(INCH/HR) =   0.19
```

```
  AREA-AVERAGED Fp(INCH/HR) =   0.42  AREA-AVERAGED Ap =   0.46
  TOTAL AREA(ACRES) =        4.3         PEAK FLOW RATE(CFS) =      16.28

  END OF SUBAREA CHANNEL FLOW HYDRAULICS:
  DEPTH(FEET) =  0.78   FLOW VELOCITY(FEET/SEC.) =   5.91
  LONGEST FLOWPATH FROM NODE   1100.00 TO NODE   1170.00 =     864.00 FEET.
============================================================================
  END OF STUDY SUMMARY:
  TOTAL AREA(ACRES)     =        4.3  TC(MIN.) =      7.00
  EFFECTIVE AREA(ACRES) =      4.16  AREA-AVERAGED Fm(INCH/HR)=  0.19
  AREA-AVERAGED Fp(INCH/HR) =  0.42  AREA-AVERAGED Ap = 0.460
  PEAK FLOW RATE(CFS)   =      16.28

  ** PEAK FLOW RATE TABLE **
   STREAM       Q      Tc   Intensity   Fp(Fm)     Ap     Ae     HEADWATER
   NUMBER     (CFS)  (MIN.) (INCH/HR) (INCH/HR)         (ACRES)    NODE
      1       16.28    7.00    4.537  0.42( 0.19) 0.46       4.2    1140.00
      2       15.72    7.80    4.253  0.42( 0.19) 0.45       4.3    1100.00
============================================================================
============================================================================
  END OF RATIONAL METHOD ANALYSIS
```

```
____________________________________________________________________________
****************************************************************************
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             Ver. 15.0  Release Date: 04/01/2008  License ID 1555

                           Analysis prepared by:





 ************************** DESCRIPTION OF STUDY **************************
* REDLANDS PASSENGER RAIL PROJECT                                          *
* EXISTING HYDROLOGY 100 YEAR STORM                                        *
* BASIN 2000                                                               *
 **************************************************************************

  FILE NAME: C:\RPRP\EPRP\2000.DAT
  TIME/DATE OF STUDY: 15:21 09/11/2012
============================================================================
  USER SPECIFIED HYDROLOGY AND HYDRAULIC MODEL INFORMATION:
============================================================================
                    --*TIME-OF-CONCENTRATION MODEL*--

  USER SPECIFIED STORM EVENT(YEAR) =  100.00
  SPECIFIED MINIMUM PIPE SIZE(INCH) =  12.00
  SPECIFIED PERCENT OF GRADIENTS(DECIMAL) TO USE FOR FRICTION SLOPE = 1.00
  *USER-DEFINED LOGARITHMIC INTERPOLATION USED FOR RAINFALL*

  SLOPE OF INTENSITY DURATION CURVE(LOG(I;IN/HR) vs. LOG(Tc;MIN)) = 0.6000
  USER SPECIFIED 1-HOUR INTENSITY(INCH/HOUR) = 1.2500

  *ANTECEDENT MOISTURE CONDITION (AMC) III ASSUMED FOR RATIONAL METHOD*

  *USER-DEFINED STREET-SECTIONS FOR COUPLED PIPEFLOW AND STREETFLOW MODEL*
     HALF-  CROWN TO   STREET-CROSSFALL:   CURB  GUTTER-GEOMETRIES:  MANNING
     WIDTH  CROSSFALL  IN-  / OUT-/PARK-  HEIGHT  WIDTH  LIP   HIKE  FACTOR
NO.   (FT)     (FT)    SIDE / SIDE/ WAY    (FT)    (FT)  (FT)  (FT)    (n)
===  =====  =========  =================  ======  ===== ====== ===== =======
  1   30.0     20.0    0.018/0.018/0.020   0.67    2.00 0.0312 0.167 0.0150

  GLOBAL STREET FLOW-DEPTH CONSTRAINTS:
    1. Relative Flow-Depth =  0.20 FEET
       as (Maximum Allowable Street Flow Depth) - (Top-of-Curb)
    2. (Depth)*(Velocity) Constraint = 10.0 (FT*FT/S)
  *SIZE PIPE WITH A FLOW CAPACITY GREATER THAN
   OR EQUAL TO THE UPSTREAM TRIBUTARY PIPE.*
  *USER-SPECIFIED MINIMUM TOPOGRAPHIC SLOPE ADJUSTMENT NOT SELECTED

****************************************************************************
  FLOW PROCESS FROM NODE   2100.00 TO NODE   2110.00 IS CODE =  21
----------------------------------------------------------------------------
  >>>>>RATIONAL METHOD INITIAL SUBAREA ANALYSIS<<<<<
  >>USE TIME-OF-CONCENTRATION NOMOGRAPH FOR INITIAL SUBAREA<<
============================================================================
  INITIAL SUBAREA FLOW-LENGTH(FEET) =   180.00
  ELEVATION DATA: UPSTREAM(FEET) =   1020.80  DOWNSTREAM(FEET) =   1020.50

  Tc = K*[(LENGTH** 3.00)/(ELEVATION CHANGE)]**0.20
  SUBAREA ANALYSIS USED MINIMUM Tc(MIN.) =   13.858
  * 100 YEAR RAINFALL INTENSITY(INCH/HR) =  3.012
  SUBAREA Tc AND LOSS RATE DATA(AMC III):
   DEVELOPMENT TYPE/      SCS SOIL   AREA      Fp         Ap     SCS   Tc
       LAND USE            GROUP   (ACRES)  (INCH/HR)  (DECIMAL)  CN  (MIN.)
  PUBLIC PARK                B        1.00      0.42     0.850    76   13.86
  SUBAREA AVERAGE PERVIOUS LOSS RATE, Fp(INCH/HR) =  0.42
  SUBAREA AVERAGE PERVIOUS AREA FRACTION, Ap =  0.850
  SUBAREA RUNOFF(CFS) =      2.39
```

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 TOTAL AREA(ACRES) =      1.00   PEAK FLOW RATE(CFS) =      2.39

****************************************************************************
 FLOW PROCESS FROM NODE   2110.00 TO NODE   2120.00 IS CODE =  51
----------------------------------------------------------------------------
 >>>>>COMPUTE TRAPEZOIDAL CHANNEL FLOW<<<<<
 >>>>>TRAVELTIME THRU SUBAREA (EXISTING ELEMENT)<<<<<
============================================================================
 ELEVATION DATA: UPSTREAM(FEET) =   1020.50  DOWNSTREAM(FEET) =   1019.00
 CHANNEL LENGTH THRU SUBAREA(FEET) =   330.00   CHANNEL SLOPE =  0.0045
 CHANNEL BASE(FEET) =    2.00   "Z" FACTOR =   3.000
 MANNING'S FACTOR = 0.030   MAXIMUM DEPTH(FEET) =   1.00
 * 100 YEAR RAINFALL INTENSITY(INCH/HR) =  2.668
 SUBAREA LOSS RATE DATA(AMC III):
  DEVELOPMENT TYPE/      SCS SOIL   AREA      Fp        Ap     SCS
      LAND USE            GROUP   (ACRES)  (INCH/HR)  (DECIMAL)  CN
 PUBLIC PARK                B       1.50      0.42     0.850    76
 SUBAREA AVERAGE PERVIOUS LOSS RATE, Fp(INCH/HR) =  0.42
 SUBAREA AVERAGE PERVIOUS AREA FRACTION, Ap =  0.850
 TRAVEL TIME COMPUTED USING ESTIMATED FLOW(CFS) =       3.95
 TRAVEL TIME THRU SUBAREA BASED ON VELOCITY(FEET/SEC.) =   1.77
 AVERAGE FLOW DEPTH(FEET) =   0.59   TRAVEL TIME(MIN.) =   3.10
 Tc(MIN.) =   16.96
 SUBAREA AREA(ACRES) =     1.50       SUBAREA RUNOFF(CFS) =    3.12
 EFFECTIVE AREA(ACRES) =      2.50     AREA-AVERAGED Fm(INCH/HR) =   0.36
 AREA-AVERAGED Fp(INCH/HR) =   0.42  AREA-AVERAGED Ap =   0.85
 TOTAL AREA(ACRES) =        2.5        PEAK FLOW RATE(CFS) =       5.19

 END OF SUBAREA CHANNEL FLOW HYDRAULICS:
 DEPTH(FEET) =  0.67   FLOW VELOCITY(FEET/SEC.) =   1.91
 LONGEST FLOWPATH FROM NODE   2100.00 TO NODE   2120.00 =     510.00 FEET.

****************************************************************************
 FLOW PROCESS FROM NODE   2120.00 TO NODE   2130.00 IS CODE =  51
----------------------------------------------------------------------------
 >>>>>COMPUTE TRAPEZOIDAL CHANNEL FLOW<<<<<
 >>>>>TRAVELTIME THRU SUBAREA (EXISTING ELEMENT)<<<<<
============================================================================
 ELEVATION DATA: UPSTREAM(FEET) =   1019.00  DOWNSTREAM(FEET) =   1014.80
 CHANNEL LENGTH THRU SUBAREA(FEET) =  1290.00   CHANNEL SLOPE =  0.0033
 CHANNEL BASE(FEET) =    2.00   "Z" FACTOR =   2.000
 MANNING'S FACTOR = 0.030   MAXIMUM DEPTH(FEET) =   1.00
 * 100 YEAR RAINFALL INTENSITY(INCH/HR) =  1.980
 SUBAREA LOSS RATE DATA(AMC III):
  DEVELOPMENT TYPE/      SCS SOIL   AREA      Fp        Ap     SCS
      LAND USE            GROUP   (ACRES)  (INCH/HR)  (DECIMAL)  CN
 PUBLIC PARK                B       2.50      0.42     0.850    76
 SUBAREA AVERAGE PERVIOUS LOSS RATE, Fp(INCH/HR) =  0.42
 SUBAREA AVERAGE PERVIOUS AREA FRACTION, Ap =  0.850
 TRAVEL TIME COMPUTED USING ESTIMATED FLOW(CFS) =       7.03
 TRAVEL TIME THRU SUBAREA BASED ON VELOCITY(FEET/SEC.) =   1.97
 AVERAGE FLOW DEPTH(FEET) =   0.93   TRAVEL TIME(MIN.) =  10.91
 Tc(MIN.) =   27.86
 SUBAREA AREA(ACRES) =     2.50       SUBAREA RUNOFF(CFS) =    3.65
 EFFECTIVE AREA(ACRES) =      5.00     AREA-AVERAGED Fm(INCH/HR) =   0.36
 AREA-AVERAGED Fp(INCH/HR) =   0.42  AREA-AVERAGED Ap =   0.85
 TOTAL AREA(ACRES) =        5.0        PEAK FLOW RATE(CFS) =       7.29

 END OF SUBAREA CHANNEL FLOW HYDRAULICS:
 DEPTH(FEET) =  0.94   FLOW VELOCITY(FEET/SEC.) =   1.99
 LONGEST FLOWPATH FROM NODE   2100.00 TO NODE   2130.00 =    1800.00 FEET.
============================================================================
 END OF STUDY SUMMARY:
 TOTAL AREA(ACRES)     =        5.0  TC(MIN.) =     27.86
 EFFECTIVE AREA(ACRES) =      5.00  AREA-AVERAGED Fm(INCH/HR)=  0.36
 AREA-AVERAGED Fp(INCH/HR) =  0.42  AREA-AVERAGED Ap = 0.850
 PEAK FLOW RATE(CFS)    =      7.29
============================================================================
============================================================================
 END OF RATIONAL METHOD ANALYSIS
```

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____________________________________________________________________________
****************************************************************************
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                           Analysis prepared by:




 ************************* DESCRIPTION OF STUDY *************************
* REDLANDS PASSENGER RAIL PROGRAM                                          *
* EXISTING 100 YEAR ANALYSIS                                               *
* DRAINAGE AREA 3000                                                       *
 **************************************************************************

  FILE NAME: C:\RPRP\3000.DAT
  TIME/DATE OF STUDY: 10:31 05/23/2012
============================================================================
  USER SPECIFIED HYDROLOGY AND HYDRAULIC MODEL INFORMATION:
============================================================================
                    --*TIME-OF-CONCENTRATION MODEL*--

  USER SPECIFIED STORM EVENT(YEAR) =  100.00
  SPECIFIED MINIMUM PIPE SIZE(INCH) =  12.00
  SPECIFIED PERCENT OF GRADIENTS(DECIMAL) TO USE FOR FRICTION SLOPE = 1.00
  *USER-DEFINED LOGARITHMIC INTERPOLATION USED FOR RAINFALL*

  SLOPE OF INTENSITY DURATION CURVE(LOG(I;IN/HR) vs. LOG(Tc;MIN)) = 0.6000
  USER SPECIFIED 1-HOUR INTENSITY(INCH/HOUR) = 1.2500

  *ANTECEDENT MOISTURE CONDITION (AMC) III ASSUMED FOR RATIONAL METHOD*

  *USER-DEFINED STREET-SECTIONS FOR COUPLED PIPEFLOW AND STREETFLOW MODEL*
     HALF-  CROWN TO   STREET-CROSSFALL:   CURB  GUTTER-GEOMETRIES:  MANNING
     WIDTH  CROSSFALL  IN-  / OUT-/PARK-  HEIGHT  WIDTH  LIP   HIKE  FACTOR
NO.   (FT)     (FT)    SIDE / SIDE/ WAY    (FT)    (FT)  (FT)  (FT)    (n)
===  =====  =========  =================  ======  ===== ====== ===== =======
  1   30.0     20.0    0.018/0.018/0.020   0.67    2.00 0.0313 0.167 0.0150

  GLOBAL STREET FLOW-DEPTH CONSTRAINTS:
    1. Relative Flow-Depth =  0.20 FEET
       as (Maximum Allowable Street Flow Depth) - (Top-of-Curb)
    2. (Depth)*(Velocity) Constraint = 10.0 (FT*FT/S)
  *SIZE PIPE WITH A FLOW CAPACITY GREATER THAN
   OR EQUAL TO THE UPSTREAM TRIBUTARY PIPE.*
  *USER-SPECIFIED MINIMUM TOPOGRAPHIC SLOPE ADJUSTMENT NOT SELECTED

****************************************************************************
  FLOW PROCESS FROM NODE   3000.00 TO NODE   3010.00 IS CODE =  21
----------------------------------------------------------------------------
  >>>>>RATIONAL METHOD INITIAL SUBAREA ANALYSIS<<<<<
  >>USE TIME-OF-CONCENTRATION NOMOGRAPH FOR INITIAL SUBAREA<<
============================================================================
  INITIAL SUBAREA FLOW-LENGTH(FEET) =  1350.00
  ELEVATION DATA: UPSTREAM(FEET) =   1021.00  DOWNSTREAM(FEET) =   1015.00

  Tc = K*[(LENGTH** 3.00)/(ELEVATION CHANGE)]**0.20
  SUBAREA ANALYSIS USED MINIMUM Tc(MIN.) =   21.750
  * 100 YEAR RAINFALL INTENSITY(INCH/HR) =  2.298
  SUBAREA Tc AND LOSS RATE DATA(AMC III):
   DEVELOPMENT TYPE/      SCS SOIL   AREA      Fp         Ap     SCS   Tc
       LAND USE            GROUP   (ACRES)  (INCH/HR)  (DECIMAL)  CN  (MIN.)
  RESIDENTIAL
  "3-4 DWELLINGS/ACRE"       B        0.80      0.42     0.600    76   21.75
  SUBAREA AVERAGE PERVIOUS LOSS RATE, Fp(INCH/HR) =  0.42
  SUBAREA AVERAGE PERVIOUS AREA FRACTION, Ap =  0.600
```

```
  SUBAREA RUNOFF(CFS) =      1.47
  TOTAL AREA(ACRES) =      0.80   PEAK FLOW RATE(CFS) =      1.47
============================================================================
  END OF STUDY SUMMARY:
  TOTAL AREA(ACRES)     =        0.8  TC(MIN.) =     21.75
  EFFECTIVE AREA(ACRES) =      0.80  AREA-AVERAGED Fm(INCH/HR)=  0.25
  AREA-AVERAGED Fp(INCH/HR) =  0.42  AREA-AVERAGED Ap = 0.600
  PEAK FLOW RATE(CFS)   =       1.47
============================================================================
============================================================================
  END OF RATIONAL METHOD ANALYSIS
```

```
****************************************************************************
             RATIONAL METHOD HYDROLOGY COMPUTER PROGRAM PACKAGE
          (Reference: 1986 SAN BERNARDINO CO. HYDROLOGY CRITERION)
         (c) Copyright 1983-2008 Advanced Engineering Software (aes)
             Ver. 15.0  Release Date: 04/01/2008  License ID 1555

                           Analysis prepared by:





 ************************** DESCRIPTION OF STUDY **************************
* REDLANDS PASSENGER RAIL PROJECT                                          *
* EXISTING 100 YEAR ANALYSIS                                               *
* DRAINAGE AREA 5000                                                       *
 **************************************************************************

  FILE NAME: C:\RPRP\5000.DAT
  TIME/DATE OF STUDY: 11:31 06/01/2012
============================================================================
  USER SPECIFIED HYDROLOGY AND HYDRAULIC MODEL INFORMATION:
============================================================================
                    --*TIME-OF-CONCENTRATION MODEL*--

  USER SPECIFIED STORM EVENT(YEAR) =  100.00
  SPECIFIED MINIMUM PIPE SIZE(INCH) =  12.00
  SPECIFIED PERCENT OF GRADIENTS(DECIMAL) TO USE FOR FRICTION SLOPE = 1.00
  *USER-DEFINED LOGARITHMIC INTERPOLATION USED FOR RAINFALL*

  SLOPE OF INTENSITY DURATION CURVE(LOG(I;IN/HR) vs. LOG(Tc;MIN)) = 0.6000
  USER SPECIFIED 1-HOUR INTENSITY(INCH/HOUR) = 1.2500

  *ANTECEDENT MOISTURE CONDITION (AMC) III ASSUMED FOR RATIONAL METHOD*

  *USER-DEFINED STREET-SECTIONS FOR COUPLED PIPEFLOW AND STREETFLOW MODEL*
     HALF-  CROWN TO   STREET-CROSSFALL:   CURB  GUTTER-GEOMETRIES:  MANNING
     WIDTH  CROSSFALL  IN-  / OUT-/PARK-  HEIGHT  WIDTH  LIP   HIKE  FACTOR
NO.   (FT)     (FT)    SIDE / SIDE/ WAY    (FT)    (FT)  (FT)  (FT)    (n)
===  =====  =========  =================  ======  ===== ====== ===== =======
  1   30.0     20.0    0.018/0.018/0.020   0.67    2.00 0.0313 0.167 0.0150

  GLOBAL STREET FLOW-DEPTH CONSTRAINTS:
    1. Relative Flow-Depth =  0.20 FEET
       as (Maximum Allowable Street Flow Depth) - (Top-of-Curb)
    2. (Depth)*(Velocity) Constraint = 10.0 (FT*FT/S)
  *SIZE PIPE WITH A FLOW CAPACITY GREATER THAN
   OR EQUAL TO THE UPSTREAM TRIBUTARY PIPE.*
  *USER-SPECIFIED MINIMUM TOPOGRAPHIC SLOPE ADJUSTMENT NOT SELECTED

****************************************************************************
  FLOW PROCESS FROM NODE   5000.00 TO NODE   5005.00 IS CODE =  21
----------------------------------------------------------------------------
  >>>>>RATIONAL METHOD INITIAL SUBAREA ANALYSIS<<<<<
  >>USE TIME-OF-CONCENTRATION NOMOGRAPH FOR INITIAL SUBAREA<<
============================================================================
  INITIAL SUBAREA FLOW-LENGTH(FEET) =   194.00
  ELEVATION DATA: UPSTREAM(FEET) =   1024.00  DOWNSTREAM(FEET) =   1022.50

  Tc = K*[(LENGTH** 3.00)/(ELEVATION CHANGE)]**0.20
  SUBAREA ANALYSIS USED MINIMUM Tc(MIN.) =   10.505
  * 100 YEAR RAINFALL INTENSITY(INCH/HR) =  3.556
  SUBAREA Tc AND LOSS RATE DATA(AMC III):
   DEVELOPMENT TYPE/      SCS SOIL   AREA      Fp         Ap     SCS   Tc
       LAND USE            GROUP   (ACRES)  (INCH/HR)  (DECIMAL)  CN  (MIN.)
  PUBLIC PARK                B       1.00      0.42     0.850    76   10.51
  SUBAREA AVERAGE PERVIOUS LOSS RATE, Fp(INCH/HR) =  0.42
  SUBAREA AVERAGE PERVIOUS AREA FRACTION, Ap =  0.850
  SUBAREA RUNOFF(CFS) =      2.88
```

```
  TOTAL AREA(ACRES) =      1.00   PEAK FLOW RATE(CFS) =      2.88

****************************************************************************
  FLOW PROCESS FROM NODE   5005.00 TO NODE   5010.00 IS CODE =  51
----------------------------------------------------------------------------
  >>>>>COMPUTE TRAPEZOIDAL CHANNEL FLOW<<<<<
  >>>>>TRAVELTIME THRU SUBAREA (EXISTING ELEMENT)<<<<<
============================================================================
  ELEVATION DATA: UPSTREAM(FEET) =   1022.60  DOWNSTREAM(FEET) =   1020.00
  CHANNEL LENGTH THRU SUBAREA(FEET) =   490.00   CHANNEL SLOPE =  0.0053
  CHANNEL BASE(FEET) =    5.00   "Z" FACTOR =   3.000
  MANNING'S FACTOR = 0.030   MAXIMUM DEPTH(FEET) =   1.00
  * 100 YEAR RAINFALL INTENSITY(INCH/HR) =  2.951
  SUBAREA LOSS RATE DATA(AMC III):
   DEVELOPMENT TYPE/      SCS SOIL   AREA      Fp         Ap     SCS
       LAND USE            GROUP   (ACRES)  (INCH/HR)  (DECIMAL)  CN
  PUBLIC PARK                B       4.80      0.42     0.850    76
  SUBAREA AVERAGE PERVIOUS LOSS RATE, Fp(INCH/HR) =  0.42
  SUBAREA AVERAGE PERVIOUS AREA FRACTION, Ap =  0.850
  TRAVEL TIME COMPUTED USING ESTIMATED FLOW(CFS) =       8.52
  TRAVEL TIME THRU SUBAREA BASED ON VELOCITY(FEET/SEC.) =   2.13
  AVERAGE FLOW DEPTH(FEET) =   0.59   TRAVEL TIME(MIN.) =   3.83
  Tc(MIN.) =   14.34
  SUBAREA AREA(ACRES) =     4.80       SUBAREA RUNOFF(CFS) =   11.19
  EFFECTIVE AREA(ACRES) =      5.80     AREA-AVERAGED Fm(INCH/HR) =   0.36
  AREA-AVERAGED Fp(INCH/HR) =   0.42  AREA-AVERAGED Ap =   0.85
  TOTAL AREA(ACRES) =        5.8         PEAK FLOW RATE(CFS) =      13.53

  END OF SUBAREA CHANNEL FLOW HYDRAULICS:
  DEPTH(FEET) =  0.76   FLOW VELOCITY(FEET/SEC.) =   2.45
  LONGEST FLOWPATH FROM NODE   5000.00 TO NODE   5010.00 =     684.00 FEET.

****************************************************************************
  FLOW PROCESS FROM NODE   5010.00 TO NODE   5015.00 IS CODE =  62
----------------------------------------------------------------------------
  >>>>>COMPUTE STREET FLOW TRAVEL TIME THRU SUBAREA<<<<<
  >>>>>(STREET TABLE SECTION #  1 USED)<<<<<
============================================================================
  UPSTREAM ELEVATION(FEET) = 1020.00  DOWNSTREAM ELEVATION(FEET) = 1018.60
  STREET LENGTH(FEET) =   309.00   CURB HEIGHT(INCHES) =  8.0
  STREET HALFWIDTH(FEET) = 30.00

  DISTANCE FROM CROWN TO CROSSFALL GRADEBREAK(FEET) =  20.00
  INSIDE STREET CROSSFALL(DECIMAL) =  0.018
  OUTSIDE STREET CROSSFALL(DECIMAL)  =  0.018

  SPECIFIED NUMBER OF HALFSTREETS CARRYING RUNOFF =  1
  STREET PARKWAY CROSSFALL(DECIMAL)  =  0.020
  Manning's FRICTION FACTOR for Streetflow Section(curb-to-curb) =   0.0150
  Manning's FRICTION FACTOR for Back-of-Walk Flow Section =   0.0200

    **TRAVEL TIME COMPUTED USING ESTIMATED FLOW(CFS) =      18.43
    STREETFLOW MODEL RESULTS USING ESTIMATED FLOW:
    STREET FLOW DEPTH(FEET) =  0.66
    HALFSTREET FLOOD WIDTH(FEET) =   27.62
    AVERAGE FLOW VELOCITY(FEET/SEC.) =    2.63
    PRODUCT OF DEPTH&VELOCITY(FT*FT/SEC.) =    1.73
  STREET FLOW TRAVEL TIME(MIN.) =   1.96   Tc(MIN.) =   16.30
  * 100 YEAR RAINFALL INTENSITY(INCH/HR) =  2.733
  SUBAREA LOSS RATE DATA(AMC III):
   DEVELOPMENT TYPE/      SCS SOIL   AREA      Fp         Ap     SCS
       LAND USE            GROUP   (ACRES)  (INCH/HR)  (DECIMAL)  CN
  RESIDENTIAL
  "2 DWELLINGS/ACRE"         B       4.47      0.42     0.700    76
  SUBAREA AVERAGE PERVIOUS LOSS RATE, Fp(INCH/HR) =  0.42
  SUBAREA AVERAGE PERVIOUS AREA FRACTION, Ap =  0.700
  SUBAREA AREA(ACRES) =    4.47      SUBAREA RUNOFF(CFS) =    9.80
  EFFECTIVE AREA(ACRES) =     10.27    AREA-AVERAGED Fm(INCH/HR) =  0.33
  AREA-AVERAGED Fp(INCH/HR) =  0.42  AREA-AVERAGED Ap =  0.78
  TOTAL AREA(ACRES) =       10.3        PEAK FLOW RATE(CFS) =      22.19
```

```
  END OF SUBAREA STREET FLOW HYDRAULICS:
  DEPTH(FEET) = 0.69   HALFSTREET FLOOD WIDTH(FEET) =  30.92
  FLOW VELOCITY(FEET/SEC.) =  2.75   DEPTH*VELOCITY(FT*FT/SEC.) =   1.91
  LONGEST FLOWPATH FROM NODE   5000.00 TO NODE   5015.00 =     993.00 FEET.

****************************************************************************
  FLOW PROCESS FROM NODE   5015.00 TO NODE   5020.00 IS CODE =  62
----------------------------------------------------------------------------
  >>>>>COMPUTE STREET FLOW TRAVEL TIME THRU SUBAREA<<<<<
  >>>>>(STREET TABLE SECTION #  1 USED)<<<<<
============================================================================
  UPSTREAM ELEVATION(FEET) = 1018.60  DOWNSTREAM ELEVATION(FEET) = 1017.30
  STREET LENGTH(FEET) =   328.00   CURB HEIGHT(INCHES) =  8.0
  STREET HALFWIDTH(FEET) = 30.00

  DISTANCE FROM CROWN TO CROSSFALL GRADEBREAK(FEET) =  20.00
  INSIDE STREET CROSSFALL(DECIMAL) =  0.018
  OUTSIDE STREET CROSSFALL(DECIMAL)  =  0.018

  SPECIFIED NUMBER OF HALFSTREETS CARRYING RUNOFF =  1
  STREET PARKWAY CROSSFALL(DECIMAL)  =  0.020
  Manning's FRICTION FACTOR for Streetflow Section(curb-to-curb) =   0.0150
  Manning's FRICTION FACTOR for Back-of-Walk Flow Section =   0.0200

    **TRAVEL TIME COMPUTED USING ESTIMATED FLOW(CFS) =      25.78
    ***STREET FLOW SPLITS OVER STREET-CROWN***
    FULL DEPTH(FEET) =    0.70   FLOOD WIDTH(FEET) =   31.58
    FULL HALF-STREET VELOCITY(FEET/SEC.) =    2.59
    SPLIT DEPTH(FEET) =    0.45   SPLIT FLOOD WIDTH(FEET) =   16.13
    SPLIT FLOW(CFS) =    4.44   SPLIT VELOCITY(FEET/SEC.) =    1.76
    STREETFLOW MODEL RESULTS USING ESTIMATED FLOW:
    STREET FLOW DEPTH(FEET) =  0.70
    HALFSTREET FLOOD WIDTH(FEET) =   31.58
    AVERAGE FLOW VELOCITY(FEET/SEC.) =    2.59
    PRODUCT OF DEPTH&VELOCITY(FT*FT/SEC.) =    1.81
  STREET FLOW TRAVEL TIME(MIN.) =   2.11   Tc(MIN.) =   18.41
  * 100 YEAR RAINFALL INTENSITY(INCH/HR) =  2.540
  SUBAREA LOSS RATE DATA(AMC III):
   DEVELOPMENT TYPE/      SCS SOIL   AREA      Fp         Ap     SCS
       LAND USE            GROUP   (ACRES)  (INCH/HR)  (DECIMAL)  CN
  RESIDENTIAL
  "2 DWELLINGS/ACRE"         B        3.56      0.42     0.700    76
  SUBAREA AVERAGE PERVIOUS LOSS RATE, Fp(INCH/HR) =  0.42
  SUBAREA AVERAGE PERVIOUS AREA FRACTION, Ap =  0.700
  SUBAREA AREA(ACRES) =    3.56      SUBAREA RUNOFF(CFS) =    7.19
  EFFECTIVE AREA(ACRES) =     13.83    AREA-AVERAGED Fm(INCH/HR) =  0.32
  AREA-AVERAGED Fp(INCH/HR) =  0.42  AREA-AVERAGED Ap =  0.76
  TOTAL AREA(ACRES) =       13.8        PEAK FLOW RATE(CFS) =      27.59

  END OF SUBAREA STREET FLOW HYDRAULICS:
  DEPTH(FEET) = 0.70   HALFSTREET FLOOD WIDTH(FEET) =  31.58
  FLOW VELOCITY(FEET/SEC.) =  2.59   DEPTH*VELOCITY(FT*FT/SEC.) =   1.81
  LONGEST FLOWPATH FROM NODE   5000.00 TO NODE   5020.00 =    1321.00 FEET.

****************************************************************************
  FLOW PROCESS FROM NODE   5020.00 TO NODE   5025.00 IS CODE =  62
----------------------------------------------------------------------------
  >>>>>COMPUTE STREET FLOW TRAVEL TIME THRU SUBAREA<<<<<
  >>>>>(STREET TABLE SECTION #  1 USED)<<<<<
============================================================================
  UPSTREAM ELEVATION(FEET) = 1017.30  DOWNSTREAM ELEVATION(FEET) = 1017.00
  STREET LENGTH(FEET) =   308.00   CURB HEIGHT(INCHES) =  8.0
  STREET HALFWIDTH(FEET) = 30.00

  DISTANCE FROM CROWN TO CROSSFALL GRADEBREAK(FEET) =  20.00
  INSIDE STREET CROSSFALL(DECIMAL) =  0.018
  OUTSIDE STREET CROSSFALL(DECIMAL)  =  0.018

  SPECIFIED NUMBER OF HALFSTREETS CARRYING RUNOFF =  1
  STREET PARKWAY CROSSFALL(DECIMAL)  =  0.020
  Manning's FRICTION FACTOR for Streetflow Section(curb-to-curb) =   0.0150
```

```
  Manning's FRICTION FACTOR for Back-of-Walk Flow Section =   0.0200

    **TRAVEL TIME COMPUTED USING ESTIMATED FLOW(CFS) =      30.14
    ***STREET FLOWING FULL***
    STREETFLOW MODEL RESULTS USING ESTIMATED FLOW:
    STREET FLOW DEPTH(FEET) =  0.76
    HALFSTREET FLOOD WIDTH(FEET) =   34.79
    AVERAGE FLOW VELOCITY(FEET/SEC.) =    1.45
    PRODUCT OF DEPTH&VELOCITY(FT*FT/SEC.) =    1.11
  STREET FLOW TRAVEL TIME(MIN.) =   3.54   Tc(MIN.) =   21.95
  * 100 YEAR RAINFALL INTENSITY(INCH/HR) =  2.285
  SUBAREA LOSS RATE DATA(AMC III):
   DEVELOPMENT TYPE/      SCS SOIL   AREA      Fp         Ap     SCS
       LAND USE            GROUP   (ACRES)  (INCH/HR)  (DECIMAL)  CN
  RESIDENTIAL
  "3-4 DWELLINGS/ACRE"       B        2.78      0.42     0.600    76
  SUBAREA AVERAGE PERVIOUS LOSS RATE, Fp(INCH/HR) =  0.42
  SUBAREA AVERAGE PERVIOUS AREA FRACTION, Ap =  0.600
  SUBAREA AREA(ACRES) =    2.78      SUBAREA RUNOFF(CFS) =    5.08
  EFFECTIVE AREA(ACRES) =     16.61    AREA-AVERAGED Fm(INCH/HR) =  0.31
  AREA-AVERAGED Fp(INCH/HR) =  0.42  AREA-AVERAGED Ap =  0.74
  TOTAL AREA(ACRES) =       16.6        PEAK FLOW RATE(CFS) =      29.51

  END OF SUBAREA STREET FLOW HYDRAULICS:
  DEPTH(FEET) = 0.76   HALFSTREET FLOOD WIDTH(FEET) =  34.60
  FLOW VELOCITY(FEET/SEC.) =  1.44   DEPTH*VELOCITY(FT*FT/SEC.) =   1.09
  LONGEST FLOWPATH FROM NODE   5000.00 TO NODE   5025.00 =    1629.00 FEET.

****************************************************************************
  FLOW PROCESS FROM NODE   5025.00 TO NODE   5030.00 IS CODE =  62
----------------------------------------------------------------------------
  >>>>>COMPUTE STREET FLOW TRAVEL TIME THRU SUBAREA<<<<<
  >>>>>(STREET TABLE SECTION #  1 USED)<<<<<
============================================================================
  UPSTREAM ELEVATION(FEET) = 1017.00  DOWNSTREAM ELEVATION(FEET) = 1016.00
  STREET LENGTH(FEET) =   487.22   CURB HEIGHT(INCHES) =  8.0
  STREET HALFWIDTH(FEET) = 30.00

  DISTANCE FROM CROWN TO CROSSFALL GRADEBREAK(FEET) =  20.00
  INSIDE STREET CROSSFALL(DECIMAL) =  0.018
  OUTSIDE STREET CROSSFALL(DECIMAL)  =  0.018

  SPECIFIED NUMBER OF HALFSTREETS CARRYING RUNOFF =  1
  STREET PARKWAY CROSSFALL(DECIMAL)  =  0.020
  Manning's FRICTION FACTOR for Streetflow Section(curb-to-curb) =   0.0150
  Manning's FRICTION FACTOR for Back-of-Walk Flow Section =   0.0200

    **TRAVEL TIME COMPUTED USING ESTIMATED FLOW(CFS) =      32.43
    ***STREET FLOWING FULL***
    STREETFLOW MODEL RESULTS USING ESTIMATED FLOW:
    STREET FLOW DEPTH(FEET) =  0.71
    HALFSTREET FLOOD WIDTH(FEET) =   32.04
    AVERAGE FLOW VELOCITY(FEET/SEC.) =    1.90
    PRODUCT OF DEPTH&VELOCITY(FT*FT/SEC.) =    1.34
  STREET FLOW TRAVEL TIME(MIN.) =   4.28   Tc(MIN.) =   26.23
  * 100 YEAR RAINFALL INTENSITY(INCH/HR) =  2.054
  SUBAREA LOSS RATE DATA(AMC III):
   DEVELOPMENT TYPE/      SCS SOIL   AREA      Fp         Ap     SCS
       LAND USE            GROUP   (ACRES)  (INCH/HR)  (DECIMAL)  CN
  RESIDENTIAL
  "3-4 DWELLINGS/ACRE"       B        3.60      0.42     0.600    76
  SUBAREA AVERAGE PERVIOUS LOSS RATE, Fp(INCH/HR) =  0.42
  SUBAREA AVERAGE PERVIOUS AREA FRACTION, Ap =  0.600
  SUBAREA AREA(ACRES) =    3.60      SUBAREA RUNOFF(CFS) =    5.83
  EFFECTIVE AREA(ACRES) =     20.21    AREA-AVERAGED Fm(INCH/HR) =  0.30
  AREA-AVERAGED Fp(INCH/HR) =  0.42  AREA-AVERAGED Ap =  0.71
  TOTAL AREA(ACRES) =       20.2        PEAK FLOW RATE(CFS) =      31.88

  END OF SUBAREA STREET FLOW HYDRAULICS:
  DEPTH(FEET) = 0.71   HALFSTREET FLOOD WIDTH(FEET) =  31.92
  FLOW VELOCITY(FEET/SEC.) =  1.88   DEPTH*VELOCITY(FT*FT/SEC.) =   1.33
```

```
  LONGEST FLOWPATH FROM NODE   5000.00 TO NODE   5030.00 =    2116.22 FEET.

****************************************************************************
  FLOW PROCESS FROM NODE   5030.00 TO NODE   5030.00 IS CODE =  82
----------------------------------------------------------------------------
  >>>>>ADD SUBAREA RUNOFF TO MAINLINE, AT MAINLINE Tc,<<<<<
  >>>>>(AND COMPUTE INITIAL SUBAREA RUNOFF)<<<<<
============================================================================
  INITIAL SUBAREA FLOW-LENGTH(FEET) =  1190.00
  ELEVATION DATA: UPSTREAM(FEET) =   1020.50  DOWNSTREAM(FEET) =   1016.00

  Tc = K*[(LENGTH** 3.00)/(ELEVATION CHANGE)]**0.20
  SUBAREA ANALYSIS USED MINIMUM Tc(MIN.) =   15.760
  * 100 YEAR RAINFALL INTENSITY(INCH/HR) =  2.788
  SUBAREA Tc AND LOSS RATE DATA(AMC III):
   DEVELOPMENT TYPE/      SCS SOIL   AREA      Fp         Ap     SCS   Tc
       LAND USE            GROUP   (ACRES)  (INCH/HR)  (DECIMAL)  CN  (MIN.)
  COMMERCIAL                 B        1.10      0.42     0.100    76   15.76
  SUBAREA AVERAGE PERVIOUS LOSS RATE, Fp(INCH/HR) =  0.42
  SUBAREA AVERAGE PERVIOUS AREA FRACTION, Ap =  0.100
  SUBAREA AREA(ACRES) =    1.10   INITIAL SUBAREA RUNOFF(CFS) =    2.72

  ** ADD SUBAREA RUNOFF TO MAINLINE AT MAINLINE Tc:
  MAINLINE Tc(MIN.) =   26.23
  * 100 YEAR RAINFALL INTENSITY(INCH/HR) =  2.054
  SUBAREA AREA(ACRES) =    1.10      SUBAREA RUNOFF(CFS) =    1.99
  EFFECTIVE AREA(ACRES) =     21.31   AREA-AVERAGED Fm(INCH/HR) =  0.29
  AREA-AVERAGED Fp(INCH/HR) =  0.42  AREA-AVERAGED Ap =  0.68
  TOTAL AREA(ACRES) =       21.3       PEAK FLOW RATE(CFS) =      33.87

****************************************************************************
  FLOW PROCESS FROM NODE   5030.00 TO NODE   5040.00 IS CODE =  51
----------------------------------------------------------------------------
  >>>>>COMPUTE TRAPEZOIDAL CHANNEL FLOW<<<<<
  >>>>>TRAVELTIME THRU SUBAREA (EXISTING ELEMENT)<<<<<
============================================================================
  ELEVATION DATA: UPSTREAM(FEET) =   1016.00  DOWNSTREAM(FEET) =   1014.00
  CHANNEL LENGTH THRU SUBAREA(FEET) =   904.60   CHANNEL SLOPE =  0.0022
  CHANNEL BASE(FEET) =    3.00   "Z" FACTOR =   2.000
  MANNING'S FACTOR = 0.030   MAXIMUM DEPTH(FEET) =   2.00
  * 100 YEAR RAINFALL INTENSITY(INCH/HR) =  1.819
  SUBAREA LOSS RATE DATA(AMC III):
   DEVELOPMENT TYPE/      SCS SOIL   AREA      Fp         Ap     SCS
       LAND USE            GROUP   (ACRES)  (INCH/HR)  (DECIMAL)  CN
  PUBLIC PARK                B        0.90      0.42     0.850    76
  SUBAREA AVERAGE PERVIOUS LOSS RATE, Fp(INCH/HR) =  0.42
  SUBAREA AVERAGE PERVIOUS AREA FRACTION, Ap =  0.850
  TRAVEL TIME COMPUTED USING ESTIMATED FLOW(CFS) =      34.46
  TRAVEL TIME THRU SUBAREA BASED ON VELOCITY(FEET/SEC.) =   2.56
  AVERAGE FLOW DEPTH(FEET) =   1.95   TRAVEL TIME(MIN.) =   5.89
  Tc(MIN.) =   32.11
  SUBAREA AREA(ACRES) =     0.90       SUBAREA RUNOFF(CFS) =    1.18
  EFFECTIVE AREA(ACRES) =     22.21     AREA-AVERAGED Fm(INCH/HR) =   0.29
  AREA-AVERAGED Fp(INCH/HR) =   0.42  AREA-AVERAGED Ap =   0.69
  TOTAL AREA(ACRES) =       22.2         PEAK FLOW RATE(CFS) =      33.87
  NOTE: PEAK FLOW RATE DEFAULTED TO UPSTREAM VALUE

  END OF SUBAREA CHANNEL FLOW HYDRAULICS:
  DEPTH(FEET) =  1.94   FLOW VELOCITY(FEET/SEC.) =   2.55
  LONGEST FLOWPATH FROM NODE   5000.00 TO NODE   5040.00 =    3020.82 FEET.

****************************************************************************
  FLOW PROCESS FROM NODE   5040.00 TO NODE   5040.00 IS CODE =  81
----------------------------------------------------------------------------
  >>>>>ADDITION OF SUBAREA TO MAINLINE PEAK FLOW<<<<<
============================================================================
  MAINLINE Tc(MIN.) =   32.11
  * 100 YEAR RAINFALL INTENSITY(INCH/HR) =  1.819
  SUBAREA LOSS RATE DATA(AMC III):
   DEVELOPMENT TYPE/      SCS SOIL   AREA      Fp         Ap     SCS
       LAND USE            GROUP   (ACRES)  (INCH/HR)  (DECIMAL)  CN
```

```
  RESIDENTIAL
  "3-4 DWELLINGS/ACRE"       B        4.40      0.42     0.600    76
  SUBAREA AVERAGE PERVIOUS LOSS RATE, Fp(INCH/HR) =  0.42
  SUBAREA AVERAGE PERVIOUS AREA FRACTION, Ap =  0.600
  SUBAREA AREA(ACRES) =    4.40      SUBAREA RUNOFF(CFS) =    6.20
  EFFECTIVE AREA(ACRES) =     26.61   AREA-AVERAGED Fm(INCH/HR) =  0.28
  AREA-AVERAGED Fp(INCH/HR) =  0.42  AREA-AVERAGED Ap =  0.67
  TOTAL AREA(ACRES) =       26.6       PEAK FLOW RATE(CFS) =      36.75

****************************************************************************
  FLOW PROCESS FROM NODE   5040.00 TO NODE   5050.00 IS CODE =  51
----------------------------------------------------------------------------
  >>>>>COMPUTE TRAPEZOIDAL CHANNEL FLOW<<<<<
  >>>>>TRAVELTIME THRU SUBAREA (EXISTING ELEMENT)<<<<<
============================================================================
  ELEVATION DATA: UPSTREAM(FEET) =   1014.00  DOWNSTREAM(FEET) =   1010.00
  CHANNEL LENGTH THRU SUBAREA(FEET) =   565.00   CHANNEL SLOPE =  0.0071
  CHANNEL BASE(FEET) =    5.00   "Z" FACTOR =   3.000
  MANNING'S FACTOR = 0.030   MAXIMUM DEPTH(FEET) =   2.00
  * 100 YEAR RAINFALL INTENSITY(INCH/HR) =  1.736
  SUBAREA LOSS RATE DATA(AMC III):
   DEVELOPMENT TYPE/      SCS SOIL   AREA      Fp         Ap     SCS
       LAND USE            GROUP   (ACRES)  (INCH/HR)  (DECIMAL)  CN
  PUBLIC PARK                B        0.40      0.42     0.850    76
  SUBAREA AVERAGE PERVIOUS LOSS RATE, Fp(INCH/HR) =  0.42
  SUBAREA AVERAGE PERVIOUS AREA FRACTION, Ap =  0.850
  TRAVEL TIME COMPUTED USING ESTIMATED FLOW(CFS) =      36.99
  TRAVEL TIME THRU SUBAREA BASED ON VELOCITY(FEET/SEC.) =   3.64
  AVERAGE FLOW DEPTH(FEET) =   1.19   TRAVEL TIME(MIN.) =   2.59
  Tc(MIN.) =   34.70
  SUBAREA AREA(ACRES) =     0.40       SUBAREA RUNOFF(CFS) =    0.50
  EFFECTIVE AREA(ACRES) =     27.01     AREA-AVERAGED Fm(INCH/HR) =   0.29
  AREA-AVERAGED Fp(INCH/HR) =   0.42  AREA-AVERAGED Ap =   0.68
  TOTAL AREA(ACRES) =       27.0         PEAK FLOW RATE(CFS) =      36.75
  NOTE: PEAK FLOW RATE DEFAULTED TO UPSTREAM VALUE

  END OF SUBAREA CHANNEL FLOW HYDRAULICS:
  DEPTH(FEET) =  1.19   FLOW VELOCITY(FEET/SEC.) =   3.62
  LONGEST FLOWPATH FROM NODE   5000.00 TO NODE   5050.00 =    3585.82 FEET.

****************************************************************************
  FLOW PROCESS FROM NODE   5050.00 TO NODE   5050.00 IS CODE =  82
----------------------------------------------------------------------------
  >>>>>ADD SUBAREA RUNOFF TO MAINLINE, AT MAINLINE Tc,<<<<<
  >>>>>(AND COMPUTE INITIAL SUBAREA RUNOFF)<<<<<
============================================================================
  INITIAL SUBAREA FLOW-LENGTH(FEET) =   584.00
  ELEVATION DATA: UPSTREAM(FEET) =   1016.00  DOWNSTREAM(FEET) =   1010.00

  Tc = K*[(LENGTH** 3.00)/(ELEVATION CHANGE)]**0.20
  SUBAREA ANALYSIS USED MINIMUM Tc(MIN.) =    9.707
  * 100 YEAR RAINFALL INTENSITY(INCH/HR) =  3.729
  SUBAREA Tc AND LOSS RATE DATA(AMC III):
   DEVELOPMENT TYPE/      SCS SOIL   AREA      Fp         Ap     SCS   Tc
       LAND USE            GROUP   (ACRES)  (INCH/HR)  (DECIMAL)  CN  (MIN.)
  COMMERCIAL                 B        3.30      0.42     0.100    76    9.71
  SUBAREA AVERAGE PERVIOUS LOSS RATE, Fp(INCH/HR) =  0.42
  SUBAREA AVERAGE PERVIOUS AREA FRACTION, Ap =  0.100
  SUBAREA AREA(ACRES) =    3.30   INITIAL SUBAREA RUNOFF(CFS) =   10.95

  ** ADD SUBAREA RUNOFF TO MAINLINE AT MAINLINE Tc:
  MAINLINE Tc(MIN.) =   34.70
  * 100 YEAR RAINFALL INTENSITY(INCH/HR) =  1.736
  SUBAREA AREA(ACRES) =    3.30      SUBAREA RUNOFF(CFS) =    5.03
  EFFECTIVE AREA(ACRES) =     30.31   AREA-AVERAGED Fm(INCH/HR) =  0.26
  AREA-AVERAGED Fp(INCH/HR) =  0.42  AREA-AVERAGED Ap =  0.61
  TOTAL AREA(ACRES) =       30.3       PEAK FLOW RATE(CFS) =      40.29

****************************************************************************
  FLOW PROCESS FROM NODE   5050.00 TO NODE   5050.00 IS CODE =  82
----------------------------------------------------------------------------
```

```
 >>>>>ADD SUBAREA RUNOFF TO MAINLINE, AT MAINLINE Tc,<<<<<
 >>>>>(AND COMPUTE INITIAL SUBAREA RUNOFF)<<<<<
============================================================================
 INITIAL SUBAREA FLOW-LENGTH(FEET) =   267.00
 ELEVATION DATA: UPSTREAM(FEET) =   1013.40  DOWNSTREAM(FEET) =   1010.00

 Tc = K*[(LENGTH** 3.00)/(ELEVATION CHANGE)]**0.20
 SUBAREA ANALYSIS USED MINIMUM Tc(MIN.) =    6.800
 * 100 YEAR RAINFALL INTENSITY(INCH/HR) =  4.616
 SUBAREA Tc AND LOSS RATE DATA(AMC III):
  DEVELOPMENT TYPE/      SCS SOIL   AREA      Fp         Ap     SCS   Tc
      LAND USE            GROUP   (ACRES)  (INCH/HR)  (DECIMAL)  CN  (MIN.)
 COMMERCIAL                 B        0.80      0.42     0.100    76    6.80
 SUBAREA AVERAGE PERVIOUS LOSS RATE, Fp(INCH/HR) =  0.42
 SUBAREA AVERAGE PERVIOUS AREA FRACTION, Ap =  0.100
 SUBAREA AREA(ACRES) =    0.80   INITIAL SUBAREA RUNOFF(CFS) =    3.29

 ** ADD SUBAREA RUNOFF TO MAINLINE AT MAINLINE Tc:
 MAINLINE Tc(MIN.) =   34.70
 * 100 YEAR RAINFALL INTENSITY(INCH/HR) =  1.736
 SUBAREA AREA(ACRES) =    0.80      SUBAREA RUNOFF(CFS) =    1.22
 EFFECTIVE AREA(ACRES) =     31.11   AREA-AVERAGED Fm(INCH/HR) =  0.25
 AREA-AVERAGED Fp(INCH/HR) =  0.42  AREA-AVERAGED Ap =  0.60
 TOTAL AREA(ACRES) =       31.1       PEAK FLOW RATE(CFS) =      41.51
============================================================================
 END OF STUDY SUMMARY:
 TOTAL AREA(ACRES)     =       31.1  TC(MIN.) =     34.70
 EFFECTIVE AREA(ACRES) =     31.11  AREA-AVERAGED Fm(INCH/HR)=  0.25
 AREA-AVERAGED Fp(INCH/HR) =  0.42  AREA-AVERAGED Ap = 0.599
 PEAK FLOW RATE(CFS)   =      41.51
============================================================================
============================================================================
 END OF RATIONAL METHOD ANALYSIS
```

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****************************************************************************
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              Ver. 15.0  Release Date: 04/01/2008  License ID 1555

                           Analysis prepared by:




 ************************** DESCRIPTION OF STUDY **************************
* REDLANDS PASSENGER RAIL PROJECT                                          *
* 100 YEAR STORM EVENT                                                     *
* BASIN 5500                                                               *
 **************************************************************************

  FILE NAME: C:\RPRP\EPRP\5500.DAT
  TIME/DATE OF STUDY: 17:21 07/13/2012
============================================================================
  USER SPECIFIED HYDROLOGY AND HYDRAULIC MODEL INFORMATION:
============================================================================
                    --*TIME-OF-CONCENTRATION MODEL*--

  USER SPECIFIED STORM EVENT(YEAR) =  100.00
  SPECIFIED MINIMUM PIPE SIZE(INCH) =  12.00
  SPECIFIED PERCENT OF GRADIENTS(DECIMAL) TO USE FOR FRICTION SLOPE = 0.90
  *USER-DEFINED LOGARITHMIC INTERPOLATION USED FOR RAINFALL*

  SLOPE OF INTENSITY DURATION CURVE(LOG(I;IN/HR) vs. LOG(Tc;MIN)) = 0.6000
  USER SPECIFIED 1-HOUR INTENSITY(INCH/HOUR) = 1.2500

  *ANTECEDENT MOISTURE CONDITION (AMC) III ASSUMED FOR RATIONAL METHOD*

  *USER-DEFINED STREET-SECTIONS FOR COUPLED PIPEFLOW AND STREETFLOW MODEL*
     HALF-  CROWN TO   STREET-CROSSFALL:   CURB  GUTTER-GEOMETRIES:  MANNING
     WIDTH  CROSSFALL  IN-  / OUT-/PARK-  HEIGHT  WIDTH  LIP   HIKE  FACTOR
NO.   (FT)     (FT)    SIDE / SIDE/ WAY    (FT)    (FT)  (FT)  (FT)    (n)
===  =====  =========  =================  ======   ===== ====== ===== =======
  1   30.0     20.0    0.018/0.018/0.020   0.67    2.00 0.0312 0.167 0.0150
  2   20.0     15.0    0.020/0.020/0.020   0.50    1.50 0.0312 0.125 0.0170

  GLOBAL STREET FLOW-DEPTH CONSTRAINTS:
    1. Relative Flow-Depth =  0.20 FEET
       as (Maximum Allowable Street Flow Depth) - (Top-of-Curb)
    2. (Depth)*(Velocity) Constraint = 10.0 (FT*FT/S)
  *SIZE PIPE WITH A FLOW CAPACITY GREATER THAN
   OR EQUAL TO THE UPSTREAM TRIBUTARY PIPE.*
  *USER-SPECIFIED MINIMUM TOPOGRAPHIC SLOPE ADJUSTMENT NOT SELECTED

****************************************************************************
  FLOW PROCESS FROM NODE   5501.00 TO NODE   5502.00 IS CODE =  21
----------------------------------------------------------------------------
  >>>>>RATIONAL METHOD INITIAL SUBAREA ANALYSIS<<<<<
  >>USE TIME-OF-CONCENTRATION NOMOGRAPH FOR INITIAL SUBAREA<<
============================================================================
  INITIAL SUBAREA FLOW-LENGTH(FEET) =   283.50
  ELEVATION DATA: UPSTREAM(FEET) =   1030.00  DOWNSTREAM(FEET) =   1028.00

  Tc = K*[(LENGTH** 3.00)/(ELEVATION CHANGE)]**0.20
  SUBAREA ANALYSIS USED MINIMUM Tc(MIN.) =   12.453
  * 100 YEAR RAINFALL INTENSITY(INCH/HR) =  3.211
  SUBAREA Tc AND LOSS RATE DATA(AMC III):
   DEVELOPMENT TYPE/      SCS SOIL   AREA      Fp         Ap     SCS   Tc
       LAND USE            GROUP   (ACRES)  (INCH/HR)  (DECIMAL)  CN  (MIN.)
  PUBLIC PARK                 B       0.90      0.42      0.850    76   12.45
  SUBAREA AVERAGE PERVIOUS LOSS RATE, Fp(INCH/HR) =  0.42
  SUBAREA AVERAGE PERVIOUS AREA FRACTION, Ap =  0.850
```

```
  SUBAREA RUNOFF(CFS) =      2.31
  TOTAL AREA(ACRES) =      0.90   PEAK FLOW RATE(CFS) =      2.31

****************************************************************************
  FLOW PROCESS FROM NODE   5502.00 TO NODE   5503.00 IS CODE =  51
----------------------------------------------------------------------------
  >>>>>COMPUTE TRAPEZOIDAL CHANNEL FLOW<<<<<
  >>>>>TRAVELTIME THRU SUBAREA (EXISTING ELEMENT)<<<<<
============================================================================
  ELEVATION DATA: UPSTREAM(FEET) =   1028.00  DOWNSTREAM(FEET) =   1024.00
  CHANNEL LENGTH THRU SUBAREA(FEET) =  1472.00   CHANNEL SLOPE =  0.0027
  CHANNEL BASE(FEET) =    5.00   "Z" FACTOR =   5.000
  MANNING'S FACTOR = 0.017   MAXIMUM DEPTH(FEET) =   5.00
  * 100 YEAR RAINFALL INTENSITY(INCH/HR) =  2.427
  SUBAREA LOSS RATE DATA(AMC III):
   DEVELOPMENT TYPE/      SCS SOIL   AREA      Fp         Ap     SCS
       LAND USE            GROUP   (ACRES)  (INCH/HR)  (DECIMAL)  CN
  RESIDENTIAL
  "3-4 DWELLINGS/ACRE"       B       27.50      0.42     0.600    76
  SUBAREA AVERAGE PERVIOUS LOSS RATE, Fp(INCH/HR) =  0.42
  SUBAREA AVERAGE PERVIOUS AREA FRACTION, Ap =  0.600
  TRAVEL TIME COMPUTED USING ESTIMATED FLOW(CFS) =      29.63
  TRAVEL TIME THRU SUBAREA BASED ON VELOCITY(FEET/SEC.) =   3.31
  AVERAGE FLOW DEPTH(FEET) =   0.93   TRAVEL TIME(MIN.) =   7.41
  Tc(MIN.) =   19.86
  SUBAREA AREA(ACRES) =    27.50       SUBAREA RUNOFF(CFS) =   53.78
  EFFECTIVE AREA(ACRES) =     28.40     AREA-AVERAGED Fm(INCH/HR) =   0.26
  AREA-AVERAGED Fp(INCH/HR) =   0.42  AREA-AVERAGED Ap =   0.61
  TOTAL AREA(ACRES) =       28.4         PEAK FLOW RATE(CFS) =      55.45

  END OF SUBAREA CHANNEL FLOW HYDRAULICS:
  DEPTH(FEET) =  1.26   FLOW VELOCITY(FEET/SEC.) =   3.91
  LONGEST FLOWPATH FROM NODE   5501.00 TO NODE   5503.00 =    1755.50 FEET.

****************************************************************************
  FLOW PROCESS FROM NODE   5503.00 TO NODE   5503.00 IS CODE =  81
----------------------------------------------------------------------------
  >>>>>ADDITION OF SUBAREA TO MAINLINE PEAK FLOW<<<<<
============================================================================
  MAINLINE Tc(MIN.) =   19.86
  * 100 YEAR RAINFALL INTENSITY(INCH/HR) =  2.427
  SUBAREA LOSS RATE DATA(AMC III):
   DEVELOPMENT TYPE/      SCS SOIL   AREA      Fp         Ap     SCS
       LAND USE            GROUP   (ACRES)  (INCH/HR)  (DECIMAL)  CN
  PUBLIC PARK                B       11.10      0.42     0.850    76
  SUBAREA AVERAGE PERVIOUS LOSS RATE, Fp(INCH/HR) =  0.42
  SUBAREA AVERAGE PERVIOUS AREA FRACTION, Ap =  0.850
  SUBAREA AREA(ACRES) =   11.10      SUBAREA RUNOFF(CFS) =   20.65
  EFFECTIVE AREA(ACRES) =     39.50   AREA-AVERAGED Fm(INCH/HR) =  0.29
  AREA-AVERAGED Fp(INCH/HR) =  0.42  AREA-AVERAGED Ap =  0.68
  TOTAL AREA(ACRES) =       39.5       PEAK FLOW RATE(CFS) =      76.10

****************************************************************************
  FLOW PROCESS FROM NODE   5503.00 TO NODE   5504.00 IS CODE =  62
----------------------------------------------------------------------------
  >>>>>COMPUTE STREET FLOW TRAVEL TIME THRU SUBAREA<<<<<
  >>>>>(STREET TABLE SECTION #  2 USED)<<<<<
============================================================================
  UPSTREAM ELEVATION(FEET) = 1024.00  DOWNSTREAM ELEVATION(FEET) = 1015.00
  STREET LENGTH(FEET) =  1482.60   CURB HEIGHT(INCHES) =  6.0
  STREET HALFWIDTH(FEET) = 20.00

  DISTANCE FROM CROWN TO CROSSFALL GRADEBREAK(FEET) =  15.00
  INSIDE STREET CROSSFALL(DECIMAL) =  0.020
  OUTSIDE STREET CROSSFALL(DECIMAL)  =  0.020

  SPECIFIED NUMBER OF HALFSTREETS CARRYING RUNOFF =  2
  STREET PARKWAY CROSSFALL(DECIMAL)  =  0.020
  Manning's FRICTION FACTOR for Streetflow Section(curb-to-curb) =   0.0170
  Manning's FRICTION FACTOR for Back-of-Walk Flow Section =   0.0170
```

```
    **TRAVEL TIME COMPUTED USING ESTIMATED FLOW(CFS) =      92.67
    ***STREET FLOWING FULL***
    STREETFLOW MODEL RESULTS USING ESTIMATED FLOW:
    STREET FLOW DEPTH(FEET) =  0.81
    HALFSTREET FLOOD WIDTH(FEET) =   35.75
    AVERAGE FLOW VELOCITY(FEET/SEC.) =    3.75
    PRODUCT OF DEPTH&VELOCITY(FT*FT/SEC.) =    3.05
  STREET FLOW TRAVEL TIME(MIN.) =   6.60   Tc(MIN.) =   26.46
  * 100 YEAR RAINFALL INTENSITY(INCH/HR) =  2.043
  SUBAREA LOSS RATE DATA(AMC III):
   DEVELOPMENT TYPE/      SCS SOIL   AREA      Fp         Ap     SCS
       LAND USE            GROUP   (ACRES)  (INCH/HR)  (DECIMAL)  CN
  COMMERCIAL                 B       18.40      0.42     0.100    76
  SUBAREA AVERAGE PERVIOUS LOSS RATE, Fp(INCH/HR) =  0.42
  SUBAREA AVERAGE PERVIOUS AREA FRACTION, Ap =  0.100
  SUBAREA AREA(ACRES) =   18.40      SUBAREA RUNOFF(CFS) =   33.13
  EFFECTIVE AREA(ACRES) =     57.90    AREA-AVERAGED Fm(INCH/HR) =  0.21
  AREA-AVERAGED Fp(INCH/HR) =  0.42  AREA-AVERAGED Ap =  0.49
  TOTAL AREA(ACRES) =       57.9        PEAK FLOW RATE(CFS) =      95.60

  END OF SUBAREA STREET FLOW HYDRAULICS:
  DEPTH(FEET) = 0.82   HALFSTREET FLOOD WIDTH(FEET) =  36.17
  FLOW VELOCITY(FEET/SEC.) =  3.77   DEPTH*VELOCITY(FT*FT/SEC.) =   3.10
  *NOTE: INITIAL SUBAREA NOMOGRAPH WITH SUBAREA PARAMETERS,
         AND L = 1482.6 FT WITH ELEVATION-DROP =   9.0 FT, IS   45.7 CFS,
         WHICH EXCEEDS THE TOP-OF-CURB STREET CAPACITY AT NODE   5504.00
  LONGEST FLOWPATH FROM NODE   5501.00 TO NODE   5504.00 =    3238.10 FEET.
============================================================================
  END OF STUDY SUMMARY:
  TOTAL AREA(ACRES)     =       57.9  TC(MIN.) =     26.46
  EFFECTIVE AREA(ACRES) =     57.90  AREA-AVERAGED Fm(INCH/HR)=  0.21
  AREA-AVERAGED Fp(INCH/HR) =  0.42  AREA-AVERAGED Ap = 0.493
  PEAK FLOW RATE(CFS)   =      95.60
============================================================================
============================================================================
  END OF RATIONAL METHOD ANALYSIS
```

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****************************************************************************
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                           Analysis prepared by:




 ************************** DESCRIPTION OF STUDY **************************
* REDLANDS PASSENGER RAIL PROJECT                                          *
* EXISTING HYDROLOGY 100 YEAR                                              *
* BASIN 7000                                                               *
 **************************************************************************

  FILE NAME: C:\RPRP\EPRP\7000.DAT
  TIME/DATE OF STUDY: 18:03 02/13/2012
============================================================================
  USER SPECIFIED HYDROLOGY AND HYDRAULIC MODEL INFORMATION:
============================================================================
                    --*TIME-OF-CONCENTRATION MODEL*--

  USER SPECIFIED STORM EVENT(YEAR) =  100.00
  SPECIFIED MINIMUM PIPE SIZE(INCH) =  12.00
  SPECIFIED PERCENT OF GRADIENTS(DECIMAL) TO USE FOR FRICTION SLOPE = 0.90
  *USER-DEFINED LOGARITHMIC INTERPOLATION USED FOR RAINFALL*

  SLOPE OF INTENSITY DURATION CURVE(LOG(I;IN/HR) vs. LOG(Tc;MIN)) = 0.6000
  USER SPECIFIED 1-HOUR INTENSITY(INCH/HOUR) = 1.2500

  *ANTECEDENT MOISTURE CONDITION (AMC) III ASSUMED FOR RATIONAL METHOD*

  *USER-DEFINED STREET-SECTIONS FOR COUPLED PIPEFLOW AND STREETFLOW MODEL*
     HALF-  CROWN TO   STREET-CROSSFALL:   CURB  GUTTER-GEOMETRIES:  MANNING
     WIDTH  CROSSFALL  IN-  / OUT-/PARK-  HEIGHT  WIDTH  LIP   HIKE  FACTOR
NO.   (FT)     (FT)    SIDE / SIDE/ WAY    (FT)    (FT)  (FT)  (FT)    (n)
===  =====  =========  =================  ======  ===== ====== ===== =======
  1   30.0     20.0    0.018/0.018/0.020   0.67    2.00 0.0312 0.167 0.0150
  2   13.0      8.0    0.018/0.018/0.020   0.67    2.00 0.0312 0.167 0.0150
  3   25.0     15.0    0.018/0.018/0.020   0.67    2.00 0.0312 0.167 0.0150
  4   35.0     25.0    0.018/0.018/0.020   0.67    2.00 0.0312 0.167 0.0150
  5   20.0     15.0    0.018/0.018/0.020   0.67    2.00 0.0312 0.167 0.0150

  GLOBAL STREET FLOW-DEPTH CONSTRAINTS:
    1. Relative Flow-Depth =  0.20 FEET
       as (Maximum Allowable Street Flow Depth) - (Top-of-Curb)
    2. (Depth)*(Velocity) Constraint = 10.0 (FT*FT/S)
  *SIZE PIPE WITH A FLOW CAPACITY GREATER THAN
   OR EQUAL TO THE UPSTREAM TRIBUTARY PIPE.*
  *USER-SPECIFIED MINIMUM TOPOGRAPHIC SLOPE ADJUSTMENT NOT SELECTED

****************************************************************************
  FLOW PROCESS FROM NODE   7000.00 TO NODE   7010.00 IS CODE =  21
----------------------------------------------------------------------------
  >>>>>RATIONAL METHOD INITIAL SUBAREA ANALYSIS<<<<<
  >>USE TIME-OF-CONCENTRATION NOMOGRAPH FOR INITIAL SUBAREA<<
============================================================================
  INITIAL SUBAREA FLOW-LENGTH(FEET) =   162.00
  ELEVATION DATA: UPSTREAM(FEET) =   1016.00  DOWNSTREAM(FEET) =   1013.00

  Tc = K*[(LENGTH** 3.00)/(ELEVATION CHANGE)]**0.20
  SUBAREA ANALYSIS USED MINIMUM Tc(MIN.) =    8.208
  * 100 YEAR RAINFALL INTENSITY(INCH/HR) =  4.123
  SUBAREA Tc AND LOSS RATE DATA(AMC III):
   DEVELOPMENT TYPE/      SCS SOIL   AREA      Fp         Ap     SCS   Tc
       LAND USE            GROUP   (ACRES)  (INCH/HR)  (DECIMAL)  CN  (MIN.)
```

```
 PUBLIC PARK                B        0.10      0.42     0.850    76    8.21
 SUBAREA AVERAGE PERVIOUS LOSS RATE, Fp(INCH/HR) =  0.42
 SUBAREA AVERAGE PERVIOUS AREA FRACTION, Ap =  0.850
 SUBAREA RUNOFF(CFS) =      0.34
 TOTAL AREA(ACRES) =      0.10   PEAK FLOW RATE(CFS) =      0.34

****************************************************************************
 FLOW PROCESS FROM NODE   7010.00 TO NODE   7020.00 IS CODE =  51
----------------------------------------------------------------------------
 >>>>>COMPUTE TRAPEZOIDAL CHANNEL FLOW<<<<<
 >>>>>TRAVELTIME THRU SUBAREA (EXISTING ELEMENT)<<<<<
============================================================================
 ELEVATION DATA: UPSTREAM(FEET) =   1013.00  DOWNSTREAM(FEET) =   1010.50
 CHANNEL LENGTH THRU SUBAREA(FEET) =   276.00   CHANNEL SLOPE =  0.0091
 CHANNEL BASE(FEET) =    2.00   "Z" FACTOR =   2.000
 MANNING'S FACTOR = 0.030   MAXIMUM DEPTH(FEET) =   1.00
 * 100 YEAR RAINFALL INTENSITY(INCH/HR) =  3.355
 SUBAREA LOSS RATE DATA(AMC III):
  DEVELOPMENT TYPE/      SCS SOIL   AREA      Fp         Ap     SCS
     LAND USE            GROUP   (ACRES)  (INCH/HR)  (DECIMAL)  CN
 PUBLIC PARK                B        0.20      0.42     0.850    76
 SUBAREA AVERAGE PERVIOUS LOSS RATE, Fp(INCH/HR) =  0.42
 SUBAREA AVERAGE PERVIOUS AREA FRACTION, Ap =  0.850
 TRAVEL TIME COMPUTED USING ESTIMATED FLOW(CFS) =      0.61
 TRAVEL TIME THRU SUBAREA BASED ON VELOCITY(FEET/SEC.) =   1.37
 AVERAGE FLOW DEPTH(FEET) =   0.19   TRAVEL TIME(MIN.) =   3.37
 Tc(MIN.) =   11.58
 SUBAREA AREA(ACRES) =     0.20       SUBAREA RUNOFF(CFS) =    0.54
 EFFECTIVE AREA(ACRES) =      0.30     AREA-AVERAGED Fm(INCH/HR) =   0.36
 AREA-AVERAGED Fp(INCH/HR) =   0.42  AREA-AVERAGED Ap =   0.85
 TOTAL AREA(ACRES) =       0.3         PEAK FLOW RATE(CFS) =      0.81

 END OF SUBAREA CHANNEL FLOW HYDRAULICS:
 DEPTH(FEET) =  0.22   FLOW VELOCITY(FEET/SEC.) =   1.52
 LONGEST FLOWPATH FROM NODE   7000.00 TO NODE   7020.00 =     438.00 FEET.

****************************************************************************
 FLOW PROCESS FROM NODE   7020.00 TO NODE   7020.00 IS CODE =  81
----------------------------------------------------------------------------
 >>>>>ADDITION OF SUBAREA TO MAINLINE PEAK FLOW<<<<<
============================================================================
 MAINLINE Tc(MIN.) =   11.58
 * 100 YEAR RAINFALL INTENSITY(INCH/HR) =  3.355
 SUBAREA LOSS RATE DATA(AMC III):
  DEVELOPMENT TYPE/      SCS SOIL   AREA      Fp         Ap     SCS
     LAND USE            GROUP   (ACRES)  (INCH/HR)  (DECIMAL)  CN
 PUBLIC PARK                B        0.10      0.42     0.850    76
 SUBAREA AVERAGE PERVIOUS LOSS RATE, Fp(INCH/HR) =  0.42
 SUBAREA AVERAGE PERVIOUS AREA FRACTION, Ap =  0.850
 SUBAREA AREA(ACRES) =    0.10      SUBAREA RUNOFF(CFS) =    0.27
 EFFECTIVE AREA(ACRES) =      0.40   AREA-AVERAGED Fm(INCH/HR) =  0.36
 AREA-AVERAGED Fp(INCH/HR) =  0.42  AREA-AVERAGED Ap =  0.85
 TOTAL AREA(ACRES) =       0.4       PEAK FLOW RATE(CFS) =      1.08
============================================================================
 END OF STUDY SUMMARY:
 TOTAL AREA(ACRES)     =        0.4  TC(MIN.) =     11.58
 EFFECTIVE AREA(ACRES) =      0.40  AREA-AVERAGED Fm(INCH/HR)=  0.36
 AREA-AVERAGED Fp(INCH/HR) =  0.42  AREA-AVERAGED Ap = 0.850
 PEAK FLOW RATE(CFS)   =      1.08
============================================================================
============================================================================
 END OF RATIONAL METHOD ANALYSIS
```

```
****************************************************************************
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                          Analysis prepared by:




 ************************** DESCRIPTION OF STUDY **************************
* REDLANDS PASSENGER RAIL PROJECT                                          *
* EXISTING 100 YEAR ANALYSIS                                               *
* DRAINAGE AREA 8000                                                       *
 **************************************************************************

  FILE NAME: C:\RPRP\8000.DAT
  TIME/DATE OF STUDY: 12:18 06/01/2012
============================================================================
  USER SPECIFIED HYDROLOGY AND HYDRAULIC MODEL INFORMATION:
============================================================================
                    --*TIME-OF-CONCENTRATION MODEL*--

  USER SPECIFIED STORM EVENT(YEAR) =  100.00
  SPECIFIED MINIMUM PIPE SIZE(INCH) =  12.00
  SPECIFIED PERCENT OF GRADIENTS(DECIMAL) TO USE FOR FRICTION SLOPE = 0.90
  *USER-DEFINED LOGARITHMIC INTERPOLATION USED FOR RAINFALL*

  SLOPE OF INTENSITY DURATION CURVE(LOG(I;IN/HR) vs. LOG(Tc;MIN)) = 0.6000
  USER SPECIFIED 1-HOUR INTENSITY(INCH/HOUR) = 1.2500

  *ANTECEDENT MOISTURE CONDITION (AMC) III ASSUMED FOR RATIONAL METHOD*

  *USER-DEFINED STREET-SECTIONS FOR COUPLED PIPEFLOW AND STREETFLOW MODEL*
     HALF-  CROWN TO   STREET-CROSSFALL:   CURB  GUTTER-GEOMETRIES:  MANNING
     WIDTH  CROSSFALL  IN-  / OUT-/PARK-  HEIGHT  WIDTH  LIP   HIKE  FACTOR
NO.  (FT)     (FT)     SIDE / SIDE/ WAY    (FT)    (FT)  (FT)  (FT)    (n)
===  =====  =========  =================  ======  ===== ====== ===== =======
  1   30.0     20.0    0.018/0.018/0.020   0.67    2.00 0.0313 0.167 0.0150
  2   13.0      8.0    0.018/0.018/0.020   0.67    2.00 0.0313 0.167 0.0150
  3   25.0     15.0    0.018/0.018/0.020   0.67    2.00 0.0313 0.167 0.0150
  4   35.0     25.0    0.018/0.018/0.020   0.67    2.00 0.0313 0.167 0.0150
  5   20.0     15.0    0.018/0.018/0.020   0.67    2.00 0.0313 0.167 0.0150

  GLOBAL STREET FLOW-DEPTH CONSTRAINTS:
    1. Relative Flow-Depth =  0.20 FEET
       as (Maximum Allowable Street Flow Depth) - (Top-of-Curb)
    2. (Depth)*(Velocity) Constraint = 10.0 (FT*FT/S)
  *SIZE PIPE WITH A FLOW CAPACITY GREATER THAN
   OR EQUAL TO THE UPSTREAM TRIBUTARY PIPE.*
  *USER-SPECIFIED MINIMUM TOPOGRAPHIC SLOPE ADJUSTMENT NOT SELECTED

****************************************************************************
  FLOW PROCESS FROM NODE   8000.00 TO NODE   8010.00 IS CODE =  21
----------------------------------------------------------------------------
  >>>>>RATIONAL METHOD INITIAL SUBAREA ANALYSIS<<<<<
  >>USE TIME-OF-CONCENTRATION NOMOGRAPH FOR INITIAL SUBAREA<<
============================================================================
  INITIAL SUBAREA FLOW-LENGTH(FEET) =   300.00
  ELEVATION DATA: UPSTREAM(FEET) =   1011.50  DOWNSTREAM(FEET) =   1002.00

  Tc = K*[(LENGTH** 3.00)/(ELEVATION CHANGE)]**0.20
  SUBAREA ANALYSIS USED MINIMUM Tc(MIN.) =    8.047
  * 100 YEAR RAINFALL INTENSITY(INCH/HR) =  4.173
  SUBAREA Tc AND LOSS RATE DATA(AMC III):
   DEVELOPMENT TYPE/      SCS SOIL   AREA      Fp         Ap     SCS   Tc
       LAND USE             GROUP   (ACRES)  (INCH/HR)  (DECIMAL)  CN  (MIN.)
```

```
  RESIDENTIAL
  "3-4 DWELLINGS/ACRE"       B        0.40      0.42     0.600    76    8.05
  SUBAREA AVERAGE PERVIOUS LOSS RATE, Fp(INCH/HR) =  0.42
  SUBAREA AVERAGE PERVIOUS AREA FRACTION, Ap =  0.600
  SUBAREA RUNOFF(CFS) =      1.41
  TOTAL AREA(ACRES) =      0.40   PEAK FLOW RATE(CFS) =      1.41
============================================================================
  END OF STUDY SUMMARY:
  TOTAL AREA(ACRES)     =        0.4  TC(MIN.) =      8.05
  EFFECTIVE AREA(ACRES) =      0.40  AREA-AVERAGED Fm(INCH/HR)=  0.25
  AREA-AVERAGED Fp(INCH/HR) =  0.42  AREA-AVERAGED Ap = 0.600
  PEAK FLOW RATE(CFS)   =       1.41
============================================================================
============================================================================
  END OF RATIONAL METHOD ANALYSIS
```

```
****************************************************************************
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                           Analysis prepared by:




 ************************** DESCRIPTION OF STUDY **************************
 * REDLANDS PASSENGER RAIL PROJECT                                          *
 * EXISTING HYDROLOGY 100 YEAR                                              *
 * BASIN 8100                                                               *
 **************************************************************************

  FILE NAME: C:\RPRP\EPRP\8100.DAT
  TIME/DATE OF STUDY: 18:16 02/13/2012
============================================================================
  USER SPECIFIED HYDROLOGY AND HYDRAULIC MODEL INFORMATION:
============================================================================
                    --*TIME-OF-CONCENTRATION MODEL*--

  USER SPECIFIED STORM EVENT(YEAR) =  100.00
  SPECIFIED MINIMUM PIPE SIZE(INCH) =  12.00
  SPECIFIED PERCENT OF GRADIENTS(DECIMAL) TO USE FOR FRICTION SLOPE = 0.90
  *USER-DEFINED LOGARITHMIC INTERPOLATION USED FOR RAINFALL*

  SLOPE OF INTENSITY DURATION CURVE(LOG(I;IN/HR) vs. LOG(Tc;MIN)) = 0.6000
  USER SPECIFIED 1-HOUR INTENSITY(INCH/HOUR) = 1.2500

  *ANTECEDENT MOISTURE CONDITION (AMC) III ASSUMED FOR RATIONAL METHOD*

  *USER-DEFINED STREET-SECTIONS FOR COUPLED PIPEFLOW AND STREETFLOW MODEL*
     HALF-  CROWN TO   STREET-CROSSFALL:   CURB  GUTTER-GEOMETRIES:  MANNING
     WIDTH  CROSSFALL  IN-  / OUT-/PARK-  HEIGHT  WIDTH  LIP   HIKE  FACTOR
NO.   (FT)     (FT)    SIDE / SIDE/ WAY    (FT)    (FT)  (FT)  (FT)    (n)
===  =====  =========  =================  ======  ===== ====== ===== =======
  1   30.0     20.0    0.018/0.018/0.020   0.67    2.00 0.0312 0.167 0.0150
  2   13.0      8.0    0.018/0.018/0.020   0.67    2.00 0.0312 0.167 0.0150
  3   25.0     15.0    0.018/0.018/0.020   0.67    2.00 0.0312 0.167 0.0150
  4   35.0     25.0    0.018/0.018/0.020   0.67    2.00 0.0312 0.167 0.0150
  5   20.0     15.0    0.018/0.018/0.020   0.67    2.00 0.0312 0.167 0.0150

  GLOBAL STREET FLOW-DEPTH CONSTRAINTS:
    1. Relative Flow-Depth =  0.20 FEET
       as (Maximum Allowable Street Flow Depth) - (Top-of-Curb)
    2. (Depth)*(Velocity) Constraint = 10.0 (FT*FT/S)
  *SIZE PIPE WITH A FLOW CAPACITY GREATER THAN
   OR EQUAL TO THE UPSTREAM TRIBUTARY PIPE.*
  *USER-SPECIFIED MINIMUM TOPOGRAPHIC SLOPE ADJUSTMENT NOT SELECTED

****************************************************************************
  FLOW PROCESS FROM NODE   8100.00 TO NODE   8110.00 IS CODE =  21
----------------------------------------------------------------------------
  >>>>>RATIONAL METHOD INITIAL SUBAREA ANALYSIS<<<<<
  >>USE TIME-OF-CONCENTRATION NOMOGRAPH FOR INITIAL SUBAREA<<
============================================================================
  INITIAL SUBAREA FLOW-LENGTH(FEET) =   103.00
  ELEVATION DATA: UPSTREAM(FEET) =   1012.00  DOWNSTREAM(FEET) =   1010.60

  Tc = K*[(LENGTH** 3.00)/(ELEVATION CHANGE)]**0.20
  SUBAREA ANALYSIS USED MINIMUM Tc(MIN.) =    7.285
  * 100 YEAR RAINFALL INTENSITY(INCH/HR) =  4.429
  SUBAREA Tc AND LOSS RATE DATA(AMC III):
   DEVELOPMENT TYPE/      SCS SOIL   AREA      Fp         Ap     SCS   Tc
       LAND USE            GROUP   (ACRES)  (INCH/HR)  (DECIMAL)  CN  (MIN.)
```

```
 PUBLIC PARK                B        0.10      0.42     0.850    76    7.28
 SUBAREA AVERAGE PERVIOUS LOSS RATE, Fp(INCH/HR) =  0.42
 SUBAREA AVERAGE PERVIOUS AREA FRACTION, Ap =  0.850
 SUBAREA RUNOFF(CFS) =      0.37
 TOTAL AREA(ACRES) =      0.10   PEAK FLOW RATE(CFS) =      0.37

****************************************************************************
 FLOW PROCESS FROM NODE   8110.00 TO NODE   8120.00 IS CODE =  51
----------------------------------------------------------------------------
 >>>>>COMPUTE TRAPEZOIDAL CHANNEL FLOW<<<<<
 >>>>>TRAVELTIME THRU SUBAREA (EXISTING ELEMENT)<<<<<
============================================================================
 ELEVATION DATA: UPSTREAM(FEET) =   1010.60  DOWNSTREAM(FEET) =   1002.00
 CHANNEL LENGTH THRU SUBAREA(FEET) =   300.00   CHANNEL SLOPE =  0.0287
 CHANNEL BASE(FEET) =    2.00   "Z" FACTOR =   2.000
 MANNING'S FACTOR = 0.030   MAXIMUM DEPTH(FEET) =   1.00
 * 100 YEAR RAINFALL INTENSITY(INCH/HR) =  3.760
 SUBAREA LOSS RATE DATA(AMC III):
  DEVELOPMENT TYPE/      SCS SOIL   AREA      Fp         Ap     SCS
     LAND USE            GROUP   (ACRES)  (INCH/HR)  (DECIMAL)  CN
 PUBLIC PARK                B        0.30      0.42     0.850    76
 SUBAREA AVERAGE PERVIOUS LOSS RATE, Fp(INCH/HR) =  0.42
 SUBAREA AVERAGE PERVIOUS AREA FRACTION, Ap =  0.850
 TRAVEL TIME COMPUTED USING ESTIMATED FLOW(CFS) =      0.83
 TRAVEL TIME THRU SUBAREA BASED ON VELOCITY(FEET/SEC.) =   2.18
 AVERAGE FLOW DEPTH(FEET) =   0.16   TRAVEL TIME(MIN.) =   2.29
 Tc(MIN.) =    9.57
 SUBAREA AREA(ACRES) =     0.30       SUBAREA RUNOFF(CFS) =    0.92
 EFFECTIVE AREA(ACRES) =      0.40     AREA-AVERAGED Fm(INCH/HR) =   0.36
 AREA-AVERAGED Fp(INCH/HR) =   0.42  AREA-AVERAGED Ap =   0.85
 TOTAL AREA(ACRES) =        0.4         PEAK FLOW RATE(CFS) =       1.22

 END OF SUBAREA CHANNEL FLOW HYDRAULICS:
 DEPTH(FEET) =  0.20   FLOW VELOCITY(FEET/SEC.) =   2.53
 LONGEST FLOWPATH FROM NODE   8100.00 TO NODE   8120.00 =     403.00 FEET.

****************************************************************************
 FLOW PROCESS FROM NODE   8120.00 TO NODE   8120.00 IS CODE =  81
----------------------------------------------------------------------------
 >>>>>ADDITION OF SUBAREA TO MAINLINE PEAK FLOW<<<<<
============================================================================
 MAINLINE Tc(MIN.) =    9.57
 * 100 YEAR RAINFALL INTENSITY(INCH/HR) =  3.760
 SUBAREA LOSS RATE DATA(AMC III):
  DEVELOPMENT TYPE/      SCS SOIL   AREA      Fp         Ap     SCS
     LAND USE            GROUP   (ACRES)  (INCH/HR)  (DECIMAL)  CN
 PUBLIC PARK                B        0.30      0.42     0.850    76
 SUBAREA AVERAGE PERVIOUS LOSS RATE, Fp(INCH/HR) =  0.42
 SUBAREA AVERAGE PERVIOUS AREA FRACTION, Ap =  0.850
 SUBAREA AREA(ACRES) =    0.30      SUBAREA RUNOFF(CFS) =    0.92
 EFFECTIVE AREA(ACRES) =      0.70   AREA-AVERAGED Fm(INCH/HR) =  0.36
 AREA-AVERAGED Fp(INCH/HR) =  0.42  AREA-AVERAGED Ap =  0.85
 TOTAL AREA(ACRES) =        0.7       PEAK FLOW RATE(CFS) =       2.14
============================================================================
 END OF STUDY SUMMARY:
 TOTAL AREA(ACRES)     =        0.7  TC(MIN.) =      9.57
 EFFECTIVE AREA(ACRES) =      0.70  AREA-AVERAGED Fm(INCH/HR)=  0.36
 AREA-AVERAGED Fp(INCH/HR) =  0.42  AREA-AVERAGED Ap = 0.850
 PEAK FLOW RATE(CFS)   =       2.14
============================================================================
============================================================================
 END OF RATIONAL METHOD ANALYSIS
```

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****************************************************************************
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                           Analysis prepared by:






 ************************** DESCRIPTION OF STUDY **************************
* REDLANDS PASSENGER RAIL PROJECT                                          *
* EXISTING 100 YEAR ANALYSIS                                               *
* DRAINAGE AREA 8300                                                       *
 **************************************************************************

  FILE NAME: C:\RPRP\8300.DAT
  TIME/DATE OF STUDY: 13:14 06/01/2012
----------------------------------------------------------------------------
  USER SPECIFIED HYDROLOGY AND HYDRAULIC MODEL INFORMATION:
----------------------------------------------------------------------------
                    --*TIME-OF-CONCENTRATION MODEL*--

  USER SPECIFIED STORM EVENT(YEAR) =  100.00
  SPECIFIED MINIMUM PIPE SIZE(INCH) =  12.00
  SPECIFIED PERCENT OF GRADIENTS(DECIMAL) TO USE FOR FRICTION SLOPE = 0.90
  *USER-DEFINED LOGARITHMIC INTERPOLATION USED FOR RAINFALL*

  SLOPE OF INTENSITY DURATION CURVE(LOG(I;IN/HR) vs. LOG(Tc;MIN)) = 0.6000
  USER SPECIFIED 1-HOUR INTENSITY(INCH/HOUR) = 1.2500

  *ANTECEDENT MOISTURE CONDITION (AMC) III ASSUMED FOR RATIONAL METHOD*

  *USER-DEFINED STREET-SECTIONS FOR COUPLED PIPEFLOW AND STREETFLOW MODEL*
     HALF-  CROWN TO   STREET-CROSSFALL:   CURB  GUTTER-GEOMETRIES:  MANNING
     WIDTH  CROSSFALL  IN-  / OUT-/PARK-  HEIGHT  WIDTH  LIP   HIKE  FACTOR
NO.   (FT)     (FT)    SIDE / SIDE/ WAY    (FT)    (FT)  (FT)  (FT)    (n)
===  =====  =========  =================  ======  ===== ====== ===== =======
  1   30.0     20.0    0.018/0.018/0.020   0.67    2.00 0.0313 0.167 0.0150
  2   13.0      8.0    0.018/0.018/0.020   0.67    2.00 0.0313 0.167 0.0150
  3   25.0     15.0    0.018/0.018/0.020   0.67    2.00 0.0313 0.167 0.0150
  4   35.0     25.0    0.018/0.018/0.020   0.67    2.00 0.0313 0.167 0.0150
  5   20.0     15.0    0.018/0.018/0.020   0.67    2.00 0.0313 0.167 0.0150

  GLOBAL STREET FLOW-DEPTH CONSTRAINTS:
    1. Relative Flow-Depth =  0.20 FEET
       as (Maximum Allowable Street Flow Depth) - (Top-of-Curb)
    2. (Depth)*(Velocity) Constraint = 10.0 (FT*FT/S)
  *SIZE PIPE WITH A FLOW CAPACITY GREATER THAN
   OR EQUAL TO THE UPSTREAM TRIBUTARY PIPE.*
  *USER-SPECIFIED MINIMUM TOPOGRAPHIC SLOPE ADJUSTMENT NOT SELECTED

****************************************************************************
  FLOW PROCESS FROM NODE   8300.00 TO NODE   8310.00 IS CODE =  21
----------------------------------------------------------------------------
  >>>>>RATIONAL METHOD INITIAL SUBAREA ANALYSIS<<<<<
  >>USE TIME-OF-CONCENTRATION NOMOGRAPH FOR INITIAL SUBAREA<<
============================================================================
  INITIAL SUBAREA FLOW-LENGTH(FEET) =   620.00
  ELEVATION DATA: UPSTREAM(FEET) =   1007.00  DOWNSTREAM(FEET) =   1001.00

  Tc = K*[(LENGTH** 3.00)/(ELEVATION CHANGE)]**0.20
  SUBAREA ANALYSIS USED MINIMUM Tc(MIN.) =   13.636
  * 100 YEAR RAINFALL INTENSITY(INCH/HR) =  3.041
  SUBAREA Tc AND LOSS RATE DATA(AMC III):
   DEVELOPMENT TYPE/      SCS SOIL   AREA      Fp         Ap     SCS   Tc
       LAND USE             GROUP   (ACRES)  (INCH/HR)  (DECIMAL)  CN  (MIN.)
```

```
  RESIDENTIAL
  "3-4 DWELLINGS/ACRE"       B        0.80      0.42     0.600    76   13.64
  SUBAREA AVERAGE PERVIOUS LOSS RATE, Fp(INCH/HR) =  0.42
  SUBAREA AVERAGE PERVIOUS AREA FRACTION, Ap =  0.600
  SUBAREA RUNOFF(CFS) =      2.01
  TOTAL AREA(ACRES) =      0.80   PEAK FLOW RATE(CFS) =      2.01
============================================================================
  END OF STUDY SUMMARY:
  TOTAL AREA(ACRES)     =        0.8  TC(MIN.) =     13.64
  EFFECTIVE AREA(ACRES) =      0.80  AREA-AVERAGED Fm(INCH/HR)=  0.25
  AREA-AVERAGED Fp(INCH/HR) =  0.42  AREA-AVERAGED Ap = 0.600
  PEAK FLOW RATE(CFS)   =       2.01
============================================================================
============================================================================
  END OF RATIONAL METHOD ANALYSIS
```

```
____________________________________________________________________________
****************************************************************************
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                           Analysis prepared by:




 ************************** DESCRIPTION OF STUDY **************************
* REDLANDS PASSENGER RAIL PROJECT                                          *
* EXISTING 100 YEAR ANALYSIS                                               *
* DRAINAGE AREA 9000                                                       *
 **************************************************************************

  FILE NAME: C:\RPRP\9000.DAT
  TIME/DATE OF STUDY: 12:51 06/01/2012
============================================================================
  USER SPECIFIED HYDROLOGY AND HYDRAULIC MODEL INFORMATION:
============================================================================
                    --*TIME-OF-CONCENTRATION MODEL*--

  USER SPECIFIED STORM EVENT(YEAR) =  100.00
  SPECIFIED MINIMUM PIPE SIZE(INCH) =  12.00
  SPECIFIED PERCENT OF GRADIENTS(DECIMAL) TO USE FOR FRICTION SLOPE = 0.90
  *USER-DEFINED LOGARITHMIC INTERPOLATION USED FOR RAINFALL*

  SLOPE OF INTENSITY DURATION CURVE(LOG(I;IN/HR) vs. LOG(Tc;MIN)) = 0.6000
  USER SPECIFIED 1-HOUR INTENSITY(INCH/HOUR) = 1.2500

  *ANTECEDENT MOISTURE CONDITION (AMC) III ASSUMED FOR RATIONAL METHOD*

  *USER-DEFINED STREET-SECTIONS FOR COUPLED PIPEFLOW AND STREETFLOW MODEL*
     HALF-  CROWN TO   STREET-CROSSFALL:   CURB  GUTTER-GEOMETRIES:  MANNING
     WIDTH  CROSSFALL  IN-  / OUT-/PARK-  HEIGHT  WIDTH  LIP   HIKE  FACTOR
NO.   (FT)     (FT)    SIDE / SIDE/ WAY    (FT)    (FT)  (FT)  (FT)    (n)
===  =====  =========  =================  ======   ===== ====== ===== =======
  1   30.0     20.0    0.018/0.018/0.020   0.67    2.00 0.0313 0.167 0.0150
  2   13.0      8.0    0.018/0.018/0.020   0.67    2.00 0.0313 0.167 0.0150
  3   25.0     15.0    0.018/0.018/0.020   0.67    2.00 0.0313 0.167 0.0150
  4   35.0     25.0    0.018/0.018/0.020   0.67    2.00 0.0313 0.167 0.0150
  5   20.0     15.0    0.018/0.018/0.020   0.67    2.00 0.0313 0.167 0.0150

  GLOBAL STREET FLOW-DEPTH CONSTRAINTS:
    1. Relative Flow-Depth =  0.20 FEET
       as (Maximum Allowable Street Flow Depth) - (Top-of-Curb)
    2. (Depth)*(Velocity) Constraint = 10.0 (FT*FT/S)
  *SIZE PIPE WITH A FLOW CAPACITY GREATER THAN
   OR EQUAL TO THE UPSTREAM TRIBUTARY PIPE.*
  *USER-SPECIFIED MINIMUM TOPOGRAPHIC SLOPE ADJUSTMENT NOT SELECTED

****************************************************************************
  FLOW PROCESS FROM NODE   9000.00 TO NODE   9020.00 IS CODE =  21
----------------------------------------------------------------------------
  >>>>>RATIONAL METHOD INITIAL SUBAREA ANALYSIS<<<<<
  >>USE TIME-OF-CONCENTRATION NOMOGRAPH FOR INITIAL SUBAREA<<
============================================================================
  INITIAL SUBAREA FLOW-LENGTH(FEET) =   799.00
  ELEVATION DATA: UPSTREAM(FEET) =   1010.50  DOWNSTREAM(FEET) =   1004.00

  Tc = K*[(LENGTH** 3.00)/(ELEVATION CHANGE)]**0.20
  SUBAREA ANALYSIS USED MINIMUM Tc(MIN.) =   15.626
  * 100 YEAR RAINFALL INTENSITY(INCH/HR) =  2.802
  SUBAREA Tc AND LOSS RATE DATA(AMC III):
   DEVELOPMENT TYPE/      SCS SOIL   AREA      Fp         Ap     SCS   Tc
       LAND USE            GROUP   (ACRES)  (INCH/HR)  (DECIMAL)  CN  (MIN.)
```

```
  RESIDENTIAL
  "3-4 DWELLINGS/ACRE"       B        0.60      0.42     0.600    76   15.63
  SUBAREA AVERAGE PERVIOUS LOSS RATE, Fp(INCH/HR) =  0.42
  SUBAREA AVERAGE PERVIOUS AREA FRACTION, Ap =  0.600
  SUBAREA RUNOFF(CFS) =      1.38
  TOTAL AREA(ACRES) =      0.60   PEAK FLOW RATE(CFS) =      1.38

****************************************************************************
  FLOW PROCESS FROM NODE   9020.00 TO NODE   9020.00 IS CODE =  81
----------------------------------------------------------------------------
  >>>>>ADDITION OF SUBAREA TO MAINLINE PEAK FLOW<<<<<
============================================================================
  MAINLINE Tc(MIN.) =   15.63
  * 100 YEAR RAINFALL INTENSITY(INCH/HR) =  2.802
  SUBAREA LOSS RATE DATA(AMC III):
   DEVELOPMENT TYPE/      SCS SOIL   AREA      Fp         Ap     SCS
       LAND USE            GROUP   (ACRES)  (INCH/HR)  (DECIMAL)  CN
  COMMERCIAL                 B        1.00      0.42     0.100    76
  SUBAREA AVERAGE PERVIOUS LOSS RATE, Fp(INCH/HR) =  0.42
  SUBAREA AVERAGE PERVIOUS AREA FRACTION, Ap =  0.100
  SUBAREA AREA(ACRES) =    1.00      SUBAREA RUNOFF(CFS) =    2.48
  EFFECTIVE AREA(ACRES) =      1.60   AREA-AVERAGED Fm(INCH/HR) =  0.12
  AREA-AVERAGED Fp(INCH/HR) =  0.42  AREA-AVERAGED Ap =  0.29
  TOTAL AREA(ACRES) =        1.6       PEAK FLOW RATE(CFS) =       3.86

****************************************************************************
  FLOW PROCESS FROM NODE   9020.00 TO NODE   9020.00 IS CODE =   1
----------------------------------------------------------------------------
  >>>>>DESIGNATE INDEPENDENT STREAM FOR CONFLUENCE<<<<<
============================================================================
  TOTAL NUMBER OF STREAMS =  2
  CONFLUENCE VALUES USED FOR INDEPENDENT STREAM  1 ARE:
  TIME OF CONCENTRATION(MIN.) =   15.63
  RAINFALL INTENSITY(INCH/HR) =   2.80
  AREA-AVERAGED Fm(INCH/HR) =  0.12
  AREA-AVERAGED Fp(INCH/HR) =  0.42
  AREA-AVERAGED Ap =  0.29
  EFFECTIVE STREAM AREA(ACRES) =       1.60
  TOTAL STREAM AREA(ACRES) =       1.60
  PEAK FLOW RATE(CFS) AT CONFLUENCE =       3.86

****************************************************************************
  FLOW PROCESS FROM NODE   9030.00 TO NODE   9040.00 IS CODE =  21
----------------------------------------------------------------------------
  >>>>>RATIONAL METHOD INITIAL SUBAREA ANALYSIS<<<<<
  >>USE TIME-OF-CONCENTRATION NOMOGRAPH FOR INITIAL SUBAREA<<
============================================================================
  INITIAL SUBAREA FLOW-LENGTH(FEET) =   363.00
  ELEVATION DATA: UPSTREAM(FEET) =   1009.00  DOWNSTREAM(FEET) =   1007.30

  Tc = K*[(LENGTH** 3.00)/(ELEVATION CHANGE)]**0.20
  SUBAREA ANALYSIS USED MINIMUM Tc(MIN.) =   12.728
  * 100 YEAR RAINFALL INTENSITY(INCH/HR) =  3.169
  SUBAREA Tc AND LOSS RATE DATA(AMC III):
   DEVELOPMENT TYPE/      SCS SOIL   AREA      Fp         Ap     SCS   Tc
       LAND USE            GROUP   (ACRES)  (INCH/HR)  (DECIMAL)  CN  (MIN.)
  RESIDENTIAL
  "3-4 DWELLINGS/ACRE"       B        0.30      0.42     0.600    76   12.73
  SUBAREA AVERAGE PERVIOUS LOSS RATE, Fp(INCH/HR) =  0.42
  SUBAREA AVERAGE PERVIOUS AREA FRACTION, Ap =  0.600
  SUBAREA RUNOFF(CFS) =      0.79
  TOTAL AREA(ACRES) =      0.30   PEAK FLOW RATE(CFS) =      0.79

****************************************************************************
  FLOW PROCESS FROM NODE   9040.00 TO NODE   9040.00 IS CODE =  81
----------------------------------------------------------------------------
  >>>>>ADDITION OF SUBAREA TO MAINLINE PEAK FLOW<<<<<
============================================================================
  MAINLINE Tc(MIN.) =   12.73
  * 100 YEAR RAINFALL INTENSITY(INCH/HR) =  3.169
  SUBAREA LOSS RATE DATA(AMC III):
```

```
  DEVELOPMENT TYPE/      SCS SOIL   AREA      Fp         Ap     SCS
      LAND USE            GROUP   (ACRES)  (INCH/HR)  (DECIMAL)  CN
 COMMERCIAL                 B       0.70      0.42     0.100    76
 SUBAREA AVERAGE PERVIOUS LOSS RATE, Fp(INCH/HR) =  0.42
 SUBAREA AVERAGE PERVIOUS AREA FRACTION, Ap =  0.100
 SUBAREA AREA(ACRES) =    0.70      SUBAREA RUNOFF(CFS) =    1.97
 EFFECTIVE AREA(ACRES) =      1.00   AREA-AVERAGED Fm(INCH/HR) =  0.11
 AREA-AVERAGED Fp(INCH/HR) =  0.42  AREA-AVERAGED Ap =  0.25
 TOTAL AREA(ACRES) =        1.0       PEAK FLOW RATE(CFS) =       2.76

****************************************************************************
 FLOW PROCESS FROM NODE   9040.00 TO NODE   9050.00 IS CODE =  51
----------------------------------------------------------------------------
 >>>>>COMPUTE TRAPEZOIDAL CHANNEL FLOW<<<<<
 >>>>>TRAVELTIME THRU SUBAREA (EXISTING ELEMENT)<<<<<
============================================================================
 ELEVATION DATA: UPSTREAM(FEET) =   1007.30  DOWNSTREAM(FEET) =   1007.00
 CHANNEL LENGTH THRU SUBAREA(FEET) =   237.00   CHANNEL SLOPE =  0.0013
 CHANNEL BASE(FEET) =    4.00   "Z" FACTOR =   4.000
 MANNING'S FACTOR = 0.030   MAXIMUM DEPTH(FEET) =   1.00
 * 100 YEAR RAINFALL INTENSITY(INCH/HR) =  2.662
 SUBAREA LOSS RATE DATA(AMC III):
  DEVELOPMENT TYPE/      SCS SOIL   AREA      Fp         Ap     SCS
      LAND USE            GROUP   (ACRES)  (INCH/HR)  (DECIMAL)  CN
 RESIDENTIAL
 "3-4 DWELLINGS/ACRE"       B       0.10      0.42     0.600    76
 SUBAREA AVERAGE PERVIOUS LOSS RATE, Fp(INCH/HR) =  0.42
 SUBAREA AVERAGE PERVIOUS AREA FRACTION, Ap =  0.600
 TRAVEL TIME COMPUTED USING ESTIMATED FLOW(CFS) =       2.87
 TRAVEL TIME THRU SUBAREA BASED ON VELOCITY(FEET/SEC.) =   0.92
 AVERAGE FLOW DEPTH(FEET) =   0.51   TRAVEL TIME(MIN.) =   4.29
 Tc(MIN.) =   17.02
 SUBAREA AREA(ACRES) =     0.10       SUBAREA RUNOFF(CFS) =    0.22
 EFFECTIVE AREA(ACRES) =      1.10     AREA-AVERAGED Fm(INCH/HR) =   0.12
 AREA-AVERAGED Fp(INCH/HR) =   0.42  AREA-AVERAGED Ap =   0.28
 TOTAL AREA(ACRES) =        1.1         PEAK FLOW RATE(CFS) =       2.76
 NOTE: PEAK FLOW RATE DEFAULTED TO UPSTREAM VALUE

 END OF SUBAREA CHANNEL FLOW HYDRAULICS:
 DEPTH(FEET) =  0.50   FLOW VELOCITY(FEET/SEC.) =   0.92
 LONGEST FLOWPATH FROM NODE   9030.00 TO NODE   9050.00 =     600.00 FEET.

****************************************************************************
 FLOW PROCESS FROM NODE   9050.00 TO NODE   9050.00 IS CODE =  81
----------------------------------------------------------------------------
 >>>>>ADDITION OF SUBAREA TO MAINLINE PEAK FLOW<<<<<
============================================================================
 MAINLINE Tc(MIN.) =   17.02
 * 100 YEAR RAINFALL INTENSITY(INCH/HR) =  2.662
 SUBAREA LOSS RATE DATA(AMC III):
  DEVELOPMENT TYPE/      SCS SOIL   AREA      Fp         Ap     SCS
      LAND USE            GROUP   (ACRES)  (INCH/HR)  (DECIMAL)  CN
 COMMERCIAL                 B       1.10      0.42     0.100    76
 SUBAREA AVERAGE PERVIOUS LOSS RATE, Fp(INCH/HR) =  0.42
 SUBAREA AVERAGE PERVIOUS AREA FRACTION, Ap =  0.100
 SUBAREA AREA(ACRES) =    1.10      SUBAREA RUNOFF(CFS) =    2.59
 EFFECTIVE AREA(ACRES) =      2.20   AREA-AVERAGED Fm(INCH/HR) =  0.08
 AREA-AVERAGED Fp(INCH/HR) =  0.42  AREA-AVERAGED Ap =  0.19
 TOTAL AREA(ACRES) =        2.2       PEAK FLOW RATE(CFS) =       5.11

****************************************************************************
 FLOW PROCESS FROM NODE   9050.00 TO NODE   9020.00 IS CODE =  51
----------------------------------------------------------------------------
 >>>>>COMPUTE TRAPEZOIDAL CHANNEL FLOW<<<<<
 >>>>>TRAVELTIME THRU SUBAREA (EXISTING ELEMENT)<<<<<
============================================================================
 ELEVATION DATA: UPSTREAM(FEET) =   1007.00  DOWNSTREAM(FEET) =   1004.00
 CHANNEL LENGTH THRU SUBAREA(FEET) =   168.00   CHANNEL SLOPE =  0.0179
 CHANNEL BASE(FEET) =    4.00   "Z" FACTOR =   3.000
 MANNING'S FACTOR = 0.030   MAXIMUM DEPTH(FEET) =   1.00
 * 100 YEAR RAINFALL INTENSITY(INCH/HR) =  2.575
```

```
  SUBAREA LOSS RATE DATA(AMC III):
   DEVELOPMENT TYPE/      SCS SOIL   AREA      Fp         Ap     SCS
       LAND USE            GROUP   (ACRES)  (INCH/HR)  (DECIMAL)  CN
  RESIDENTIAL
  "3-4 DWELLINGS/ACRE"       B        0.10      0.42     0.600    76
  SUBAREA AVERAGE PERVIOUS LOSS RATE, Fp(INCH/HR) =  0.42
  SUBAREA AVERAGE PERVIOUS AREA FRACTION, Ap =  0.600
  TRAVEL TIME COMPUTED USING ESTIMATED FLOW(CFS) =       5.22
  TRAVEL TIME THRU SUBAREA BASED ON VELOCITY(FEET/SEC.) =   2.89
  AVERAGE FLOW DEPTH(FEET) =   0.36   TRAVEL TIME(MIN.) =   0.97
  Tc(MIN.) =   17.99
  SUBAREA AREA(ACRES) =     0.10       SUBAREA RUNOFF(CFS) =    0.21
  EFFECTIVE AREA(ACRES) =      2.30     AREA-AVERAGED Fm(INCH/HR) =   0.09
  AREA-AVERAGED Fp(INCH/HR) =   0.42  AREA-AVERAGED Ap =   0.21
  TOTAL AREA(ACRES) =        2.3         PEAK FLOW RATE(CFS) =       5.15

  END OF SUBAREA CHANNEL FLOW HYDRAULICS:
  DEPTH(FEET) =  0.35   FLOW VELOCITY(FEET/SEC.) =   2.87
  LONGEST FLOWPATH FROM NODE   9030.00 TO NODE   9020.00 =     768.00 FEET.

****************************************************************************
  FLOW PROCESS FROM NODE   9020.00 TO NODE   9020.00 IS CODE =   1
----------------------------------------------------------------------------
  >>>>>DESIGNATE INDEPENDENT STREAM FOR CONFLUENCE<<<<<
  >>>>>AND COMPUTE VARIOUS CONFLUENCED STREAM VALUES<<<<<
============================================================================
  TOTAL NUMBER OF STREAMS =  2
  CONFLUENCE VALUES USED FOR INDEPENDENT STREAM  2 ARE:
  TIME OF CONCENTRATION(MIN.) =   17.99
  RAINFALL INTENSITY(INCH/HR) =   2.58
  AREA-AVERAGED Fm(INCH/HR) =  0.09
  AREA-AVERAGED Fp(INCH/HR) =  0.42
  AREA-AVERAGED Ap =  0.21
  EFFECTIVE STREAM AREA(ACRES) =       2.30
  TOTAL STREAM AREA(ACRES) =       2.30
  PEAK FLOW RATE(CFS) AT CONFLUENCE =       5.15

  ** CONFLUENCE DATA **
   STREAM       Q      Tc   Intensity   Fp(Fm)     Ap     Ae     HEADWATER
   NUMBER     (CFS)  (MIN.) (INCH/HR) (INCH/HR)         (ACRES)    NODE
      1        3.86   15.63    2.802  0.42( 0.12) 0.29       1.6    9000.00
      2        5.15   17.99    2.575  0.42( 0.09) 0.21       2.3    9030.00

  RAINFALL INTENSITY AND TIME OF CONCENTRATION RATIO
  CONFLUENCE FORMULA USED FOR  2 STREAMS.

  ** PEAK FLOW RATE TABLE **
   STREAM       Q      Tc   Intensity   Fp(Fm)     Ap     Ae     HEADWATER
   NUMBER     (CFS)  (MIN.) (INCH/HR) (INCH/HR)         (ACRES)    NODE
      1        8.74   15.63    2.802  0.42( 0.10) 0.24       3.6    9000.00
      2        8.68   17.99    2.575  0.42( 0.10) 0.24       3.9    9030.00

  COMPUTED CONFLUENCE ESTIMATES ARE AS FOLLOWS:
  PEAK FLOW RATE(CFS) =       8.74    Tc(MIN.) =    15.63
  EFFECTIVE AREA(ACRES) =       3.60   AREA-AVERAGED Fm(INCH/HR) =  0.10
  AREA-AVERAGED Fp(INCH/HR) =  0.42  AREA-AVERAGED Ap =  0.24
  TOTAL AREA(ACRES) =        3.9
  LONGEST FLOWPATH FROM NODE   9000.00 TO NODE   9020.00 =     799.00 FEET.

****************************************************************************
  FLOW PROCESS FROM NODE   9020.00 TO NODE   9060.00 IS CODE =  41
----------------------------------------------------------------------------
  >>>>>COMPUTE PIPE-FLOW TRAVEL TIME THRU SUBAREA<<<<<
  >>>>>USING USER-SPECIFIED PIPESIZE (EXISTING ELEMENT)<<<<<
============================================================================
  ELEVATION DATA: UPSTREAM(FEET) =  1004.00  DOWNSTREAM(FEET) =  1003.90
  FLOW LENGTH(FEET) =    40.00   MANNING'S N =  0.024
  DEPTH OF FLOW IN  36.0 INCH PIPE IS  18.2 INCHES
  PIPE-FLOW VELOCITY(FEET/SEC.) =   2.44
  GIVEN PIPE DIAMETER(INCH) =  36.00    NUMBER OF PIPES =   1
  PIPE-FLOW(CFS) =       8.74
```

```
  PIPE TRAVEL TIME(MIN.) =   0.27    Tc(MIN.) =   15.90
  LONGEST FLOWPATH FROM NODE   9000.00 TO NODE   9060.00 =     839.00 FEET.

****************************************************************************
  FLOW PROCESS FROM NODE   9060.00 TO NODE   9060.00 IS CODE =  81
----------------------------------------------------------------------------
  >>>>>ADDITION OF SUBAREA TO MAINLINE PEAK FLOW<<<<<
============================================================================
  MAINLINE Tc(MIN.) =   15.90
  * 100 YEAR RAINFALL INTENSITY(INCH/HR) =  2.773
  SUBAREA LOSS RATE DATA(AMC III):
   DEVELOPMENT TYPE/      SCS SOIL   AREA      Fp         Ap     SCS
       LAND USE            GROUP   (ACRES)  (INCH/HR)  (DECIMAL)  CN
  RESIDENTIAL
  "3-4 DWELLINGS/ACRE"       B        0.30      0.42     0.600    76
  SUBAREA AVERAGE PERVIOUS LOSS RATE, Fp(INCH/HR) =  0.42
  SUBAREA AVERAGE PERVIOUS AREA FRACTION, Ap =  0.600
  SUBAREA AREA(ACRES) =    0.30      SUBAREA RUNOFF(CFS) =    0.68
  EFFECTIVE AREA(ACRES) =      3.90   AREA-AVERAGED Fm(INCH/HR) =  0.11
  AREA-AVERAGED Fp(INCH/HR) =  0.42  AREA-AVERAGED Ap =  0.27
  TOTAL AREA(ACRES) =        4.2       PEAK FLOW RATE(CFS) =       9.33

****************************************************************************
  FLOW PROCESS FROM NODE   9060.00 TO NODE   9410.00 IS CODE =  51
----------------------------------------------------------------------------
  >>>>>COMPUTE TRAPEZOIDAL CHANNEL FLOW<<<<<
  >>>>>TRAVELTIME THRU SUBAREA (EXISTING ELEMENT)<<<<<
============================================================================
  ELEVATION DATA: UPSTREAM(FEET) =   1003.90  DOWNSTREAM(FEET) =   1002.00
  CHANNEL LENGTH THRU SUBAREA(FEET) =   345.00   CHANNEL SLOPE =  0.0055
  CHANNEL BASE(FEET) =    2.00   "Z" FACTOR =   2.000
  MANNING'S FACTOR = 0.015   MAXIMUM DEPTH(FEET) =   1.00
  * 100 YEAR RAINFALL INTENSITY(INCH/HR) =  2.642
  SUBAREA LOSS RATE DATA(AMC III):
   DEVELOPMENT TYPE/      SCS SOIL   AREA      Fp         Ap     SCS
       LAND USE            GROUP   (ACRES)  (INCH/HR)  (DECIMAL)  CN
  COMMERCIAL                 B        0.10      0.42     0.100    76
  SUBAREA AVERAGE PERVIOUS LOSS RATE, Fp(INCH/HR) =  0.42
  SUBAREA AVERAGE PERVIOUS AREA FRACTION, Ap =  0.100
  TRAVEL TIME COMPUTED USING ESTIMATED FLOW(CFS) =       9.44
  TRAVEL TIME THRU SUBAREA BASED ON VELOCITY(FEET/SEC.) =   4.30
  AVERAGE FLOW DEPTH(FEET) =   0.66   TRAVEL TIME(MIN.) =   1.34
  Tc(MIN.) =   17.24
  SUBAREA AREA(ACRES) =     0.10       SUBAREA RUNOFF(CFS) =    0.23
  EFFECTIVE AREA(ACRES) =      4.00     AREA-AVERAGED Fm(INCH/HR) =   0.11
  AREA-AVERAGED Fp(INCH/HR) =   0.42  AREA-AVERAGED Ap =   0.27
  TOTAL AREA(ACRES) =        4.3         PEAK FLOW RATE(CFS) =       9.33
  NOTE: PEAK FLOW RATE DEFAULTED TO UPSTREAM VALUE

  END OF SUBAREA CHANNEL FLOW HYDRAULICS:
  DEPTH(FEET) =  0.66   FLOW VELOCITY(FEET/SEC.) =   4.27
  LONGEST FLOWPATH FROM NODE   9000.00 TO NODE   9410.00 =    1184.00 FEET.

****************************************************************************
  FLOW PROCESS FROM NODE   9410.00 TO NODE   9410.00 IS CODE =  81
----------------------------------------------------------------------------
  >>>>>ADDITION OF SUBAREA TO MAINLINE PEAK FLOW<<<<<
============================================================================
  MAINLINE Tc(MIN.) =   17.24
  * 100 YEAR RAINFALL INTENSITY(INCH/HR) =  2.642
  SUBAREA LOSS RATE DATA(AMC III):
   DEVELOPMENT TYPE/      SCS SOIL   AREA      Fp         Ap     SCS
       LAND USE            GROUP   (ACRES)  (INCH/HR)  (DECIMAL)  CN
  COMMERCIAL                 B        6.50      0.42     0.100    76
  SUBAREA AVERAGE PERVIOUS LOSS RATE, Fp(INCH/HR) =  0.42
  SUBAREA AVERAGE PERVIOUS AREA FRACTION, Ap =  0.100
  SUBAREA AREA(ACRES) =    6.50      SUBAREA RUNOFF(CFS) =   15.21
  EFFECTIVE AREA(ACRES) =     10.50   AREA-AVERAGED Fm(INCH/HR) =  0.07
  AREA-AVERAGED Fp(INCH/HR) =  0.42  AREA-AVERAGED Ap =  0.16
  TOTAL AREA(ACRES) =       10.8       PEAK FLOW RATE(CFS) =      24.31
```

```
****************************************************************************
  FLOW PROCESS FROM NODE   9410.00 TO NODE   9420.00 IS CODE =  61
----------------------------------------------------------------------------
  >>>>>COMPUTE STREET FLOW TRAVEL TIME THRU SUBAREA<<<<<
  >>>>>(STANDARD CURB SECTION USED)<<<<<
============================================================================
  UPSTREAM ELEVATION(FEET) = 1002.00  DOWNSTREAM ELEVATION(FEET) = 1000.00
  STREET LENGTH(FEET) =   352.00   CURB HEIGHT(INCHES) =  8.0
  STREET HALFWIDTH(FEET) = 20.00

  DISTANCE FROM CROWN TO CROSSFALL GRADEBREAK(FEET) =  15.00
  INSIDE STREET CROSSFALL(DECIMAL) =  0.018
  OUTSIDE STREET CROSSFALL(DECIMAL)  =  0.018

  SPECIFIED NUMBER OF HALFSTREETS CARRYING RUNOFF =  2
  STREET PARKWAY CROSSFALL(DECIMAL)  =  0.020
  Manning's FRICTION FACTOR for Streetflow Section(curb-to-curb) =   0.0130
  Manning's FRICTION FACTOR for Back-of-Walk Flow Section =   0.0200

    **TRAVEL TIME COMPUTED USING ESTIMATED FLOW(CFS) =      28.15
    ***STREET FLOWING FULL***
    STREETFLOW MODEL RESULTS USING ESTIMATED FLOW:
    STREET FLOW DEPTH(FEET) =  0.56
    HALFSTREET FLOOD WIDTH(FEET) =   20.00
    AVERAGE FLOW VELOCITY(FEET/SEC.) =    3.12
    PRODUCT OF DEPTH&VELOCITY(FT*FT/SEC.) =    1.74
  STREET FLOW TRAVEL TIME(MIN.) =   1.88   Tc(MIN.) =   19.12
  * 100 YEAR RAINFALL INTENSITY(INCH/HR) =  2.483
  SUBAREA LOSS RATE DATA(AMC III):
   DEVELOPMENT TYPE/      SCS SOIL   AREA      Fp         Ap     SCS
       LAND USE            GROUP   (ACRES)  (INCH/HR)  (DECIMAL)  CN
  COMMERCIAL                 B        3.50      0.42     0.100    76
  SUBAREA AVERAGE PERVIOUS LOSS RATE, Fp(INCH/HR) =  0.42
  SUBAREA AVERAGE PERVIOUS AREA FRACTION, Ap =  0.100
  SUBAREA AREA(ACRES) =    3.50      SUBAREA RUNOFF(CFS) =    7.69
  EFFECTIVE AREA(ACRES) =     14.00    AREA-AVERAGED Fm(INCH/HR) =  0.06
  AREA-AVERAGED Fp(INCH/HR) =  0.42  AREA-AVERAGED Ap =  0.15
  TOTAL AREA(ACRES) =       14.3        PEAK FLOW RATE(CFS) =      30.49

  END OF SUBAREA STREET FLOW HYDRAULICS:
  DEPTH(FEET) = 0.57   HALFSTREET FLOOD WIDTH(FEET) =  20.00
  FLOW VELOCITY(FEET/SEC.) =  3.22   DEPTH*VELOCITY(FT*FT/SEC.) =   1.83
  LONGEST FLOWPATH FROM NODE   9000.00 TO NODE   9420.00 =    1536.00 FEET.
============================================================================
  END OF STUDY SUMMARY:
  TOTAL AREA(ACRES)     =       14.3  TC(MIN.) =     19.12
  EFFECTIVE AREA(ACRES) =     14.00  AREA-AVERAGED Fm(INCH/HR)=  0.06
  AREA-AVERAGED Fp(INCH/HR) =  0.42  AREA-AVERAGED Ap = 0.148
  PEAK FLOW RATE(CFS)   =      30.49

  ** PEAK FLOW RATE TABLE **
   STREAM       Q      Tc   Intensity   Fp(Fm)     Ap     Ae     HEADWATER
   NUMBER     (CFS)  (MIN.) (INCH/HR) (INCH/HR)         (ACRES)    NODE
      1       30.49   19.12    2.483  0.42( 0.06) 0.15      14.0    9000.00
      2       28.94   21.53    2.312  0.42( 0.06) 0.15      14.3    9030.00
============================================================================
============================================================================
  END OF RATIONAL METHOD ANALYSIS
```

```
****************************************************************************
             RATIONAL METHOD HYDROLOGY COMPUTER PROGRAM PACKAGE
          (Reference: 1986 SAN BERNARDINO CO. HYDROLOGY CRITERION)
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             Ver. 15.0  Release Date: 04/01/2008  License ID 1555

                           Analysis prepared by:




 ************************** DESCRIPTION OF STUDY **************************
* REDLANDS PASSENGER RAIL PROJECT                                          *
* EXISTING 100 YEAR ANALYSIS                                               *
* DRAINAGE AREA 11000                                                      *
 **************************************************************************

  FILE NAME: C:\RPRP\11000.DAT
  TIME/DATE OF STUDY: 12:45 05/23/2012
============================================================================
  USER SPECIFIED HYDROLOGY AND HYDRAULIC MODEL INFORMATION:
============================================================================
                    --*TIME-OF-CONCENTRATION MODEL*--

  USER SPECIFIED STORM EVENT(YEAR) =  100.00
  SPECIFIED MINIMUM PIPE SIZE(INCH) =  12.00
  SPECIFIED PERCENT OF GRADIENTS(DECIMAL) TO USE FOR FRICTION SLOPE = 0.90
  *USER-DEFINED LOGARITHMIC INTERPOLATION USED FOR RAINFALL*

  SLOPE OF INTENSITY DURATION CURVE(LOG(I;IN/HR) vs. LOG(Tc;MIN)) = 0.6000
  USER SPECIFIED 1-HOUR INTENSITY(INCH/HOUR) = 1.2500

  *ANTECEDENT MOISTURE CONDITION (AMC) III ASSUMED FOR RATIONAL METHOD*

  *USER-DEFINED STREET-SECTIONS FOR COUPLED PIPEFLOW AND STREETFLOW MODEL*
     HALF-  CROWN TO   STREET-CROSSFALL:   CURB  GUTTER-GEOMETRIES:  MANNING
     WIDTH  CROSSFALL  IN-  / OUT-/PARK-  HEIGHT  WIDTH  LIP   HIKE  FACTOR
NO.  (FT)     (FT)     SIDE / SIDE/ WAY    (FT)    (FT)  (FT)  (FT)    (n)
===  =====  =========  =================  ======   ===== ====== ===== =======
  1   30.0     20.0    0.018/0.018/0.020   0.67    2.00 0.0313 0.167 0.0150
  2   13.0      8.0    0.018/0.018/0.020   0.67    2.00 0.0313 0.167 0.0150
  3   25.0     15.0    0.018/0.018/0.020   0.67    2.00 0.0313 0.167 0.0150
  4   35.0     25.0    0.018/0.018/0.020   0.67    2.00 0.0313 0.167 0.0150
  5   20.0     15.0    0.018/0.018/0.020   0.67    2.00 0.0313 0.167 0.0150

  GLOBAL STREET FLOW-DEPTH CONSTRAINTS:
    1. Relative Flow-Depth =  0.20 FEET
       as (Maximum Allowable Street Flow Depth) - (Top-of-Curb)
    2. (Depth)*(Velocity) Constraint = 10.0 (FT*FT/S)
  *SIZE PIPE WITH A FLOW CAPACITY GREATER THAN
   OR EQUAL TO THE UPSTREAM TRIBUTARY PIPE.*
  *USER-SPECIFIED MINIMUM TOPOGRAPHIC SLOPE ADJUSTMENT NOT SELECTED

****************************************************************************
  FLOW PROCESS FROM NODE  11000.00 TO NODE  11010.00 IS CODE =  21
----------------------------------------------------------------------------
  >>>>>RATIONAL METHOD INITIAL SUBAREA ANALYSIS<<<<<
  >>USE TIME-OF-CONCENTRATION NOMOGRAPH FOR INITIAL SUBAREA<<
============================================================================
  INITIAL SUBAREA FLOW-LENGTH(FEET) =  1180.00
  ELEVATION DATA: UPSTREAM(FEET) =   1035.00  DOWNSTREAM(FEET) =   1030.00

  Tc = K*[(LENGTH** 3.00)/(ELEVATION CHANGE)]**0.20
  SUBAREA ANALYSIS USED MINIMUM Tc(MIN.) =   15.354
  * 100 YEAR RAINFALL INTENSITY(INCH/HR) =  2.832
  SUBAREA Tc AND LOSS RATE DATA(AMC III):
   DEVELOPMENT TYPE/      SCS SOIL   AREA      Fp         Ap     SCS   Tc
       LAND USE             GROUP   (ACRES)  (INCH/HR)  (DECIMAL)  CN  (MIN.)
```

```
  COMMERCIAL                 B        1.00      0.42     0.100    76   15.35
  SUBAREA AVERAGE PERVIOUS LOSS RATE, Fp(INCH/HR) =  0.42
  SUBAREA AVERAGE PERVIOUS AREA FRACTION, Ap =  0.100
  SUBAREA RUNOFF(CFS) =      2.51
  TOTAL AREA(ACRES) =      1.00   PEAK FLOW RATE(CFS) =      2.51

****************************************************************************
  FLOW PROCESS FROM NODE  11010.00 TO NODE  11020.00 IS CODE =  62
----------------------------------------------------------------------------
  >>>>>COMPUTE STREET FLOW TRAVEL TIME THRU SUBAREA<<<<<
  >>>>>(STREET TABLE SECTION #  4 USED)<<<<<
============================================================================
  UPSTREAM ELEVATION(FEET) = 1030.00  DOWNSTREAM ELEVATION(FEET) = 1026.00
  STREET LENGTH(FEET) =   730.00   CURB HEIGHT(INCHES) =  8.0
  STREET HALFWIDTH(FEET) = 35.00

  DISTANCE FROM CROWN TO CROSSFALL GRADEBREAK(FEET) =  25.00
  INSIDE STREET CROSSFALL(DECIMAL) =  0.018
  OUTSIDE STREET CROSSFALL(DECIMAL)  =  0.018

  SPECIFIED NUMBER OF HALFSTREETS CARRYING RUNOFF =  1
  STREET PARKWAY CROSSFALL(DECIMAL)  =  0.020
  Manning's FRICTION FACTOR for Streetflow Section(curb-to-curb) =   0.0150
  Manning's FRICTION FACTOR for Back-of-Walk Flow Section =   0.0150

    **TRAVEL TIME COMPUTED USING ESTIMATED FLOW(CFS) =       3.22
    STREETFLOW MODEL RESULTS USING ESTIMATED FLOW:
    STREET FLOW DEPTH(FEET) =  0.40
    HALFSTREET FLOOD WIDTH(FEET) =   13.08
    AVERAGE FLOW VELOCITY(FEET/SEC.) =    1.86
    PRODUCT OF DEPTH&VELOCITY(FT*FT/SEC.) =    0.74
  STREET FLOW TRAVEL TIME(MIN.) =   6.55   Tc(MIN.) =   21.90
  * 100 YEAR RAINFALL INTENSITY(INCH/HR) =  2.288
  SUBAREA LOSS RATE DATA(AMC III):
   DEVELOPMENT TYPE/      SCS SOIL   AREA      Fp         Ap     SCS
       LAND USE            GROUP   (ACRES)  (INCH/HR)  (DECIMAL)  CN
  COMMERCIAL                 B        0.70      0.42     0.100    76
  SUBAREA AVERAGE PERVIOUS LOSS RATE, Fp(INCH/HR) =  0.42
  SUBAREA AVERAGE PERVIOUS AREA FRACTION, Ap =  0.100
  SUBAREA AREA(ACRES) =    0.70      SUBAREA RUNOFF(CFS) =    1.42
  EFFECTIVE AREA(ACRES) =      1.70    AREA-AVERAGED Fm(INCH/HR) =  0.04
  AREA-AVERAGED Fp(INCH/HR) =  0.42  AREA-AVERAGED Ap =  0.10
  TOTAL AREA(ACRES) =        1.7        PEAK FLOW RATE(CFS) =       3.44

  END OF SUBAREA STREET FLOW HYDRAULICS:
  DEPTH(FEET) = 0.40   HALFSTREET FLOOD WIDTH(FEET) =  13.47
  FLOW VELOCITY(FEET/SEC.) =  1.88   DEPTH*VELOCITY(FT*FT/SEC.) =   0.76
  LONGEST FLOWPATH FROM NODE  11000.00 TO NODE  11020.00 =    1910.00 FEET.

****************************************************************************
  FLOW PROCESS FROM NODE  11020.00 TO NODE  11020.00 IS CODE =  81
----------------------------------------------------------------------------
  >>>>>ADDITION OF SUBAREA TO MAINLINE PEAK FLOW<<<<<
============================================================================
  MAINLINE Tc(MIN.) =   21.90
  * 100 YEAR RAINFALL INTENSITY(INCH/HR) =  2.288
  SUBAREA LOSS RATE DATA(AMC III):
   DEVELOPMENT TYPE/      SCS SOIL   AREA      Fp         Ap     SCS
       LAND USE            GROUP   (ACRES)  (INCH/HR)  (DECIMAL)  CN
  RESIDENTIAL
  ".4 DWELLING/ACRE"         B       13.30      0.42     0.900    76
  SUBAREA AVERAGE PERVIOUS LOSS RATE, Fp(INCH/HR) =  0.42
  SUBAREA AVERAGE PERVIOUS AREA FRACTION, Ap =  0.900
  SUBAREA AREA(ACRES) =   13.30      SUBAREA RUNOFF(CFS) =   22.84
  EFFECTIVE AREA(ACRES) =     15.00   AREA-AVERAGED Fm(INCH/HR) =  0.34
  AREA-AVERAGED Fp(INCH/HR) =  0.42  AREA-AVERAGED Ap =  0.81
  TOTAL AREA(ACRES) =       15.0       PEAK FLOW RATE(CFS) =      26.27

****************************************************************************
  FLOW PROCESS FROM NODE  11020.00 TO NODE  11030.00 IS CODE =  62
----------------------------------------------------------------------------
```

```
  >>>>>COMPUTE STREET FLOW TRAVEL TIME THRU SUBAREA<<<<<
  >>>>>(STREET TABLE SECTION #  4 USED)<<<<<
============================================================================
  UPSTREAM ELEVATION(FEET) = 1026.00  DOWNSTREAM ELEVATION(FEET) = 1019.00
  STREET LENGTH(FEET) =   800.00   CURB HEIGHT(INCHES) =  8.0
  STREET HALFWIDTH(FEET) = 35.00

  DISTANCE FROM CROWN TO CROSSFALL GRADEBREAK(FEET) =  25.00
  INSIDE STREET CROSSFALL(DECIMAL) =  0.018
  OUTSIDE STREET CROSSFALL(DECIMAL)  =  0.018

  SPECIFIED NUMBER OF HALFSTREETS CARRYING RUNOFF =  1
  STREET PARKWAY CROSSFALL(DECIMAL)  =  0.020
  Manning's FRICTION FACTOR for Streetflow Section(curb-to-curb) =   0.0150
  Manning's FRICTION FACTOR for Back-of-Walk Flow Section =   0.0150

    **TRAVEL TIME COMPUTED USING ESTIMATED FLOW(CFS) =      27.29
    STREETFLOW MODEL RESULTS USING ESTIMATED FLOW:
    STREET FLOW DEPTH(FEET) =  0.67
    HALFSTREET FLOOD WIDTH(FEET) =   28.38
    AVERAGE FLOW VELOCITY(FEET/SEC.) =    3.71
    PRODUCT OF DEPTH&VELOCITY(FT*FT/SEC.) =    2.49
  STREET FLOW TRAVEL TIME(MIN.) =   3.60   Tc(MIN.) =   25.50
  * 100 YEAR RAINFALL INTENSITY(INCH/HR) =  2.089
  SUBAREA LOSS RATE DATA(AMC III):
   DEVELOPMENT TYPE/      SCS SOIL   AREA      Fp         Ap     SCS
       LAND USE            GROUP   (ACRES)  (INCH/HR)  (DECIMAL)  CN
  COMMERCIAL                 B        1.10      0.42     0.100    76
  SUBAREA AVERAGE PERVIOUS LOSS RATE, Fp(INCH/HR) =  0.42
  SUBAREA AVERAGE PERVIOUS AREA FRACTION, Ap =  0.100
  SUBAREA AREA(ACRES) =    1.10      SUBAREA RUNOFF(CFS) =    2.03
  EFFECTIVE AREA(ACRES) =     16.10    AREA-AVERAGED Fm(INCH/HR) =  0.32
  AREA-AVERAGED Fp(INCH/HR) =  0.42  AREA-AVERAGED Ap =  0.76
  TOTAL AREA(ACRES) =       16.1        PEAK FLOW RATE(CFS) =      26.27
  NOTE: PEAK FLOW RATE DEFAULTED TO UPSTREAM VALUE

  END OF SUBAREA STREET FLOW HYDRAULICS:
  DEPTH(FEET) = 0.66   HALFSTREET FLOOD WIDTH(FEET) =  27.72
  FLOW VELOCITY(FEET/SEC.) =  3.69   DEPTH*VELOCITY(FT*FT/SEC.) =   2.44
  LONGEST FLOWPATH FROM NODE  11000.00 TO NODE  11030.00 =    2710.00 FEET.

****************************************************************************
  FLOW PROCESS FROM NODE   1130.00 TO NODE   1130.00 IS CODE =  81
----------------------------------------------------------------------------
  >>>>>ADDITION OF SUBAREA TO MAINLINE PEAK FLOW<<<<<
============================================================================
  MAINLINE Tc(MIN.) =   25.50
  * 100 YEAR RAINFALL INTENSITY(INCH/HR) =  2.089
  SUBAREA LOSS RATE DATA(AMC III):
   DEVELOPMENT TYPE/      SCS SOIL   AREA      Fp         Ap     SCS
       LAND USE            GROUP   (ACRES)  (INCH/HR)  (DECIMAL)  CN
  COMMERCIAL                 B        6.40      0.42     0.100    76
  SUBAREA AVERAGE PERVIOUS LOSS RATE, Fp(INCH/HR) =  0.42
  SUBAREA AVERAGE PERVIOUS AREA FRACTION, Ap =  0.100
  SUBAREA AREA(ACRES) =    6.40      SUBAREA RUNOFF(CFS) =   11.79
  EFFECTIVE AREA(ACRES) =     22.50   AREA-AVERAGED Fm(INCH/HR) =  0.24
  AREA-AVERAGED Fp(INCH/HR) =  0.42  AREA-AVERAGED Ap =  0.57
  TOTAL AREA(ACRES) =       22.5       PEAK FLOW RATE(CFS) =      37.39

****************************************************************************
  FLOW PROCESS FROM NODE  11030.00 TO NODE  11040.00 IS CODE =  41
----------------------------------------------------------------------------
  >>>>>COMPUTE PIPE-FLOW TRAVEL TIME THRU SUBAREA<<<<<
  >>>>>USING USER-SPECIFIED PIPESIZE (EXISTING ELEMENT)<<<<<
============================================================================
  ELEVATION DATA: UPSTREAM(FEET) =  1015.00  DOWNSTREAM(FEET) =  1014.50
  FLOW LENGTH(FEET) =   210.00   MANNING'S N =  0.017
  ASSUME FULL-FLOWING PIPELINE
  PIPE-FLOW VELOCITY(FEET/SEC.) =  14.17
  PIPE FLOW VELOCITY = (TOTAL FLOW)/(PIPE CROSS SECTION AREA)
  GIVEN PIPE DIAMETER(INCH) =  22.00    NUMBER OF PIPES =   1
```

```
  PIPE-FLOW(CFS) =      37.39
  PIPE TRAVEL TIME(MIN.) =   0.25    Tc(MIN.) =   25.74
  LONGEST FLOWPATH FROM NODE  11000.00 TO NODE  11040.00 =    2920.00 FEET.

****************************************************************************
  FLOW PROCESS FROM NODE  11040.00 TO NODE  11040.00 IS CODE =  81
----------------------------------------------------------------------------
  >>>>>ADDITION OF SUBAREA TO MAINLINE PEAK FLOW<<<<<
============================================================================
  MAINLINE Tc(MIN.) =   25.74
  * 100 YEAR RAINFALL INTENSITY(INCH/HR) =  2.077
  SUBAREA LOSS RATE DATA(AMC III):
   DEVELOPMENT TYPE/      SCS SOIL   AREA      Fp         Ap     SCS
       LAND USE             GROUP   (ACRES)  (INCH/HR)  (DECIMAL)  CN
  COMMERCIAL                  B        2.40      0.42     0.100    76
  SUBAREA AVERAGE PERVIOUS LOSS RATE, Fp(INCH/HR) =  0.42
  SUBAREA AVERAGE PERVIOUS AREA FRACTION, Ap =  0.100
  SUBAREA AREA(ACRES) =    2.40      SUBAREA RUNOFF(CFS) =    4.39
  EFFECTIVE AREA(ACRES) =     24.90   AREA-AVERAGED Fm(INCH/HR) =  0.22
  AREA-AVERAGED Fp(INCH/HR) =  0.42  AREA-AVERAGED Ap =  0.53
  TOTAL AREA(ACRES) =       24.9       PEAK FLOW RATE(CFS) =      41.54

****************************************************************************
  FLOW PROCESS FROM NODE  11040.00 TO NODE  11050.00 IS CODE =  62
----------------------------------------------------------------------------
  >>>>>COMPUTE STREET FLOW TRAVEL TIME THRU SUBAREA<<<<<
  >>>>>(STREET TABLE SECTION #  1 USED)<<<<<
============================================================================
  UPSTREAM ELEVATION(FEET) = 1014.50  DOWNSTREAM ELEVATION(FEET) = 1008.50
  STREET LENGTH(FEET) =   850.00   CURB HEIGHT(INCHES) =  8.0
  STREET HALFWIDTH(FEET) = 30.00

  DISTANCE FROM CROWN TO CROSSFALL GRADEBREAK(FEET) =  20.00
  INSIDE STREET CROSSFALL(DECIMAL) =  0.018
  OUTSIDE STREET CROSSFALL(DECIMAL)  =  0.018

  SPECIFIED NUMBER OF HALFSTREETS CARRYING RUNOFF =  1
  STREET PARKWAY CROSSFALL(DECIMAL)  =  0.020
  Manning's FRICTION FACTOR for Streetflow Section(curb-to-curb) =   0.0150
  Manning's FRICTION FACTOR for Back-of-Walk Flow Section =   0.0200

    **TRAVEL TIME COMPUTED USING ESTIMATED FLOW(CFS) =      42.05
    ***STREET FLOW SPLITS OVER STREET-CROWN***
    FULL DEPTH(FEET) =    0.70   FLOOD WIDTH(FEET) =   31.58
    FULL HALF-STREET VELOCITY(FEET/SEC.) =    3.45
    SPLIT DEPTH(FEET) =    0.56   SPLIT FLOOD WIDTH(FEET) =   22.46
    SPLIT FLOW(CFS) =   13.56   SPLIT VELOCITY(FEET/SEC.) =    2.89
    STREETFLOW MODEL RESULTS USING ESTIMATED FLOW:
    STREET FLOW DEPTH(FEET) =  0.70
    HALFSTREET FLOOD WIDTH(FEET) =   31.58
    AVERAGE FLOW VELOCITY(FEET/SEC.) =    3.45
    PRODUCT OF DEPTH&VELOCITY(FT*FT/SEC.) =    2.41
  STREET FLOW TRAVEL TIME(MIN.) =   4.11   Tc(MIN.) =   29.85
  * 100 YEAR RAINFALL INTENSITY(INCH/HR) =  1.900
  SUBAREA LOSS RATE DATA(AMC III):
   DEVELOPMENT TYPE/      SCS SOIL   AREA      Fp         Ap     SCS
       LAND USE             GROUP   (ACRES)  (INCH/HR)  (DECIMAL)  CN
  COMMERCIAL                  B        0.60      0.42     0.100    76
  SUBAREA AVERAGE PERVIOUS LOSS RATE, Fp(INCH/HR) =  0.42
  SUBAREA AVERAGE PERVIOUS AREA FRACTION, Ap =  0.100
  SUBAREA AREA(ACRES) =    0.60      SUBAREA RUNOFF(CFS) =    1.00
  EFFECTIVE AREA(ACRES) =     25.50    AREA-AVERAGED Fm(INCH/HR) =  0.22
  AREA-AVERAGED Fp(INCH/HR) =  0.42  AREA-AVERAGED Ap =  0.52
  TOTAL AREA(ACRES) =       25.5        PEAK FLOW RATE(CFS) =      41.54
  NOTE: PEAK FLOW RATE DEFAULTED TO UPSTREAM VALUE

  END OF SUBAREA STREET FLOW HYDRAULICS:
  DEPTH(FEET) = 0.70   HALFSTREET FLOOD WIDTH(FEET) =  31.58
  FLOW VELOCITY(FEET/SEC.) =  3.45   DEPTH*VELOCITY(FT*FT/SEC.) =   2.41
  LONGEST FLOWPATH FROM NODE  11000.00 TO NODE  11050.00 =    3770.00 FEET.
```

```
****************************************************************************
  FLOW PROCESS FROM NODE  11050.00 TO NODE  11050.00 IS CODE =  81
----------------------------------------------------------------------------
  >>>>>ADDITION OF SUBAREA TO MAINLINE PEAK FLOW<<<<<
============================================================================
  MAINLINE Tc(MIN.) =   29.85
  * 100 YEAR RAINFALL INTENSITY(INCH/HR) =  1.900
  SUBAREA LOSS RATE DATA(AMC III):
   DEVELOPMENT TYPE/      SCS SOIL   AREA      Fp         Ap     SCS
       LAND USE            GROUP   (ACRES)  (INCH/HR)  (DECIMAL)  CN
  COMMERCIAL                 B       4.90      0.42     0.100    76
  SUBAREA AVERAGE PERVIOUS LOSS RATE, Fp(INCH/HR) =  0.42
  SUBAREA AVERAGE PERVIOUS AREA FRACTION, Ap =  0.100
  SUBAREA AREA(ACRES) =    4.90      SUBAREA RUNOFF(CFS) =    8.19
  EFFECTIVE AREA(ACRES) =     30.40   AREA-AVERAGED Fm(INCH/HR) =  0.19
  AREA-AVERAGED Fp(INCH/HR) =  0.42  AREA-AVERAGED Ap =  0.45
  TOTAL AREA(ACRES) =       30.4       PEAK FLOW RATE(CFS) =      46.79

****************************************************************************
  FLOW PROCESS FROM NODE  11050.00 TO NODE  11060.00 IS CODE =  41
----------------------------------------------------------------------------
  >>>>>COMPUTE PIPE-FLOW TRAVEL TIME THRU SUBAREA<<<<<
  >>>>>USING USER-SPECIFIED PIPESIZE (EXISTING ELEMENT)<<<<<
============================================================================
  ELEVATION DATA: UPSTREAM(FEET) =  1008.50  DOWNSTREAM(FEET) =  1007.90
  FLOW LENGTH(FEET) =    44.00   MANNING'S N =  0.024
  ASSUME FULL-FLOWING PIPELINE
  PIPE-FLOW VELOCITY(FEET/SEC.) =   5.66
  (PIPE FLOW VELOCITY CORRESPONDING TO FULL PIPE CAPACITY FLOW)
  GIVEN PIPE DIAMETER(INCH) =  36.00    NUMBER OF PIPES =   1
  PIPE-FLOW(CFS) =      46.79
  PIPE TRAVEL TIME(MIN.) =   0.13    Tc(MIN.) =   29.98
  LONGEST FLOWPATH FROM NODE  11000.00 TO NODE  11060.00 =    3814.00 FEET.

****************************************************************************
  FLOW PROCESS FROM NODE  11060.00 TO NODE  11060.00 IS CODE =   1
----------------------------------------------------------------------------
  >>>>>DESIGNATE INDEPENDENT STREAM FOR CONFLUENCE<<<<<
============================================================================
  TOTAL NUMBER OF STREAMS =  2
  CONFLUENCE VALUES USED FOR INDEPENDENT STREAM  1 ARE:
  TIME OF CONCENTRATION(MIN.) =   29.98
  RAINFALL INTENSITY(INCH/HR) =   1.90
  AREA-AVERAGED Fm(INCH/HR) =  0.19
  AREA-AVERAGED Fp(INCH/HR) =  0.42
  AREA-AVERAGED Ap =  0.45
  EFFECTIVE STREAM AREA(ACRES) =      30.40
  TOTAL STREAM AREA(ACRES) =      30.40
  PEAK FLOW RATE(CFS) AT CONFLUENCE =      46.79

****************************************************************************
  FLOW PROCESS FROM NODE  11065.00 TO NODE  11070.00 IS CODE =  21
----------------------------------------------------------------------------
  >>>>>RATIONAL METHOD INITIAL SUBAREA ANALYSIS<<<<<
  >>USE TIME-OF-CONCENTRATION NOMOGRAPH FOR INITIAL SUBAREA<<
============================================================================
  INITIAL SUBAREA FLOW-LENGTH(FEET) =  2090.00
  ELEVATION DATA: UPSTREAM(FEET) =   1034.00  DOWNSTREAM(FEET) =   1016.00

  Tc = K*[(LENGTH** 3.00)/(ELEVATION CHANGE)]**0.20
  SUBAREA ANALYSIS USED MINIMUM Tc(MIN.) =   16.746
  * 100 YEAR RAINFALL INTENSITY(INCH/HR) =  2.688
  SUBAREA Tc AND LOSS RATE DATA(AMC III):
   DEVELOPMENT TYPE/      SCS SOIL   AREA      Fp         Ap     SCS   Tc
       LAND USE            GROUP   (ACRES)  (INCH/HR)  (DECIMAL)  CN  (MIN.)
  COMMERCIAL                 B       1.90      0.42     0.100    76   16.75
  SUBAREA AVERAGE PERVIOUS LOSS RATE, Fp(INCH/HR) =  0.42
  SUBAREA AVERAGE PERVIOUS AREA FRACTION, Ap =  0.100
  SUBAREA RUNOFF(CFS) =      4.52
  TOTAL AREA(ACRES) =      1.90   PEAK FLOW RATE(CFS) =      4.52
```

```
****************************************************************************
  FLOW PROCESS FROM NODE  11070.00 TO NODE  11080.00 IS CODE =  41
----------------------------------------------------------------------------
  >>>>>COMPUTE PIPE-FLOW TRAVEL TIME THRU SUBAREA<<<<<
  >>>>>USING USER-SPECIFIED PIPESIZE (EXISTING ELEMENT)<<<<<
============================================================================
  ELEVATION DATA: UPSTREAM(FEET) =  1016.00  DOWNSTREAM(FEET) =  1011.50
  FLOW LENGTH(FEET) =   580.00   MANNING'S N =  0.013
  DEPTH OF FLOW IN  24.0 INCH PIPE IS   8.0 INCHES
  PIPE-FLOW VELOCITY(FEET/SEC.) =   4.94
  GIVEN PIPE DIAMETER(INCH) =  24.00    NUMBER OF PIPES =   1
  PIPE-FLOW(CFS) =       4.52
  PIPE TRAVEL TIME(MIN.) =   1.96    Tc(MIN.) =   18.70
  LONGEST FLOWPATH FROM NODE  11065.00 TO NODE  11080.00 =    2670.00 FEET.

****************************************************************************
  FLOW PROCESS FROM NODE  11080.00 TO NODE  11080.00 IS CODE =  81
----------------------------------------------------------------------------
  >>>>>ADDITION OF SUBAREA TO MAINLINE PEAK FLOW<<<<<
============================================================================
  MAINLINE Tc(MIN.) =   18.70
  * 100 YEAR RAINFALL INTENSITY(INCH/HR) =  2.516
  SUBAREA LOSS RATE DATA(AMC III):
   DEVELOPMENT TYPE/      SCS SOIL   AREA      Fp         Ap     SCS
       LAND USE            GROUP   (ACRES)  (INCH/HR)  (DECIMAL)  CN
  COMMERCIAL                 B        0.40      0.42     0.100    76
  SUBAREA AVERAGE PERVIOUS LOSS RATE, Fp(INCH/HR) =  0.42
  SUBAREA AVERAGE PERVIOUS AREA FRACTION, Ap =  0.100
  SUBAREA AREA(ACRES) =    0.40      SUBAREA RUNOFF(CFS) =    0.89
  EFFECTIVE AREA(ACRES) =      2.30   AREA-AVERAGED Fm(INCH/HR) =  0.04
  AREA-AVERAGED Fp(INCH/HR) =  0.42  AREA-AVERAGED Ap =  0.10
  TOTAL AREA(ACRES) =        2.3       PEAK FLOW RATE(CFS) =       5.12

****************************************************************************
  FLOW PROCESS FROM NODE  11080.00 TO NODE  11090.00 IS CODE =  62
----------------------------------------------------------------------------
  >>>>>COMPUTE STREET FLOW TRAVEL TIME THRU SUBAREA<<<<<
  >>>>>(STREET TABLE SECTION #  1 USED)<<<<<
============================================================================
  UPSTREAM ELEVATION(FEET) = 1011.50  DOWNSTREAM ELEVATION(FEET) = 1008.80
  STREET LENGTH(FEET) =   525.00   CURB HEIGHT(INCHES) =  8.0
  STREET HALFWIDTH(FEET) = 30.00

  DISTANCE FROM CROWN TO CROSSFALL GRADEBREAK(FEET) =  20.00
  INSIDE STREET CROSSFALL(DECIMAL) =  0.018
  OUTSIDE STREET CROSSFALL(DECIMAL)  =  0.018

  SPECIFIED NUMBER OF HALFSTREETS CARRYING RUNOFF =  1
  STREET PARKWAY CROSSFALL(DECIMAL)  =  0.020
  Manning's FRICTION FACTOR for Streetflow Section(curb-to-curb) =   0.0150
  Manning's FRICTION FACTOR for Back-of-Walk Flow Section =   0.0200

    **TRAVEL TIME COMPUTED USING ESTIMATED FLOW(CFS) =       5.51
    STREETFLOW MODEL RESULTS USING ESTIMATED FLOW:
    STREET FLOW DEPTH(FEET) =  0.46
    HALFSTREET FLOOD WIDTH(FEET) =   16.68
    AVERAGE FLOW VELOCITY(FEET/SEC.) =    2.06
    PRODUCT OF DEPTH&VELOCITY(FT*FT/SEC.) =    0.95
  STREET FLOW TRAVEL TIME(MIN.) =   4.25   Tc(MIN.) =   22.95
  * 100 YEAR RAINFALL INTENSITY(INCH/HR) =  2.225
  SUBAREA LOSS RATE DATA(AMC III):
   DEVELOPMENT TYPE/      SCS SOIL   AREA      Fp         Ap     SCS
       LAND USE            GROUP   (ACRES)  (INCH/HR)  (DECIMAL)  CN
  COMMERCIAL                 B        0.40      0.42     0.100    76
  SUBAREA AVERAGE PERVIOUS LOSS RATE, Fp(INCH/HR) =  0.42
  SUBAREA AVERAGE PERVIOUS AREA FRACTION, Ap =  0.100
  SUBAREA AREA(ACRES) =    0.40      SUBAREA RUNOFF(CFS) =    0.79
  EFFECTIVE AREA(ACRES) =      2.70    AREA-AVERAGED Fm(INCH/HR) =  0.04
  AREA-AVERAGED Fp(INCH/HR) =  0.42  AREA-AVERAGED Ap =  0.10
  TOTAL AREA(ACRES) =        2.7        PEAK FLOW RATE(CFS) =       5.30
```

```
  END OF SUBAREA STREET FLOW HYDRAULICS:
  DEPTH(FEET) = 0.46   HALFSTREET FLOOD WIDTH(FEET) =  16.45
  FLOW VELOCITY(FEET/SEC.) =  2.03   DEPTH*VELOCITY(FT*FT/SEC.) =   0.93
  LONGEST FLOWPATH FROM NODE  11065.00 TO NODE  11090.00 =    3195.00 FEET.

****************************************************************************
  FLOW PROCESS FROM NODE  11090.00 TO NODE  11090.00 IS CODE =  81
----------------------------------------------------------------------------
  >>>>>ADDITION OF SUBAREA TO MAINLINE PEAK FLOW<<<<<
============================================================================
  MAINLINE Tc(MIN.) =   22.95
  * 100 YEAR RAINFALL INTENSITY(INCH/HR) =  2.225
  SUBAREA LOSS RATE DATA(AMC III):
   DEVELOPMENT TYPE/      SCS SOIL   AREA      Fp         Ap     SCS
       LAND USE            GROUP   (ACRES)  (INCH/HR)  (DECIMAL)  CN
  COMMERCIAL                 B       1.50      0.42     0.100    76
  SUBAREA AVERAGE PERVIOUS LOSS RATE, Fp(INCH/HR) =  0.42
  SUBAREA AVERAGE PERVIOUS AREA FRACTION, Ap =  0.100
  SUBAREA AREA(ACRES) =    1.50      SUBAREA RUNOFF(CFS) =    2.95
  EFFECTIVE AREA(ACRES) =      4.20   AREA-AVERAGED Fm(INCH/HR) =  0.04
  AREA-AVERAGED Fp(INCH/HR) =  0.42  AREA-AVERAGED Ap =  0.10
  TOTAL AREA(ACRES) =       4.2       PEAK FLOW RATE(CFS) =       8.25

****************************************************************************
  FLOW PROCESS FROM NODE  11090.00 TO NODE  11060.00 IS CODE =  41
----------------------------------------------------------------------------
  >>>>>COMPUTE PIPE-FLOW TRAVEL TIME THRU SUBAREA<<<<<
  >>>>>USING USER-SPECIFIED PIPESIZE (EXISTING ELEMENT)<<<<<
============================================================================
  ELEVATION DATA: UPSTREAM(FEET) =  1008.80  DOWNSTREAM(FEET) =  1007.90
  FLOW LENGTH(FEET) =    66.00   MANNING'S N =  0.024
  DEPTH OF FLOW IN  22.0 INCH PIPE IS  14.4 INCHES
  PIPE-FLOW VELOCITY(FEET/SEC.) =   4.49
  GIVEN PIPE DIAMETER(INCH) =  22.00    NUMBER OF PIPES =   1
  PIPE-FLOW(CFS) =       8.25
  PIPE TRAVEL TIME(MIN.) =   0.24    Tc(MIN.) =   23.20
  LONGEST FLOWPATH FROM NODE  11065.00 TO NODE  11060.00 =    3261.00 FEET.

****************************************************************************
  FLOW PROCESS FROM NODE  11060.00 TO NODE  11060.00 IS CODE =   1
----------------------------------------------------------------------------
  >>>>>DESIGNATE INDEPENDENT STREAM FOR CONFLUENCE<<<<<
  >>>>>AND COMPUTE VARIOUS CONFLUENCED STREAM VALUES<<<<<
============================================================================
  TOTAL NUMBER OF STREAMS =  2
  CONFLUENCE VALUES USED FOR INDEPENDENT STREAM  2 ARE:
  TIME OF CONCENTRATION(MIN.) =   23.20
  RAINFALL INTENSITY(INCH/HR) =   2.21
  AREA-AVERAGED Fm(INCH/HR) =  0.04
  AREA-AVERAGED Fp(INCH/HR) =  0.42
  AREA-AVERAGED Ap =  0.10
  EFFECTIVE STREAM AREA(ACRES) =       4.20
  TOTAL STREAM AREA(ACRES) =       4.20
  PEAK FLOW RATE(CFS) AT CONFLUENCE =       8.25

  ** CONFLUENCE DATA **
   STREAM       Q      Tc   Intensity   Fp(Fm)     Ap     Ae     HEADWATER
   NUMBER     (CFS)  (MIN.) (INCH/HR) (INCH/HR)         (ACRES)    NODE
      1       46.79   29.98    1.896  0.42( 0.19) 0.45      30.4   11000.00
      2        8.25   23.20    2.211  0.42( 0.04) 0.10       4.2   11065.00

  RAINFALL INTENSITY AND TIME OF CONCENTRATION RATIO
  CONFLUENCE FORMULA USED FOR  2 STREAMS.

  ** PEAK FLOW RATE TABLE **
   STREAM       Q      Tc   Intensity   Fp(Fm)     Ap     Ae     HEADWATER
   NUMBER     (CFS)  (MIN.) (INCH/HR) (INCH/HR)         (ACRES)    NODE
      1       51.15   23.20    2.211  0.42( 0.17) 0.40      27.7   11065.00
      2       53.84   29.98    1.896  0.42( 0.17) 0.41      34.6   11000.00

  COMPUTED CONFLUENCE ESTIMATES ARE AS FOLLOWS:
```

```
  PEAK FLOW RATE(CFS) =      53.84    Tc(MIN.) =    29.98
  EFFECTIVE AREA(ACRES) =      34.60   AREA-AVERAGED Fm(INCH/HR) =  0.17
  AREA-AVERAGED Fp(INCH/HR) =  0.42  AREA-AVERAGED Ap =  0.41
  TOTAL AREA(ACRES) =      34.6
  LONGEST FLOWPATH FROM NODE  11000.00 TO NODE  11060.00 =    3814.00 FEET.

****************************************************************************
  FLOW PROCESS FROM NODE  11060.00 TO NODE  11065.00 IS CODE =  41
----------------------------------------------------------------------------
  >>>>>COMPUTE PIPE-FLOW TRAVEL TIME THRU SUBAREA<<<<<
  >>>>>USING USER-SPECIFIED PIPESIZE (EXISTING ELEMENT)<<<<<
============================================================================
  ELEVATION DATA: UPSTREAM(FEET) =  1007.90  DOWNSTREAM(FEET) =  1005.00
  FLOW LENGTH(FEET) =   224.00   MANNING'S N =  0.024
  ASSUME FULL-FLOWING PIPELINE
  PIPE-FLOW VELOCITY(FEET/SEC.) =   5.52
  (PIPE FLOW VELOCITY CORRESPONDING TO FULL PIPE CAPACITY FLOW)
  GIVEN PIPE DIAMETER(INCH) =  36.00    NUMBER OF PIPES =   1
  PIPE-FLOW(CFS) =      53.84
  PIPE TRAVEL TIME(MIN.) =   0.68    Tc(MIN.) =   30.65
  LONGEST FLOWPATH FROM NODE  11000.00 TO NODE  11065.00 =    4038.00 FEET.
============================================================================
  END OF STUDY SUMMARY:
  TOTAL AREA(ACRES)     =       34.6  TC(MIN.) =     30.65
  EFFECTIVE AREA(ACRES) =     34.60  AREA-AVERAGED Fm(INCH/HR)=  0.17
  AREA-AVERAGED Fp(INCH/HR) =  0.42  AREA-AVERAGED Ap = 0.408
  PEAK FLOW RATE(CFS)   =      53.84

  ** PEAK FLOW RATE TABLE **
   STREAM       Q      Tc   Intensity   Fp(Fm)     Ap     Ae     HEADWATER
   NUMBER     (CFS)  (MIN.) (INCH/HR) (INCH/HR)         (ACRES)    NODE
      1       51.15   23.88    2.173  0.42( 0.17) 0.40      27.7   11065.00
      2       53.84   30.65    1.870  0.42( 0.17) 0.41      34.6   11000.00
============================================================================
============================================================================
  END OF RATIONAL METHOD ANALYSIS
```

```
****************************************************************************
             RATIONAL METHOD HYDROLOGY COMPUTER PROGRAM PACKAGE
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             Ver. 15.0  Release Date: 04/01/2008  License ID 1555

                           Analysis prepared by:




 ************************** DESCRIPTION OF STUDY **************************
* REDLANDS PASSENGER RAIL                                                  *
* EXISTING HYDROLOGY 100 YEAR STORM                                        *
* BASIN 12000                                                              *
 **************************************************************************

  FILE NAME: C:\RPRP\12000.DAT
  TIME/DATE OF STUDY: 09:45 11/12/2012
============================================================================
  USER SPECIFIED HYDROLOGY AND HYDRAULIC MODEL INFORMATION:
============================================================================
                    --*TIME-OF-CONCENTRATION MODEL*--

  USER SPECIFIED STORM EVENT(YEAR) =  100.00
  SPECIFIED MINIMUM PIPE SIZE(INCH) =  12.00
  SPECIFIED PERCENT OF GRADIENTS(DECIMAL) TO USE FOR FRICTION SLOPE = 0.90
  *USER-DEFINED LOGARITHMIC INTERPOLATION USED FOR RAINFALL*

  SLOPE OF INTENSITY DURATION CURVE(LOG(I;IN/HR) vs. LOG(Tc;MIN)) = 0.6000
  USER SPECIFIED 1-HOUR INTENSITY(INCH/HOUR) = 1.2500

  *ANTECEDENT MOISTURE CONDITION (AMC) III ASSUMED FOR RATIONAL METHOD*

  *USER-DEFINED STREET-SECTIONS FOR COUPLED PIPEFLOW AND STREETFLOW MODEL*
     HALF-  CROWN TO   STREET-CROSSFALL:   CURB  GUTTER-GEOMETRIES:  MANNING
     WIDTH  CROSSFALL  IN-  / OUT-/PARK-  HEIGHT  WIDTH  LIP   HIKE  FACTOR
NO.   (FT)     (FT)    SIDE / SIDE/ WAY    (FT)    (FT)  (FT)  (FT)    (n)
===  =====  =========  =================  ======   ===== ====== ===== =======
  1   30.0     20.0    0.018/0.018/0.020   0.67    2.00 0.0313 0.167 0.0150
  2   20.0     15.0    0.020/0.020/0.020   0.50    1.50 0.0313 0.125 0.0170

  GLOBAL STREET FLOW-DEPTH CONSTRAINTS:
    1. Relative Flow-Depth =  0.20 FEET
       as (Maximum Allowable Street Flow Depth) - (Top-of-Curb)
    2. (Depth)*(Velocity) Constraint = 10.0 (FT*FT/S)
  *SIZE PIPE WITH A FLOW CAPACITY GREATER THAN
   OR EQUAL TO THE UPSTREAM TRIBUTARY PIPE.*
  *USER-SPECIFIED MINIMUM TOPOGRAPHIC SLOPE ADJUSTMENT NOT SELECTED

****************************************************************************
  FLOW PROCESS FROM NODE  12000.00 TO NODE  12010.00 IS CODE =  21
----------------------------------------------------------------------------
  >>>>>RATIONAL METHOD INITIAL SUBAREA ANALYSIS<<<<<
  >>USE TIME-OF-CONCENTRATION NOMOGRAPH FOR INITIAL SUBAREA<<
============================================================================
  INITIAL SUBAREA FLOW-LENGTH(FEET) =   700.00
  ELEVATION DATA: UPSTREAM(FEET) =   1009.00  DOWNSTREAM(FEET) =   1007.30

  Tc = K*[(LENGTH** 3.00)/(ELEVATION CHANGE)]**0.20
  SUBAREA ANALYSIS USED MINIMUM Tc(MIN.) =   18.874
  * 100 YEAR RAINFALL INTENSITY(INCH/HR) =  2.502
  SUBAREA Tc AND LOSS RATE DATA(AMC III):
   DEVELOPMENT TYPE/      SCS SOIL   AREA      Fp         Ap     SCS   Tc
       LAND USE            GROUP   (ACRES)  (INCH/HR)  (DECIMAL)  CN  (MIN.)
  RESIDENTIAL
  "3-4 DWELLINGS/ACRE"       B        0.40      0.42     0.600    76   18.87
  SUBAREA AVERAGE PERVIOUS LOSS RATE, Fp(INCH/HR) =  0.42
```

```
  SUBAREA AVERAGE PERVIOUS AREA FRACTION, Ap =  0.600
  SUBAREA RUNOFF(CFS) =      0.81
  TOTAL AREA(ACRES) =      0.40   PEAK FLOW RATE(CFS) =      0.81

****************************************************************************
  FLOW PROCESS FROM NODE  12010.00 TO NODE  12010.00 IS CODE =  81
----------------------------------------------------------------------------
  >>>>>ADDITION OF SUBAREA TO MAINLINE PEAK FLOW<<<<<
============================================================================
  MAINLINE Tc(MIN.) =   18.87
  * 100 YEAR RAINFALL INTENSITY(INCH/HR) =  2.502
  SUBAREA LOSS RATE DATA(AMC III):
   DEVELOPMENT TYPE/      SCS SOIL   AREA      Fp        Ap     SCS
       LAND USE            GROUP   (ACRES)  (INCH/HR)  (DECIMAL)  CN
  COMMERCIAL                 B        0.40      0.42     0.100    76
  RESIDENTIAL
  "1 DWELLING/ACRE"          B        0.90      0.42     0.800    76
  RESIDENTIAL
  ".4 DWELLING/ACRE"         B        0.90      0.42     0.900    76
  PUBLIC PARK                B        1.70      0.42     0.850    76
  SUBAREA AVERAGE PERVIOUS LOSS RATE, Fp(INCH/HR) =  0.42
  SUBAREA AVERAGE PERVIOUS AREA FRACTION, Ap =  0.773
  SUBAREA AREA(ACRES) =    3.90      SUBAREA RUNOFF(CFS) =    7.63
  EFFECTIVE AREA(ACRES) =      4.30   AREA-AVERAGED Fm(INCH/HR) =  0.32
  AREA-AVERAGED Fp(INCH/HR) =  0.42  AREA-AVERAGED Ap =  0.76
  TOTAL AREA(ACRES) =        4.3       PEAK FLOW RATE(CFS) =      8.44

****************************************************************************
  FLOW PROCESS FROM NODE  12010.00 TO NODE  12020.00 IS CODE =  51
----------------------------------------------------------------------------
  >>>>>COMPUTE TRAPEZOIDAL CHANNEL FLOW<<<<<
  >>>>>TRAVELTIME THRU SUBAREA (EXISTING ELEMENT)<<<<<
============================================================================
  ELEVATION DATA: UPSTREAM(FEET) =   1007.30  DOWNSTREAM(FEET) =   1005.80
  CHANNEL LENGTH THRU SUBAREA(FEET) =   420.00   CHANNEL SLOPE =  0.0036
  CHANNEL BASE(FEET) =    5.00   "Z" FACTOR =   4.000
  MANNING'S FACTOR = 0.030   MAXIMUM DEPTH(FEET) =   1.00
  * 100 YEAR RAINFALL INTENSITY(INCH/HR) =  2.235
  SUBAREA LOSS RATE DATA(AMC III):
   DEVELOPMENT TYPE/      SCS SOIL   AREA      Fp        Ap     SCS
       LAND USE            GROUP   (ACRES)  (INCH/HR)  (DECIMAL)  CN
  RESIDENTIAL
  "3-4 DWELLINGS/ACRE"       B        0.20      0.42     0.600    76
  SUBAREA AVERAGE PERVIOUS LOSS RATE, Fp(INCH/HR) =  0.42
  SUBAREA AVERAGE PERVIOUS AREA FRACTION, Ap =  0.600
  TRAVEL TIME COMPUTED USING ESTIMATED FLOW(CFS) =       8.62
  TRAVEL TIME THRU SUBAREA BASED ON VELOCITY(FEET/SEC.) =   1.79
  AVERAGE FLOW DEPTH(FEET) =   0.64   TRAVEL TIME(MIN.) =   3.91
  Tc(MIN.) =   22.79
  SUBAREA AREA(ACRES) =     0.20       SUBAREA RUNOFF(CFS) =    0.36
  EFFECTIVE AREA(ACRES) =      4.50     AREA-AVERAGED Fm(INCH/HR) =   0.32
  AREA-AVERAGED Fp(INCH/HR) =   0.42  AREA-AVERAGED Ap =   0.75
  TOTAL AREA(ACRES) =        4.5         PEAK FLOW RATE(CFS) =      8.44
  NOTE: PEAK FLOW RATE DEFAULTED TO UPSTREAM VALUE

  END OF SUBAREA CHANNEL FLOW HYDRAULICS:
  DEPTH(FEET) =  0.63   FLOW VELOCITY(FEET/SEC.) =   1.78
  LONGEST FLOWPATH FROM NODE  12000.00 TO NODE  12020.00 =    1120.00 FEET.

****************************************************************************
  FLOW PROCESS FROM NODE  12020.00 TO NODE  12020.00 IS CODE =  81
----------------------------------------------------------------------------
  >>>>>ADDITION OF SUBAREA TO MAINLINE PEAK FLOW<<<<<
============================================================================
  MAINLINE Tc(MIN.) =   22.79
  * 100 YEAR RAINFALL INTENSITY(INCH/HR) =  2.235
  SUBAREA LOSS RATE DATA(AMC III):
   DEVELOPMENT TYPE/      SCS SOIL   AREA      Fp        Ap     SCS
       LAND USE            GROUP   (ACRES)  (INCH/HR)  (DECIMAL)  CN
  RESIDENTIAL
  ".4 DWELLING/ACRE"         B        0.70      0.42     0.900    76
```

```
 RESIDENTIAL
 "1 DWELLING/ACRE"          B        0.70      0.42     0.800    76
 RESIDENTIAL
 "1 DWELLING/ACRE"          B        2.20      0.42     0.800    76
 SUBAREA AVERAGE PERVIOUS LOSS RATE, Fp(INCH/HR) =  0.42
 SUBAREA AVERAGE PERVIOUS AREA FRACTION, Ap =  0.819
 SUBAREA AREA(ACRES) =    3.60      SUBAREA RUNOFF(CFS) =    6.12
 EFFECTIVE AREA(ACRES) =      8.10   AREA-AVERAGED Fm(INCH/HR) =  0.33
 AREA-AVERAGED Fp(INCH/HR) =  0.42  AREA-AVERAGED Ap =  0.78
 TOTAL AREA(ACRES) =        8.1       PEAK FLOW RATE(CFS) =      13.88

****************************************************************************
 FLOW PROCESS FROM NODE  12020.00 TO NODE  12020.00 IS CODE =   1
----------------------------------------------------------------------------
 >>>>>DESIGNATE INDEPENDENT STREAM FOR CONFLUENCE<<<<<
============================================================================
 TOTAL NUMBER OF STREAMS =  2
 CONFLUENCE VALUES USED FOR INDEPENDENT STREAM  1 ARE:
 TIME OF CONCENTRATION(MIN.) =   22.79
 RAINFALL INTENSITY(INCH/HR) =   2.23
 AREA-AVERAGED Fm(INCH/HR) =  0.33
 AREA-AVERAGED Fp(INCH/HR) =  0.42
 AREA-AVERAGED Ap =  0.78
 EFFECTIVE STREAM AREA(ACRES) =       8.10
 TOTAL STREAM AREA(ACRES) =       8.10
 PEAK FLOW RATE(CFS) AT CONFLUENCE =      13.88

****************************************************************************
 FLOW PROCESS FROM NODE  12030.00 TO NODE  12020.00 IS CODE =  21
----------------------------------------------------------------------------
 >>>>>RATIONAL METHOD INITIAL SUBAREA ANALYSIS<<<<<
 >>USE TIME-OF-CONCENTRATION NOMOGRAPH FOR INITIAL SUBAREA<<
============================================================================
 INITIAL SUBAREA FLOW-LENGTH(FEET) =  1140.00
 ELEVATION DATA: UPSTREAM(FEET) =   1012.00  DOWNSTREAM(FEET) =   1005.80

 Tc = K*[(LENGTH** 3.00)/(ELEVATION CHANGE)]**0.20
 SUBAREA ANALYSIS USED MINIMUM Tc(MIN.) =   19.524
 * 100 YEAR RAINFALL INTENSITY(INCH/HR) =  2.452
 SUBAREA Tc AND LOSS RATE DATA(AMC III):
  DEVELOPMENT TYPE/      SCS SOIL   AREA      Fp         Ap     SCS   Tc
      LAND USE            GROUP   (ACRES)  (INCH/HR)  (DECIMAL)  CN  (MIN.)
 RESIDENTIAL
 "3-4 DWELLINGS/ACRE"       B        0.60      0.42     0.600    76   19.52
 SUBAREA AVERAGE PERVIOUS LOSS RATE, Fp(INCH/HR) =  0.42
 SUBAREA AVERAGE PERVIOUS AREA FRACTION, Ap =  0.600
 SUBAREA RUNOFF(CFS) =      1.19
 TOTAL AREA(ACRES) =      0.60   PEAK FLOW RATE(CFS) =      1.19

****************************************************************************
 FLOW PROCESS FROM NODE  12030.00 TO NODE  12030.00 IS CODE =  81
----------------------------------------------------------------------------
 >>>>>ADDITION OF SUBAREA TO MAINLINE PEAK FLOW<<<<<
============================================================================
 MAINLINE Tc(MIN.) =   19.52
 * 100 YEAR RAINFALL INTENSITY(INCH/HR) =  2.452
 SUBAREA LOSS RATE DATA(AMC III):
  DEVELOPMENT TYPE/      SCS SOIL   AREA      Fp         Ap     SCS
      LAND USE            GROUP   (ACRES)  (INCH/HR)  (DECIMAL)  CN
 PUBLIC PARK                B        3.10      0.42     0.850    76
 PUBLIC PARK                B        0.60      0.42     0.850    76
 RESIDENTIAL
 "1 DWELLING/ACRE"          B        0.70      0.42     0.800    76
 PUBLIC PARK                B        0.70      0.42     0.850    76
 SUBAREA AVERAGE PERVIOUS LOSS RATE, Fp(INCH/HR) =  0.42
 SUBAREA AVERAGE PERVIOUS AREA FRACTION, Ap =  0.843
 SUBAREA AREA(ACRES) =    5.10      SUBAREA RUNOFF(CFS) =    9.62
 EFFECTIVE AREA(ACRES) =      5.70   AREA-AVERAGED Fm(INCH/HR) =  0.35
 AREA-AVERAGED Fp(INCH/HR) =  0.42  AREA-AVERAGED Ap =  0.82
 TOTAL AREA(ACRES) =        5.7       PEAK FLOW RATE(CFS) =      10.80
```

****************************************************************************

FLOW PROCESS FROM NODE 12030.00 TO NODE 12030.00 IS CODE = 1

----------------------------------------------------------------------------

>>>>>DESIGNATE INDEPENDENT STREAM FOR CONFLUENCE<<<<<
>>>>>AND COMPUTE VARIOUS CONFLUENCED STREAM VALUES<<<<<

============================================================================

TOTAL NUMBER OF STREAMS = 2
CONFLUENCE VALUES USED FOR INDEPENDENT STREAM 2 ARE:
TIME OF CONCENTRATION(MIN.) = 19.52
RAINFALL INTENSITY(INCH/HR) = 2.45
AREA-AVERAGED Fm(INCH/HR) = 0.35
AREA-AVERAGED Fp(INCH/HR) = 0.42
AREA-AVERAGED Ap = 0.82
EFFECTIVE STREAM AREA(ACRES) = 5.70
TOTAL STREAM AREA(ACRES) = 5.70
PEAK FLOW RATE(CFS) AT CONFLUENCE = 10.80

** CONFLUENCE DATA **

| STREAM NUMBER | Q (CFS) | Tc (MIN.) | Intensity (INCH/HR) | Fp(Fm) (INCH/HR) | Ap | Ae (ACRES) | HEADWATER NODE |
|---|---|---|---|---|---|---|---|
| 1 | 13.88 | 22.79 | 2.235 | 0.42( 0.33) | 0.78 | 8.1 | 12000.00 |
| 2 | 10.80 | 19.52 | 2.452 | 0.42( 0.35) | 0.82 | 5.7 | 12030.00 |

RAINFALL INTENSITY AND TIME OF CONCENTRATION RATIO
CONFLUENCE FORMULA USED FOR 2 STREAMS.

** PEAK FLOW RATE TABLE **

| STREAM NUMBER | Q (CFS) | Tc (MIN.) | Intensity (INCH/HR) | Fp(Fm) (INCH/HR) | Ap | Ae (ACRES) | HEADWATER NODE |
|---|---|---|---|---|---|---|---|
| 1 | 24.05 | 19.52 | 2.452 | 0.42( 0.34) | 0.80 | 12.6 | 12030.00 |
| 2 | 23.57 | 22.79 | 2.235 | 0.42( 0.34) | 0.80 | 13.8 | 12000.00 |

COMPUTED CONFLUENCE ESTIMATES ARE AS FOLLOWS:
PEAK FLOW RATE(CFS) = 24.05 Tc(MIN.) = 19.52
EFFECTIVE AREA(ACRES) = 12.64 AREA-AVERAGED Fm(INCH/HR) = 0.34
AREA-AVERAGED Fp(INCH/HR) = 0.42 AREA-AVERAGED Ap = 0.80
TOTAL AREA(ACRES) = 13.8
LONGEST FLOWPATH FROM NODE 12030.00 TO NODE 12030.00 = 1140.00 FEET.

****************************************************************************

FLOW PROCESS FROM NODE 12020.00 TO NODE 12020.00 IS CODE = 81

----------------------------------------------------------------------------

>>>>>ADDITION OF SUBAREA TO MAINLINE PEAK FLOW<<<<<

============================================================================

MAINLINE Tc(MIN.) = 19.52
* 100 YEAR RAINFALL INTENSITY(INCH/HR) = 2.452
SUBAREA LOSS RATE DATA(AMC III):

| DEVELOPMENT TYPE/ LAND USE | SCS SOIL GROUP | AREA (ACRES) | Fp (INCH/HR) | Ap (DECIMAL) | SCS CN |
|---|---|---|---|---|---|
| RESIDENTIAL "3-4 DWELLINGS/ACRE" | B | 0.20 | 0.42 | 0.600 | 76 |
| RESIDENTIAL "3-4 DWELLINGS/ACRE" | B | 0.30 | 0.42 | 0.600 | 76 |

SUBAREA AVERAGE PERVIOUS LOSS RATE, Fp(INCH/HR) = 0.42
SUBAREA AVERAGE PERVIOUS AREA FRACTION, Ap = 0.600
SUBAREA AREA(ACRES) = 0.50 SUBAREA RUNOFF(CFS) = 0.99
EFFECTIVE AREA(ACRES) = 13.14 AREA-AVERAGED Fm(INCH/HR) = 0.33
AREA-AVERAGED Fp(INCH/HR) = 0.42 AREA-AVERAGED Ap = 0.79
TOTAL AREA(ACRES) = 14.3 PEAK FLOW RATE(CFS) = 25.04

****************************************************************************

FLOW PROCESS FROM NODE 12030.00 TO NODE 12030.00 IS CODE = 81

----------------------------------------------------------------------------

>>>>>ADDITION OF SUBAREA TO MAINLINE PEAK FLOW<<<<<

============================================================================

MAINLINE Tc(MIN.) = 19.52
* 100 YEAR RAINFALL INTENSITY(INCH/HR) = 2.452
SUBAREA LOSS RATE DATA(AMC III):

| DEVELOPMENT TYPE/ LAND USE | SCS SOIL GROUP | AREA (ACRES) | Fp (INCH/HR) | Ap (DECIMAL) | SCS CN |
|---|---|---|---|---|---|
| RESIDENTIAL | | | | | |

```
  "3-4 DWELLINGS/ACRE"       B        0.20      0.42     0.600    76
  RESIDENTIAL
  "3-4 DWELLINGS/ACRE"       B        0.30      0.42     0.600    76
  SUBAREA AVERAGE PERVIOUS LOSS RATE, Fp(INCH/HR) =  0.42
  SUBAREA AVERAGE PERVIOUS AREA FRACTION, Ap =  0.600
  SUBAREA AREA(ACRES) =    0.50      SUBAREA RUNOFF(CFS) =    0.99
  EFFECTIVE AREA(ACRES) =     13.64   AREA-AVERAGED Fm(INCH/HR) =  0.33
  AREA-AVERAGED Fp(INCH/HR) =  0.42  AREA-AVERAGED Ap =  0.78
  TOTAL AREA(ACRES) =       14.8       PEAK FLOW RATE(CFS) =      26.03
============================================================================
  END OF STUDY SUMMARY:
  TOTAL AREA(ACRES)     =       14.8  TC(MIN.) =     19.52
  EFFECTIVE AREA(ACRES) =     13.64  AREA-AVERAGED Fm(INCH/HR)=  0.33
  AREA-AVERAGED Fp(INCH/HR) =  0.42  AREA-AVERAGED Ap = 0.783
  PEAK FLOW RATE(CFS)   =      26.03

  ** PEAK FLOW RATE TABLE **
   STREAM       Q      Tc   Intensity   Fp(Fm)     Ap     Ae     HEADWATER
   NUMBER     (CFS)  (MIN.) (INCH/HR) (INCH/HR)         (ACRES)    NODE
      1       26.03   19.52    2.452  0.42( 0.33) 0.78      13.6   12030.00
      2       25.35   22.79    2.235  0.42( 0.33) 0.78      14.8   12000.00
============================================================================
============================================================================
  END OF RATIONAL METHOD ANALYSIS
```

```
****************************************************************************
             RATIONAL METHOD HYDROLOGY COMPUTER PROGRAM PACKAGE
          (Reference: 1986 SAN BERNARDINO CO. HYDROLOGY CRITERION)
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             Ver. 15.0  Release Date: 04/01/2008  License ID 1555

                           Analysis prepared by:




 ************************** DESCRIPTION OF STUDY **************************
 * REDLANDS PASSENGER RAIL PROJECT                                          *
 * EXISTING 100 YEAR ANALYSIS                                               *
 * DRAINAGE AREA 12100                                                      *
 **************************************************************************

  FILE NAME: C:\RPRP\12100.DAT
  TIME/DATE OF STUDY: 12:28 11/12/2012
============================================================================
  USER SPECIFIED HYDROLOGY AND HYDRAULIC MODEL INFORMATION:
============================================================================
                    --*TIME-OF-CONCENTRATION MODEL*--

  USER SPECIFIED STORM EVENT(YEAR) =  100.00
  SPECIFIED MINIMUM PIPE SIZE(INCH) =  12.00
  SPECIFIED PERCENT OF GRADIENTS(DECIMAL) TO USE FOR FRICTION SLOPE = 0.90
  *USER-DEFINED LOGARITHMIC INTERPOLATION USED FOR RAINFALL*

  SLOPE OF INTENSITY DURATION CURVE(LOG(I;IN/HR) vs. LOG(Tc;MIN)) = 0.6000
  USER SPECIFIED 1-HOUR INTENSITY(INCH/HOUR) = 1.2500

  *ANTECEDENT MOISTURE CONDITION (AMC) III ASSUMED FOR RATIONAL METHOD*

  *USER-DEFINED STREET-SECTIONS FOR COUPLED PIPEFLOW AND STREETFLOW MODEL*
     HALF-  CROWN TO   STREET-CROSSFALL:   CURB  GUTTER-GEOMETRIES:  MANNING
     WIDTH  CROSSFALL  IN-  / OUT-/PARK-  HEIGHT  WIDTH  LIP   HIKE  FACTOR
NO.   (FT)     (FT)    SIDE / SIDE/ WAY    (FT)    (FT)  (FT)  (FT)    (n)
===  =====  =========  =================  ======   ===== ====== ===== =======
  1   30.0     20.0    0.018/0.018/0.020   0.67    2.00 0.0313 0.167 0.0150
  2   20.0     15.0    0.020/0.020/0.020   0.50    1.50 0.0313 0.125 0.0170

  GLOBAL STREET FLOW-DEPTH CONSTRAINTS:
    1. Relative Flow-Depth =  0.20 FEET
       as (Maximum Allowable Street Flow Depth) - (Top-of-Curb)
    2. (Depth)*(Velocity) Constraint = 10.0 (FT*FT/S)
  *SIZE PIPE WITH A FLOW CAPACITY GREATER THAN
   OR EQUAL TO THE UPSTREAM TRIBUTARY PIPE.*
  *USER-SPECIFIED MINIMUM TOPOGRAPHIC SLOPE ADJUSTMENT NOT SELECTED

****************************************************************************
  FLOW PROCESS FROM NODE  12100.00 TO NODE  12110.00 IS CODE =  21
----------------------------------------------------------------------------
  >>>>>RATIONAL METHOD INITIAL SUBAREA ANALYSIS<<<<<
  >>USE TIME-OF-CONCENTRATION NOMOGRAPH FOR INITIAL SUBAREA<<
============================================================================
  INITIAL SUBAREA FLOW-LENGTH(FEET) =   660.00
  ELEVATION DATA: UPSTREAM(FEET) =   1009.00  DOWNSTREAM(FEET) =   1007.30

  Tc = K*[(LENGTH** 3.00)/(ELEVATION CHANGE)]**0.20
  SUBAREA ANALYSIS USED MINIMUM Tc(MIN.) =   18.219
  * 100 YEAR RAINFALL INTENSITY(INCH/HR) =  2.556
  SUBAREA Tc AND LOSS RATE DATA(AMC III):
   DEVELOPMENT TYPE/      SCS SOIL   AREA      Fp         Ap     SCS   Tc
       LAND USE            GROUP   (ACRES)  (INCH/HR)  (DECIMAL)  CN  (MIN.)
  RESIDENTIAL
  "3-4 DWELLINGS/ACRE"       B        0.40      0.42     0.600    76   18.22
  SUBAREA AVERAGE PERVIOUS LOSS RATE, Fp(INCH/HR) =  0.42
```

```
  SUBAREA AVERAGE PERVIOUS AREA FRACTION, Ap =  0.600
  SUBAREA RUNOFF(CFS) =      0.83
  TOTAL AREA(ACRES) =      0.40   PEAK FLOW RATE(CFS) =      0.83
============================================================================
  END OF STUDY SUMMARY:
  TOTAL AREA(ACRES)     =        0.4  TC(MIN.) =     18.22
  EFFECTIVE AREA(ACRES) =      0.40  AREA-AVERAGED Fm(INCH/HR)=  0.25
  AREA-AVERAGED Fp(INCH/HR) =  0.42  AREA-AVERAGED Ap = 0.600
  PEAK FLOW RATE(CFS)   =       0.83
============================================================================
============================================================================
  END OF RATIONAL METHOD ANALYSIS
```

```
****************************************************************************
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                           Analysis prepared by:




 ************************** DESCRIPTION OF STUDY **************************
* REDLANDS PASSENGER RAIL PROJECT                                          *
* EXISTING 100 YEAR ANALYSIS                                               *
* DRAINAGE AREA 12200                                                      *
 **************************************************************************

  FILE NAME: C:\RPRP\12200.DAT
  TIME/DATE OF STUDY: 12:32 11/12/2012
============================================================================
  USER SPECIFIED HYDROLOGY AND HYDRAULIC MODEL INFORMATION:
============================================================================
                    --*TIME-OF-CONCENTRATION MODEL*--

  USER SPECIFIED STORM EVENT(YEAR) =  100.00
  SPECIFIED MINIMUM PIPE SIZE(INCH) =  12.00
  SPECIFIED PERCENT OF GRADIENTS(DECIMAL) TO USE FOR FRICTION SLOPE = 0.90
  *USER-DEFINED LOGARITHMIC INTERPOLATION USED FOR RAINFALL*

  SLOPE OF INTENSITY DURATION CURVE(LOG(I;IN/HR) vs. LOG(Tc;MIN)) = 0.6000
  USER SPECIFIED 1-HOUR INTENSITY(INCH/HOUR) = 1.2500

  *ANTECEDENT MOISTURE CONDITION (AMC) III ASSUMED FOR RATIONAL METHOD*

  *USER-DEFINED STREET-SECTIONS FOR COUPLED PIPEFLOW AND STREETFLOW MODEL*
     HALF-  CROWN TO   STREET-CROSSFALL:   CURB  GUTTER-GEOMETRIES:  MANNING
     WIDTH  CROSSFALL  IN-  / OUT-/PARK-  HEIGHT  WIDTH  LIP   HIKE  FACTOR
NO.   (FT)     (FT)    SIDE / SIDE/ WAY    (FT)    (FT)  (FT)  (FT)    (n)
===  =====  =========  =================  ======   ===== ====== ===== =======
  1   30.0     20.0    0.018/0.018/0.020   0.67    2.00 0.0313 0.167 0.0150
  2   20.0     15.0    0.020/0.020/0.020   0.50    1.50 0.0313 0.125 0.0170

  GLOBAL STREET FLOW-DEPTH CONSTRAINTS:
    1. Relative Flow-Depth =  0.20 FEET
       as (Maximum Allowable Street Flow Depth) - (Top-of-Curb)
    2. (Depth)*(Velocity) Constraint = 10.0 (FT*FT/S)
  *SIZE PIPE WITH A FLOW CAPACITY GREATER THAN
   OR EQUAL TO THE UPSTREAM TRIBUTARY PIPE.*
  *USER-SPECIFIED MINIMUM TOPOGRAPHIC SLOPE ADJUSTMENT NOT SELECTED

****************************************************************************
  FLOW PROCESS FROM NODE  12200.00 TO NODE  12210.00 IS CODE =  21
----------------------------------------------------------------------------
  >>>>>RATIONAL METHOD INITIAL SUBAREA ANALYSIS<<<<<
  >>USE TIME-OF-CONCENTRATION NOMOGRAPH FOR INITIAL SUBAREA<<
============================================================================
  INITIAL SUBAREA FLOW-LENGTH(FEET) =   760.00
  ELEVATION DATA: UPSTREAM(FEET) =   1011.00  DOWNSTREAM(FEET) =   1008.00

  Tc = K*[(LENGTH** 3.00)/(ELEVATION CHANGE)]**0.20
  SUBAREA ANALYSIS USED MINIMUM Tc(MIN.) =   17.700
  * 100 YEAR RAINFALL INTENSITY(INCH/HR) =  2.600
  SUBAREA Tc AND LOSS RATE DATA(AMC III):
   DEVELOPMENT TYPE/      SCS SOIL   AREA      Fp         Ap     SCS   Tc
       LAND USE            GROUP   (ACRES)  (INCH/HR)  (DECIMAL)  CN  (MIN.)
  RESIDENTIAL
  "3-4 DWELLINGS/ACRE"       B        0.40      0.42     0.600    76   17.70
  SUBAREA AVERAGE PERVIOUS LOSS RATE, Fp(INCH/HR) =  0.42
```

```
  SUBAREA AVERAGE PERVIOUS AREA FRACTION, Ap =  0.600
  SUBAREA RUNOFF(CFS) =      0.84
  TOTAL AREA(ACRES) =      0.40   PEAK FLOW RATE(CFS) =      0.84
============================================================================
  END OF STUDY SUMMARY:
  TOTAL AREA(ACRES)     =        0.4  TC(MIN.) =     17.70
  EFFECTIVE AREA(ACRES) =      0.40  AREA-AVERAGED Fm(INCH/HR)=  0.25
  AREA-AVERAGED Fp(INCH/HR) =  0.42  AREA-AVERAGED Ap = 0.600
  PEAK FLOW RATE(CFS)   =       0.84
============================================================================
============================================================================
  END OF RATIONAL METHOD ANALYSIS
```

```
****************************************************************************
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                           Analysis prepared by:




 ************************** DESCRIPTION OF STUDY **************************
* REDLANDS PASSENGER RAIL PROJECT                                          *
* EXISTING 100 YEAR ANALYSIS                                               *
* DRAINAGE AREA 14000                                                      *
 **************************************************************************

  FILE NAME: C:\RPRP\14000.DAT
  TIME/DATE OF STUDY: 16:19 05/23/2012
============================================================================
  USER SPECIFIED HYDROLOGY AND HYDRAULIC MODEL INFORMATION:
============================================================================
                    --*TIME-OF-CONCENTRATION MODEL*--

  USER SPECIFIED STORM EVENT(YEAR) =  100.00
  SPECIFIED MINIMUM PIPE SIZE(INCH) =  12.00
  SPECIFIED PERCENT OF GRADIENTS(DECIMAL) TO USE FOR FRICTION SLOPE = 0.90
  *USER-DEFINED LOGARITHMIC INTERPOLATION USED FOR RAINFALL*

  SLOPE OF INTENSITY DURATION CURVE(LOG(I;IN/HR) vs. LOG(Tc;MIN)) = 0.6000
  USER SPECIFIED 1-HOUR INTENSITY(INCH/HOUR) = 1.2500

  *ANTECEDENT MOISTURE CONDITION (AMC) III ASSUMED FOR RATIONAL METHOD*

  *USER-DEFINED STREET-SECTIONS FOR COUPLED PIPEFLOW AND STREETFLOW MODEL*
     HALF-  CROWN TO   STREET-CROSSFALL:   CURB  GUTTER-GEOMETRIES:  MANNING
     WIDTH  CROSSFALL  IN-  / OUT-/PARK-  HEIGHT  WIDTH  LIP   HIKE  FACTOR
NO.   (FT)     (FT)    SIDE / SIDE/ WAY    (FT)    (FT)  (FT)  (FT)    (n)
===  =====  =========  =================  ======   ===== ====== ===== =======
  1   30.0     20.0    0.018/0.018/0.020   0.67    2.00 0.0313 0.167 0.0150
  2   20.0     15.0    0.020/0.020/0.020   0.50    1.50 0.0313 0.125 0.0170

  GLOBAL STREET FLOW-DEPTH CONSTRAINTS:
    1. Relative Flow-Depth =  0.20 FEET
       as (Maximum Allowable Street Flow Depth) - (Top-of-Curb)
    2. (Depth)*(Velocity) Constraint = 10.0 (FT*FT/S)
  *SIZE PIPE WITH A FLOW CAPACITY GREATER THAN
   OR EQUAL TO THE UPSTREAM TRIBUTARY PIPE.*
  *USER-SPECIFIED MINIMUM TOPOGRAPHIC SLOPE ADJUSTMENT NOT SELECTED

****************************************************************************
  FLOW PROCESS FROM NODE  14000.00 TO NODE  14010.00 IS CODE =  21
----------------------------------------------------------------------------
  >>>>>RATIONAL METHOD INITIAL SUBAREA ANALYSIS<<<<<
  >>USE TIME-OF-CONCENTRATION NOMOGRAPH FOR INITIAL SUBAREA<<
============================================================================
  INITIAL SUBAREA FLOW-LENGTH(FEET) =   700.00
  ELEVATION DATA: UPSTREAM(FEET) =   1015.00  DOWNSTREAM(FEET) =   1011.20

  Tc = K*[(LENGTH** 3.00)/(ELEVATION CHANGE)]**0.20
  SUBAREA ANALYSIS USED MINIMUM Tc(MIN.) =   16.069
  * 100 YEAR RAINFALL INTENSITY(INCH/HR) =  2.756
  SUBAREA Tc AND LOSS RATE DATA(AMC III):
   DEVELOPMENT TYPE/      SCS SOIL   AREA      Fp         Ap     SCS   Tc
       LAND USE            GROUP   (ACRES)  (INCH/HR)  (DECIMAL)  CN  (MIN.)
  RESIDENTIAL
  "3-4 DWELLINGS/ACRE"       B        0.50      0.42     0.600    76   16.07
  SUBAREA AVERAGE PERVIOUS LOSS RATE, Fp(INCH/HR) =  0.42
```

```
  SUBAREA AVERAGE PERVIOUS AREA FRACTION, Ap =  0.600
  SUBAREA RUNOFF(CFS) =      1.13
  TOTAL AREA(ACRES) =      0.50   PEAK FLOW RATE(CFS) =      1.13

****************************************************************************
  FLOW PROCESS FROM NODE  14010.00 TO NODE  14010.00 IS CODE =  81
----------------------------------------------------------------------------
  >>>>>ADDITION OF SUBAREA TO MAINLINE PEAK FLOW<<<<<
============================================================================
  MAINLINE Tc(MIN.) =   16.07
  * 100 YEAR RAINFALL INTENSITY(INCH/HR) =  2.756
  SUBAREA LOSS RATE DATA(AMC III):
   DEVELOPMENT TYPE/      SCS SOIL   AREA      Fp         Ap     SCS
       LAND USE            GROUP   (ACRES)  (INCH/HR)  (DECIMAL)  CN
  COMMERCIAL                 B        2.30      0.42     0.100    76
  SUBAREA AVERAGE PERVIOUS LOSS RATE, Fp(INCH/HR) =  0.42
  SUBAREA AVERAGE PERVIOUS AREA FRACTION, Ap =  0.100
  SUBAREA AREA(ACRES) =    2.30      SUBAREA RUNOFF(CFS) =    5.62
  EFFECTIVE AREA(ACRES) =      2.80   AREA-AVERAGED Fm(INCH/HR) =  0.08
  AREA-AVERAGED Fp(INCH/HR) =  0.42  AREA-AVERAGED Ap =  0.19
  TOTAL AREA(ACRES) =        2.8       PEAK FLOW RATE(CFS) =       6.74

****************************************************************************
  FLOW PROCESS FROM NODE  14010.00 TO NODE  14010.00 IS CODE =  81
----------------------------------------------------------------------------
  >>>>>ADDITION OF SUBAREA TO MAINLINE PEAK FLOW<<<<<
============================================================================
  MAINLINE Tc(MIN.) =   16.07
  * 100 YEAR RAINFALL INTENSITY(INCH/HR) =  2.756
  SUBAREA LOSS RATE DATA(AMC III):
   DEVELOPMENT TYPE/      SCS SOIL   AREA      Fp         Ap     SCS
       LAND USE            GROUP   (ACRES)  (INCH/HR)  (DECIMAL)  CN
  COMMERCIAL                 B        1.40      0.42     0.100    76
  SUBAREA AVERAGE PERVIOUS LOSS RATE, Fp(INCH/HR) =  0.42
  SUBAREA AVERAGE PERVIOUS AREA FRACTION, Ap =  0.100
  SUBAREA AREA(ACRES) =    1.40      SUBAREA RUNOFF(CFS) =    3.42
  EFFECTIVE AREA(ACRES) =      4.20   AREA-AVERAGED Fm(INCH/HR) =  0.07
  AREA-AVERAGED Fp(INCH/HR) =  0.42  AREA-AVERAGED Ap =  0.16
  TOTAL AREA(ACRES) =        4.2       PEAK FLOW RATE(CFS) =      10.16
============================================================================
  END OF STUDY SUMMARY:
  TOTAL AREA(ACRES)     =        4.2  TC(MIN.) =     16.07
  EFFECTIVE AREA(ACRES) =      4.20  AREA-AVERAGED Fm(INCH/HR)=  0.07
  AREA-AVERAGED Fp(INCH/HR) =  0.42  AREA-AVERAGED Ap = 0.160
  PEAK FLOW RATE(CFS)   =      10.16
============================================================================
============================================================================
  END OF RATIONAL METHOD ANALYSIS
```

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****************************************************************************
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                           Analysis prepared by:





 ************************** DESCRIPTION OF STUDY **************************
* REDLANDS PASSENGER RAIL PROJECT                                          *
* EXISTING 100 YEAR ANALYSIS                                               *
* DRAINAGE AREA 16500                                                      *
 **************************************************************************

  FILE NAME: C:\RPRP\16500.DAT
  TIME/DATE OF STUDY: 06:42 05/24/2012
============================================================================
  USER SPECIFIED HYDROLOGY AND HYDRAULIC MODEL INFORMATION:
============================================================================
                    --*TIME-OF-CONCENTRATION MODEL*--

  USER SPECIFIED STORM EVENT(YEAR) =  100.00
  SPECIFIED MINIMUM PIPE SIZE(INCH) =  12.00
  SPECIFIED PERCENT OF GRADIENTS(DECIMAL) TO USE FOR FRICTION SLOPE = 0.90
  *USER-DEFINED LOGARITHMIC INTERPOLATION USED FOR RAINFALL*

  SLOPE OF INTENSITY DURATION CURVE(LOG(I;IN/HR) vs. LOG(Tc;MIN)) = 0.6000
  USER SPECIFIED 1-HOUR INTENSITY(INCH/HOUR) = 1.2500

  *ANTECEDENT MOISTURE CONDITION (AMC) III ASSUMED FOR RATIONAL METHOD*

  *USER-DEFINED STREET-SECTIONS FOR COUPLED PIPEFLOW AND STREETFLOW MODEL*
     HALF-  CROWN TO   STREET-CROSSFALL:   CURB  GUTTER-GEOMETRIES:  MANNING
     WIDTH  CROSSFALL  IN-  / OUT-/PARK-  HEIGHT  WIDTH  LIP   HIKE  FACTOR
NO.   (FT)     (FT)    SIDE / SIDE/ WAY    (FT)    (FT)  (FT)  (FT)    (n)
===  =====  =========  =================  ======   ===== ====== ===== =======
  1   30.0     20.0    0.018/0.018/0.020   0.67    2.00 0.0313 0.167 0.0150
  2   20.0     15.0    0.020/0.020/0.020   0.50    1.50 0.0313 0.125 0.0170

  GLOBAL STREET FLOW-DEPTH CONSTRAINTS:
    1. Relative Flow-Depth =  0.20 FEET
       as (Maximum Allowable Street Flow Depth) - (Top-of-Curb)
    2. (Depth)*(Velocity) Constraint = 10.0 (FT*FT/S)
  *SIZE PIPE WITH A FLOW CAPACITY GREATER THAN
   OR EQUAL TO THE UPSTREAM TRIBUTARY PIPE.*
  *USER-SPECIFIED MINIMUM TOPOGRAPHIC SLOPE ADJUSTMENT NOT SELECTED

****************************************************************************
  FLOW PROCESS FROM NODE  16500.00 TO NODE  16510.00 IS CODE =  21
----------------------------------------------------------------------------
  >>>>>RATIONAL METHOD INITIAL SUBAREA ANALYSIS<<<<<
  >>USE TIME-OF-CONCENTRATION NOMOGRAPH FOR INITIAL SUBAREA<<
============================================================================
  INITIAL SUBAREA FLOW-LENGTH(FEET) =  1060.00
  ELEVATION DATA: UPSTREAM(FEET) =   1026.30  DOWNSTREAM(FEET) =   1017.80

  Tc = K*[(LENGTH** 3.00)/(ELEVATION CHANGE)]**0.20
  SUBAREA ANALYSIS USED MINIMUM Tc(MIN.) =   17.547
  * 100 YEAR RAINFALL INTENSITY(INCH/HR) =  2.614
  SUBAREA Tc AND LOSS RATE DATA(AMC III):
   DEVELOPMENT TYPE/      SCS SOIL   AREA      Fp         Ap     SCS   Tc
       LAND USE            GROUP   (ACRES)  (INCH/HR)  (DECIMAL)  CN  (MIN.)
  RESIDENTIAL
  "3-4 DWELLINGS/ACRE"       B        0.60      0.42     0.600    76   17.55
  SUBAREA AVERAGE PERVIOUS LOSS RATE, Fp(INCH/HR) =  0.42
```

```
  SUBAREA AVERAGE PERVIOUS AREA FRACTION, Ap =  0.600
  SUBAREA RUNOFF(CFS) =      1.27
  TOTAL AREA(ACRES) =      0.60   PEAK FLOW RATE(CFS) =      1.27

****************************************************************************
  FLOW PROCESS FROM NODE  16510.00 TO NODE  16520.00 IS CODE =  51
----------------------------------------------------------------------------
  >>>>>COMPUTE TRAPEZOIDAL CHANNEL FLOW<<<<<
  >>>>>TRAVELTIME THRU SUBAREA (EXISTING ELEMENT)<<<<<
============================================================================
  ELEVATION DATA: UPSTREAM(FEET) =   1017.80  DOWNSTREAM(FEET) =   1014.00
  CHANNEL LENGTH THRU SUBAREA(FEET) =   850.00   CHANNEL SLOPE =  0.0045
  CHANNEL BASE(FEET) =    5.00   "Z" FACTOR =   4.000
  MANNING'S FACTOR = 0.030   MAXIMUM DEPTH(FEET) =   1.00
  * 100 YEAR RAINFALL INTENSITY(INCH/HR) =  1.902
  SUBAREA LOSS RATE DATA(AMC III):
   DEVELOPMENT TYPE/      SCS SOIL   AREA      Fp         Ap     SCS
       LAND USE            GROUP   (ACRES)  (INCH/HR)  (DECIMAL)  CN
  RESIDENTIAL
  "3-4 DWELLINGS/ACRE"       B        0.50      0.42     0.600    76
  SUBAREA AVERAGE PERVIOUS LOSS RATE, Fp(INCH/HR) = 0.42
  SUBAREA AVERAGE PERVIOUS AREA FRACTION, Ap =  0.600
  TRAVEL TIME COMPUTED USING ESTIMATED FLOW(CFS) =       1.65
  TRAVEL TIME THRU SUBAREA BASED ON VELOCITY(FEET/SEC.) =   1.16
  AVERAGE FLOW DEPTH(FEET) =   0.24   TRAVEL TIME(MIN.) =  12.26
  Tc(MIN.) =   29.81
  SUBAREA AREA(ACRES) =     0.50       SUBAREA RUNOFF(CFS) =    0.74
  EFFECTIVE AREA(ACRES) =      1.10     AREA-AVERAGED Fm(INCH/HR) =   0.25
  AREA-AVERAGED Fp(INCH/HR) =   0.42  AREA-AVERAGED Ap =   0.60
  TOTAL AREA(ACRES) =        1.1         PEAK FLOW RATE(CFS) =       1.63

  END OF SUBAREA CHANNEL FLOW HYDRAULICS:
  DEPTH(FEET) =  0.24   FLOW VELOCITY(FEET/SEC.) =   1.14
  LONGEST FLOWPATH FROM NODE  16500.00 TO NODE  16520.00 =    1910.00 FEET.

****************************************************************************
  FLOW PROCESS FROM NODE  16520.00 TO NODE  16520.00 IS CODE =  81
----------------------------------------------------------------------------
  >>>>>ADDITION OF SUBAREA TO MAINLINE PEAK FLOW<<<<<
============================================================================
  MAINLINE Tc(MIN.) =   29.81
  * 100 YEAR RAINFALL INTENSITY(INCH/HR) =  1.902
  SUBAREA LOSS RATE DATA(AMC III):
   DEVELOPMENT TYPE/      SCS SOIL   AREA      Fp         Ap     SCS
       LAND USE            GROUP   (ACRES)  (INCH/HR)  (DECIMAL)  CN
  RESIDENTIAL
  "3-4 DWELLINGS/ACRE"       B        0.70      0.42     0.600    76
  SUBAREA AVERAGE PERVIOUS LOSS RATE, Fp(INCH/HR) =  0.42
  SUBAREA AVERAGE PERVIOUS AREA FRACTION, Ap =  0.600
  SUBAREA AREA(ACRES) =    0.70      SUBAREA RUNOFF(CFS) =    1.04
  EFFECTIVE AREA(ACRES) =      1.80   AREA-AVERAGED Fm(INCH/HR) =  0.25
  AREA-AVERAGED Fp(INCH/HR) =  0.42  AREA-AVERAGED Ap =  0.60
  TOTAL AREA(ACRES) =        1.8       PEAK FLOW RATE(CFS) =       2.67
============================================================================
  END OF STUDY SUMMARY:
  TOTAL AREA(ACRES)     =        1.8  TC(MIN.) =     29.81
  EFFECTIVE AREA(ACRES) =      1.80  AREA-AVERAGED Fm(INCH/HR)=  0.25
  AREA-AVERAGED Fp(INCH/HR) =  0.42  AREA-AVERAGED Ap = 0.600
  PEAK FLOW RATE(CFS)   =       2.67
============================================================================
============================================================================
  END OF RATIONAL METHOD ANALYSIS
```

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****************************************************************************
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 ************************** DESCRIPTION OF STUDY **************************
* REDLANDS PASSENGER RAIL PROOJECT                                         *
* EXISTING 100 YEAR ANALYSIS                                               *
* DRAINAGE AREA 16600                                                      *
 **************************************************************************

  FILE NAME: C:\RPRP\16600.DAT
  TIME/DATE OF STUDY: 06:54 05/24/2012
============================================================================
  USER SPECIFIED HYDROLOGY AND HYDRAULIC MODEL INFORMATION:
============================================================================
                    --*TIME-OF-CONCENTRATION MODEL*--

  USER SPECIFIED STORM EVENT(YEAR) =  100.00
  SPECIFIED MINIMUM PIPE SIZE(INCH) =  12.00
  SPECIFIED PERCENT OF GRADIENTS(DECIMAL) TO USE FOR FRICTION SLOPE = 0.90
  *USER-DEFINED LOGARITHMIC INTERPOLATION USED FOR RAINFALL*

  SLOPE OF INTENSITY DURATION CURVE(LOG(I;IN/HR) vs. LOG(Tc;MIN)) = 0.6000
  USER SPECIFIED 1-HOUR INTENSITY(INCH/HOUR) = 1.2500

  *ANTECEDENT MOISTURE CONDITION (AMC) III ASSUMED FOR RATIONAL METHOD*

  *USER-DEFINED STREET-SECTIONS FOR COUPLED PIPEFLOW AND STREETFLOW MODEL*
     HALF-  CROWN TO   STREET-CROSSFALL:   CURB  GUTTER-GEOMETRIES:  MANNING
     WIDTH  CROSSFALL  IN-  / OUT-/PARK-  HEIGHT  WIDTH  LIP   HIKE  FACTOR
NO.   (FT)     (FT)    SIDE / SIDE/ WAY    (FT)    (FT)  (FT)  (FT)    (n)
===  =====  =========  =================  ======   ===== ====== ===== =======
  1   30.0     20.0    0.018/0.018/0.020   0.67    2.00 0.0313 0.167 0.0150
  2   20.0     15.0    0.020/0.020/0.020   0.50    1.50 0.0313 0.125 0.0170

  GLOBAL STREET FLOW-DEPTH CONSTRAINTS:
    1. Relative Flow-Depth =  0.20 FEET
       as (Maximum Allowable Street Flow Depth) - (Top-of-Curb)
    2. (Depth)*(Velocity) Constraint = 10.0 (FT*FT/S)
  *SIZE PIPE WITH A FLOW CAPACITY GREATER THAN
   OR EQUAL TO THE UPSTREAM TRIBUTARY PIPE.*
  *USER-SPECIFIED MINIMUM TOPOGRAPHIC SLOPE ADJUSTMENT NOT SELECTED

****************************************************************************
  FLOW PROCESS FROM NODE  16600.00 TO NODE  16610.00 IS CODE =  21
----------------------------------------------------------------------------
  >>>>>RATIONAL METHOD INITIAL SUBAREA ANALYSIS<<<<<
  >>USE TIME-OF-CONCENTRATION NOMOGRAPH FOR INITIAL SUBAREA<<
============================================================================
  INITIAL SUBAREA FLOW-LENGTH(FEET) =   641.00
  ELEVATION DATA: UPSTREAM(FEET) =   1024.00  DOWNSTREAM(FEET) =   1021.50

  Tc = K*[(LENGTH** 3.00)/(ELEVATION CHANGE)]**0.20
  SUBAREA ANALYSIS USED MINIMUM Tc(MIN.) =   16.574
  * 100 YEAR RAINFALL INTENSITY(INCH/HR) =  2.705
  SUBAREA Tc AND LOSS RATE DATA(AMC III):
   DEVELOPMENT TYPE/      SCS SOIL   AREA      Fp         Ap     SCS   Tc
       LAND USE            GROUP   (ACRES)  (INCH/HR)  (DECIMAL)  CN  (MIN.)
  RESIDENTIAL
  "3-4 DWELLINGS/ACRE"       B        0.70      0.42     0.600    76   16.57
  SUBAREA AVERAGE PERVIOUS LOSS RATE, Fp(INCH/HR) =  0.42
```

```
  SUBAREA AVERAGE PERVIOUS AREA FRACTION, Ap =  0.600
  SUBAREA RUNOFF(CFS) =      1.54
  TOTAL AREA(ACRES) =      0.70   PEAK FLOW RATE(CFS) =      1.54

****************************************************************************
  FLOW PROCESS FROM NODE  16610.00 TO NODE  16620.00 IS CODE =  51
----------------------------------------------------------------------------
  >>>>>COMPUTE TRAPEZOIDAL CHANNEL FLOW<<<<<
  >>>>>TRAVELTIME THRU SUBAREA (EXISTING ELEMENT)<<<<<
============================================================================
  ELEVATION DATA: UPSTREAM(FEET) =   1021.50  DOWNSTREAM(FEET) =   1013.00
  CHANNEL LENGTH THRU SUBAREA(FEET) =  1250.00   CHANNEL SLOPE =  0.0068
  CHANNEL BASE(FEET) =    5.00   "Z" FACTOR =   4.000
  MANNING'S FACTOR = 0.030   MAXIMUM DEPTH(FEET) =   1.00
  * 100 YEAR RAINFALL INTENSITY(INCH/HR) =  1.852
  SUBAREA LOSS RATE DATA(AMC III):
   DEVELOPMENT TYPE/      SCS SOIL   AREA      Fp         Ap     SCS
       LAND USE            GROUP   (ACRES)  (INCH/HR)  (DECIMAL)  CN
  RESIDENTIAL
  "3-4 DWELLINGS/ACRE"       B        0.70      0.42     0.600    76
  SUBAREA AVERAGE PERVIOUS LOSS RATE, Fp(INCH/HR) =  0.42
  SUBAREA AVERAGE PERVIOUS AREA FRACTION, Ap =  0.600
  TRAVEL TIME COMPUTED USING ESTIMATED FLOW(CFS) =       2.06
  TRAVEL TIME THRU SUBAREA BASED ON VELOCITY(FEET/SEC.) =   1.43
  AVERAGE FLOW DEPTH(FEET) =   0.24   TRAVEL TIME(MIN.) =  14.59
  Tc(MIN.) =   31.16
  SUBAREA AREA(ACRES) =     0.70       SUBAREA RUNOFF(CFS) =    1.01
  EFFECTIVE AREA(ACRES) =      1.40     AREA-AVERAGED Fm(INCH/HR) =   0.25
  AREA-AVERAGED Fp(INCH/HR) =   0.42  AREA-AVERAGED Ap =   0.60
  TOTAL AREA(ACRES) =        1.4         PEAK FLOW RATE(CFS) =       2.01

  END OF SUBAREA CHANNEL FLOW HYDRAULICS:
  DEPTH(FEET) =  0.24   FLOW VELOCITY(FEET/SEC.) =   1.41
  LONGEST FLOWPATH FROM NODE  16600.00 TO NODE  16620.00 =    1891.00 FEET.
============================================================================
  END OF STUDY SUMMARY:
  TOTAL AREA(ACRES)     =        1.4  TC(MIN.) =     31.16
  EFFECTIVE AREA(ACRES) =      1.40  AREA-AVERAGED Fm(INCH/HR)=  0.25
  AREA-AVERAGED Fp(INCH/HR) =  0.42  AREA-AVERAGED Ap = 0.600
  PEAK FLOW RATE(CFS)   =       2.01
============================================================================
============================================================================
  END OF RATIONAL METHOD ANALYSIS
```

```
****************************************************************************
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                           Analysis prepared by:





 ************************** DESCRIPTION OF STUDY **************************
* REDLANDS PASSENGER RAIL PROJECT                                          *
* EXISTING 100 YEAR ANALYSIS                                               *
* DRAINAGE AREA 18000                                                      *
 **************************************************************************

  FILE NAME: C:\RPRP\18000.DAT
  TIME/DATE OF STUDY: 07:12 05/24/2012
============================================================================
  USER SPECIFIED HYDROLOGY AND HYDRAULIC MODEL INFORMATION:
============================================================================
                    --*TIME-OF-CONCENTRATION MODEL*--

  USER SPECIFIED STORM EVENT(YEAR) =  100.00
  SPECIFIED MINIMUM PIPE SIZE(INCH) =  12.00
  SPECIFIED PERCENT OF GRADIENTS(DECIMAL) TO USE FOR FRICTION SLOPE = 0.90
  *USER-DEFINED LOGARITHMIC INTERPOLATION USED FOR RAINFALL*

  SLOPE OF INTENSITY DURATION CURVE(LOG(I;IN/HR) vs. LOG(Tc;MIN)) = 0.6000
  USER SPECIFIED 1-HOUR INTENSITY(INCH/HOUR) = 1.2500

  *ANTECEDENT MOISTURE CONDITION (AMC) III ASSUMED FOR RATIONAL METHOD*

  *USER-DEFINED STREET-SECTIONS FOR COUPLED PIPEFLOW AND STREETFLOW MODEL*
     HALF-  CROWN TO   STREET-CROSSFALL:   CURB  GUTTER-GEOMETRIES:  MANNING
     WIDTH  CROSSFALL  IN-  / OUT-/PARK-  HEIGHT  WIDTH  LIP   HIKE  FACTOR
NO.   (FT)     (FT)    SIDE / SIDE/ WAY    (FT)    (FT)  (FT)  (FT)    (n)
===  =====  =========  =================  ======   ===== ====== ===== =======
  1   30.0     20.0    0.018/0.018/0.020   0.67    2.00 0.0313 0.167 0.0150
  2   13.0      8.0    0.018/0.018/0.020   0.67    2.00 0.0313 0.167 0.0150
  3   25.0     15.0    0.018/0.018/0.020   0.67    2.00 0.0313 0.167 0.0150
  4   35.0     25.0    0.018/0.018/0.020   0.67    2.00 0.0313 0.167 0.0150
  5   20.0     15.0    0.018/0.018/0.020   0.67    2.00 0.0313 0.167 0.0150

  GLOBAL STREET FLOW-DEPTH CONSTRAINTS:
    1. Relative Flow-Depth =  0.20 FEET
       as (Maximum Allowable Street Flow Depth) - (Top-of-Curb)
    2. (Depth)*(Velocity) Constraint = 10.0 (FT*FT/S)
  *SIZE PIPE WITH A FLOW CAPACITY GREATER THAN
   OR EQUAL TO THE UPSTREAM TRIBUTARY PIPE.*
  *USER-SPECIFIED MINIMUM TOPOGRAPHIC SLOPE ADJUSTMENT NOT SELECTED

****************************************************************************
  FLOW PROCESS FROM NODE  18000.00 TO NODE  18010.00 IS CODE =  21
----------------------------------------------------------------------------
  >>>>>RATIONAL METHOD INITIAL SUBAREA ANALYSIS<<<<<
  >>USE TIME-OF-CONCENTRATION NOMOGRAPH FOR INITIAL SUBAREA<<
============================================================================
  INITIAL SUBAREA FLOW-LENGTH(FEET) =   773.00
  ELEVATION DATA: UPSTREAM(FEET) =   1060.00  DOWNSTREAM(FEET) =   1054.20

  Tc = K*[(LENGTH** 3.00)/(ELEVATION CHANGE)]**0.20
  SUBAREA ANALYSIS USED MINIMUM Tc(MIN.) =   15.672
  * 100 YEAR RAINFALL INTENSITY(INCH/HR) =  2.797
  SUBAREA Tc AND LOSS RATE DATA(AMC III):
   DEVELOPMENT TYPE/      SCS SOIL   AREA      Fp         Ap     SCS   Tc
       LAND USE            GROUP   (ACRES)  (INCH/HR)  (DECIMAL)  CN  (MIN.)
```

```
  RESIDENTIAL
  "3-4 DWELLINGS/ACRE"       B        0.90      0.42     0.600    76   15.67
  SUBAREA AVERAGE PERVIOUS LOSS RATE, Fp(INCH/HR) =  0.42
  SUBAREA AVERAGE PERVIOUS AREA FRACTION, Ap =  0.600
  SUBAREA RUNOFF(CFS) =      2.06
  TOTAL AREA(ACRES) =      0.90   PEAK FLOW RATE(CFS) =      2.06

****************************************************************************
  FLOW PROCESS FROM NODE  18010.00 TO NODE  18020.00 IS CODE =  51
----------------------------------------------------------------------------
  >>>>>COMPUTE TRAPEZOIDAL CHANNEL FLOW<<<<<
  >>>>>TRAVELTIME THRU SUBAREA (EXISTING ELEMENT)<<<<<
============================================================================
  ELEVATION DATA: UPSTREAM(FEET) =   1054.20  DOWNSTREAM(FEET) =   1046.90
  CHANNEL LENGTH THRU SUBAREA(FEET) =   697.00   CHANNEL SLOPE =  0.0105
  CHANNEL BASE(FEET) =    2.00   "Z" FACTOR =   2.000
  MANNING'S FACTOR = 0.030   MAXIMUM DEPTH(FEET) =   1.00
  * 100 YEAR RAINFALL INTENSITY(INCH/HR) =  2.374
  SUBAREA LOSS RATE DATA(AMC III):
   DEVELOPMENT TYPE/      SCS SOIL   AREA      Fp         Ap     SCS
       LAND USE            GROUP   (ACRES)  (INCH/HR)  (DECIMAL)  CN
  RESIDENTIAL
  "3-4 DWELLINGS/ACRE"       B        0.90      0.42     0.600    76
  SUBAREA AVERAGE PERVIOUS LOSS RATE, Fp(INCH/HR) =  0.42
  SUBAREA AVERAGE PERVIOUS AREA FRACTION, Ap =  0.600
  TRAVEL TIME COMPUTED USING ESTIMATED FLOW(CFS) =       2.92
  TRAVEL TIME THRU SUBAREA BASED ON VELOCITY(FEET/SEC.) =   2.36
  AVERAGE FLOW DEPTH(FEET) =   0.43   TRAVEL TIME(MIN.) =   4.92
  Tc(MIN.) =   20.59
  SUBAREA AREA(ACRES) =     0.90       SUBAREA RUNOFF(CFS) =    1.72
  EFFECTIVE AREA(ACRES) =      1.80     AREA-AVERAGED Fm(INCH/HR) =   0.25
  AREA-AVERAGED Fp(INCH/HR) =   0.42  AREA-AVERAGED Ap =   0.60
  TOTAL AREA(ACRES) =        1.8         PEAK FLOW RATE(CFS) =       3.44

  END OF SUBAREA CHANNEL FLOW HYDRAULICS:
  DEPTH(FEET) =  0.48   FLOW VELOCITY(FEET/SEC.) =   2.45
  LONGEST FLOWPATH FROM NODE  18000.00 TO NODE  18020.00 =    1470.00 FEET.

****************************************************************************
  FLOW PROCESS FROM NODE  18020.00 TO NODE  18030.00 IS CODE =  41
----------------------------------------------------------------------------
  >>>>>COMPUTE PIPE-FLOW TRAVEL TIME THRU SUBAREA<<<<<
  >>>>>USING USER-SPECIFIED PIPESIZE (EXISTING ELEMENT)<<<<<
============================================================================
  ELEVATION DATA: UPSTREAM(FEET) =  1046.00  DOWNSTREAM(FEET) =  1045.10
  FLOW LENGTH(FEET) =   120.00   MANNING'S N =  0.017
  DEPTH OF FLOW IN  36.0 INCH PIPE IS   7.0 INCHES
  PIPE-FLOW VELOCITY(FEET/SEC.) =   3.58
  GIVEN PIPE DIAMETER(INCH) =  36.00    NUMBER OF PIPES =   1
  PIPE-FLOW(CFS) =       3.44
  PIPE TRAVEL TIME(MIN.) =   0.56    Tc(MIN.) =   21.15
  LONGEST FLOWPATH FROM NODE  18000.00 TO NODE  18030.00 =    1590.00 FEET.

****************************************************************************
  FLOW PROCESS FROM NODE  18030.00 TO NODE  18040.00 IS CODE =  51
----------------------------------------------------------------------------
  >>>>>COMPUTE TRAPEZOIDAL CHANNEL FLOW<<<<<
  >>>>>TRAVELTIME THRU SUBAREA (EXISTING ELEMENT)<<<<<
============================================================================
  ELEVATION DATA: UPSTREAM(FEET) =   1045.10  DOWNSTREAM(FEET) =   1044.00
  CHANNEL LENGTH THRU SUBAREA(FEET) =   180.00   CHANNEL SLOPE =  0.0061
  CHANNEL BASE(FEET) =    2.00   "Z" FACTOR =   4.000
  MANNING'S FACTOR = 0.030   MAXIMUM DEPTH(FEET) =   1.00
  * 100 YEAR RAINFALL INTENSITY(INCH/HR) =  2.235
  SUBAREA LOSS RATE DATA(AMC III):
   DEVELOPMENT TYPE/      SCS SOIL   AREA      Fp         Ap     SCS
       LAND USE            GROUP   (ACRES)  (INCH/HR)  (DECIMAL)  CN
  RESIDENTIAL
  "3-4 DWELLINGS/ACRE"       B        0.30      0.42     0.600    76
  SUBAREA AVERAGE PERVIOUS LOSS RATE, Fp(INCH/HR) =  0.42
  SUBAREA AVERAGE PERVIOUS AREA FRACTION, Ap =  0.600
```

```
  TRAVEL TIME COMPUTED USING ESTIMATED FLOW(CFS) =       3.70
  TRAVEL TIME THRU SUBAREA BASED ON VELOCITY(FEET/SEC.) =   1.85
  AVERAGE FLOW DEPTH(FEET) =   0.50   TRAVEL TIME(MIN.) =   1.62
  Tc(MIN.) =   22.78
  SUBAREA AREA(ACRES) =     0.30       SUBAREA RUNOFF(CFS) =    0.53
  EFFECTIVE AREA(ACRES) =      2.10     AREA-AVERAGED Fm(INCH/HR) =   0.25
  AREA-AVERAGED Fp(INCH/HR) =   0.42  AREA-AVERAGED Ap =   0.60
  TOTAL AREA(ACRES) =        2.1         PEAK FLOW RATE(CFS) =       3.74

  END OF SUBAREA CHANNEL FLOW HYDRAULICS:
  DEPTH(FEET) =  0.51   FLOW VELOCITY(FEET/SEC.) =   1.84
  LONGEST FLOWPATH FROM NODE  18000.00 TO NODE  18040.00 =    1770.00 FEET.

****************************************************************************
  FLOW PROCESS FROM NODE  18040.00 TO NODE  18040.00 IS CODE =  82
----------------------------------------------------------------------------
  >>>>>ADD SUBAREA RUNOFF TO MAINLINE, AT MAINLINE Tc,<<<<<
  >>>>>(AND COMPUTE INITIAL SUBAREA RUNOFF)<<<<<
============================================================================
  INITIAL SUBAREA FLOW-LENGTH(FEET) =  1580.00
  ELEVATION DATA: UPSTREAM(FEET) =   1062.00  DOWNSTREAM(FEET) =   1046.00

  Tc = K*[(LENGTH** 3.00)/(ELEVATION CHANGE)]**0.20
  SUBAREA ANALYSIS USED MINIMUM Tc(MIN.) =   19.646
  * 100 YEAR RAINFALL INTENSITY(INCH/HR) =  2.443
  SUBAREA Tc AND LOSS RATE DATA(AMC III):
   DEVELOPMENT TYPE/      SCS SOIL   AREA      Fp         Ap     SCS   Tc
       LAND USE            GROUP   (ACRES)  (INCH/HR)  (DECIMAL)  CN  (MIN.)
  RESIDENTIAL
  "3-4 DWELLINGS/ACRE"       B        1.30      0.42     0.600    76   19.65
  SUBAREA AVERAGE PERVIOUS LOSS RATE, Fp(INCH/HR) =  0.42
  SUBAREA AVERAGE PERVIOUS AREA FRACTION, Ap =  0.600
  SUBAREA AREA(ACRES) =    1.30   INITIAL SUBAREA RUNOFF(CFS) =    2.56

  ** ADD SUBAREA RUNOFF TO MAINLINE AT MAINLINE Tc:
  MAINLINE Tc(MIN.) =   22.78
  * 100 YEAR RAINFALL INTENSITY(INCH/HR) =  2.235
  SUBAREA AREA(ACRES) =    1.30      SUBAREA RUNOFF(CFS) =    2.32
  EFFECTIVE AREA(ACRES) =      3.40   AREA-AVERAGED Fm(INCH/HR) =  0.25
  AREA-AVERAGED Fp(INCH/HR) =  0.42  AREA-AVERAGED Ap =  0.60
  TOTAL AREA(ACRES) =        3.4       PEAK FLOW RATE(CFS) =       6.06

****************************************************************************
  FLOW PROCESS FROM NODE  18040.00 TO NODE  18050.00 IS CODE =  51
----------------------------------------------------------------------------
  >>>>>COMPUTE TRAPEZOIDAL CHANNEL FLOW<<<<<
  >>>>>TRAVELTIME THRU SUBAREA (EXISTING ELEMENT)<<<<<
============================================================================
  ELEVATION DATA: UPSTREAM(FEET) =   1044.00  DOWNSTREAM(FEET) =   1030.60
  CHANNEL LENGTH THRU SUBAREA(FEET) =  1650.00   CHANNEL SLOPE =  0.0081
  CHANNEL BASE(FEET) =    2.00   "Z" FACTOR =   4.000
  MANNING'S FACTOR = 0.030   MAXIMUM DEPTH(FEET) =   1.00
  * 100 YEAR RAINFALL INTENSITY(INCH/HR) =  1.754
  SUBAREA LOSS RATE DATA(AMC III):
   DEVELOPMENT TYPE/      SCS SOIL   AREA      Fp         Ap     SCS
       LAND USE            GROUP   (ACRES)  (INCH/HR)  (DECIMAL)  CN
  RESIDENTIAL
  "3-4 DWELLINGS/ACRE"       B        1.60      0.42     0.600    76
  SUBAREA AVERAGE PERVIOUS LOSS RATE, Fp(INCH/HR) =  0.42
  SUBAREA AVERAGE PERVIOUS AREA FRACTION, Ap =  0.600
  TRAVEL TIME COMPUTED USING ESTIMATED FLOW(CFS) =       7.15
  TRAVEL TIME THRU SUBAREA BASED ON VELOCITY(FEET/SEC.) =   2.43
  AVERAGE FLOW DEPTH(FEET) =   0.64   TRAVEL TIME(MIN.) =  11.33
  Tc(MIN.) =   34.11
  SUBAREA AREA(ACRES) =     1.60       SUBAREA RUNOFF(CFS) =    2.16
  EFFECTIVE AREA(ACRES) =      5.00     AREA-AVERAGED Fm(INCH/HR) =   0.25
  AREA-AVERAGED Fp(INCH/HR) =   0.42  AREA-AVERAGED Ap =   0.60
  TOTAL AREA(ACRES) =        5.0         PEAK FLOW RATE(CFS) =       6.75

  END OF SUBAREA CHANNEL FLOW HYDRAULICS:
  DEPTH(FEET) =  0.63   FLOW VELOCITY(FEET/SEC.) =   2.38
```

```
  LONGEST FLOWPATH FROM NODE  18000.00 TO NODE  18050.00 =    3420.00 FEET.
============================================================================
  END OF STUDY SUMMARY:
  TOTAL AREA(ACRES)     =        5.0  TC(MIN.) =     34.11
  EFFECTIVE AREA(ACRES) =      5.00  AREA-AVERAGED Fm(INCH/HR)=  0.25
  AREA-AVERAGED Fp(INCH/HR) =  0.42  AREA-AVERAGED Ap = 0.600
  PEAK FLOW RATE(CFS)   =       6.75
============================================================================
============================================================================
  END OF RATIONAL METHOD ANALYSIS
```

```
____________________________________________________________________________
****************************************************************************
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                           Analysis prepared by:







 ************************* DESCRIPTION OF STUDY *************************
* REDLANDS PASSENGER RAIL                                                  *
* EXISTING HYDROLOGY 100 YEAR STORM                                        *
* BASIN 21000                                                              *
 **************************************************************************

  FILE NAME: C:\RPRP\EPRP\21000.DAT
  TIME/DATE OF STUDY: 14:31 02/16/2012
============================================================================
  USER SPECIFIED HYDROLOGY AND HYDRAULIC MODEL INFORMATION:
============================================================================
                    --*TIME-OF-CONCENTRATION MODEL*--

  USER SPECIFIED STORM EVENT(YEAR) =  100.00
  SPECIFIED MINIMUM PIPE SIZE(INCH) =  12.00
  SPECIFIED PERCENT OF GRADIENTS(DECIMAL) TO USE FOR FRICTION SLOPE = 0.90
  *USER-DEFINED LOGARITHMIC INTERPOLATION USED FOR RAINFALL*

  SLOPE OF INTENSITY DURATION CURVE(LOG(I;IN/HR) vs. LOG(Tc;MIN)) = 0.6000
  USER SPECIFIED 1-HOUR INTENSITY(INCH/HOUR) = 1.2500

  *ANTECEDENT MOISTURE CONDITION (AMC) III ASSUMED FOR RATIONAL METHOD*

  *USER-DEFINED STREET-SECTIONS FOR COUPLED PIPEFLOW AND STREETFLOW MODEL*
     HALF-  CROWN TO   STREET-CROSSFALL:   CURB  GUTTER-GEOMETRIES:  MANNING
     WIDTH  CROSSFALL  IN-  / OUT-/PARK-  HEIGHT  WIDTH  LIP   HIKE  FACTOR
NO.   (FT)     (FT)    SIDE / SIDE/ WAY    (FT)    (FT)  (FT)  (FT)    (n)
===  =====  =========  =================  ======  ===== ====== ===== =======
  1   30.0     20.0    0.018/0.018/0.020   0.67    2.00 0.0312 0.167 0.0150
  2   13.0      8.0    0.018/0.018/0.020   0.67    2.00 0.0312 0.167 0.0150
  3   25.0     15.0    0.018/0.018/0.020   0.67    2.00 0.0312 0.167 0.0150
  4   35.0     25.0    0.018/0.018/0.020   0.67    2.00 0.0312 0.167 0.0150
  5   20.0     15.0    0.018/0.018/0.020   0.67    2.00 0.0312 0.167 0.0150

  GLOBAL STREET FLOW-DEPTH CONSTRAINTS:
    1. Relative Flow-Depth =  0.20 FEET
       as (Maximum Allowable Street Flow Depth) - (Top-of-Curb)
    2. (Depth)*(Velocity) Constraint = 10.0 (FT*FT/S)
  *SIZE PIPE WITH A FLOW CAPACITY GREATER THAN
   OR EQUAL TO THE UPSTREAM TRIBUTARY PIPE.*
  *USER-SPECIFIED MINIMUM TOPOGRAPHIC SLOPE ADJUSTMENT NOT SELECTED

****************************************************************************
  FLOW PROCESS FROM NODE  21000.00 TO NODE  21010.00 IS CODE =  21
----------------------------------------------------------------------------
  >>>>>RATIONAL METHOD INITIAL SUBAREA ANALYSIS<<<<<
  >>USE TIME-OF-CONCENTRATION NOMOGRAPH FOR INITIAL SUBAREA<<
============================================================================
  INITIAL SUBAREA FLOW-LENGTH(FEET) =   505.00
  ELEVATION DATA: UPSTREAM(FEET) =   1107.50  DOWNSTREAM(FEET) =   1098.60

  Tc = K*[(LENGTH** 3.00)/(ELEVATION CHANGE)]**0.20
  SUBAREA ANALYSIS USED MINIMUM Tc(MIN.) =   13.063
  * 100 YEAR RAINFALL INTENSITY(INCH/HR) =  3.120
  SUBAREA Tc AND LOSS RATE DATA(AMC III):
   DEVELOPMENT TYPE/      SCS SOIL   AREA      Fp         Ap     SCS   Tc
      LAND USE             GROUP   (ACRES)  (INCH/HR)  (DECIMAL)  CN  (MIN.)
```

```
 PUBLIC PARK                B        0.50      0.42     0.850    76   13.06
 SUBAREA AVERAGE PERVIOUS LOSS RATE, Fp(INCH/HR) =  0.42
 SUBAREA AVERAGE PERVIOUS AREA FRACTION, Ap =  0.850
 SUBAREA RUNOFF(CFS) =      1.24
 TOTAL AREA(ACRES) =      0.50   PEAK FLOW RATE(CFS) =      1.24

****************************************************************************
 FLOW PROCESS FROM NODE  21010.00 TO NODE  21010.00 IS CODE =  81
----------------------------------------------------------------------------
 >>>>>ADDITION OF SUBAREA TO MAINLINE PEAK FLOW<<<<<
============================================================================
 MAINLINE Tc(MIN.) =   13.06
 * 100 YEAR RAINFALL INTENSITY(INCH/HR) =  3.120
 SUBAREA LOSS RATE DATA(AMC III):
  DEVELOPMENT TYPE/      SCS SOIL   AREA      Fp        Ap     SCS
      LAND USE            GROUP   (ACRES)  (INCH/HR)  (DECIMAL)  CN
 RESIDENTIAL
 "2 DWELLINGS/ACRE"         B        2.40      0.42     0.700    76
 SUBAREA AVERAGE PERVIOUS LOSS RATE, Fp(INCH/HR) =  0.42
 SUBAREA AVERAGE PERVIOUS AREA FRACTION, Ap =  0.700
 SUBAREA AREA(ACRES) =    2.40      SUBAREA RUNOFF(CFS) =    6.10
 EFFECTIVE AREA(ACRES) =      2.90   AREA-AVERAGED Fm(INCH/HR) =  0.31
 AREA-AVERAGED Fp(INCH/HR) =  0.42  AREA-AVERAGED Ap =  0.73
 TOTAL AREA(ACRES) =        2.9       PEAK FLOW RATE(CFS) =       7.34

****************************************************************************
 FLOW PROCESS FROM NODE  21010.00 TO NODE  21020.00 IS CODE =  51
----------------------------------------------------------------------------
 >>>>>COMPUTE TRAPEZOIDAL CHANNEL FLOW<<<<<
 >>>>>TRAVELTIME THRU SUBAREA (EXISTING ELEMENT)<<<<<
============================================================================
 ELEVATION DATA: UPSTREAM(FEET) =   1098.60  DOWNSTREAM(FEET) =   1097.80
 CHANNEL LENGTH THRU SUBAREA(FEET) =    523.00   CHANNEL SLOPE =  0.0015
 CHANNEL BASE(FEET) =    2.00   "Z" FACTOR =   2.000
 MANNING'S FACTOR = 0.030   MAXIMUM DEPTH(FEET) =   1.00

        ==>>WARNING: FLOW IN CHANNEL EXCEEDS CHANNEL
            CAPACITY( NORMAL DEPTH EQUAL TO SPECIFIED MAXIMUM
            ALLOWABLE DEPTH).
            AS AN APPROXIMATION, FLOWDEPTH IS SET AT MAXIMUM
            ALLOWABLE DEPTH AND IS USED FOR TRAVELTIME CALCULATIONS.

 * 100 YEAR RAINFALL INTENSITY(INCH/HR) =  2.623
 SUBAREA LOSS RATE DATA(AMC III):
  DEVELOPMENT TYPE/      SCS SOIL   AREA      Fp        Ap     SCS
      LAND USE            GROUP   (ACRES)  (INCH/HR)  (DECIMAL)  CN
 PUBLIC PARK                B        0.60      0.42     0.850    76
 SUBAREA AVERAGE PERVIOUS LOSS RATE, Fp(INCH/HR) =  0.42
 SUBAREA AVERAGE PERVIOUS AREA FRACTION, Ap =  0.850
 TRAVEL TIME COMPUTED USING ESTIMATED FLOW(CFS) =       7.96
 TRAVEL TIME THRU SUBAREA BASED ON VELOCITY(FEET/SEC.) =   1.99
 AVERAGE FLOW DEPTH(FEET) =   1.00   TRAVEL TIME(MIN.) =   4.38
 Tc(MIN.) =   17.45
 SUBAREA AREA(ACRES) =     0.60       SUBAREA RUNOFF(CFS) =    1.22
 EFFECTIVE AREA(ACRES) =      3.50     AREA-AVERAGED Fm(INCH/HR) =   0.32
 AREA-AVERAGED Fp(INCH/HR) =   0.42  AREA-AVERAGED Ap =   0.75
 TOTAL AREA(ACRES) =        3.5         PEAK FLOW RATE(CFS) =       7.34
 NOTE: PEAK FLOW RATE DEFAULTED TO UPSTREAM VALUE

        ==>>WARNING: FLOW IN CHANNEL EXCEEDS CHANNEL
            CAPACITY( NORMAL DEPTH EQUAL TO SPECIFIED MAXIMUM
            ALLOWABLE DEPTH).
            AS AN APPROXIMATION, FLOWDEPTH IS SET AT MAXIMUM
            ALLOWABLE DEPTH AND IS USED FOR TRAVELTIME CALCULATIONS.


 END OF SUBAREA CHANNEL FLOW HYDRAULICS:
 DEPTH(FEET) =  1.00   FLOW VELOCITY(FEET/SEC.) =   1.84

 ==>FLOWDEPTH EXCEEDS MAXIMUM ALLOWABLE DEPTH
```

```
 LONGEST FLOWPATH FROM NODE  21000.00 TO NODE  21020.00 =    1028.00 FEET.

****************************************************************************
 FLOW PROCESS FROM NODE  21020.00 TO NODE  21020.00 IS CODE =  81
----------------------------------------------------------------------------
 >>>>>ADDITION OF SUBAREA TO MAINLINE PEAK FLOW<<<<<
============================================================================
 MAINLINE Tc(MIN.) =   17.45
 * 100 YEAR RAINFALL INTENSITY(INCH/HR) =  2.623
 SUBAREA LOSS RATE DATA(AMC III):
  DEVELOPMENT TYPE/      SCS SOIL   AREA      Fp         Ap     SCS
     LAND USE            GROUP   (ACRES)  (INCH/HR)  (DECIMAL)  CN
 RESIDENTIAL
 "2 DWELLINGS/ACRE"         B       11.60      0.42     0.700    76
 SUBAREA AVERAGE PERVIOUS LOSS RATE, Fp(INCH/HR) =  0.42
 SUBAREA AVERAGE PERVIOUS AREA FRACTION, Ap =  0.700
 SUBAREA AREA(ACRES) =   11.60      SUBAREA RUNOFF(CFS) =   24.29
 EFFECTIVE AREA(ACRES) =     15.10   AREA-AVERAGED Fm(INCH/HR) =  0.30
 AREA-AVERAGED Fp(INCH/HR) =  0.42  AREA-AVERAGED Ap =  0.71
 TOTAL AREA(ACRES) =       15.1       PEAK FLOW RATE(CFS) =      31.56

****************************************************************************
 FLOW PROCESS FROM NODE  21020.00 TO NODE  21030.00 IS CODE =  51
----------------------------------------------------------------------------
 >>>>>COMPUTE TRAPEZOIDAL CHANNEL FLOW<<<<<
 >>>>>TRAVELTIME THRU SUBAREA (EXISTING ELEMENT)<<<<<
============================================================================
 ELEVATION DATA: UPSTREAM(FEET) =   1097.80  DOWNSTREAM(FEET) =   1092.90
 CHANNEL LENGTH THRU SUBAREA(FEET) =   315.00   CHANNEL SLOPE =  0.0156
 CHANNEL BASE(FEET) =    2.00   "Z" FACTOR =   2.000
 MANNING'S FACTOR = 0.030   MAXIMUM DEPTH(FEET) =   1.00

        ==>>WARNING: FLOW IN CHANNEL EXCEEDS CHANNEL
            CAPACITY( NORMAL DEPTH EQUAL TO SPECIFIED MAXIMUM
            ALLOWABLE DEPTH).
            AS AN APPROXIMATION, FLOWDEPTH IS SET AT MAXIMUM
            ALLOWABLE DEPTH AND IS USED FOR TRAVELTIME CALCULATIONS.

 * 100 YEAR RAINFALL INTENSITY(INCH/HR) =  2.565
 SUBAREA LOSS RATE DATA(AMC III):
  DEVELOPMENT TYPE/      SCS SOIL   AREA      Fp         Ap     SCS
     LAND USE            GROUP   (ACRES)  (INCH/HR)  (DECIMAL)  CN
 PUBLIC PARK                B        0.40      0.42     0.850    76
 SUBAREA AVERAGE PERVIOUS LOSS RATE, Fp(INCH/HR) =  0.42
 SUBAREA AVERAGE PERVIOUS AREA FRACTION, Ap =  0.850
 TRAVEL TIME COMPUTED USING ESTIMATED FLOW(CFS) =      31.96
 TRAVEL TIME THRU SUBAREA BASED ON VELOCITY(FEET/SEC.) =   7.99
 AVERAGE FLOW DEPTH(FEET) =   1.00   TRAVEL TIME(MIN.) =   0.66
 Tc(MIN.) =   18.10
 SUBAREA AREA(ACRES) =     0.40       SUBAREA RUNOFF(CFS) =    0.79
 EFFECTIVE AREA(ACRES) =     15.50     AREA-AVERAGED Fm(INCH/HR) =   0.30
 AREA-AVERAGED Fp(INCH/HR) =   0.42  AREA-AVERAGED Ap =   0.71
 TOTAL AREA(ACRES) =       15.5         PEAK FLOW RATE(CFS) =      31.57

        ==>>WARNING: FLOW IN CHANNEL EXCEEDS CHANNEL
            CAPACITY( NORMAL DEPTH EQUAL TO SPECIFIED MAXIMUM
            ALLOWABLE DEPTH).
            AS AN APPROXIMATION, FLOWDEPTH IS SET AT MAXIMUM
            ALLOWABLE DEPTH AND IS USED FOR TRAVELTIME CALCULATIONS.


 END OF SUBAREA CHANNEL FLOW HYDRAULICS:
 DEPTH(FEET) =  1.00   FLOW VELOCITY(FEET/SEC.) =   7.89

 ==>FLOWDEPTH EXCEEDS MAXIMUM ALLOWABLE DEPTH

 LONGEST FLOWPATH FROM NODE  21000.00 TO NODE  21030.00 =    1343.00 FEET.

****************************************************************************
 FLOW PROCESS FROM NODE  21030.00 TO NODE  21030.00 IS CODE =  81
----------------------------------------------------------------------------
```

```
  >>>>>ADDITION OF SUBAREA TO MAINLINE PEAK FLOW<<<<<
==============================================================================
  MAINLINE Tc(MIN.) =   18.10
  * 100 YEAR RAINFALL INTENSITY(INCH/HR) =  2.565
  SUBAREA LOSS RATE DATA(AMC III):
   DEVELOPMENT TYPE/      SCS SOIL   AREA      Fp         Ap     SCS
       LAND USE            GROUP   (ACRES)  (INCH/HR)  (DECIMAL)  CN
  RESIDENTIAL
  "1 DWELLING/ACRE"          B        2.90      0.42     0.800    76
  SUBAREA AVERAGE PERVIOUS LOSS RATE, Fp(INCH/HR) =  0.42
  SUBAREA AVERAGE PERVIOUS AREA FRACTION, Ap =  0.800
  SUBAREA AREA(ACRES) =    2.90      SUBAREA RUNOFF(CFS) =    5.81
  EFFECTIVE AREA(ACRES) =     18.40   AREA-AVERAGED Fm(INCH/HR) =  0.31
  AREA-AVERAGED Fp(INCH/HR) =  0.42  AREA-AVERAGED Ap =  0.73
  TOTAL AREA(ACRES) =       18.4       PEAK FLOW RATE(CFS) =      37.38

****************************************************************************
  FLOW PROCESS FROM NODE  21030.00 TO NODE  21040.00 IS CODE =  51
----------------------------------------------------------------------------
  >>>>>COMPUTE TRAPEZOIDAL CHANNEL FLOW<<<<<
  >>>>>TRAVELTIME THRU SUBAREA (EXISTING ELEMENT)<<<<<
==============================================================================
  ELEVATION DATA: UPSTREAM(FEET) =   1092.90  DOWNSTREAM(FEET) =   1084.00
  CHANNEL LENGTH THRU SUBAREA(FEET) =   884.00   CHANNEL SLOPE =  0.0101
  CHANNEL BASE(FEET) =    2.00   "Z" FACTOR =   2.000
  MANNING'S FACTOR = 0.030   MAXIMUM DEPTH(FEET) =   1.00

         ==>>WARNING: FLOW IN CHANNEL EXCEEDS CHANNEL
             CAPACITY( NORMAL DEPTH EQUAL TO SPECIFIED MAXIMUM
             ALLOWABLE DEPTH).
             AS AN APPROXIMATION, FLOWDEPTH IS SET AT MAXIMUM
             ALLOWABLE DEPTH AND IS USED FOR TRAVELTIME CALCULATIONS.

  * 100 YEAR RAINFALL INTENSITY(INCH/HR) =  2.443
  SUBAREA LOSS RATE DATA(AMC III):
   DEVELOPMENT TYPE/      SCS SOIL   AREA      Fp         Ap     SCS
       LAND USE            GROUP   (ACRES)  (INCH/HR)  (DECIMAL)  CN
  PUBLIC PARK                B        1.00      0.42     0.850    76
  SUBAREA AVERAGE PERVIOUS LOSS RATE, Fp(INCH/HR) =  0.42
  SUBAREA AVERAGE PERVIOUS AREA FRACTION, Ap =  0.850
  TRAVEL TIME COMPUTED USING ESTIMATED FLOW(CFS) =      38.32
  TRAVEL TIME THRU SUBAREA BASED ON VELOCITY(FEET/SEC.) =   9.58
  AVERAGE FLOW DEPTH(FEET) =   1.00   TRAVEL TIME(MIN.) =   1.54
  Tc(MIN.) =   19.64
  SUBAREA AREA(ACRES) =     1.00       SUBAREA RUNOFF(CFS) =    1.88
  EFFECTIVE AREA(ACRES) =     19.40     AREA-AVERAGED Fm(INCH/HR) =   0.31
  AREA-AVERAGED Fp(INCH/HR) =   0.42  AREA-AVERAGED Ap =   0.73
  TOTAL AREA(ACRES) =       19.4         PEAK FLOW RATE(CFS) =      37.38
  NOTE: PEAK FLOW RATE DEFAULTED TO UPSTREAM VALUE

         ==>>WARNING: FLOW IN CHANNEL EXCEEDS CHANNEL
             CAPACITY( NORMAL DEPTH EQUAL TO SPECIFIED MAXIMUM
             ALLOWABLE DEPTH).
             AS AN APPROXIMATION, FLOWDEPTH IS SET AT MAXIMUM
             ALLOWABLE DEPTH AND IS USED FOR TRAVELTIME CALCULATIONS.


  END OF SUBAREA CHANNEL FLOW HYDRAULICS:
  DEPTH(FEET) =  1.00   FLOW VELOCITY(FEET/SEC.) =   9.35

  ==>FLOWDEPTH EXCEEDS MAXIMUM ALLOWABLE DEPTH

  LONGEST FLOWPATH FROM NODE  21000.00 TO NODE  21040.00 =    2227.00 FEET.

****************************************************************************
  FLOW PROCESS FROM NODE  21040.00 TO NODE  21040.00 IS CODE =  81
----------------------------------------------------------------------------
  >>>>>ADDITION OF SUBAREA TO MAINLINE PEAK FLOW<<<<<
==============================================================================
  MAINLINE Tc(MIN.) =   19.64
  * 100 YEAR RAINFALL INTENSITY(INCH/HR) =  2.443
```

```
  SUBAREA LOSS RATE DATA(AMC III):
   DEVELOPMENT TYPE/      SCS SOIL   AREA      Fp         Ap     SCS
       LAND USE            GROUP   (ACRES)  (INCH/HR)  (DECIMAL)  CN
  RESIDENTIAL
  "2 DWELLINGS/ACRE"         B        5.30      0.42     0.700    76
  SUBAREA AVERAGE PERVIOUS LOSS RATE, Fp(INCH/HR) =  0.42
  SUBAREA AVERAGE PERVIOUS AREA FRACTION, Ap =  0.700
  SUBAREA AREA(ACRES) =    5.30      SUBAREA RUNOFF(CFS) =   10.24
  EFFECTIVE AREA(ACRES) =     24.70   AREA-AVERAGED Fm(INCH/HR) =  0.31
  AREA-AVERAGED Fp(INCH/HR) =  0.42  AREA-AVERAGED Ap =  0.73
  TOTAL AREA(ACRES) =       24.7       PEAK FLOW RATE(CFS) =      47.47

****************************************************************************
  FLOW PROCESS FROM NODE  21040.00 TO NODE  21050.00 IS CODE =  51
----------------------------------------------------------------------------
  >>>>>COMPUTE TRAPEZOIDAL CHANNEL FLOW<<<<<
  >>>>>TRAVELTIME THRU SUBAREA (EXISTING ELEMENT)<<<<<
============================================================================
  ELEVATION DATA: UPSTREAM(FEET) =   1084.00  DOWNSTREAM(FEET) =   1080.50
  CHANNEL LENGTH THRU SUBAREA(FEET) =   288.00   CHANNEL SLOPE =  0.0122
  CHANNEL BASE(FEET) =    2.00   "Z" FACTOR =   2.000
  MANNING'S FACTOR = 0.030   MAXIMUM DEPTH(FEET) =   1.00

         ==>>WARNING: FLOW IN CHANNEL EXCEEDS CHANNEL
             CAPACITY( NORMAL DEPTH EQUAL TO SPECIFIED MAXIMUM
             ALLOWABLE DEPTH).
             AS AN APPROXIMATION, FLOWDEPTH IS SET AT MAXIMUM
             ALLOWABLE DEPTH AND IS USED FOR TRAVELTIME CALCULATIONS.

  * 100 YEAR RAINFALL INTENSITY(INCH/HR) =  2.413
  SUBAREA LOSS RATE DATA(AMC III):
   DEVELOPMENT TYPE/      SCS SOIL   AREA      Fp         Ap     SCS
       LAND USE            GROUP   (ACRES)  (INCH/HR)  (DECIMAL)  CN
  PUBLIC PARK                B        0.30      0.42     0.850    76
  SUBAREA AVERAGE PERVIOUS LOSS RATE, Fp(INCH/HR) =  0.42
  SUBAREA AVERAGE PERVIOUS AREA FRACTION, Ap =  0.850
  TRAVEL TIME COMPUTED USING ESTIMATED FLOW(CFS) =      47.75
  TRAVEL TIME THRU SUBAREA BASED ON VELOCITY(FEET/SEC.) =  11.94
  AVERAGE FLOW DEPTH(FEET) =   1.00   TRAVEL TIME(MIN.) =   0.40
  Tc(MIN.) =   20.04
  SUBAREA AREA(ACRES) =     0.30       SUBAREA RUNOFF(CFS) =    0.55
  EFFECTIVE AREA(ACRES) =     25.00     AREA-AVERAGED Fm(INCH/HR) =   0.31
  AREA-AVERAGED Fp(INCH/HR) =   0.42  AREA-AVERAGED Ap =   0.73
  TOTAL AREA(ACRES) =       25.0         PEAK FLOW RATE(CFS) =      47.47
  NOTE: PEAK FLOW RATE DEFAULTED TO UPSTREAM VALUE

         ==>>WARNING: FLOW IN CHANNEL EXCEEDS CHANNEL
             CAPACITY( NORMAL DEPTH EQUAL TO SPECIFIED MAXIMUM
             ALLOWABLE DEPTH).
             AS AN APPROXIMATION, FLOWDEPTH IS SET AT MAXIMUM
             ALLOWABLE DEPTH AND IS USED FOR TRAVELTIME CALCULATIONS.


  END OF SUBAREA CHANNEL FLOW HYDRAULICS:
  DEPTH(FEET) =  1.00   FLOW VELOCITY(FEET/SEC.) =  11.87

  ==>FLOWDEPTH EXCEEDS MAXIMUM ALLOWABLE DEPTH

  LONGEST FLOWPATH FROM NODE  21000.00 TO NODE  21050.00 =    2515.00 FEET.

****************************************************************************
  FLOW PROCESS FROM NODE  21050.00 TO NODE  21050.00 IS CODE =  81
----------------------------------------------------------------------------
  >>>>>ADDITION OF SUBAREA TO MAINLINE PEAK FLOW<<<<<
============================================================================
  MAINLINE Tc(MIN.) =   20.04
  * 100 YEAR RAINFALL INTENSITY(INCH/HR) =  2.413
  SUBAREA LOSS RATE DATA(AMC III):
   DEVELOPMENT TYPE/      SCS SOIL   AREA      Fp         Ap     SCS
       LAND USE            GROUP   (ACRES)  (INCH/HR)  (DECIMAL)  CN
  RESIDENTIAL
```

```
  "2 DWELLINGS/ACRE"         B       1.50      0.42     0.700    76
  SUBAREA AVERAGE PERVIOUS LOSS RATE, Fp(INCH/HR) =  0.42
  SUBAREA AVERAGE PERVIOUS AREA FRACTION, Ap =  0.700
  SUBAREA AREA(ACRES) =    1.50      SUBAREA RUNOFF(CFS) =    2.86
  EFFECTIVE AREA(ACRES) =     26.50   AREA-AVERAGED Fm(INCH/HR) =  0.31
  AREA-AVERAGED Fp(INCH/HR) =  0.42  AREA-AVERAGED Ap =  0.73
  TOTAL AREA(ACRES) =       26.5       PEAK FLOW RATE(CFS) =      50.23

****************************************************************************
  FLOW PROCESS FROM NODE  21050.00 TO NODE  21060.00 IS CODE =  51
----------------------------------------------------------------------------
  >>>>>COMPUTE TRAPEZOIDAL CHANNEL FLOW<<<<<
  >>>>>TRAVELTIME THRU SUBAREA (EXISTING ELEMENT)<<<<<
============================================================================
  ELEVATION DATA: UPSTREAM(FEET) =   1080.50  DOWNSTREAM(FEET) =   1079.30
  CHANNEL LENGTH THRU SUBAREA(FEET) =   246.00   CHANNEL SLOPE =  0.0049
  CHANNEL BASE(FEET) =    2.00   "Z" FACTOR =   2.000
  MANNING'S FACTOR = 0.030   MAXIMUM DEPTH(FEET) =   1.00

         ==>>WARNING: FLOW IN CHANNEL EXCEEDS CHANNEL
             CAPACITY( NORMAL DEPTH EQUAL TO SPECIFIED MAXIMUM
             ALLOWABLE DEPTH).
             AS AN APPROXIMATION, FLOWDEPTH IS SET AT MAXIMUM
             ALLOWABLE DEPTH AND IS USED FOR TRAVELTIME CALCULATIONS.

  * 100 YEAR RAINFALL INTENSITY(INCH/HR) =  2.390
  SUBAREA LOSS RATE DATA(AMC III):
   DEVELOPMENT TYPE/      SCS SOIL   AREA      Fp        Ap     SCS
       LAND USE            GROUP   (ACRES)  (INCH/HR)  (DECIMAL)  CN
  PUBLIC PARK                B       0.30      0.42     0.850    76
  SUBAREA AVERAGE PERVIOUS LOSS RATE, Fp(INCH/HR) =  0.42
  SUBAREA AVERAGE PERVIOUS AREA FRACTION, Ap =  0.850
  TRAVEL TIME COMPUTED USING ESTIMATED FLOW(CFS) =      50.50
  TRAVEL TIME THRU SUBAREA BASED ON VELOCITY(FEET/SEC.) =  12.63
  AVERAGE FLOW DEPTH(FEET) =   1.00   TRAVEL TIME(MIN.) =   0.32
  Tc(MIN.) =   20.37
  SUBAREA AREA(ACRES) =     0.30       SUBAREA RUNOFF(CFS) =    0.55
  EFFECTIVE AREA(ACRES) =     26.80     AREA-AVERAGED Fm(INCH/HR) =   0.31
  AREA-AVERAGED Fp(INCH/HR) =   0.42  AREA-AVERAGED Ap =   0.73
  TOTAL AREA(ACRES) =       26.8         PEAK FLOW RATE(CFS) =      50.23
  NOTE: PEAK FLOW RATE DEFAULTED TO UPSTREAM VALUE

         ==>>WARNING: FLOW IN CHANNEL EXCEEDS CHANNEL
             CAPACITY( NORMAL DEPTH EQUAL TO SPECIFIED MAXIMUM
             ALLOWABLE DEPTH).
             AS AN APPROXIMATION, FLOWDEPTH IS SET AT MAXIMUM
             ALLOWABLE DEPTH AND IS USED FOR TRAVELTIME CALCULATIONS.


  END OF SUBAREA CHANNEL FLOW HYDRAULICS:
  DEPTH(FEET) =  1.00   FLOW VELOCITY(FEET/SEC.) =  12.56

  ==>FLOWDEPTH EXCEEDS MAXIMUM ALLOWABLE DEPTH

  LONGEST FLOWPATH FROM NODE  21000.00 TO NODE  21060.00 =    2761.00 FEET.

****************************************************************************
  FLOW PROCESS FROM NODE  21060.00 TO NODE  21060.00 IS CODE =  81
----------------------------------------------------------------------------
  >>>>>ADDITION OF SUBAREA TO MAINLINE PEAK FLOW<<<<<
============================================================================
  MAINLINE Tc(MIN.) =   20.37
  * 100 YEAR RAINFALL INTENSITY(INCH/HR) =  2.390
  SUBAREA LOSS RATE DATA(AMC III):
   DEVELOPMENT TYPE/      SCS SOIL   AREA      Fp        Ap     SCS
       LAND USE            GROUP   (ACRES)  (INCH/HR)  (DECIMAL)  CN
  RESIDENTIAL
  "2 DWELLINGS/ACRE"         B       1.30      0.42     0.700    76
  SUBAREA AVERAGE PERVIOUS LOSS RATE, Fp(INCH/HR) =  0.42
  SUBAREA AVERAGE PERVIOUS AREA FRACTION, Ap =  0.700
  SUBAREA AREA(ACRES) =    1.30      SUBAREA RUNOFF(CFS) =    2.45
```

```
  EFFECTIVE AREA(ACRES) =     28.10   AREA-AVERAGED Fm(INCH/HR) =  0.31
  AREA-AVERAGED Fp(INCH/HR) =  0.42  AREA-AVERAGED Ap =  0.73
  TOTAL AREA(ACRES) =       28.1       PEAK FLOW RATE(CFS) =      52.67

****************************************************************************
  FLOW PROCESS FROM NODE  21060.00 TO NODE  21070.00 IS CODE =  51
----------------------------------------------------------------------------
  >>>>>COMPUTE TRAPEZOIDAL CHANNEL FLOW<<<<<
  >>>>>TRAVELTIME THRU SUBAREA (EXISTING ELEMENT)<<<<<
============================================================================
  ELEVATION DATA: UPSTREAM(FEET) =   1079.40  DOWNSTREAM(FEET) =   1079.20
  CHANNEL LENGTH THRU SUBAREA(FEET) =    82.00   CHANNEL SLOPE =  0.0024
  CHANNEL BASE(FEET) =    2.00   "Z" FACTOR =   2.000
  MANNING'S FACTOR = 0.030   MAXIMUM DEPTH(FEET) =   1.00

         ==>>WARNING: FLOW IN CHANNEL EXCEEDS CHANNEL
             CAPACITY( NORMAL DEPTH EQUAL TO SPECIFIED MAXIMUM
             ALLOWABLE DEPTH).
             AS AN APPROXIMATION, FLOWDEPTH IS SET AT MAXIMUM
             ALLOWABLE DEPTH AND IS USED FOR TRAVELTIME CALCULATIONS.

  * 100 YEAR RAINFALL INTENSITY(INCH/HR) =  2.383
  SUBAREA LOSS RATE DATA(AMC III):
   DEVELOPMENT TYPE/      SCS SOIL   AREA      Fp         Ap     SCS
      LAND USE            GROUP   (ACRES)  (INCH/HR)  (DECIMAL)  CN
  PUBLIC PARK               B       0.10      0.42     0.850    76
  SUBAREA AVERAGE PERVIOUS LOSS RATE, Fp(INCH/HR) =  0.42
  SUBAREA AVERAGE PERVIOUS AREA FRACTION, Ap =  0.850
  TRAVEL TIME COMPUTED USING ESTIMATED FLOW(CFS) =      52.76
  TRAVEL TIME THRU SUBAREA BASED ON VELOCITY(FEET/SEC.) =  13.19
  AVERAGE FLOW DEPTH(FEET) =   1.00   TRAVEL TIME(MIN.) =   0.10
  Tc(MIN.) =   20.47
  SUBAREA AREA(ACRES) =     0.10       SUBAREA RUNOFF(CFS) =    0.18
  EFFECTIVE AREA(ACRES) =     28.20     AREA-AVERAGED Fm(INCH/HR) =   0.31
  AREA-AVERAGED Fp(INCH/HR) =   0.42  AREA-AVERAGED Ap =   0.73
  TOTAL AREA(ACRES) =       28.2         PEAK FLOW RATE(CFS) =      52.67
  NOTE: PEAK FLOW RATE DEFAULTED TO UPSTREAM VALUE

         ==>>WARNING: FLOW IN CHANNEL EXCEEDS CHANNEL
             CAPACITY( NORMAL DEPTH EQUAL TO SPECIFIED MAXIMUM
             ALLOWABLE DEPTH).
             AS AN APPROXIMATION, FLOWDEPTH IS SET AT MAXIMUM
             ALLOWABLE DEPTH AND IS USED FOR TRAVELTIME CALCULATIONS.


  END OF SUBAREA CHANNEL FLOW HYDRAULICS:
  DEPTH(FEET) =  1.00   FLOW VELOCITY(FEET/SEC.) =  13.17

  ==>FLOWDEPTH EXCEEDS MAXIMUM ALLOWABLE DEPTH

  LONGEST FLOWPATH FROM NODE  21000.00 TO NODE  21070.00 =    2843.00 FEET.

****************************************************************************
  FLOW PROCESS FROM NODE  21070.00 TO NODE  21080.00 IS CODE =  62
----------------------------------------------------------------------------
  >>>>>COMPUTE STREET FLOW TRAVEL TIME THRU SUBAREA<<<<<
  >>>>>(STREET TABLE SECTION #  5 USED)<<<<<
============================================================================
  UPSTREAM ELEVATION(FEET) = 1079.20  DOWNSTREAM ELEVATION(FEET) = 1079.00
  STREET LENGTH(FEET) =    66.00   CURB HEIGHT(INCHES) =  8.0
  STREET HALFWIDTH(FEET) = 20.00

  DISTANCE FROM CROWN TO CROSSFALL GRADEBREAK(FEET) =  15.00
  INSIDE STREET CROSSFALL(DECIMAL) =  0.018
  OUTSIDE STREET CROSSFALL(DECIMAL)  =  0.018

  SPECIFIED NUMBER OF HALFSTREETS CARRYING RUNOFF =  1
  STREET PARKWAY CROSSFALL(DECIMAL)  =  0.020
  Manning's FRICTION FACTOR for Streetflow Section(curb-to-curb) =   0.0150
  Manning's FRICTION FACTOR for Back-of-Walk Flow Section =   0.0150
```

```
    **TRAVEL TIME COMPUTED USING ESTIMATED FLOW(CFS) =      53.04
    ***STREET FLOWING FULL***
    STREETFLOW MODEL RESULTS USING ESTIMATED FLOW:
    STREET FLOW DEPTH(FEET) =  0.76
    HALFSTREET FLOOD WIDTH(FEET) =   24.89
    AVERAGE FLOW VELOCITY(FEET/SEC.) =    2.99
    PRODUCT OF DEPTH&VELOCITY(FT*FT/SEC.) =    2.28
  STREET FLOW TRAVEL TIME(MIN.) =   0.37   Tc(MIN.) =   20.84
  * 100 YEAR RAINFALL INTENSITY(INCH/HR) =  2.358
  SUBAREA LOSS RATE DATA(AMC III):
   DEVELOPMENT TYPE/      SCS SOIL   AREA      Fp         Ap     SCS
       LAND USE            GROUP   (ACRES)  (INCH/HR)  (DECIMAL)  CN
  RESIDENTIAL
  "1 DWELLING/ACRE"          B        0.40      0.42     0.800    76
  SUBAREA AVERAGE PERVIOUS LOSS RATE, Fp(INCH/HR) =  0.42
  SUBAREA AVERAGE PERVIOUS AREA FRACTION, Ap =  0.800
  SUBAREA AREA(ACRES) =    0.40      SUBAREA RUNOFF(CFS) =    0.73
  EFFECTIVE AREA(ACRES) =     28.60    AREA-AVERAGED Fm(INCH/HR) =  0.31
  AREA-AVERAGED Fp(INCH/HR) =  0.42  AREA-AVERAGED Ap =  0.73
  TOTAL AREA(ACRES) =       28.6        PEAK FLOW RATE(CFS) =      52.75

  END OF SUBAREA STREET FLOW HYDRAULICS:
  DEPTH(FEET) = 0.76   HALFSTREET FLOOD WIDTH(FEET) =  24.83
  FLOW VELOCITY(FEET/SEC.) =  2.98   DEPTH*VELOCITY(FT*FT/SEC.) =   2.28
  LONGEST FLOWPATH FROM NODE  21000.00 TO NODE  21080.00 =    2909.00 FEET.
============================================================================
  END OF STUDY SUMMARY:
  TOTAL AREA(ACRES)     =       28.6  TC(MIN.) =     20.84
  EFFECTIVE AREA(ACRES) =     28.60  AREA-AVERAGED Fm(INCH/HR)=  0.31
  AREA-AVERAGED Fp(INCH/HR) =  0.42  AREA-AVERAGED Ap = 0.728
  PEAK FLOW RATE(CFS)   =      52.75
============================================================================
============================================================================
  END OF RATIONAL METHOD ANALYSIS
```

```
____________________________________________________________________________
****************************************************************************
             RATIONAL METHOD HYDROLOGY COMPUTER PROGRAM PACKAGE
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             Ver. 15.0  Release Date: 04/01/2008  License ID 1555

                           Analysis prepared by:




 ************************** DESCRIPTION OF STUDY **************************
 * REDLANDS PASSENGER RAIL                                                  *
 * EXISTING HYDROLOGY 100 YEAR STORM                                        *
 * BASIN 22000                                                              *
 **************************************************************************

  FILE NAME: C:\RPRP\EPRP\22000.DAT
  TIME/DATE OF STUDY: 14:36 02/16/2012
============================================================================
  USER SPECIFIED HYDROLOGY AND HYDRAULIC MODEL INFORMATION:
============================================================================
                    --*TIME-OF-CONCENTRATION MODEL*--

  USER SPECIFIED STORM EVENT(YEAR) =  100.00
  SPECIFIED MINIMUM PIPE SIZE(INCH) =  12.00
  SPECIFIED PERCENT OF GRADIENTS(DECIMAL) TO USE FOR FRICTION SLOPE = 0.90
  *USER-DEFINED LOGARITHMIC INTERPOLATION USED FOR RAINFALL*

  SLOPE OF INTENSITY DURATION CURVE(LOG(I;IN/HR) vs. LOG(Tc;MIN)) = 0.6000
  USER SPECIFIED 1-HOUR INTENSITY(INCH/HOUR) = 1.2500

  *ANTECEDENT MOISTURE CONDITION (AMC) III ASSUMED FOR RATIONAL METHOD*

  *USER-DEFINED STREET-SECTIONS FOR COUPLED PIPEFLOW AND STREETFLOW MODEL*
     HALF-  CROWN TO   STREET-CROSSFALL:   CURB  GUTTER-GEOMETRIES:  MANNING
     WIDTH  CROSSFALL  IN- / OUT-/PARK-  HEIGHT  WIDTH  LIP   HIKE  FACTOR
NO.   (FT)     (FT)    SIDE / SIDE/ WAY    (FT)    (FT)  (FT)  (FT)    (n)
===  =====  =========  =================  ======  ===== ====== ===== =======
  1   30.0     20.0    0.018/0.018/0.020   0.67    2.00 0.0312 0.167 0.0150
  2   13.0      8.0    0.018/0.018/0.020   0.67    2.00 0.0312 0.167 0.0150
  3   25.0     15.0    0.018/0.018/0.020   0.67    2.00 0.0312 0.167 0.0150
  4   35.0     25.0    0.018/0.018/0.020   0.67    2.00 0.0312 0.167 0.0150
  5   20.0     15.0    0.018/0.018/0.020   0.67    2.00 0.0312 0.167 0.0150

  GLOBAL STREET FLOW-DEPTH CONSTRAINTS:
    1. Relative Flow-Depth =  0.20 FEET
       as (Maximum Allowable Street Flow Depth) - (Top-of-Curb)
    2. (Depth)*(Velocity) Constraint = 10.0 (FT*FT/S)
  *SIZE PIPE WITH A FLOW CAPACITY GREATER THAN
   OR EQUAL TO THE UPSTREAM TRIBUTARY PIPE.*
  *USER-SPECIFIED MINIMUM TOPOGRAPHIC SLOPE ADJUSTMENT NOT SELECTED

****************************************************************************
  FLOW PROCESS FROM NODE  22000.00 TO NODE  22010.00 IS CODE =  21
----------------------------------------------------------------------------
  >>>>>RATIONAL METHOD INITIAL SUBAREA ANALYSIS<<<<<
  >>USE TIME-OF-CONCENTRATION NOMOGRAPH FOR INITIAL SUBAREA<<
============================================================================
  INITIAL SUBAREA FLOW-LENGTH(FEET) =   980.00
  ELEVATION DATA: UPSTREAM(FEET) =   1088.90  DOWNSTREAM(FEET) =   1079.50

  Tc = K*[(LENGTH** 3.00)/(ELEVATION CHANGE)]**0.20
  SUBAREA ANALYSIS USED MINIMUM Tc(MIN.) =   19.233
  * 100 YEAR RAINFALL INTENSITY(INCH/HR) =  2.474
  SUBAREA Tc AND LOSS RATE DATA(AMC III):
   DEVELOPMENT TYPE/      SCS SOIL   AREA      Fp         Ap     SCS   Tc
       LAND USE            GROUP   (ACRES)  (INCH/HR)  (DECIMAL)  CN  (MIN.)
```

```
  PUBLIC PARK                 B        0.60      0.42     0.850    76   19.23
  SUBAREA AVERAGE PERVIOUS LOSS RATE, Fp(INCH/HR) =  0.42
  SUBAREA AVERAGE PERVIOUS AREA FRACTION, Ap =  0.850
  SUBAREA RUNOFF(CFS) =      1.14
  TOTAL AREA(ACRES) =      0.60   PEAK FLOW RATE(CFS) =      1.14
============================================================================
  END OF STUDY SUMMARY:
  TOTAL AREA(ACRES)     =        0.6  TC(MIN.) =     19.23
  EFFECTIVE AREA(ACRES) =      0.60  AREA-AVERAGED Fm(INCH/HR)=  0.36
  AREA-AVERAGED Fp(INCH/HR) =  0.42  AREA-AVERAGED Ap = 0.850
  PEAK FLOW RATE(CFS)   =       1.14
============================================================================
============================================================================
  END OF RATIONAL METHOD ANALYSIS
```

```
____________________________________________________________________________
****************************************************************************
             RATIONAL METHOD HYDROLOGY COMPUTER PROGRAM PACKAGE
          (Reference: 1986 SAN BERNARDINO CO. HYDROLOGY CRITERION)
         (c) Copyright 1983-2008 Advanced Engineering Software (aes)
             Ver. 15.0  Release Date: 04/01/2008  License ID 1555

                           Analysis prepared by:





 ************************** DESCRIPTION OF STUDY **************************
* REDLANDS PASSENGER RAIL                                                  *
* EXISTING HYDROLOGY 100 YEAR STORM                                        *
* BASIN 23000                                                              *
 **************************************************************************

  FILE NAME: C:\RPRP\EPRP\23000.DAT
  TIME/DATE OF STUDY: 14:38 02/16/2012
============================================================================
  USER SPECIFIED HYDROLOGY AND HYDRAULIC MODEL INFORMATION:
============================================================================
                    --*TIME-OF-CONCENTRATION MODEL*--

  USER SPECIFIED STORM EVENT(YEAR) =  100.00
  SPECIFIED MINIMUM PIPE SIZE(INCH) =  12.00
  SPECIFIED PERCENT OF GRADIENTS(DECIMAL) TO USE FOR FRICTION SLOPE = 0.90
  *USER-DEFINED LOGARITHMIC INTERPOLATION USED FOR RAINFALL*

  SLOPE OF INTENSITY DURATION CURVE(LOG(I;IN/HR) vs. LOG(Tc;MIN)) = 0.6000
  USER SPECIFIED 1-HOUR INTENSITY(INCH/HOUR) = 1.2500

  *ANTECEDENT MOISTURE CONDITION (AMC) III ASSUMED FOR RATIONAL METHOD*

  *USER-DEFINED STREET-SECTIONS FOR COUPLED PIPEFLOW AND STREETFLOW MODEL*
     HALF-  CROWN TO   STREET-CROSSFALL:   CURB  GUTTER-GEOMETRIES:  MANNING
     WIDTH  CROSSFALL  IN-  / OUT-/PARK-  HEIGHT  WIDTH  LIP   HIKE  FACTOR
NO.   (FT)     (FT)    SIDE / SIDE/ WAY    (FT)    (FT)  (FT)  (FT)    (n)
===  =====  =========  =================  ======  ===== ====== ===== =======
  1   30.0     20.0    0.018/0.018/0.020   0.67    2.00 0.0312 0.167 0.0150
  2   13.0      8.0    0.018/0.018/0.020   0.67    2.00 0.0312 0.167 0.0150
  3   25.0     15.0    0.018/0.018/0.020   0.67    2.00 0.0312 0.167 0.0150
  4   35.0     25.0    0.018/0.018/0.020   0.67    2.00 0.0312 0.167 0.0150
  5   20.0     15.0    0.018/0.018/0.020   0.67    2.00 0.0312 0.167 0.0150

  GLOBAL STREET FLOW-DEPTH CONSTRAINTS:
    1. Relative Flow-Depth =  0.20 FEET
       as (Maximum Allowable Street Flow Depth) - (Top-of-Curb)
    2. (Depth)*(Velocity) Constraint = 10.0 (FT*FT/S)
  *SIZE PIPE WITH A FLOW CAPACITY GREATER THAN
   OR EQUAL TO THE UPSTREAM TRIBUTARY PIPE.*
  *USER-SPECIFIED MINIMUM TOPOGRAPHIC SLOPE ADJUSTMENT NOT SELECTED

****************************************************************************
  FLOW PROCESS FROM NODE  23000.00 TO NODE  23010.00 IS CODE =  21
----------------------------------------------------------------------------
  >>>>>RATIONAL METHOD INITIAL SUBAREA ANALYSIS<<<<<
  >>USE TIME-OF-CONCENTRATION NOMOGRAPH FOR INITIAL SUBAREA<<
============================================================================
  INITIAL SUBAREA FLOW-LENGTH(FEET) =   348.00
  ELEVATION DATA: UPSTREAM(FEET) =   1111.70  DOWNSTREAM(FEET) =   1107.00

  Tc = K*[(LENGTH** 3.00)/(ELEVATION CHANGE)]**0.20
  SUBAREA ANALYSIS USED MINIMUM Tc(MIN.) =   11.871
  * 100 YEAR RAINFALL INTENSITY(INCH/HR) =  3.305
  SUBAREA Tc AND LOSS RATE DATA(AMC III):
   DEVELOPMENT TYPE/      SCS SOIL   AREA      Fp         Ap     SCS   Tc
       LAND USE             GROUP   (ACRES)  (INCH/HR)  (DECIMAL)  CN  (MIN.)
```

```
  PUBLIC PARK                 B        0.60      0.42     0.850    76   11.87
  SUBAREA AVERAGE PERVIOUS LOSS RATE, Fp(INCH/HR) =  0.42
  SUBAREA AVERAGE PERVIOUS AREA FRACTION, Ap =  0.850
  SUBAREA RUNOFF(CFS) =      1.59
  TOTAL AREA(ACRES) =      0.60   PEAK FLOW RATE(CFS) =      1.59
============================================================================
  END OF STUDY SUMMARY:
  TOTAL AREA(ACRES)     =        0.6  TC(MIN.) =     11.87
  EFFECTIVE AREA(ACRES) =      0.60  AREA-AVERAGED Fm(INCH/HR)=  0.36
  AREA-AVERAGED Fp(INCH/HR) =  0.42  AREA-AVERAGED Ap = 0.850
  PEAK FLOW RATE(CFS)   =       1.59
============================================================================
============================================================================
  END OF RATIONAL METHOD ANALYSIS
```

```
****************************************************************************
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              Ver. 15.0  Release Date: 04/01/2008  License ID 1555

                           Analysis prepared by:




 ************************** DESCRIPTION OF STUDY **************************
* REDLANDS PASSENGER RAIL PROJECT                                          *
* EXISTING 100 YEAR ANALYSIS                                               *
* DRAINAGE AREA 24000                                                      *
 **************************************************************************

  FILE NAME: C:\RPRP\24000.DAT
  TIME/DATE OF STUDY: 11:40 06/18/2012
============================================================================
  USER SPECIFIED HYDROLOGY AND HYDRAULIC MODEL INFORMATION:
============================================================================
                    --*TIME-OF-CONCENTRATION MODEL*--

  USER SPECIFIED STORM EVENT(YEAR) =  100.00
  SPECIFIED MINIMUM PIPE SIZE(INCH) =  12.00
  SPECIFIED PERCENT OF GRADIENTS(DECIMAL) TO USE FOR FRICTION SLOPE = 0.90
  *USER-DEFINED LOGARITHMIC INTERPOLATION USED FOR RAINFALL*

  SLOPE OF INTENSITY DURATION CURVE(LOG(I;IN/HR) vs. LOG(Tc;MIN)) = 0.6000
  USER SPECIFIED 1-HOUR INTENSITY(INCH/HOUR) = 1.2500

  *ANTECEDENT MOISTURE CONDITION (AMC) III ASSUMED FOR RATIONAL METHOD*

  *USER-DEFINED STREET-SECTIONS FOR COUPLED PIPEFLOW AND STREETFLOW MODEL*
     HALF-  CROWN TO   STREET-CROSSFALL:   CURB  GUTTER-GEOMETRIES:  MANNING
     WIDTH  CROSSFALL  IN-  / OUT-/PARK-  HEIGHT  WIDTH  LIP   HIKE  FACTOR
NO.   (FT)     (FT)    SIDE / SIDE/ WAY    (FT)    (FT)  (FT)  (FT)    (n)
===  =====  =========  =================  ======   ===== ====== ===== =======
  1   30.0     20.0    0.018/0.018/0.020   0.67    2.00 0.0313 0.167 0.0150
  2   13.0      8.0    0.018/0.018/0.020   0.67    2.00 0.0313 0.167 0.0150
  3   25.0     15.0    0.018/0.018/0.020   0.67    2.00 0.0313 0.167 0.0150
  4   35.0     25.0    0.018/0.018/0.020   0.67    2.00 0.0313 0.167 0.0150
  5   20.0     15.0    0.018/0.018/0.020   0.67    2.00 0.0313 0.167 0.0150

  GLOBAL STREET FLOW-DEPTH CONSTRAINTS:
    1. Relative Flow-Depth =  0.20 FEET
       as (Maximum Allowable Street Flow Depth) - (Top-of-Curb)
    2. (Depth)*(Velocity) Constraint = 10.0 (FT*FT/S)
  *SIZE PIPE WITH A FLOW CAPACITY GREATER THAN
   OR EQUAL TO THE UPSTREAM TRIBUTARY PIPE.*
  *USER-SPECIFIED MINIMUM TOPOGRAPHIC SLOPE ADJUSTMENT NOT SELECTED

****************************************************************************
  FLOW PROCESS FROM NODE  24000.00 TO NODE  24005.00 IS CODE =  21
----------------------------------------------------------------------------
  >>>>>RATIONAL METHOD INITIAL SUBAREA ANALYSIS<<<<<
  >>USE TIME-OF-CONCENTRATION NOMOGRAPH FOR INITIAL SUBAREA<<
============================================================================
  INITIAL SUBAREA FLOW-LENGTH(FEET) =   973.00
  ELEVATION DATA: UPSTREAM(FEET) =   1279.00  DOWNSTREAM(FEET) =   1261.00

  Tc = K*[(LENGTH** 3.00)/(ELEVATION CHANGE)]**0.20
  SUBAREA ANALYSIS USED MINIMUM Tc(MIN.) =   10.585
  * 100 YEAR RAINFALL INTENSITY(INCH/HR) =  3.540
  SUBAREA Tc AND LOSS RATE DATA(AMC III):
   DEVELOPMENT TYPE/      SCS SOIL   AREA      Fp         Ap     SCS   Tc
       LAND USE            GROUP   (ACRES)  (INCH/HR)  (DECIMAL)  CN  (MIN.)
```

```
  COMMERCIAL                  B        0.90      0.42     0.100    76   10.58
  SUBAREA AVERAGE PERVIOUS LOSS RATE, Fp(INCH/HR) =  0.42
  SUBAREA AVERAGE PERVIOUS AREA FRACTION, Ap =  0.100
  SUBAREA RUNOFF(CFS) =      2.83
  TOTAL AREA(ACRES) =      0.90   PEAK FLOW RATE(CFS) =      2.83

****************************************************************************
  FLOW PROCESS FROM NODE  24005.00 TO NODE  24005.00 IS CODE =  81
----------------------------------------------------------------------------
  >>>>>ADDITION OF SUBAREA TO MAINLINE PEAK FLOW<<<<<
============================================================================
  MAINLINE Tc(MIN.) =   10.58
  * 100 YEAR RAINFALL INTENSITY(INCH/HR) =  3.540
  SUBAREA LOSS RATE DATA(AMC III):
   DEVELOPMENT TYPE/      SCS SOIL   AREA      Fp         Ap     SCS
       LAND USE            GROUP   (ACRES)  (INCH/HR)  (DECIMAL)  CN
  COMMERCIAL                  B        4.50      0.42     0.100    76
  SUBAREA AVERAGE PERVIOUS LOSS RATE, Fp(INCH/HR) =  0.42
  SUBAREA AVERAGE PERVIOUS AREA FRACTION, Ap =  0.100
  SUBAREA AREA(ACRES) =    4.50      SUBAREA RUNOFF(CFS) =   14.17
  EFFECTIVE AREA(ACRES) =      5.40   AREA-AVERAGED Fm(INCH/HR) =  0.04
  AREA-AVERAGED Fp(INCH/HR) =  0.42  AREA-AVERAGED Ap =  0.10
  TOTAL AREA(ACRES) =        5.4       PEAK FLOW RATE(CFS) =      17.00

****************************************************************************
  FLOW PROCESS FROM NODE  24005.00 TO NODE  24010.00 IS CODE =  62
----------------------------------------------------------------------------
  >>>>>COMPUTE STREET FLOW TRAVEL TIME THRU SUBAREA<<<<<
  >>>>>(STREET TABLE SECTION #  4 USED)<<<<<
============================================================================
  UPSTREAM ELEVATION(FEET) = 1261.00  DOWNSTREAM ELEVATION(FEET) = 1256.00
  STREET LENGTH(FEET) =   273.00   CURB HEIGHT(INCHES) =  8.0
  STREET HALFWIDTH(FEET) = 35.00

  DISTANCE FROM CROWN TO CROSSFALL GRADEBREAK(FEET) =  25.00
  INSIDE STREET CROSSFALL(DECIMAL) =  0.018
  OUTSIDE STREET CROSSFALL(DECIMAL)  =  0.018

  SPECIFIED NUMBER OF HALFSTREETS CARRYING RUNOFF =  1
  STREET PARKWAY CROSSFALL(DECIMAL)  =  0.020
  Manning's FRICTION FACTOR for Streetflow Section(curb-to-curb) =   0.0150
  Manning's FRICTION FACTOR for Back-of-Walk Flow Section =   0.0150

    **TRAVEL TIME COMPUTED USING ESTIMATED FLOW(CFS) =      17.44
    STREETFLOW MODEL RESULTS USING ESTIMATED FLOW:
    STREET FLOW DEPTH(FEET) =  0.53
    HALFSTREET FLOOD WIDTH(FEET) =   20.50
    AVERAGE FLOW VELOCITY(FEET/SEC.) =    4.39
    PRODUCT OF DEPTH&VELOCITY(FT*FT/SEC.) =    2.33
  STREET FLOW TRAVEL TIME(MIN.) =   1.04   Tc(MIN.) =   11.62
  * 100 YEAR RAINFALL INTENSITY(INCH/HR) =  3.347
  SUBAREA LOSS RATE DATA(AMC III):
   DEVELOPMENT TYPE/      SCS SOIL   AREA      Fp         Ap     SCS
       LAND USE            GROUP   (ACRES)  (INCH/HR)  (DECIMAL)  CN
  COMMERCIAL                  B        0.30      0.42     0.100    76
  SUBAREA AVERAGE PERVIOUS LOSS RATE, Fp(INCH/HR) =  0.42
  SUBAREA AVERAGE PERVIOUS AREA FRACTION, Ap =  0.100
  SUBAREA AREA(ACRES) =    0.30      SUBAREA RUNOFF(CFS) =    0.89
  EFFECTIVE AREA(ACRES) =      5.70    AREA-AVERAGED Fm(INCH/HR) =  0.04
  AREA-AVERAGED Fp(INCH/HR) =  0.42  AREA-AVERAGED Ap =  0.10
  TOTAL AREA(ACRES) =        5.7        PEAK FLOW RATE(CFS) =      17.00
  NOTE: PEAK FLOW RATE DEFAULTED TO UPSTREAM VALUE

  END OF SUBAREA STREET FLOW HYDRAULICS:
  DEPTH(FEET) = 0.53   HALFSTREET FLOOD WIDTH(FEET) =  20.21
  FLOW VELOCITY(FEET/SEC.) =  4.39   DEPTH*VELOCITY(FT*FT/SEC.) =   2.31
  LONGEST FLOWPATH FROM NODE  24000.00 TO NODE  24010.00 =    1246.00 FEET.

****************************************************************************
  FLOW PROCESS FROM NODE  24010.00 TO NODE  24010.00 IS CODE =  81
----------------------------------------------------------------------------
```

```
  >>>>>ADDITION OF SUBAREA TO MAINLINE PEAK FLOW<<<<<
==========================================================================
  MAINLINE Tc(MIN.) =   11.62
  * 100 YEAR RAINFALL INTENSITY(INCH/HR) =  3.347
  SUBAREA LOSS RATE DATA(AMC III):
   DEVELOPMENT TYPE/      SCS SOIL   AREA      Fp         Ap     SCS
       LAND USE            GROUP   (ACRES)  (INCH/HR)  (DECIMAL)  CN
  COMMERCIAL                 B        7.70      0.42     0.100    76
  SUBAREA AVERAGE PERVIOUS LOSS RATE, Fp(INCH/HR) =  0.42
  SUBAREA AVERAGE PERVIOUS AREA FRACTION, Ap =  0.100
  SUBAREA AREA(ACRES) =    7.70      SUBAREA RUNOFF(CFS) =   22.90
  EFFECTIVE AREA(ACRES) =     13.40   AREA-AVERAGED Fm(INCH/HR) =  0.04
  AREA-AVERAGED Fp(INCH/HR) =  0.42  AREA-AVERAGED Ap =  0.10
  TOTAL AREA(ACRES) =       13.4       PEAK FLOW RATE(CFS) =      39.85

****************************************************************************
  FLOW PROCESS FROM NODE  24010.00 TO NODE  24015.00 IS CODE =  62
----------------------------------------------------------------------------
  >>>>>COMPUTE STREET FLOW TRAVEL TIME THRU SUBAREA<<<<<
  >>>>>(STREET TABLE SECTION #  4 USED)<<<<<
==========================================================================
  UPSTREAM ELEVATION(FEET) = 1256.00  DOWNSTREAM ELEVATION(FEET) = 1248.00
  STREET LENGTH(FEET) =   490.00   CURB HEIGHT(INCHES) =  8.0
  STREET HALFWIDTH(FEET) = 35.00

  DISTANCE FROM CROWN TO CROSSFALL GRADEBREAK(FEET) =  25.00
  INSIDE STREET CROSSFALL(DECIMAL) =  0.018
  OUTSIDE STREET CROSSFALL(DECIMAL)  =  0.018

  SPECIFIED NUMBER OF HALFSTREETS CARRYING RUNOFF =  1
  STREET PARKWAY CROSSFALL(DECIMAL)  =  0.020
  Manning's FRICTION FACTOR for Streetflow Section(curb-to-curb) =   0.0150
  Manning's FRICTION FACTOR for Back-of-Walk Flow Section =   0.0150

    **TRAVEL TIME COMPUTED USING ESTIMATED FLOW(CFS) =      40.68
    STREETFLOW MODEL RESULTS USING ESTIMATED FLOW:
    STREET FLOW DEPTH(FEET) =  0.69
    HALFSTREET FLOOD WIDTH(FEET) =   30.24
    AVERAGE FLOW VELOCITY(FEET/SEC.) =    5.17
    PRODUCT OF DEPTH&VELOCITY(FT*FT/SEC.) =    3.55
  STREET FLOW TRAVEL TIME(MIN.) =   1.58   Tc(MIN.) =   13.20
  * 100 YEAR RAINFALL INTENSITY(INCH/HR) =  3.100
  SUBAREA LOSS RATE DATA(AMC III):
   DEVELOPMENT TYPE/      SCS SOIL   AREA      Fp         Ap     SCS
       LAND USE            GROUP   (ACRES)  (INCH/HR)  (DECIMAL)  CN
  COMMERCIAL                 B        0.60      0.42     0.100    76
  SUBAREA AVERAGE PERVIOUS LOSS RATE, Fp(INCH/HR) =  0.42
  SUBAREA AVERAGE PERVIOUS AREA FRACTION, Ap =  0.100
  SUBAREA AREA(ACRES) =    0.60      SUBAREA RUNOFF(CFS) =    1.65
  EFFECTIVE AREA(ACRES) =     14.00    AREA-AVERAGED Fm(INCH/HR) =  0.04
  AREA-AVERAGED Fp(INCH/HR) =  0.42  AREA-AVERAGED Ap =  0.10
  TOTAL AREA(ACRES) =       14.0        PEAK FLOW RATE(CFS) =      39.85
  NOTE: PEAK FLOW RATE DEFAULTED TO UPSTREAM VALUE

  END OF SUBAREA STREET FLOW HYDRAULICS:
  DEPTH(FEET) = 0.68   HALFSTREET FLOOD WIDTH(FEET) =  29.68
  FLOW VELOCITY(FEET/SEC.) =  5.17   DEPTH*VELOCITY(FT*FT/SEC.) =   3.53
  LONGEST FLOWPATH FROM NODE  24000.00 TO NODE  24015.00 =    1736.00 FEET.

****************************************************************************
  FLOW PROCESS FROM NODE  24015.00 TO NODE  24015.00 IS CODE =  81
----------------------------------------------------------------------------
  >>>>>ADDITION OF SUBAREA TO MAINLINE PEAK FLOW<<<<<
==========================================================================
  MAINLINE Tc(MIN.) =   13.20
  * 100 YEAR RAINFALL INTENSITY(INCH/HR) =  3.100
  SUBAREA LOSS RATE DATA(AMC III):
   DEVELOPMENT TYPE/      SCS SOIL   AREA      Fp         Ap     SCS
       LAND USE            GROUP   (ACRES)  (INCH/HR)  (DECIMAL)  CN
  COMMERCIAL                 B       10.30      0.42     0.100    76
  SUBAREA AVERAGE PERVIOUS LOSS RATE, Fp(INCH/HR) =  0.42
```

```
  SUBAREA AVERAGE PERVIOUS AREA FRACTION, Ap =  0.100
  SUBAREA AREA(ACRES) =   10.30      SUBAREA RUNOFF(CFS) =   28.35
  EFFECTIVE AREA(ACRES) =     24.30   AREA-AVERAGED Fm(INCH/HR) =  0.04
  AREA-AVERAGED Fp(INCH/HR) =  0.42  AREA-AVERAGED Ap =  0.10
  TOTAL AREA(ACRES) =       24.3       PEAK FLOW RATE(CFS) =      66.88

****************************************************************************
  FLOW PROCESS FROM NODE  24015.00 TO NODE  24020.00 IS CODE =  62
----------------------------------------------------------------------------
  >>>>>COMPUTE STREET FLOW TRAVEL TIME THRU SUBAREA<<<<<
  >>>>>(STREET TABLE SECTION #  4 USED)<<<<<
============================================================================
  UPSTREAM ELEVATION(FEET) = 1248.00  DOWNSTREAM ELEVATION(FEET) = 1245.00
  STREET LENGTH(FEET) =   180.00   CURB HEIGHT(INCHES) =  8.0
  STREET HALFWIDTH(FEET) = 35.00

  DISTANCE FROM CROWN TO CROSSFALL GRADEBREAK(FEET) =  25.00
  INSIDE STREET CROSSFALL(DECIMAL) =  0.018
  OUTSIDE STREET CROSSFALL(DECIMAL)  =  0.018

  SPECIFIED NUMBER OF HALFSTREETS CARRYING RUNOFF =  1
  STREET PARKWAY CROSSFALL(DECIMAL)  =  0.020
  Manning's FRICTION FACTOR for Streetflow Section(curb-to-curb) =   0.0150
  Manning's FRICTION FACTOR for Back-of-Walk Flow Section =   0.0150

    **TRAVEL TIME COMPUTED USING ESTIMATED FLOW(CFS) =      67.15
    ***STREET FLOW SPLITS OVER STREET-CROWN***
    FULL DEPTH(FEET) =    0.79   FLOOD WIDTH(FEET) =   41.28
    FULL HALF-STREET VELOCITY(FEET/SEC.) =    5.78
    SPLIT DEPTH(FEET) =    0.20   SPLIT FLOOD WIDTH(FEET) =    2.03
    SPLIT FLOW(CFS) =    0.05   SPLIT VELOCITY(FEET/SEC.) =    0.20
    STREETFLOW MODEL RESULTS USING ESTIMATED FLOW:
    STREET FLOW DEPTH(FEET) =  0.79
    HALFSTREET FLOOD WIDTH(FEET) =   41.28
    AVERAGE FLOW VELOCITY(FEET/SEC.) =    5.78
    PRODUCT OF DEPTH&VELOCITY(FT*FT/SEC.) =    4.58
  STREET FLOW TRAVEL TIME(MIN.) =   0.52   Tc(MIN.) =   13.72
  * 100 YEAR RAINFALL INTENSITY(INCH/HR) =  3.029
  SUBAREA LOSS RATE DATA(AMC III):
   DEVELOPMENT TYPE/      SCS SOIL   AREA      Fp         Ap     SCS
       LAND USE            GROUP   (ACRES)  (INCH/HR)  (DECIMAL)  CN
  COMMERCIAL                 B        0.20      0.42     0.100    76
  SUBAREA AVERAGE PERVIOUS LOSS RATE, Fp(INCH/HR) =  0.42
  SUBAREA AVERAGE PERVIOUS AREA FRACTION, Ap =  0.100
  SUBAREA AREA(ACRES) =    0.20      SUBAREA RUNOFF(CFS) =    0.54
  EFFECTIVE AREA(ACRES) =     24.50    AREA-AVERAGED Fm(INCH/HR) =  0.04
  AREA-AVERAGED Fp(INCH/HR) =  0.42  AREA-AVERAGED Ap =  0.10
  TOTAL AREA(ACRES) =       24.5        PEAK FLOW RATE(CFS) =      66.88
  NOTE: PEAK FLOW RATE DEFAULTED TO UPSTREAM VALUE

  END OF SUBAREA STREET FLOW HYDRAULICS:
  DEPTH(FEET) = 0.79   HALFSTREET FLOOD WIDTH(FEET) =  41.19
  FLOW VELOCITY(FEET/SEC.) =  5.78   DEPTH*VELOCITY(FT*FT/SEC.) =   4.57
  LONGEST FLOWPATH FROM NODE  24000.00 TO NODE  24020.00 =    1916.00 FEET.

****************************************************************************
  FLOW PROCESS FROM NODE  24020.00 TO NODE  24020.00 IS CODE =  81
----------------------------------------------------------------------------
  >>>>>ADDITION OF SUBAREA TO MAINLINE PEAK FLOW<<<<<
============================================================================
  MAINLINE Tc(MIN.) =   13.72
  * 100 YEAR RAINFALL INTENSITY(INCH/HR) =  3.029
  SUBAREA LOSS RATE DATA(AMC III):
   DEVELOPMENT TYPE/      SCS SOIL   AREA      Fp         Ap     SCS
       LAND USE            GROUP   (ACRES)  (INCH/HR)  (DECIMAL)  CN
  COMMERCIAL                 B        3.80      0.42     0.100    76
  SUBAREA AVERAGE PERVIOUS LOSS RATE, Fp(INCH/HR) =  0.42
  SUBAREA AVERAGE PERVIOUS AREA FRACTION, Ap =  0.100
  SUBAREA AREA(ACRES) =    3.80      SUBAREA RUNOFF(CFS) =   10.22
  EFFECTIVE AREA(ACRES) =     28.30   AREA-AVERAGED Fm(INCH/HR) =  0.04
  AREA-AVERAGED Fp(INCH/HR) =  0.42  AREA-AVERAGED Ap =  0.10
```

```
  TOTAL AREA(ACRES) =       28.3       PEAK FLOW RATE(CFS) =      76.08

****************************************************************************
  FLOW PROCESS FROM NODE  24020.00 TO NODE  24025.00 IS CODE =  62
----------------------------------------------------------------------------
  >>>>>COMPUTE STREET FLOW TRAVEL TIME THRU SUBAREA<<<<<
  >>>>>(STREET TABLE SECTION #  4 USED)<<<<<
============================================================================
  UPSTREAM ELEVATION(FEET) = 1245.00  DOWNSTREAM ELEVATION(FEET) = 1236.00
  STREET LENGTH(FEET) =   600.00   CURB HEIGHT(INCHES) =  8.0
  STREET HALFWIDTH(FEET) = 35.00

  DISTANCE FROM CROWN TO CROSSFALL GRADEBREAK(FEET) =  25.00
  INSIDE STREET CROSSFALL(DECIMAL) =  0.018
  OUTSIDE STREET CROSSFALL(DECIMAL)  =  0.018

  SPECIFIED NUMBER OF HALFSTREETS CARRYING RUNOFF =  1
  STREET PARKWAY CROSSFALL(DECIMAL)  =  0.020
  Manning's FRICTION FACTOR for Streetflow Section(curb-to-curb) =   0.0150
  Manning's FRICTION FACTOR for Back-of-Walk Flow Section =   0.0150

    **TRAVEL TIME COMPUTED USING ESTIMATED FLOW(CFS) =      77.33
    ***STREET FLOW SPLITS OVER STREET-CROWN***
    FULL DEPTH(FEET) =    0.79   FLOOD WIDTH(FEET) =   41.28
    FULL HALF-STREET VELOCITY(FEET/SEC.) =    5.48
    SPLIT DEPTH(FEET) =    0.51   SPLIT FLOOD WIDTH(FEET) =   19.33
    SPLIT FLOW(CFS) =   13.67   SPLIT VELOCITY(FEET/SEC.) =    3.85
    STREETFLOW MODEL RESULTS USING ESTIMATED FLOW:
    STREET FLOW DEPTH(FEET) =  0.79
    HALFSTREET FLOOD WIDTH(FEET) =   41.28
    AVERAGE FLOW VELOCITY(FEET/SEC.) =    5.48
    PRODUCT OF DEPTH&VELOCITY(FT*FT/SEC.) =    4.34
  STREET FLOW TRAVEL TIME(MIN.) =   1.82   Tc(MIN.) =   15.55
  * 100 YEAR RAINFALL INTENSITY(INCH/HR) =  2.811
  SUBAREA LOSS RATE DATA(AMC III):
   DEVELOPMENT TYPE/      SCS SOIL   AREA      Fp         Ap     SCS
       LAND USE            GROUP   (ACRES)  (INCH/HR)  (DECIMAL)  CN
  COMMERCIAL                 B       1.00      0.42     0.100    76
  SUBAREA AVERAGE PERVIOUS LOSS RATE, Fp(INCH/HR) =  0.42
  SUBAREA AVERAGE PERVIOUS AREA FRACTION, Ap =  0.100
  SUBAREA AREA(ACRES) =    1.00      SUBAREA RUNOFF(CFS) =    2.49
  EFFECTIVE AREA(ACRES) =     29.30    AREA-AVERAGED Fm(INCH/HR) =  0.04
  AREA-AVERAGED Fp(INCH/HR) =  0.42  AREA-AVERAGED Ap =  0.10
  TOTAL AREA(ACRES) =       29.3        PEAK FLOW RATE(CFS) =      76.08
  NOTE: PEAK FLOW RATE DEFAULTED TO UPSTREAM VALUE

  END OF SUBAREA STREET FLOW HYDRAULICS:
  DEPTH(FEET) = 0.79   HALFSTREET FLOOD WIDTH(FEET) =  41.28
  FLOW VELOCITY(FEET/SEC.) =  5.48   DEPTH*VELOCITY(FT*FT/SEC.) =   4.34
  LONGEST FLOWPATH FROM NODE  24000.00 TO NODE  24025.00 =    2516.00 FEET.

****************************************************************************
  FLOW PROCESS FROM NODE  24025.00 TO NODE  24025.00 IS CODE =  82
----------------------------------------------------------------------------
  >>>>>ADD SUBAREA RUNOFF TO MAINLINE, AT MAINLINE Tc,<<<<<
  >>>>>(AND COMPUTE INITIAL SUBAREA RUNOFF)<<<<<
============================================================================
  INITIAL SUBAREA FLOW-LENGTH(FEET) =  2520.00
  ELEVATION DATA: UPSTREAM(FEET) =   1279.00  DOWNSTREAM(FEET) =   1236.00

  Tc = K*[(LENGTH** 3.00)/(ELEVATION CHANGE)]**0.20
  SUBAREA ANALYSIS USED MINIMUM Tc(MIN.) =   15.741
  * 100 YEAR RAINFALL INTENSITY(INCH/HR) =  2.790
  SUBAREA Tc AND LOSS RATE DATA(AMC III):
   DEVELOPMENT TYPE/      SCS SOIL   AREA      Fp         Ap     SCS   Tc
       LAND USE            GROUP   (ACRES)  (INCH/HR)  (DECIMAL)  CN  (MIN.)
  COMMERCIAL                 B      10.10      0.42     0.100    76   15.74
  SUBAREA AVERAGE PERVIOUS LOSS RATE, Fp(INCH/HR) =  0.42
  SUBAREA AVERAGE PERVIOUS AREA FRACTION, Ap =  0.100
  SUBAREA AREA(ACRES) =   10.10   INITIAL SUBAREA RUNOFF(CFS) =   24.98
```

```
 ** ADD SUBAREA RUNOFF TO MAINLINE AT MAINLINE Tc:
 MAINLINE Tc(MIN.) =   15.55
 * 100 YEAR RAINFALL INTENSITY(INCH/HR) =  2.811
 SUBAREA AREA(ACRES) =   10.10      SUBAREA RUNOFF(CFS) =   25.17
 EFFECTIVE AREA(ACRES) =     39.40   AREA-AVERAGED Fm(INCH/HR) =  0.04
 AREA-AVERAGED Fp(INCH/HR) =  0.42  AREA-AVERAGED Ap =  0.10
 TOTAL AREA(ACRES) =       39.4       PEAK FLOW RATE(CFS) =      98.17

****************************************************************************
 FLOW PROCESS FROM NODE  24025.00 TO NODE  24025.00 IS CODE =   1
----------------------------------------------------------------------------
 >>>>>DESIGNATE INDEPENDENT STREAM FOR CONFLUENCE<<<<<
============================================================================
 TOTAL NUMBER OF STREAMS =  2
 CONFLUENCE VALUES USED FOR INDEPENDENT STREAM  1 ARE:
 TIME OF CONCENTRATION(MIN.) =   15.55
 RAINFALL INTENSITY(INCH/HR) =   2.81
 AREA-AVERAGED Fm(INCH/HR) =  0.04
 AREA-AVERAGED Fp(INCH/HR) =  0.42
 AREA-AVERAGED Ap =  0.10
 EFFECTIVE STREAM AREA(ACRES) =      39.40
 TOTAL STREAM AREA(ACRES) =      39.40
 PEAK FLOW RATE(CFS) AT CONFLUENCE =      98.17

****************************************************************************
 FLOW PROCESS FROM NODE  24030.00 TO NODE  24035.00 IS CODE =  21
----------------------------------------------------------------------------
 >>>>>RATIONAL METHOD INITIAL SUBAREA ANALYSIS<<<<<
 >>USE TIME-OF-CONCENTRATION NOMOGRAPH FOR INITIAL SUBAREA<<
============================================================================
 INITIAL SUBAREA FLOW-LENGTH(FEET) =   920.00
 ELEVATION DATA: UPSTREAM(FEET) =   1310.00  DOWNSTREAM(FEET) =   1287.00

 Tc = K*[(LENGTH** 3.00)/(ELEVATION CHANGE)]**0.20
 SUBAREA ANALYSIS USED MINIMUM Tc(MIN.) =   14.041
 * 100 YEAR RAINFALL INTENSITY(INCH/HR) =  2.988
 SUBAREA Tc AND LOSS RATE DATA(AMC III):
  DEVELOPMENT TYPE/      SCS SOIL   AREA      Fp         Ap     SCS   Tc
      LAND USE            GROUP   (ACRES)  (INCH/HR)  (DECIMAL)  CN  (MIN.)
 RESIDENTIAL
 "2 DWELLINGS/ACRE"         B        2.20      0.42     0.700    76   14.04
 SUBAREA AVERAGE PERVIOUS LOSS RATE, Fp(INCH/HR) =  0.42
 SUBAREA AVERAGE PERVIOUS AREA FRACTION, Ap =  0.700
 SUBAREA RUNOFF(CFS) =      5.33
 TOTAL AREA(ACRES) =      2.20   PEAK FLOW RATE(CFS) =      5.33

****************************************************************************
 FLOW PROCESS FROM NODE  24035.00 TO NODE  24040.00 IS CODE =  41
----------------------------------------------------------------------------
 >>>>>COMPUTE PIPE-FLOW TRAVEL TIME THRU SUBAREA<<<<<
 >>>>>USING USER-SPECIFIED PIPESIZE (EXISTING ELEMENT)<<<<<
============================================================================
 ELEVATION DATA: UPSTREAM(FEET) =  1287.00  DOWNSTREAM(FEET) =  1269.00
 FLOW LENGTH(FEET) =   450.00   MANNING'S N =  0.013
 DEPTH OF FLOW IN  24.0 INCH PIPE IS   5.7 INCHES
 PIPE-FLOW VELOCITY(FEET/SEC.) =   9.30
 GIVEN PIPE DIAMETER(INCH) =  24.00    NUMBER OF PIPES =   1
 PIPE-FLOW(CFS) =       5.33
 PIPE TRAVEL TIME(MIN.) =   0.81    Tc(MIN.) =   14.85
 LONGEST FLOWPATH FROM NODE  24030.00 TO NODE  24040.00 =    1370.00 FEET.

****************************************************************************
 FLOW PROCESS FROM NODE  24040.00 TO NODE  24040.00 IS CODE =  81
----------------------------------------------------------------------------
 >>>>>ADDITION OF SUBAREA TO MAINLINE PEAK FLOW<<<<<
============================================================================
 MAINLINE Tc(MIN.) =   14.85
 * 100 YEAR RAINFALL INTENSITY(INCH/HR) =  2.889
 SUBAREA LOSS RATE DATA(AMC III):
  DEVELOPMENT TYPE/      SCS SOIL   AREA      Fp         Ap     SCS
      LAND USE            GROUP   (ACRES)  (INCH/HR)  (DECIMAL)  CN
```

```
  RESIDENTIAL
  "2 DWELLINGS/ACRE"          B       12.60      0.42     0.700    76
  SUBAREA AVERAGE PERVIOUS LOSS RATE, Fp(INCH/HR) =  0.42
  SUBAREA AVERAGE PERVIOUS AREA FRACTION, Ap =  0.700
  SUBAREA AREA(ACRES) =   12.60      SUBAREA RUNOFF(CFS) =   29.41
  EFFECTIVE AREA(ACRES) =     14.80   AREA-AVERAGED Fm(INCH/HR) =  0.30
  AREA-AVERAGED Fp(INCH/HR) =  0.42  AREA-AVERAGED Ap =  0.70
  TOTAL AREA(ACRES) =       14.8       PEAK FLOW RATE(CFS) =      34.54

****************************************************************************
  FLOW PROCESS FROM NODE  24040.00 TO NODE  24045.00 IS CODE =  41
----------------------------------------------------------------------------
  >>>>>COMPUTE PIPE-FLOW TRAVEL TIME THRU SUBAREA<<<<<
  >>>>>USING USER-SPECIFIED PIPESIZE (EXISTING ELEMENT)<<<<<
============================================================================
  ELEVATION DATA: UPSTREAM(FEET) =  1269.00  DOWNSTREAM(FEET) =  1253.00
  FLOW LENGTH(FEET) =   940.00   MANNING'S N =  0.013
  DEPTH OF FLOW IN  30.0 INCH PIPE IS  18.1 INCHES
  PIPE-FLOW VELOCITY(FEET/SEC.) =  11.12
  GIVEN PIPE DIAMETER(INCH) =  30.00    NUMBER OF PIPES =   1
  PIPE-FLOW(CFS) =      34.54
  PIPE TRAVEL TIME(MIN.) =   1.41    Tc(MIN.) =   16.26
  LONGEST FLOWPATH FROM NODE  24030.00 TO NODE  24045.00 =    2310.00 FEET.

****************************************************************************
  FLOW PROCESS FROM NODE  24045.00 TO NODE  24045.00 IS CODE =  81
----------------------------------------------------------------------------
  >>>>>ADDITION OF SUBAREA TO MAINLINE PEAK FLOW<<<<<
============================================================================
  MAINLINE Tc(MIN.) =   16.26
  * 100 YEAR RAINFALL INTENSITY(INCH/HR) =  2.736
  SUBAREA LOSS RATE DATA(AMC III):
   DEVELOPMENT TYPE/      SCS SOIL   AREA      Fp         Ap     SCS
       LAND USE            GROUP   (ACRES)  (INCH/HR)  (DECIMAL)  CN
  RESIDENTIAL
  "2 DWELLINGS/ACRE"          B       10.60      0.42     0.700    76
  SUBAREA AVERAGE PERVIOUS LOSS RATE, Fp(INCH/HR) =  0.42
  SUBAREA AVERAGE PERVIOUS AREA FRACTION, Ap =  0.700
  SUBAREA AREA(ACRES) =   10.60      SUBAREA RUNOFF(CFS) =   23.28
  EFFECTIVE AREA(ACRES) =     25.40   AREA-AVERAGED Fm(INCH/HR) =  0.30
  AREA-AVERAGED Fp(INCH/HR) =  0.42  AREA-AVERAGED Ap =  0.70
  TOTAL AREA(ACRES) =       25.4       PEAK FLOW RATE(CFS) =      55.79

****************************************************************************
  FLOW PROCESS FROM NODE  24045.00 TO NODE  24050.00 IS CODE =  41
----------------------------------------------------------------------------
  >>>>>COMPUTE PIPE-FLOW TRAVEL TIME THRU SUBAREA<<<<<
  >>>>>USING USER-SPECIFIED PIPESIZE (EXISTING ELEMENT)<<<<<
============================================================================
  ELEVATION DATA: UPSTREAM(FEET) =  1253.00  DOWNSTREAM(FEET) =  1242.00
  FLOW LENGTH(FEET) =   500.00   MANNING'S N =  0.013
  DEPTH OF FLOW IN  30.0 INCH PIPE IS  23.7 INCHES
  PIPE-FLOW VELOCITY(FEET/SEC.) =  13.39
  GIVEN PIPE DIAMETER(INCH) =  30.00    NUMBER OF PIPES =   1
  PIPE-FLOW(CFS) =      55.79
  PIPE TRAVEL TIME(MIN.) =   0.62    Tc(MIN.) =   16.88
  LONGEST FLOWPATH FROM NODE  24030.00 TO NODE  24050.00 =    2810.00 FEET.

****************************************************************************
  FLOW PROCESS FROM NODE  24050.00 TO NODE  24050.00 IS CODE =  81
----------------------------------------------------------------------------
  >>>>>ADDITION OF SUBAREA TO MAINLINE PEAK FLOW<<<<<
============================================================================
  MAINLINE Tc(MIN.) =   16.88
  * 100 YEAR RAINFALL INTENSITY(INCH/HR) =  2.675
  SUBAREA LOSS RATE DATA(AMC III):
   DEVELOPMENT TYPE/      SCS SOIL   AREA      Fp         Ap     SCS
       LAND USE            GROUP   (ACRES)  (INCH/HR)  (DECIMAL)  CN
  RESIDENTIAL
  "2 DWELLINGS/ACRE"          B        7.10      0.42     0.700    76
  SUBAREA AVERAGE PERVIOUS LOSS RATE, Fp(INCH/HR) =  0.42
```

```
  SUBAREA AVERAGE PERVIOUS AREA FRACTION, Ap =  0.700
  SUBAREA AREA(ACRES) =    7.10      SUBAREA RUNOFF(CFS) =   15.20
  EFFECTIVE AREA(ACRES) =     32.50   AREA-AVERAGED Fm(INCH/HR) =  0.30
  AREA-AVERAGED Fp(INCH/HR) =  0.42  AREA-AVERAGED Ap =  0.70
  TOTAL AREA(ACRES) =       32.5       PEAK FLOW RATE(CFS) =      69.60

****************************************************************************
  FLOW PROCESS FROM NODE  24050.00 TO NODE  24025.00 IS CODE =  62
----------------------------------------------------------------------------
  >>>>>COMPUTE STREET FLOW TRAVEL TIME THRU SUBAREA<<<<<
  >>>>>(STREET TABLE SECTION #  4 USED)<<<<<
============================================================================
  UPSTREAM ELEVATION(FEET) = 1242.00  DOWNSTREAM ELEVATION(FEET) = 1236.00
  STREET LENGTH(FEET) =  1307.00   CURB HEIGHT(INCHES) =  8.0
  STREET HALFWIDTH(FEET) = 35.00

  DISTANCE FROM CROWN TO CROSSFALL GRADEBREAK(FEET) =  25.00
  INSIDE STREET CROSSFALL(DECIMAL) =  0.018
  OUTSIDE STREET CROSSFALL(DECIMAL)  =  0.018

  SPECIFIED NUMBER OF HALFSTREETS CARRYING RUNOFF =  1
  STREET PARKWAY CROSSFALL(DECIMAL)  =  0.020
  Manning's FRICTION FACTOR for Streetflow Section(curb-to-curb) =   0.0150
  Manning's FRICTION FACTOR for Back-of-Walk Flow Section =   0.0150

    **TRAVEL TIME COMPUTED USING ESTIMATED FLOW(CFS) =      80.96
    ***STREET FLOWING FULL***
    STREETFLOW MODEL RESULTS USING ESTIMATED FLOW:
    STREET FLOW DEPTH(FEET) =  0.82
    HALFSTREET FLOOD WIDTH(FEET) =   42.59
    AVERAGE FLOW VELOCITY(FEET/SEC.) =    3.18
    PRODUCT OF DEPTH&VELOCITY(FT*FT/SEC.) =    2.61
  STREET FLOW TRAVEL TIME(MIN.) =   6.84   Tc(MIN.) =   23.72
  * 100 YEAR RAINFALL INTENSITY(INCH/HR) =  2.181
  SUBAREA LOSS RATE DATA(AMC III):
   DEVELOPMENT TYPE/      SCS SOIL   AREA      Fp         Ap     SCS
       LAND USE            GROUP   (ACRES)  (INCH/HR)  (DECIMAL)  CN
  COMMERCIAL                 B      11.80      0.42     0.100    76
  SUBAREA AVERAGE PERVIOUS LOSS RATE, Fp(INCH/HR) =  0.42
  SUBAREA AVERAGE PERVIOUS AREA FRACTION, Ap =  0.100
  SUBAREA AREA(ACRES) =   11.80      SUBAREA RUNOFF(CFS) =   22.72
  EFFECTIVE AREA(ACRES) =     44.30    AREA-AVERAGED Fm(INCH/HR) =  0.23
  AREA-AVERAGED Fp(INCH/HR) =  0.42  AREA-AVERAGED Ap =  0.54
  TOTAL AREA(ACRES) =       44.3        PEAK FLOW RATE(CFS) =      77.86

  END OF SUBAREA STREET FLOW HYDRAULICS:
  DEPTH(FEET) = 0.81   HALFSTREET FLOOD WIDTH(FEET) =  42.23
  FLOW VELOCITY(FEET/SEC.) =  3.14   DEPTH*VELOCITY(FT*FT/SEC.) =   2.55
  *NOTE: INITIAL SUBAREA NOMOGRAPH WITH SUBAREA PARAMETERS,
         AND L = 1307.0 FT WITH ELEVATION-DROP =   6.0 FT, IS   29.2 CFS,
         WHICH EXCEEDS THE TOP-OF-CURB STREET CAPACITY AT NODE  24025.00
  LONGEST FLOWPATH FROM NODE  24030.00 TO NODE  24025.00 =    4117.00 FEET.

****************************************************************************
  FLOW PROCESS FROM NODE  24025.00 TO NODE  24025.00 IS CODE =   1
----------------------------------------------------------------------------
  >>>>>DESIGNATE INDEPENDENT STREAM FOR CONFLUENCE<<<<<
  >>>>>AND COMPUTE VARIOUS CONFLUENCED STREAM VALUES<<<<<
============================================================================
  TOTAL NUMBER OF STREAMS =  2
  CONFLUENCE VALUES USED FOR INDEPENDENT STREAM  2 ARE:
  TIME OF CONCENTRATION(MIN.) =   23.72
  RAINFALL INTENSITY(INCH/HR) =   2.18
  AREA-AVERAGED Fm(INCH/HR) =  0.23
  AREA-AVERAGED Fp(INCH/HR) =  0.42
  AREA-AVERAGED Ap =  0.54
  EFFECTIVE STREAM AREA(ACRES) =      44.30
  TOTAL STREAM AREA(ACRES) =      44.30
  PEAK FLOW RATE(CFS) AT CONFLUENCE =      77.86

  ** CONFLUENCE DATA **
```

```
  STREAM      Q      Tc   Intensity   Fp(Fm)     Ap     Ae     HEADWATER
  NUMBER     (CFS)  (MIN.) (INCH/HR) (INCH/HR)         (ACRES)    NODE
     1       98.17   15.55    2.811  0.42( 0.04) 0.10      39.4   24000.00
     2       77.86   23.72    2.181  0.42( 0.23) 0.54      44.3   24030.00

 RAINFALL INTENSITY AND TIME OF CONCENTRATION RATIO
 CONFLUENCE FORMULA USED FOR  2 STREAMS.

 ** PEAK FLOW RATE TABLE **
  STREAM      Q      Tc   Intensity   Fp(Fm)     Ap     Ae     HEADWATER
  NUMBER     (CFS)  (MIN.) (INCH/HR) (INCH/HR)         (ACRES)    NODE
     1      165.65   15.55    2.811  0.42( 0.12) 0.29      68.4   24000.00
     2      153.72   23.72    2.181  0.42( 0.14) 0.33      83.7   24030.00

 COMPUTED CONFLUENCE ESTIMATES ARE AS FOLLOWS:
 PEAK FLOW RATE(CFS) =     165.65    Tc(MIN.) =    15.55
 EFFECTIVE AREA(ACRES) =      68.43   AREA-AVERAGED Fm(INCH/HR) =  0.12
 AREA-AVERAGED Fp(INCH/HR) =  0.42  AREA-AVERAGED Ap =  0.29
 TOTAL AREA(ACRES) =       83.7
 LONGEST FLOWPATH FROM NODE  24030.00 TO NODE  24025.00 =    4117.00 FEET.

****************************************************************************
 FLOW PROCESS FROM NODE  24025.00 TO NODE  24055.00 IS CODE =  41
----------------------------------------------------------------------------
 >>>>>COMPUTE PIPE-FLOW TRAVEL TIME THRU SUBAREA<<<<<
 >>>>>USING USER-SPECIFIED PIPESIZE (EXISTING ELEMENT)<<<<<
============================================================================
 ELEVATION DATA: UPSTREAM(FEET) =  1230.00  DOWNSTREAM(FEET) =  1205.00
 FLOW LENGTH(FEET) =  1650.00   MANNING'S N =  0.013
 DEPTH OF FLOW IN  48.0 INCH PIPE IS  38.8 INCHES
 PIPE-FLOW VELOCITY(FEET/SEC.) =  15.22
 GIVEN PIPE DIAMETER(INCH) =  48.00    NUMBER OF PIPES =   1
 PIPE-FLOW(CFS) =     165.65
 PIPE TRAVEL TIME(MIN.) =   1.81    Tc(MIN.) =   17.35
 LONGEST FLOWPATH FROM NODE  24030.00 TO NODE  24055.00 =    5767.00 FEET.

****************************************************************************
 FLOW PROCESS FROM NODE  24055.00 TO NODE  24055.00 IS CODE =  81
----------------------------------------------------------------------------
 >>>>>ADDITION OF SUBAREA TO MAINLINE PEAK FLOW<<<<<
============================================================================
 MAINLINE Tc(MIN.) =   17.35
 * 100 YEAR RAINFALL INTENSITY(INCH/HR) =  2.631
 SUBAREA LOSS RATE DATA(AMC III):
  DEVELOPMENT TYPE/      SCS SOIL   AREA      Fp         Ap     SCS
      LAND USE            GROUP   (ACRES)  (INCH/HR)  (DECIMAL)  CN
 PUBLIC PARK                B       29.10      0.42     0.850    76
 SUBAREA AVERAGE PERVIOUS LOSS RATE, Fp(INCH/HR) =  0.42
 SUBAREA AVERAGE PERVIOUS AREA FRACTION, Ap =  0.850
 SUBAREA AREA(ACRES) =    29.10      SUBAREA RUNOFF(CFS) =   59.50
 EFFECTIVE AREA(ACRES) =     97.53   AREA-AVERAGED Fm(INCH/HR) =  0.19
 AREA-AVERAGED Fp(INCH/HR) =  0.42  AREA-AVERAGED Ap =  0.45
 TOTAL AREA(ACRES) =      112.8       PEAK FLOW RATE(CFS) =     214.09

****************************************************************************
 FLOW PROCESS FROM NODE  24055.00 TO NODE  24060.00 IS CODE =  41
----------------------------------------------------------------------------
 >>>>>COMPUTE PIPE-FLOW TRAVEL TIME THRU SUBAREA<<<<<
 >>>>>USING USER-SPECIFIED PIPESIZE (EXISTING ELEMENT)<<<<<
============================================================================
 ELEVATION DATA: UPSTREAM(FEET) =  1205.00  DOWNSTREAM(FEET) =  1190.00
 FLOW LENGTH(FEET) =  1090.00   MANNING'S N =  0.013
 ASSUME FULL-FLOWING PIPELINE
 PIPE-FLOW VELOCITY(FEET/SEC.) =  14.52
 PIPE FLOW VELOCITY = (TOTAL FLOW)/(PIPE CROSS SECTION AREA)
 GIVEN PIPE DIAMETER(INCH) =  52.00    NUMBER OF PIPES =   1
 PIPE-FLOW(CFS) =     214.09
 PIPE TRAVEL TIME(MIN.) =   1.25    Tc(MIN.) =   18.60
 LONGEST FLOWPATH FROM NODE  24030.00 TO NODE  24060.00 =    6857.00 FEET.

****************************************************************************
```

```
  FLOW PROCESS FROM NODE  24060.00 TO NODE  24060.00 IS CODE =  81
----------------------------------------------------------------------------
  >>>>>ADDITION OF SUBAREA TO MAINLINE PEAK FLOW<<<<<
============================================================================
  MAINLINE Tc(MIN.) =   18.60
  * 100 YEAR RAINFALL INTENSITY(INCH/HR) =  2.524
  SUBAREA LOSS RATE DATA(AMC III):
   DEVELOPMENT TYPE/      SCS SOIL   AREA      Fp         Ap     SCS
       LAND USE            GROUP   (ACRES)  (INCH/HR)  (DECIMAL)  CN
  CONDOMINIUMS               B       11.00      0.42     0.350    76
  SUBAREA AVERAGE PERVIOUS LOSS RATE, Fp(INCH/HR) =  0.42
  SUBAREA AVERAGE PERVIOUS AREA FRACTION, Ap =  0.350
  SUBAREA AREA(ACRES) =   11.00      SUBAREA RUNOFF(CFS) =   23.52
  EFFECTIVE AREA(ACRES) =    108.53   AREA-AVERAGED Fm(INCH/HR) =  0.19
  AREA-AVERAGED Fp(INCH/HR) =  0.42  AREA-AVERAGED Ap =  0.44
  TOTAL AREA(ACRES) =      123.8       PEAK FLOW RATE(CFS) =     228.16

****************************************************************************
  FLOW PROCESS FROM NODE  24060.00 TO NODE  24065.00 IS CODE =  41
----------------------------------------------------------------------------
  >>>>>COMPUTE PIPE-FLOW TRAVEL TIME THRU SUBAREA<<<<<
  >>>>>USING USER-SPECIFIED PIPESIZE (EXISTING ELEMENT)<<<<<
============================================================================
  ELEVATION DATA: UPSTREAM(FEET) =  1190.00  DOWNSTREAM(FEET) =  1155.00
  FLOW LENGTH(FEET) =  2675.00   MANNING'S N =  0.013
  ASSUME FULL-FLOWING PIPELINE
  PIPE-FLOW VELOCITY(FEET/SEC.) =  15.47
  PIPE FLOW VELOCITY = (TOTAL FLOW)/(PIPE CROSS SECTION AREA)
  GIVEN PIPE DIAMETER(INCH) =  52.00    NUMBER OF PIPES =   1
  PIPE-FLOW(CFS) =     228.16
  PIPE TRAVEL TIME(MIN.) =   2.88    Tc(MIN.) =   21.49
  LONGEST FLOWPATH FROM NODE  24030.00 TO NODE  24065.00 =    9532.00 FEET.

****************************************************************************
  FLOW PROCESS FROM NODE  24065.00 TO NODE  24065.00 IS CODE =  81
----------------------------------------------------------------------------
  >>>>>ADDITION OF SUBAREA TO MAINLINE PEAK FLOW<<<<<
============================================================================
  MAINLINE Tc(MIN.) =   21.49
  * 100 YEAR RAINFALL INTENSITY(INCH/HR) =  2.315
  SUBAREA LOSS RATE DATA(AMC III):
   DEVELOPMENT TYPE/      SCS SOIL   AREA      Fp         Ap     SCS
       LAND USE            GROUP   (ACRES)  (INCH/HR)  (DECIMAL)  CN
  CONDOMINIUMS               B      209.60      0.42     0.350    76
  SUBAREA AVERAGE PERVIOUS LOSS RATE, Fp(INCH/HR) =  0.42
  SUBAREA AVERAGE PERVIOUS AREA FRACTION, Ap =  0.350
  SUBAREA AREA(ACRES) =  209.60      SUBAREA RUNOFF(CFS) =  408.73
  EFFECTIVE AREA(ACRES) =    318.13   AREA-AVERAGED Fm(INCH/HR) =  0.16
  AREA-AVERAGED Fp(INCH/HR) =  0.42  AREA-AVERAGED Ap =  0.38
  TOTAL AREA(ACRES) =      333.4       PEAK FLOW RATE(CFS) =     616.48

****************************************************************************
  FLOW PROCESS FROM NODE  24065.00 TO NODE  24070.00 IS CODE =  41
----------------------------------------------------------------------------
  >>>>>COMPUTE PIPE-FLOW TRAVEL TIME THRU SUBAREA<<<<<
  >>>>>USING USER-SPECIFIED PIPESIZE (EXISTING ELEMENT)<<<<<
============================================================================
  ELEVATION DATA: UPSTREAM(FEET) =  1155.00  DOWNSTREAM(FEET) =  1104.00
  FLOW LENGTH(FEET) =  4780.00   MANNING'S N =  0.013
  ASSUME FULL-FLOWING PIPELINE
  PIPE-FLOW VELOCITY(FEET/SEC.) =  21.80
  PIPE FLOW VELOCITY = (TOTAL FLOW)/(PIPE CROSS SECTION AREA)
  GIVEN PIPE DIAMETER(INCH) =  72.00    NUMBER OF PIPES =   1
  PIPE-FLOW(CFS) =     616.48
  PIPE TRAVEL TIME(MIN.) =   3.65    Tc(MIN.) =   25.14
  LONGEST FLOWPATH FROM NODE  24030.00 TO NODE  24070.00 =   14312.00 FEET.

****************************************************************************
  FLOW PROCESS FROM NODE  24070.00 TO NODE  24070.00 IS CODE =  81
----------------------------------------------------------------------------
  >>>>>ADDITION OF SUBAREA TO MAINLINE PEAK FLOW<<<<<
```

```
============================================================================
  MAINLINE Tc(MIN.) =   25.14
  * 100 YEAR RAINFALL INTENSITY(INCH/HR) =  2.107
  SUBAREA LOSS RATE DATA(AMC III):
   DEVELOPMENT TYPE/      SCS SOIL   AREA      Fp         Ap     SCS
       LAND USE            GROUP   (ACRES)  (INCH/HR)  (DECIMAL)  CN
  CONDOMINIUMS               B       48.70      0.42     0.350    76
  SUBAREA AVERAGE PERVIOUS LOSS RATE, Fp(INCH/HR) =  0.42
  SUBAREA AVERAGE PERVIOUS AREA FRACTION, Ap =  0.350
  SUBAREA AREA(ACRES) =   48.70      SUBAREA RUNOFF(CFS) =   85.84
  EFFECTIVE AREA(ACRES) =    366.83   AREA-AVERAGED Fm(INCH/HR) =  0.16
  AREA-AVERAGED Fp(INCH/HR) =  0.42  AREA-AVERAGED Ap =  0.38
  TOTAL AREA(ACRES) =      382.1       PEAK FLOW RATE(CFS) =     642.73
============================================================================
  END OF STUDY SUMMARY:
  TOTAL AREA(ACRES)     =      382.1  TC(MIN.) =     25.14
  EFFECTIVE AREA(ACRES) =    366.83  AREA-AVERAGED Fm(INCH/HR)=  0.16
  AREA-AVERAGED Fp(INCH/HR) =  0.42  AREA-AVERAGED Ap = 0.378
  PEAK FLOW RATE(CFS)   =     642.73

  ** PEAK FLOW RATE TABLE **
   STREAM       Q      Tc   Intensity   Fp(Fm)     Ap     Ae     HEADWATER
   NUMBER     (CFS)  (MIN.) (INCH/HR) (INCH/HR)         (ACRES)    NODE
      1      642.73   25.14    2.107  0.42( 0.16) 0.38     366.8   24000.00
      2      545.66   34.27    1.749  0.42( 0.16) 0.38     382.1   24030.00
============================================================================
============================================================================
  END OF RATIONAL METHOD ANALYSIS
```

```
****************************************************************************
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                           Analysis prepared by:




 ************************** DESCRIPTION OF STUDY **************************
 * REDLANDS PASSENGER RAIL PROJECT                                          *
 * EXISTING 100 YEAR ANALYSIS                                               *
 * DRAINAGE AREA 24100                                                      *
 **************************************************************************

  FILE NAME: C:\RPRP\24100.DAT
  TIME/DATE OF STUDY: 11:01 06/18/2012
============================================================================
  USER SPECIFIED HYDROLOGY AND HYDRAULIC MODEL INFORMATION:
============================================================================
                    --*TIME-OF-CONCENTRATION MODEL*--

  USER SPECIFIED STORM EVENT(YEAR) =  100.00
  SPECIFIED MINIMUM PIPE SIZE(INCH) =  12.00
  SPECIFIED PERCENT OF GRADIENTS(DECIMAL) TO USE FOR FRICTION SLOPE = 0.90
  *USER-DEFINED LOGARITHMIC INTERPOLATION USED FOR RAINFALL*

  SLOPE OF INTENSITY DURATION CURVE(LOG(I;IN/HR) vs. LOG(Tc;MIN)) = 0.6000
  USER SPECIFIED 1-HOUR INTENSITY(INCH/HOUR) = 1.2500

  *ANTECEDENT MOISTURE CONDITION (AMC) III ASSUMED FOR RATIONAL METHOD*

  *USER-DEFINED STREET-SECTIONS FOR COUPLED PIPEFLOW AND STREETFLOW MODEL*
     HALF-  CROWN TO   STREET-CROSSFALL:   CURB  GUTTER-GEOMETRIES:  MANNING
     WIDTH  CROSSFALL  IN-  / OUT-/PARK-  HEIGHT  WIDTH  LIP   HIKE  FACTOR
NO.   (FT)     (FT)    SIDE / SIDE/ WAY    (FT)    (FT)  (FT)  (FT)    (n)
===  =====  =========  =================  ======  ===== ====== ===== =======
  1   30.0     20.0    0.018/0.018/0.020   0.67    2.00 0.0313 0.167 0.0150
  2   13.0      8.0    0.018/0.018/0.020   0.67    2.00 0.0313 0.167 0.0150
  3   25.0     15.0    0.018/0.018/0.020   0.67    2.00 0.0313 0.167 0.0150
  4   35.0     25.0    0.018/0.018/0.020   0.67    2.00 0.0313 0.167 0.0150
  5   20.0     15.0    0.018/0.018/0.020   0.67    2.00 0.0313 0.167 0.0150

  GLOBAL STREET FLOW-DEPTH CONSTRAINTS:
    1. Relative Flow-Depth =  0.20 FEET
       as (Maximum Allowable Street Flow Depth) - (Top-of-Curb)
    2. (Depth)*(Velocity) Constraint = 10.0 (FT*FT/S)
  *SIZE PIPE WITH A FLOW CAPACITY GREATER THAN
   OR EQUAL TO THE UPSTREAM TRIBUTARY PIPE.*
  *USER-SPECIFIED MINIMUM TOPOGRAPHIC SLOPE ADJUSTMENT NOT SELECTED

****************************************************************************
  FLOW PROCESS FROM NODE  24100.00 TO NODE  24105.00 IS CODE =  21
----------------------------------------------------------------------------
  >>>>>RATIONAL METHOD INITIAL SUBAREA ANALYSIS<<<<<
  >>USE TIME-OF-CONCENTRATION NOMOGRAPH FOR INITIAL SUBAREA<<
============================================================================
  INITIAL SUBAREA FLOW-LENGTH(FEET) =   930.00
  ELEVATION DATA: UPSTREAM(FEET) =   1146.00  DOWNSTREAM(FEET) =   1135.00

  Tc = K*[(LENGTH** 3.00)/(ELEVATION CHANGE)]**0.20
  SUBAREA ANALYSIS USED MINIMUM Tc(MIN.) =   11.368
  * 100 YEAR RAINFALL INTENSITY(INCH/HR) =  3.391
  SUBAREA Tc AND LOSS RATE DATA(AMC III):
   DEVELOPMENT TYPE/      SCS SOIL   AREA      Fp         Ap     SCS   Tc
       LAND USE            GROUP   (ACRES)  (INCH/HR)  (DECIMAL)  CN  (MIN.)
```

```
 COMMERCIAL                 B        1.60      0.42     0.100    76   11.37
 SUBAREA AVERAGE PERVIOUS LOSS RATE, Fp(INCH/HR) =  0.42
 SUBAREA AVERAGE PERVIOUS AREA FRACTION, Ap =  0.100
 SUBAREA RUNOFF(CFS) =      4.82
 TOTAL AREA(ACRES) =      1.60   PEAK FLOW RATE(CFS) =      4.82

****************************************************************************
 FLOW PROCESS FROM NODE  24105.00 TO NODE  24110.00 IS CODE =  62
----------------------------------------------------------------------------
 >>>>>COMPUTE STREET FLOW TRAVEL TIME THRU SUBAREA<<<<<
 >>>>>(STREET TABLE SECTION #  4 USED)<<<<<
============================================================================
 UPSTREAM ELEVATION(FEET) = 1135.00  DOWNSTREAM ELEVATION(FEET) = 1121.00
 STREET LENGTH(FEET) =  1370.00   CURB HEIGHT(INCHES) =  8.0
 STREET HALFWIDTH(FEET) = 35.00

 DISTANCE FROM CROWN TO CROSSFALL GRADEBREAK(FEET) =  25.00
 INSIDE STREET CROSSFALL(DECIMAL) =  0.018
 OUTSIDE STREET CROSSFALL(DECIMAL)  =  0.018

 SPECIFIED NUMBER OF HALFSTREETS CARRYING RUNOFF =  1
 STREET PARKWAY CROSSFALL(DECIMAL)  =  0.020
 Manning's FRICTION FACTOR for Streetflow Section(curb-to-curb) =   0.0150
 Manning's FRICTION FACTOR for Back-of-Walk Flow Section =   0.0150

   **TRAVEL TIME COMPUTED USING ESTIMATED FLOW(CFS) =      11.73
   STREETFLOW MODEL RESULTS USING ESTIMATED FLOW:
   STREET FLOW DEPTH(FEET) =  0.52
   HALFSTREET FLOOD WIDTH(FEET) =   19.62
   AVERAGE FLOW VELOCITY(FEET/SEC.) =    3.21
   PRODUCT OF DEPTH&VELOCITY(FT*FT/SEC.) =    1.65
 STREET FLOW TRAVEL TIME(MIN.) =   7.12   Tc(MIN.) =   18.49
 * 100 YEAR RAINFALL INTENSITY(INCH/HR) =  2.533
 SUBAREA LOSS RATE DATA(AMC III):
  DEVELOPMENT TYPE/      SCS SOIL   AREA      Fp         Ap     SCS
      LAND USE            GROUP   (ACRES)  (INCH/HR)  (DECIMAL)  CN
 COMMERCIAL                 B        6.10      0.42     0.100    76
 SUBAREA AVERAGE PERVIOUS LOSS RATE, Fp(INCH/HR) =  0.42
 SUBAREA AVERAGE PERVIOUS AREA FRACTION, Ap =  0.100
 SUBAREA AREA(ACRES) =    6.10      SUBAREA RUNOFF(CFS) =   13.67
 EFFECTIVE AREA(ACRES) =      7.70    AREA-AVERAGED Fm(INCH/HR) =  0.04
 AREA-AVERAGED Fp(INCH/HR) =  0.42  AREA-AVERAGED Ap =  0.10
 TOTAL AREA(ACRES) =        7.7        PEAK FLOW RATE(CFS) =      17.26

 END OF SUBAREA STREET FLOW HYDRAULICS:
 DEPTH(FEET) = 0.57   HALFSTREET FLOOD WIDTH(FEET) =  22.84
 FLOW VELOCITY(FEET/SEC.) =  3.53   DEPTH*VELOCITY(FT*FT/SEC.) =   2.02
 LONGEST FLOWPATH FROM NODE  24100.00 TO NODE  24110.00 =    2300.00 FEET.

****************************************************************************
 FLOW PROCESS FROM NODE  24110.00 TO NODE  24070.00 IS CODE =  62
----------------------------------------------------------------------------
 >>>>>COMPUTE STREET FLOW TRAVEL TIME THRU SUBAREA<<<<<
 >>>>>(STREET TABLE SECTION #  4 USED)<<<<<
============================================================================
 UPSTREAM ELEVATION(FEET) = 1121.00  DOWNSTREAM ELEVATION(FEET) = 1111.00
 STREET LENGTH(FEET) =   800.00   CURB HEIGHT(INCHES) =  8.0
 STREET HALFWIDTH(FEET) = 35.00

 DISTANCE FROM CROWN TO CROSSFALL GRADEBREAK(FEET) =  25.00
 INSIDE STREET CROSSFALL(DECIMAL) =  0.018
 OUTSIDE STREET CROSSFALL(DECIMAL)  =  0.018

 SPECIFIED NUMBER OF HALFSTREETS CARRYING RUNOFF =  1
 STREET PARKWAY CROSSFALL(DECIMAL)  =  0.020
 Manning's FRICTION FACTOR for Streetflow Section(curb-to-curb) =   0.0150
 Manning's FRICTION FACTOR for Back-of-Walk Flow Section =   0.0150

   **TRAVEL TIME COMPUTED USING ESTIMATED FLOW(CFS) =      18.98
   STREETFLOW MODEL RESULTS USING ESTIMATED FLOW:
   STREET FLOW DEPTH(FEET) =  0.57
```

```
    HALFSTREET FLOOD WIDTH(FEET) =   22.84
    AVERAGE FLOW VELOCITY(FEET/SEC.) =    3.88
    PRODUCT OF DEPTH&VELOCITY(FT*FT/SEC.) =    2.23
  STREET FLOW TRAVEL TIME(MIN.) =   3.44   Tc(MIN.) =   21.93
  * 100 YEAR RAINFALL INTENSITY(INCH/HR) =  2.287
  SUBAREA LOSS RATE DATA(AMC III):
   DEVELOPMENT TYPE/      SCS SOIL   AREA      Fp         Ap     SCS
       LAND USE            GROUP   (ACRES)  (INCH/HR)  (DECIMAL)  CN
  COMMERCIAL                 B        1.70      0.42     0.100    76
  SUBAREA AVERAGE PERVIOUS LOSS RATE, Fp(INCH/HR) =  0.42
  SUBAREA AVERAGE PERVIOUS AREA FRACTION, Ap =  0.100
  SUBAREA AREA(ACRES) =    1.70      SUBAREA RUNOFF(CFS) =    3.43
  EFFECTIVE AREA(ACRES) =      9.40    AREA-AVERAGED Fm(INCH/HR) =  0.04
  AREA-AVERAGED Fp(INCH/HR) =  0.42  AREA-AVERAGED Ap =  0.10
  TOTAL AREA(ACRES) =        9.4        PEAK FLOW RATE(CFS) =      18.99

  END OF SUBAREA STREET FLOW HYDRAULICS:
  DEPTH(FEET) = 0.57   HALFSTREET FLOOD WIDTH(FEET) =  22.84
  FLOW VELOCITY(FEET/SEC.) =  3.88   DEPTH*VELOCITY(FT*FT/SEC.) =   2.23
  LONGEST FLOWPATH FROM NODE  24100.00 TO NODE  24070.00 =    3100.00 FEET.

****************************************************************************
  FLOW PROCESS FROM NODE  24070.00 TO NODE  24070.00 IS CODE =  82
----------------------------------------------------------------------------
  >>>>>ADD SUBAREA RUNOFF TO MAINLINE, AT MAINLINE Tc,<<<<<
  >>>>>(AND COMPUTE INITIAL SUBAREA RUNOFF)<<<<<
============================================================================
  INITIAL SUBAREA FLOW-LENGTH(FEET) =  1912.00
  ELEVATION DATA: UPSTREAM(FEET) =   1127.40  DOWNSTREAM(FEET) =   1111.70

  Tc = K*[(LENGTH** 3.00)/(ELEVATION CHANGE)]**0.20
  SUBAREA ANALYSIS USED MINIMUM Tc(MIN.) =   16.315
  * 100 YEAR RAINFALL INTENSITY(INCH/HR) =  2.731
  SUBAREA Tc AND LOSS RATE DATA(AMC III):
   DEVELOPMENT TYPE/      SCS SOIL   AREA      Fp         Ap     SCS   Tc
       LAND USE            GROUP   (ACRES)  (INCH/HR)  (DECIMAL)  CN  (MIN.)
  COMMERCIAL                 B       15.40      0.42     0.100    76   16.31
  SUBAREA AVERAGE PERVIOUS LOSS RATE, Fp(INCH/HR) =  0.42
  SUBAREA AVERAGE PERVIOUS AREA FRACTION, Ap =  0.100
  SUBAREA AREA(ACRES) =   15.40   INITIAL SUBAREA RUNOFF(CFS) =   37.26

  ** ADD SUBAREA RUNOFF TO MAINLINE AT MAINLINE Tc:
  MAINLINE Tc(MIN.) =   21.93
  * 100 YEAR RAINFALL INTENSITY(INCH/HR) =  2.287
  SUBAREA AREA(ACRES) =   15.40      SUBAREA RUNOFF(CFS) =   31.11
  EFFECTIVE AREA(ACRES) =     24.80   AREA-AVERAGED Fm(INCH/HR) =  0.04
  AREA-AVERAGED Fp(INCH/HR) =  0.42  AREA-AVERAGED Ap =  0.10
  TOTAL AREA(ACRES) =       24.8       PEAK FLOW RATE(CFS) =      50.10
============================================================================
  END OF STUDY SUMMARY:
  TOTAL AREA(ACRES)     =       24.8  TC(MIN.) =     21.93
  EFFECTIVE AREA(ACRES) =     24.80  AREA-AVERAGED Fm(INCH/HR)=  0.04
  AREA-AVERAGED Fp(INCH/HR) =  0.42  AREA-AVERAGED Ap = 0.100
  PEAK FLOW RATE(CFS)   =      50.10
============================================================================
============================================================================
  END OF RATIONAL METHOD ANALYSIS
```

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____________________________________________________________________________
****************************************************************************
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                           Analysis prepared by:







 ************************* DESCRIPTION OF STUDY ************************
* REDLANDS PASSENGER RAIL                                                  *
* EXISTING HYDROLOGY 100 YEAR STORM                                        *
* BASIN 26000                                                              *
 **************************************************************************

  FILE NAME: C:\RPRP\EPRP\26000.DAT
  TIME/DATE OF STUDY: 14:54 02/16/2012
============================================================================
  USER SPECIFIED HYDROLOGY AND HYDRAULIC MODEL INFORMATION:
============================================================================
                    --*TIME-OF-CONCENTRATION MODEL*--

  USER SPECIFIED STORM EVENT(YEAR) =  100.00
  SPECIFIED MINIMUM PIPE SIZE(INCH) =  12.00
  SPECIFIED PERCENT OF GRADIENTS(DECIMAL) TO USE FOR FRICTION SLOPE = 0.90
  *USER-DEFINED LOGARITHMIC INTERPOLATION USED FOR RAINFALL*

  SLOPE OF INTENSITY DURATION CURVE(LOG(I;IN/HR) vs. LOG(Tc;MIN)) = 0.6000
  USER SPECIFIED 1-HOUR INTENSITY(INCH/HOUR) = 1.2500

  *ANTECEDENT MOISTURE CONDITION (AMC) III ASSUMED FOR RATIONAL METHOD*

  *USER-DEFINED STREET-SECTIONS FOR COUPLED PIPEFLOW AND STREETFLOW MODEL*
     HALF-  CROWN TO   STREET-CROSSFALL:   CURB  GUTTER-GEOMETRIES:  MANNING
     WIDTH  CROSSFALL  IN-  / OUT-/PARK-  HEIGHT  WIDTH  LIP   HIKE  FACTOR
NO.   (FT)     (FT)    SIDE / SIDE/ WAY    (FT)    (FT)  (FT)  (FT)    (n)
===  =====  =========  =================  ======  ===== ====== ===== =======
  1   30.0     20.0    0.018/0.018/0.020   0.67    2.00 0.0312 0.167 0.0150
  2   13.0      8.0    0.018/0.018/0.020   0.67    2.00 0.0312 0.167 0.0150
  3   25.0     15.0    0.018/0.018/0.020   0.67    2.00 0.0312 0.167 0.0150
  4   35.0     25.0    0.018/0.018/0.020   0.67    2.00 0.0312 0.167 0.0150
  5   20.0     15.0    0.018/0.018/0.020   0.67    2.00 0.0312 0.167 0.0150

  GLOBAL STREET FLOW-DEPTH CONSTRAINTS:
    1. Relative Flow-Depth =  0.20 FEET
       as (Maximum Allowable Street Flow Depth) - (Top-of-Curb)
    2. (Depth)*(Velocity) Constraint = 10.0 (FT*FT/S)
  *SIZE PIPE WITH A FLOW CAPACITY GREATER THAN
   OR EQUAL TO THE UPSTREAM TRIBUTARY PIPE.*
  *USER-SPECIFIED MINIMUM TOPOGRAPHIC SLOPE ADJUSTMENT NOT SELECTED

****************************************************************************
  FLOW PROCESS FROM NODE  26000.00 TO NODE  26010.00 IS CODE =  21
----------------------------------------------------------------------------
  >>>>>RATIONAL METHOD INITIAL SUBAREA ANALYSIS<<<<<
  >>USE TIME-OF-CONCENTRATION NOMOGRAPH FOR INITIAL SUBAREA<<
============================================================================
  INITIAL SUBAREA FLOW-LENGTH(FEET) =   750.00
  ELEVATION DATA: UPSTREAM(FEET) =   1126.60  DOWNSTREAM(FEET) =   1120.70

  Tc = K*[(LENGTH** 3.00)/(ELEVATION CHANGE)]**0.20
  SUBAREA ANALYSIS USED MINIMUM Tc(MIN.) =   17.981
  * 100 YEAR RAINFALL INTENSITY(INCH/HR) =  2.576
  SUBAREA Tc AND LOSS RATE DATA(AMC III):
   DEVELOPMENT TYPE/      SCS SOIL   AREA      Fp         Ap     SCS   Tc
       LAND USE            GROUP   (ACRES)  (INCH/HR)  (DECIMAL)  CN  (MIN.)
```

```
  PUBLIC PARK                B        0.60      0.42     0.850    76   17.98
  SUBAREA AVERAGE PERVIOUS LOSS RATE, Fp(INCH/HR) =  0.42
  SUBAREA AVERAGE PERVIOUS AREA FRACTION, Ap =  0.850
  SUBAREA RUNOFF(CFS) =      1.20
  TOTAL AREA(ACRES) =      0.60   PEAK FLOW RATE(CFS) =      1.20

****************************************************************************
  FLOW PROCESS FROM NODE  26010.00 TO NODE  26020.00 IS CODE =  51
----------------------------------------------------------------------------
  >>>>>COMPUTE TRAPEZOIDAL CHANNEL FLOW<<<<<
  >>>>>TRAVELTIME THRU SUBAREA (EXISTING ELEMENT)<<<<<
============================================================================
  ELEVATION DATA: UPSTREAM(FEET) =   1120.70  DOWNSTREAM(FEET) =   1112.00
  CHANNEL LENGTH THRU SUBAREA(FEET) =   822.00   CHANNEL SLOPE =  0.0106
  CHANNEL BASE(FEET) =    2.00   "Z" FACTOR =   2.000
  MANNING'S FACTOR = 0.030   MAXIMUM DEPTH(FEET) =   1.00
  * 100 YEAR RAINFALL INTENSITY(INCH/HR) =  2.122
  SUBAREA LOSS RATE DATA(AMC III):
   DEVELOPMENT TYPE/      SCS SOIL   AREA      Fp         Ap     SCS
       LAND USE            GROUP   (ACRES)  (INCH/HR)  (DECIMAL)  CN
  PUBLIC PARK                B        0.60      0.42     0.850    76
  SUBAREA AVERAGE PERVIOUS LOSS RATE, Fp(INCH/HR) =  0.42
  SUBAREA AVERAGE PERVIOUS AREA FRACTION, Ap =  0.850
  TRAVEL TIME COMPUTED USING ESTIMATED FLOW(CFS) =      1.67
  TRAVEL TIME THRU SUBAREA BASED ON VELOCITY(FEET/SEC.) =   2.00
  AVERAGE FLOW DEPTH(FEET) =   0.32   TRAVEL TIME(MIN.) =   6.85
  Tc(MIN.) =   24.83
  SUBAREA AREA(ACRES) =     0.60       SUBAREA RUNOFF(CFS) =    0.95
  EFFECTIVE AREA(ACRES) =      1.20     AREA-AVERAGED Fm(INCH/HR) =   0.36
  AREA-AVERAGED Fp(INCH/HR) =   0.42  AREA-AVERAGED Ap =   0.85
  TOTAL AREA(ACRES) =        1.2         PEAK FLOW RATE(CFS) =       1.90

  END OF SUBAREA CHANNEL FLOW HYDRAULICS:
  DEPTH(FEET) =  0.34   FLOW VELOCITY(FEET/SEC.) =   2.09
  LONGEST FLOWPATH FROM NODE  26000.00 TO NODE  26020.00 =    1572.00 FEET.
============================================================================
  END OF STUDY SUMMARY:
  TOTAL AREA(ACRES)     =        1.2  TC(MIN.) =     24.83
  EFFECTIVE AREA(ACRES) =      1.20  AREA-AVERAGED Fm(INCH/HR)=  0.36
  AREA-AVERAGED Fp(INCH/HR) =  0.42  AREA-AVERAGED Ap = 0.850
  PEAK FLOW RATE(CFS)   =       1.90
============================================================================
============================================================================
  END OF RATIONAL METHOD ANALYSIS
```

```
****************************************************************************
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                           Analysis prepared by:




 ************************** DESCRIPTION OF STUDY **************************
 * REDLANDS PASSENGER RAIL PROJECT                                          *
 * EXISTING 100 YEAR ANALYSIS                                               *
 * DRAINAGE AREA 27000                                                      *
 **************************************************************************

  FILE NAME: C:\RPRP\27000.DAT
  TIME/DATE OF STUDY: 15:57 11/12/2012
============================================================================
  USER SPECIFIED HYDROLOGY AND HYDRAULIC MODEL INFORMATION:
============================================================================
                    --*TIME-OF-CONCENTRATION MODEL*--

  USER SPECIFIED STORM EVENT(YEAR) =  100.00
  SPECIFIED MINIMUM PIPE SIZE(INCH) =  12.00
  SPECIFIED PERCENT OF GRADIENTS(DECIMAL) TO USE FOR FRICTION SLOPE = 0.90
  *USER-DEFINED LOGARITHMIC INTERPOLATION USED FOR RAINFALL*

  SLOPE OF INTENSITY DURATION CURVE(LOG(I;IN/HR) vs. LOG(Tc;MIN)) = 0.6000
  USER SPECIFIED 1-HOUR INTENSITY(INCH/HOUR) = 1.2500

  *ANTECEDENT MOISTURE CONDITION (AMC) III ASSUMED FOR RATIONAL METHOD*

  *USER-DEFINED STREET-SECTIONS FOR COUPLED PIPEFLOW AND STREETFLOW MODEL*
     HALF-  CROWN TO   STREET-CROSSFALL:   CURB  GUTTER-GEOMETRIES:  MANNING
     WIDTH  CROSSFALL  IN-  / OUT-/PARK-  HEIGHT  WIDTH  LIP   HIKE  FACTOR
NO.   (FT)     (FT)    SIDE / SIDE/ WAY    (FT)    (FT)  (FT)  (FT)    (n)
===  =====  =========  =================  ======   ===== ====== ===== =======
  1   30.0     20.0    0.018/0.018/0.020   0.67    2.00 0.0313 0.167 0.0150
  2   13.0      8.0    0.018/0.018/0.020   0.67    2.00 0.0313 0.167 0.0150
  3   25.0     15.0    0.018/0.018/0.020   0.67    2.00 0.0313 0.167 0.0150
  4   35.0     25.0    0.018/0.018/0.020   0.67    2.00 0.0313 0.167 0.0150
  5   20.0     15.0    0.018/0.018/0.020   0.67    2.00 0.0313 0.167 0.0150

  GLOBAL STREET FLOW-DEPTH CONSTRAINTS:
    1. Relative Flow-Depth =  0.20 FEET
       as (Maximum Allowable Street Flow Depth) - (Top-of-Curb)
    2. (Depth)*(Velocity) Constraint = 10.0 (FT*FT/S)
  *SIZE PIPE WITH A FLOW CAPACITY GREATER THAN
   OR EQUAL TO THE UPSTREAM TRIBUTARY PIPE.*
  *USER-SPECIFIED MINIMUM TOPOGRAPHIC SLOPE ADJUSTMENT NOT SELECTED

****************************************************************************
  FLOW PROCESS FROM NODE  27000.00 TO NODE  27010.00 IS CODE =  21
----------------------------------------------------------------------------
  >>>>>RATIONAL METHOD INITIAL SUBAREA ANALYSIS<<<<<
  >>USE TIME-OF-CONCENTRATION NOMOGRAPH FOR INITIAL SUBAREA<<
============================================================================
  INITIAL SUBAREA FLOW-LENGTH(FEET) =   960.00
  ELEVATION DATA: UPSTREAM(FEET) =   1165.00  DOWNSTREAM(FEET) =   1148.30

  Tc = K*[(LENGTH** 3.00)/(ELEVATION CHANGE)]**0.20
  SUBAREA ANALYSIS USED MINIMUM Tc(MIN.) =   14.445
  * 100 YEAR RAINFALL INTENSITY(INCH/HR) =  2.937
  SUBAREA Tc AND LOSS RATE DATA(AMC III):
   DEVELOPMENT TYPE/      SCS SOIL   AREA      Fp         Ap     SCS   Tc
       LAND USE             GROUP   (ACRES)  (INCH/HR)  (DECIMAL)  CN  (MIN.)
```

```
  RESIDENTIAL
  "3-4 DWELLINGS/ACRE"       B        0.60      0.42     0.600    76   14.44
  SUBAREA AVERAGE PERVIOUS LOSS RATE, Fp(INCH/HR) =  0.42
  SUBAREA AVERAGE PERVIOUS AREA FRACTION, Ap =  0.600
  SUBAREA RUNOFF(CFS) =      1.45
  TOTAL AREA(ACRES) =      0.60   PEAK FLOW RATE(CFS) =      1.45

****************************************************************************
  FLOW PROCESS FROM NODE  27010.00 TO NODE  27020.00 IS CODE =  51
----------------------------------------------------------------------------
  >>>>>COMPUTE TRAPEZOIDAL CHANNEL FLOW<<<<<
  >>>>>TRAVELTIME THRU SUBAREA (EXISTING ELEMENT)<<<<<
============================================================================
  ELEVATION DATA: UPSTREAM(FEET) =   1149.30  DOWNSTREAM(FEET) =   1135.00
  CHANNEL LENGTH THRU SUBAREA(FEET) =  1680.00   CHANNEL SLOPE =  0.0085
  CHANNEL BASE(FEET) =    2.00   "Z" FACTOR =   2.000
  MANNING'S FACTOR = 0.030   MAXIMUM DEPTH(FEET) =   1.00
  * 100 YEAR RAINFALL INTENSITY(INCH/HR) =  1.983
  SUBAREA LOSS RATE DATA(AMC III):
   DEVELOPMENT TYPE/      SCS SOIL   AREA      Fp         Ap     SCS
       LAND USE            GROUP   (ACRES)  (INCH/HR)  (DECIMAL)  CN
  RESIDENTIAL
  "3-4 DWELLINGS/ACRE"       B        1.30      0.42     0.600    76
  SUBAREA AVERAGE PERVIOUS LOSS RATE, Fp(INCH/HR) =  0.42
  SUBAREA AVERAGE PERVIOUS AREA FRACTION, Ap =  0.600
  TRAVEL TIME COMPUTED USING ESTIMATED FLOW(CFS) =      2.48
  TRAVEL TIME THRU SUBAREA BASED ON VELOCITY(FEET/SEC.) =   2.10
  AVERAGE FLOW DEPTH(FEET) =   0.42   TRAVEL TIME(MIN.) =  13.35
  Tc(MIN.) =   27.80
  SUBAREA AREA(ACRES) =     1.30       SUBAREA RUNOFF(CFS) =    2.02
  EFFECTIVE AREA(ACRES) =      1.90     AREA-AVERAGED Fm(INCH/HR) =   0.25
  AREA-AVERAGED Fp(INCH/HR) =  0.42  AREA-AVERAGED Ap =   0.60
  TOTAL AREA(ACRES) =       1.9         PEAK FLOW RATE(CFS) =      2.96

  END OF SUBAREA CHANNEL FLOW HYDRAULICS:
  DEPTH(FEET) =  0.46   FLOW VELOCITY(FEET/SEC.) =   2.19
  LONGEST FLOWPATH FROM NODE  27000.00 TO NODE  27020.00 =    2640.00 FEET.
============================================================================
  END OF STUDY SUMMARY:
  TOTAL AREA(ACRES)     =        1.9  TC(MIN.) =     27.80
  EFFECTIVE AREA(ACRES) =      1.90  AREA-AVERAGED Fm(INCH/HR)=  0.25
  AREA-AVERAGED Fp(INCH/HR) =  0.42  AREA-AVERAGED Ap = 0.600
  PEAK FLOW RATE(CFS)   =       2.96
============================================================================
============================================================================
  END OF RATIONAL METHOD ANALYSIS
```

```
****************************************************************************
             RATIONAL METHOD HYDROLOGY COMPUTER PROGRAM PACKAGE
          (Reference: 1986 SAN BERNARDINO CO. HYDROLOGY CRITERION)
         (c) Copyright 1983-2008 Advanced Engineering Software (aes)
             Ver. 15.0  Release Date: 04/01/2008  License ID 1555

                           Analysis prepared by:




 ************************** DESCRIPTION OF STUDY **************************
* REDLANDS PASSENGER RAIL PROJECT                                          *
* EXISTING 100 YEAR ANALYSIS                                               *
* DRAINAGE AREA 28000                                                      *
 **************************************************************************

  FILE NAME: C:\RPRP\28000.DAT
  TIME/DATE OF STUDY: 13:50 06/18/2012
============================================================================
  USER SPECIFIED HYDROLOGY AND HYDRAULIC MODEL INFORMATION:
============================================================================
                    --*TIME-OF-CONCENTRATION MODEL*--

  USER SPECIFIED STORM EVENT(YEAR) =  100.00
  SPECIFIED MINIMUM PIPE SIZE(INCH) =  12.00
  SPECIFIED PERCENT OF GRADIENTS(DECIMAL) TO USE FOR FRICTION SLOPE = 0.90
  *USER-DEFINED LOGARITHMIC INTERPOLATION USED FOR RAINFALL*

  SLOPE OF INTENSITY DURATION CURVE(LOG(I;IN/HR) vs. LOG(Tc;MIN)) = 0.6000
  USER SPECIFIED 1-HOUR INTENSITY(INCH/HOUR) = 1.2500

  *ANTECEDENT MOISTURE CONDITION (AMC) III ASSUMED FOR RATIONAL METHOD*

  *USER-DEFINED STREET-SECTIONS FOR COUPLED PIPEFLOW AND STREETFLOW MODEL*
     HALF-  CROWN TO   STREET-CROSSFALL:   CURB  GUTTER-GEOMETRIES:  MANNING
     WIDTH  CROSSFALL  IN-  / OUT-/PARK-  HEIGHT  WIDTH  LIP   HIKE  FACTOR
NO.   (FT)     (FT)    SIDE / SIDE/ WAY    (FT)    (FT)  (FT)  (FT)    (n)
===  =====  =========  =================  ======  ===== ====== ===== =======
  1   30.0     20.0    0.018/0.018/0.020   0.67    2.00 0.0313 0.167 0.0150
  2   13.0      8.0    0.018/0.018/0.020   0.67    2.00 0.0313 0.167 0.0150
  3   25.0     15.0    0.018/0.018/0.020   0.67    2.00 0.0313 0.167 0.0150
  4   35.0     25.0    0.018/0.018/0.020   0.67    2.00 0.0313 0.167 0.0150
  5   20.0     15.0    0.018/0.018/0.020   0.67    2.00 0.0313 0.167 0.0150

  GLOBAL STREET FLOW-DEPTH CONSTRAINTS:
    1. Relative Flow-Depth =  0.20 FEET
       as (Maximum Allowable Street Flow Depth) - (Top-of-Curb)
    2. (Depth)*(Velocity) Constraint = 10.0 (FT*FT/S)
  *SIZE PIPE WITH A FLOW CAPACITY GREATER THAN
   OR EQUAL TO THE UPSTREAM TRIBUTARY PIPE.*
  *USER-SPECIFIED MINIMUM TOPOGRAPHIC SLOPE ADJUSTMENT NOT SELECTED

****************************************************************************
  FLOW PROCESS FROM NODE  28000.00 TO NODE  28010.00 IS CODE =  21
----------------------------------------------------------------------------
  >>>>>RATIONAL METHOD INITIAL SUBAREA ANALYSIS<<<<<
  >>USE TIME-OF-CONCENTRATION NOMOGRAPH FOR INITIAL SUBAREA<<
============================================================================
  INITIAL SUBAREA FLOW-LENGTH(FEET) =   990.00
  ELEVATION DATA: UPSTREAM(FEET) =   1156.00  DOWNSTREAM(FEET) =   1142.00

  Tc = K*[(LENGTH** 3.00)/(ELEVATION CHANGE)]**0.20
  SUBAREA ANALYSIS USED MINIMUM Tc(MIN.) =   17.869
  * 100 YEAR RAINFALL INTENSITY(INCH/HR) =  2.585
  SUBAREA Tc AND LOSS RATE DATA(AMC III):
   DEVELOPMENT TYPE/      SCS SOIL   AREA      Fp         Ap     SCS   Tc
       LAND USE             GROUP   (ACRES)  (INCH/HR)  (DECIMAL)  CN  (MIN.)
```

```
 PUBLIC PARK                B        1.30      0.42     0.850    76   17.87
 SUBAREA AVERAGE PERVIOUS LOSS RATE, Fp(INCH/HR) =  0.42
 SUBAREA AVERAGE PERVIOUS AREA FRACTION, Ap =  0.850
 SUBAREA RUNOFF(CFS) =      2.60
 TOTAL AREA(ACRES) =      1.30   PEAK FLOW RATE(CFS) =      2.60

****************************************************************************
 FLOW PROCESS FROM NODE  28010.00 TO NODE  28010.00 IS CODE =  81
----------------------------------------------------------------------------
 >>>>>ADDITION OF SUBAREA TO MAINLINE PEAK FLOW<<<<<
============================================================================
 MAINLINE Tc(MIN.) =   17.87
 * 100 YEAR RAINFALL INTENSITY(INCH/HR) =  2.585
 SUBAREA LOSS RATE DATA(AMC III):
  DEVELOPMENT TYPE/      SCS SOIL   AREA      Fp         Ap     SCS
      LAND USE            GROUP   (ACRES)  (INCH/HR)  (DECIMAL)  CN
 COMMERCIAL                 B        7.70      0.42     0.100    76
 SUBAREA AVERAGE PERVIOUS LOSS RATE, Fp(INCH/HR) =  0.42
 SUBAREA AVERAGE PERVIOUS AREA FRACTION, Ap =  0.100
 SUBAREA AREA(ACRES) =    7.70      SUBAREA RUNOFF(CFS) =   17.62
 EFFECTIVE AREA(ACRES) =      9.00   AREA-AVERAGED Fm(INCH/HR) =  0.09
 AREA-AVERAGED Fp(INCH/HR) =  0.42  AREA-AVERAGED Ap =  0.21
 TOTAL AREA(ACRES) =        9.0       PEAK FLOW RATE(CFS) =      20.23

****************************************************************************
 FLOW PROCESS FROM NODE  28010.00 TO NODE  28020.00 IS CODE =  51
----------------------------------------------------------------------------
 >>>>>COMPUTE TRAPEZOIDAL CHANNEL FLOW<<<<<
 >>>>>TRAVELTIME THRU SUBAREA (EXISTING ELEMENT)<<<<<
============================================================================
 ELEVATION DATA: UPSTREAM(FEET) =   1142.00  DOWNSTREAM(FEET) =   1128.00
 CHANNEL LENGTH THRU SUBAREA(FEET) =   990.00   CHANNEL SLOPE =  0.0141
 CHANNEL BASE(FEET) =    2.00   "Z" FACTOR =   2.000
 MANNING'S FACTOR = 0.030   MAXIMUM DEPTH(FEET) =   1.00

        ==>>WARNING: FLOW IN CHANNEL EXCEEDS CHANNEL
            CAPACITY( NORMAL DEPTH EQUAL TO SPECIFIED MAXIMUM
            ALLOWABLE DEPTH).
            AS AN APPROXIMATION, FLOWDEPTH IS SET AT MAXIMUM
            ALLOWABLE DEPTH AND IS USED FOR TRAVELTIME CALCULATIONS.

 * 100 YEAR RAINFALL INTENSITY(INCH/HR) =  2.354
 SUBAREA LOSS RATE DATA(AMC III):
  DEVELOPMENT TYPE/      SCS SOIL   AREA      Fp         Ap     SCS
      LAND USE            GROUP   (ACRES)  (INCH/HR)  (DECIMAL)  CN
 PUBLIC PARK                B        1.80      0.42     0.850    76
 SUBAREA AVERAGE PERVIOUS LOSS RATE, Fp(INCH/HR) =  0.42
 SUBAREA AVERAGE PERVIOUS AREA FRACTION, Ap =  0.850
 TRAVEL TIME COMPUTED USING ESTIMATED FLOW(CFS) =      21.85
 TRAVEL TIME THRU SUBAREA BASED ON VELOCITY(FEET/SEC.) =   5.46
 AVERAGE FLOW DEPTH(FEET) =   1.00   TRAVEL TIME(MIN.) =   3.02
 Tc(MIN.) =   20.89
 SUBAREA AREA(ACRES) =     1.80       SUBAREA RUNOFF(CFS) =    3.23
 EFFECTIVE AREA(ACRES) =     10.80     AREA-AVERAGED Fm(INCH/HR) =   0.13
 AREA-AVERAGED Fp(INCH/HR) =   0.42  AREA-AVERAGED Ap =   0.32
 TOTAL AREA(ACRES) =       10.8         PEAK FLOW RATE(CFS) =      21.59

        ==>>WARNING: FLOW IN CHANNEL EXCEEDS CHANNEL
            CAPACITY( NORMAL DEPTH EQUAL TO SPECIFIED MAXIMUM
            ALLOWABLE DEPTH).
            AS AN APPROXIMATION, FLOWDEPTH IS SET AT MAXIMUM
            ALLOWABLE DEPTH AND IS USED FOR TRAVELTIME CALCULATIONS.


 END OF SUBAREA CHANNEL FLOW HYDRAULICS:
 DEPTH(FEET) =  1.00   FLOW VELOCITY(FEET/SEC.) =   5.40

 ==>FLOWDEPTH EXCEEDS MAXIMUM ALLOWABLE DEPTH

 LONGEST FLOWPATH FROM NODE  28000.00 TO NODE  28020.00 =    1980.00 FEET.
```

```
****************************************************************************
  FLOW PROCESS FROM NODE  28020.00 TO NODE  28020.00 IS CODE =  81
----------------------------------------------------------------------------
  >>>>>ADDITION OF SUBAREA TO MAINLINE PEAK FLOW<<<<<
============================================================================
  MAINLINE Tc(MIN.) =   20.89
  * 100 YEAR RAINFALL INTENSITY(INCH/HR) =  2.354
  SUBAREA LOSS RATE DATA(AMC III):
   DEVELOPMENT TYPE/      SCS SOIL   AREA      Fp         Ap     SCS
       LAND USE            GROUP   (ACRES)  (INCH/HR)  (DECIMAL)  CN
  COMMERCIAL                 B        3.80      0.42     0.100    76
  PUBLIC PARK                B       18.10      0.42     0.850    76
  PUBLIC PARK                B       20.40      0.42     0.850    76
  SUBAREA AVERAGE PERVIOUS LOSS RATE, Fp(INCH/HR) =  0.42
  SUBAREA AVERAGE PERVIOUS AREA FRACTION, Ap =  0.783
  SUBAREA AREA(ACRES) =   42.30      SUBAREA RUNOFF(CFS) =   77.02
  EFFECTIVE AREA(ACRES) =     53.10   AREA-AVERAGED Fm(INCH/HR) =  0.29
  AREA-AVERAGED Fp(INCH/HR) =  0.42  AREA-AVERAGED Ap =  0.69
  TOTAL AREA(ACRES) =       53.1       PEAK FLOW RATE(CFS) =      98.61

****************************************************************************
  FLOW PROCESS FROM NODE  28020.00 TO NODE  28030.00 IS CODE =  41
----------------------------------------------------------------------------
  >>>>>COMPUTE PIPE-FLOW TRAVEL TIME THRU SUBAREA<<<<<
  >>>>>USING USER-SPECIFIED PIPESIZE (EXISTING ELEMENT)<<<<<
============================================================================
  ELEVATION DATA: UPSTREAM(FEET) =  1120.70  DOWNSTREAM(FEET) =  1115.40
  FLOW LENGTH(FEET) =   520.00   MANNING'S N =  0.013
  ASSUME FULL-FLOWING PIPELINE
  PIPE-FLOW VELOCITY(FEET/SEC.) =  10.25
  PIPE FLOW VELOCITY = (TOTAL FLOW)/(PIPE CROSS SECTION AREA)
  GIVEN PIPE DIAMETER(INCH) =  42.00    NUMBER OF PIPES =   1
  PIPE-FLOW(CFS) =      98.61
  PIPE TRAVEL TIME(MIN.) =   0.85    Tc(MIN.) =   21.74
  LONGEST FLOWPATH FROM NODE  28000.00 TO NODE  28030.00 =    2500.00 FEET.

****************************************************************************
  FLOW PROCESS FROM NODE  28030.00 TO NODE  28030.00 IS CODE =  81
----------------------------------------------------------------------------
  >>>>>ADDITION OF SUBAREA TO MAINLINE PEAK FLOW<<<<<
============================================================================
  MAINLINE Tc(MIN.) =   21.74
  * 100 YEAR RAINFALL INTENSITY(INCH/HR) =  2.299
  SUBAREA LOSS RATE DATA(AMC III):
   DEVELOPMENT TYPE/      SCS SOIL   AREA      Fp         Ap     SCS
       LAND USE            GROUP   (ACRES)  (INCH/HR)  (DECIMAL)  CN
  COMMERCIAL                 B        6.20      0.42     0.100    76
  COMMERCIAL                 B        2.70      0.42     0.100    76
  COMMERCIAL                 B        5.80      0.42     0.100    76
  SUBAREA AVERAGE PERVIOUS LOSS RATE, Fp(INCH/HR) =  0.42
  SUBAREA AVERAGE PERVIOUS AREA FRACTION, Ap =  0.100
  SUBAREA AREA(ACRES) =   14.70      SUBAREA RUNOFF(CFS) =   29.85
  EFFECTIVE AREA(ACRES) =     67.80   AREA-AVERAGED Fm(INCH/HR) =  0.24
  AREA-AVERAGED Fp(INCH/HR) =  0.42  AREA-AVERAGED Ap =  0.56
  TOTAL AREA(ACRES) =       67.8       PEAK FLOW RATE(CFS) =     125.81

****************************************************************************
  FLOW PROCESS FROM NODE  28030.00 TO NODE  28040.00 IS CODE =  41
----------------------------------------------------------------------------
  >>>>>COMPUTE PIPE-FLOW TRAVEL TIME THRU SUBAREA<<<<<
  >>>>>USING USER-SPECIFIED PIPESIZE (EXISTING ELEMENT)<<<<<
============================================================================
  ELEVATION DATA: UPSTREAM(FEET) =  1115.40  DOWNSTREAM(FEET) =  1107.20
  FLOW LENGTH(FEET) =   390.00   MANNING'S N =  0.013
  DEPTH OF FLOW IN  48.0 INCH PIPE IS  27.8 INCHES
  PIPE-FLOW VELOCITY(FEET/SEC.) =  16.66
  GIVEN PIPE DIAMETER(INCH) =  48.00    NUMBER OF PIPES =   1
  PIPE-FLOW(CFS) =     125.81
  PIPE TRAVEL TIME(MIN.) =   0.39    Tc(MIN.) =   22.13
  LONGEST FLOWPATH FROM NODE  28000.00 TO NODE  28040.00 =    2890.00 FEET.
```

```
****************************************************************************
  FLOW PROCESS FROM NODE  28040.00 TO NODE  28040.00 IS CODE =  81
----------------------------------------------------------------------------
  >>>>>ADDITION OF SUBAREA TO MAINLINE PEAK FLOW<<<<<
============================================================================
  MAINLINE Tc(MIN.) =   22.13
  * 100 YEAR RAINFALL INTENSITY(INCH/HR) =  2.274
  SUBAREA LOSS RATE DATA(AMC III):
   DEVELOPMENT TYPE/      SCS SOIL   AREA      Fp         Ap     SCS
       LAND USE            GROUP   (ACRES)  (INCH/HR)  (DECIMAL)  CN
  COMMERCIAL                 B        6.60      0.42     0.100    76
  SUBAREA AVERAGE PERVIOUS LOSS RATE, Fp(INCH/HR) =  0.42
  SUBAREA AVERAGE PERVIOUS AREA FRACTION, Ap =  0.100
  SUBAREA AREA(ACRES) =    6.60      SUBAREA RUNOFF(CFS) =   13.26
  EFFECTIVE AREA(ACRES) =     74.40   AREA-AVERAGED Fm(INCH/HR) =  0.22
  AREA-AVERAGED Fp(INCH/HR) =  0.42  AREA-AVERAGED Ap =  0.52
  TOTAL AREA(ACRES) =       74.4       PEAK FLOW RATE(CFS) =     137.58
============================================================================
  END OF STUDY SUMMARY:
  TOTAL AREA(ACRES)     =       74.4  TC(MIN.) =     22.13
  EFFECTIVE AREA(ACRES) =     74.40  AREA-AVERAGED Fm(INCH/HR)=  0.22
  AREA-AVERAGED Fp(INCH/HR) =  0.42  AREA-AVERAGED Ap = 0.519
  PEAK FLOW RATE(CFS)   =     137.58
============================================================================
============================================================================
  END OF RATIONAL METHOD ANALYSIS
```

```
****************************************************************************
             RATIONAL METHOD HYDROLOGY COMPUTER PROGRAM PACKAGE
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             Ver. 15.0  Release Date: 04/01/2008  License ID 1555

                           Analysis prepared by:




 ************************** DESCRIPTION OF STUDY **************************
* REDLANDS PASSENGER RAIL PROJECT                                          *
* EXISTING 100 YEAR ANALYSIS                                               *
* DRAINAGE AREA 50000                                                      *
 **************************************************************************

  FILE NAME: C:\RPRP\51000.DAT
  TIME/DATE OF STUDY: 12:56 06/05/2012
============================================================================
  USER SPECIFIED HYDROLOGY AND HYDRAULIC MODEL INFORMATION:
============================================================================
                    --*TIME-OF-CONCENTRATION MODEL*--

  USER SPECIFIED STORM EVENT(YEAR) =  100.00
  SPECIFIED MINIMUM PIPE SIZE(INCH) =  12.00
  SPECIFIED PERCENT OF GRADIENTS(DECIMAL) TO USE FOR FRICTION SLOPE = 0.90
  *USER-DEFINED LOGARITHMIC INTERPOLATION USED FOR RAINFALL*

  SLOPE OF INTENSITY DURATION CURVE(LOG(I;IN/HR) vs. LOG(Tc;MIN)) = 0.6000
  USER SPECIFIED 1-HOUR INTENSITY(INCH/HOUR) = 1.2500

  *ANTECEDENT MOISTURE CONDITION (AMC) III ASSUMED FOR RATIONAL METHOD*

  *USER-DEFINED STREET-SECTIONS FOR COUPLED PIPEFLOW AND STREETFLOW MODEL*
     HALF-  CROWN TO   STREET-CROSSFALL:   CURB  GUTTER-GEOMETRIES:  MANNING
     WIDTH  CROSSFALL  IN-  / OUT-/PARK-  HEIGHT  WIDTH  LIP   HIKE  FACTOR
NO.   (FT)     (FT)    SIDE / SIDE/ WAY    (FT)    (FT)  (FT)  (FT)    (n)
===  =====  =========  =================  ======  ===== ====== ===== =======
  1   30.0     20.0    0.018/0.018/0.020   0.67    2.00 0.0313 0.167 0.0150
  2   20.0     15.0    0.020/0.020/0.020   0.50    1.50 0.0313 0.125 0.0170

  GLOBAL STREET FLOW-DEPTH CONSTRAINTS:
    1. Relative Flow-Depth =  0.20 FEET
       as (Maximum Allowable Street Flow Depth) - (Top-of-Curb)
    2. (Depth)*(Velocity) Constraint = 10.0 (FT*FT/S)
  *SIZE PIPE WITH A FLOW CAPACITY GREATER THAN
   OR EQUAL TO THE UPSTREAM TRIBUTARY PIPE.*
  *USER-SPECIFIED MINIMUM TOPOGRAPHIC SLOPE ADJUSTMENT NOT SELECTED

****************************************************************************
  FLOW PROCESS FROM NODE  50000.00 TO NODE  50001.00 IS CODE =  21
----------------------------------------------------------------------------
  >>>>>RATIONAL METHOD INITIAL SUBAREA ANALYSIS<<<<<
  >>USE TIME-OF-CONCENTRATION NOMOGRAPH FOR INITIAL SUBAREA<<
============================================================================
  INITIAL SUBAREA FLOW-LENGTH(FEET) =   840.00
  ELEVATION DATA: UPSTREAM(FEET) =   1320.00  DOWNSTREAM(FEET) =   1294.00

  Tc = K*[(LENGTH** 3.00)/(ELEVATION CHANGE)]**0.20
  SUBAREA ANALYSIS USED MINIMUM Tc(MIN.) =    9.004
  * 100 YEAR RAINFALL INTENSITY(INCH/HR) =  3.901
  SUBAREA Tc AND LOSS RATE DATA(AMC III):
   DEVELOPMENT TYPE/      SCS SOIL   AREA      Fp         Ap     SCS   Tc
       LAND USE            GROUP   (ACRES)  (INCH/HR)  (DECIMAL)  CN  (MIN.)
  COMMERCIAL                 B        2.80      0.42      0.100    76    9.00
  SUBAREA AVERAGE PERVIOUS LOSS RATE, Fp(INCH/HR) =  0.42
  SUBAREA AVERAGE PERVIOUS AREA FRACTION, Ap =  0.100
```

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  SUBAREA RUNOFF(CFS) =      9.72
  TOTAL AREA(ACRES) =      2.80   PEAK FLOW RATE(CFS) =      9.72

****************************************************************************
  FLOW PROCESS FROM NODE  50001.00 TO NODE  50002.00 IS CODE =  41
----------------------------------------------------------------------------
  >>>>>COMPUTE PIPE-FLOW TRAVEL TIME THRU SUBAREA<<<<<
  >>>>>USING USER-SPECIFIED PIPESIZE (EXISTING ELEMENT)<<<<<
============================================================================
  ELEVATION DATA: UPSTREAM(FEET) =  1290.00  DOWNSTREAM(FEET) =  1286.00
  FLOW LENGTH(FEET) =    55.00   MANNING'S N =  0.013
  DEPTH OF FLOW IN  18.0 INCH PIPE IS   7.5 INCHES
  PIPE-FLOW VELOCITY(FEET/SEC.) =  13.98
  GIVEN PIPE DIAMETER(INCH) =  18.00    NUMBER OF PIPES =   1
  PIPE-FLOW(CFS) =       9.72
  PIPE TRAVEL TIME(MIN.) =   0.07    Tc(MIN.) =    9.07
  LONGEST FLOWPATH FROM NODE  50000.00 TO NODE  50002.00 =     895.00 FEET.

****************************************************************************
  FLOW PROCESS FROM NODE  50002.00 TO NODE  50003.00 IS CODE =  51
----------------------------------------------------------------------------
  >>>>>COMPUTE TRAPEZOIDAL CHANNEL FLOW<<<<<
  >>>>>TRAVELTIME THRU SUBAREA (EXISTING ELEMENT)<<<<<
============================================================================
  ELEVATION DATA: UPSTREAM(FEET) =   1286.00  DOWNSTREAM(FEET) =   1282.00
  CHANNEL LENGTH THRU SUBAREA(FEET) =   300.00   CHANNEL SLOPE =  0.0133
  CHANNEL BASE(FEET) =    2.00   "Z" FACTOR =   2.000
  MANNING'S FACTOR = 0.015   MAXIMUM DEPTH(FEET) =   1.00
  * 100 YEAR RAINFALL INTENSITY(INCH/HR) =  3.704
  SUBAREA LOSS RATE DATA(AMC III):
   DEVELOPMENT TYPE/      SCS SOIL   AREA      Fp         Ap     SCS
       LAND USE            GROUP   (ACRES)  (INCH/HR)  (DECIMAL)  CN
  COMMERCIAL                 B        3.20      0.42     0.100    76
  SUBAREA AVERAGE PERVIOUS LOSS RATE, Fp(INCH/HR) =  0.42
  SUBAREA AVERAGE PERVIOUS AREA FRACTION, Ap =  0.100
  TRAVEL TIME COMPUTED USING ESTIMATED FLOW(CFS) =      15.00
  TRAVEL TIME THRU SUBAREA BASED ON VELOCITY(FEET/SEC.) =   6.72
  AVERAGE FLOW DEPTH(FEET) =   0.67   TRAVEL TIME(MIN.) =   0.74
  Tc(MIN.) =    9.81
  SUBAREA AREA(ACRES) =     3.20       SUBAREA RUNOFF(CFS) =   10.55
  EFFECTIVE AREA(ACRES) =      6.00     AREA-AVERAGED Fm(INCH/HR) =   0.04
  AREA-AVERAGED Fp(INCH/HR) =   0.42  AREA-AVERAGED Ap =   0.10
  TOTAL AREA(ACRES) =        6.0         PEAK FLOW RATE(CFS) =      19.77

  END OF SUBAREA CHANNEL FLOW HYDRAULICS:
  DEPTH(FEET) =  0.77   FLOW VELOCITY(FEET/SEC.) =   7.21
  LONGEST FLOWPATH FROM NODE  50000.00 TO NODE  50003.00 =    1195.00 FEET.

****************************************************************************
  FLOW PROCESS FROM NODE  50003.00 TO NODE  50004.00 IS CODE =  41
----------------------------------------------------------------------------
  >>>>>COMPUTE PIPE-FLOW TRAVEL TIME THRU SUBAREA<<<<<
  >>>>>USING USER-SPECIFIED PIPESIZE (EXISTING ELEMENT)<<<<<
============================================================================
  ELEVATION DATA: UPSTREAM(FEET) =  1282.00  DOWNSTREAM(FEET) =  1277.00
  FLOW LENGTH(FEET) =   100.00   MANNING'S N =  0.024
  ASSUME FULL-FLOWING PIPELINE
  PIPE-FLOW VELOCITY(FEET/SEC.) =  11.19
  PIPE FLOW VELOCITY = (TOTAL FLOW)/(PIPE CROSS SECTION AREA)
  GIVEN PIPE DIAMETER(INCH) =  18.00    NUMBER OF PIPES =   1
  PIPE-FLOW(CFS) =      19.77
  PIPE TRAVEL TIME(MIN.) =   0.15    Tc(MIN.) =    9.96
  LONGEST FLOWPATH FROM NODE  50000.00 TO NODE  50004.00 =    1295.00 FEET.

****************************************************************************
  FLOW PROCESS FROM NODE  50004.00 TO NODE  50005.00 IS CODE =  51
----------------------------------------------------------------------------
  >>>>>COMPUTE TRAPEZOIDAL CHANNEL FLOW<<<<<
  >>>>>TRAVELTIME THRU SUBAREA (EXISTING ELEMENT)<<<<<
============================================================================
  ELEVATION DATA: UPSTREAM(FEET) =   1277.00  DOWNSTREAM(FEET) =   1247.00
```

```
  CHANNEL LENGTH THRU SUBAREA(FEET) =  2350.00   CHANNEL SLOPE =  0.0128
  CHANNEL BASE(FEET) =    2.00   "Z" FACTOR =   4.000
  MANNING'S FACTOR = 0.015   MAXIMUM DEPTH(FEET) =   2.00
  * 100 YEAR RAINFALL INTENSITY(INCH/HR) =  2.845
  SUBAREA LOSS RATE DATA(AMC III):
   DEVELOPMENT TYPE/      SCS SOIL   AREA      Fp         Ap     SCS
       LAND USE            GROUP   (ACRES)  (INCH/HR)  (DECIMAL)  CN
  COMMERCIAL                 B      14.90      0.42     0.100    76
  SUBAREA AVERAGE PERVIOUS LOSS RATE, Fp(INCH/HR) =  0.42
  SUBAREA AVERAGE PERVIOUS AREA FRACTION, Ap =  0.100
  TRAVEL TIME COMPUTED USING ESTIMATED FLOW(CFS) =      38.72
  TRAVEL TIME THRU SUBAREA BASED ON VELOCITY(FEET/SEC.) =   7.43
  AVERAGE FLOW DEPTH(FEET) =   0.92   TRAVEL TIME(MIN.) =   5.27
  Tc(MIN.) =   15.23
  SUBAREA AREA(ACRES) =    14.90       SUBAREA RUNOFF(CFS) =   37.59
  EFFECTIVE AREA(ACRES) =     20.90     AREA-AVERAGED Fm(INCH/HR) =   0.04
  AREA-AVERAGED Fp(INCH/HR) =   0.42  AREA-AVERAGED Ap =   0.10
  TOTAL AREA(ACRES) =       20.9         PEAK FLOW RATE(CFS) =      52.72

  END OF SUBAREA CHANNEL FLOW HYDRAULICS:
  DEPTH(FEET) =  1.05   FLOW VELOCITY(FEET/SEC.) =   8.10
  LONGEST FLOWPATH FROM NODE  50000.00 TO NODE  50005.00 =    3645.00 FEET.

****************************************************************************
  FLOW PROCESS FROM NODE  50005.00 TO NODE  50006.00 IS CODE =  41
----------------------------------------------------------------------------
  >>>>>COMPUTE PIPE-FLOW TRAVEL TIME THRU SUBAREA<<<<<
  >>>>>USING USER-SPECIFIED PIPESIZE (EXISTING ELEMENT)<<<<<
============================================================================
  ELEVATION DATA: UPSTREAM(FEET) =  1247.00  DOWNSTREAM(FEET) =  1241.00
  FLOW LENGTH(FEET) =   450.00   MANNING'S N =  0.013
  DEPTH OF FLOW IN  36.0 INCH PIPE IS  22.7 INCHES
  PIPE-FLOW VELOCITY(FEET/SEC.) =  11.25
  GIVEN PIPE DIAMETER(INCH) =  36.00    NUMBER OF PIPES =   1
  PIPE-FLOW(CFS) =      52.72
  PIPE TRAVEL TIME(MIN.) =   0.67    Tc(MIN.) =   15.90
  LONGEST FLOWPATH FROM NODE  50000.00 TO NODE  50006.00 =    4095.00 FEET.

****************************************************************************
  FLOW PROCESS FROM NODE  50006.00 TO NODE  50006.00 IS CODE =  81
----------------------------------------------------------------------------
  >>>>>ADDITION OF SUBAREA TO MAINLINE PEAK FLOW<<<<<
============================================================================
  MAINLINE Tc(MIN.) =   15.90
  * 100 YEAR RAINFALL INTENSITY(INCH/HR) =  2.773
  SUBAREA LOSS RATE DATA(AMC III):
   DEVELOPMENT TYPE/      SCS SOIL   AREA      Fp         Ap     SCS
       LAND USE            GROUP   (ACRES)  (INCH/HR)  (DECIMAL)  CN
  COMMERCIAL                 B      10.00      0.42     0.100    76
  SUBAREA AVERAGE PERVIOUS LOSS RATE, Fp(INCH/HR) =  0.42
  SUBAREA AVERAGE PERVIOUS AREA FRACTION, Ap =  0.100
  SUBAREA AREA(ACRES) =   10.00      SUBAREA RUNOFF(CFS) =   24.58
  EFFECTIVE AREA(ACRES) =     30.90   AREA-AVERAGED Fm(INCH/HR) =  0.04
  AREA-AVERAGED Fp(INCH/HR) =  0.42  AREA-AVERAGED Ap =  0.10
  TOTAL AREA(ACRES) =       30.9       PEAK FLOW RATE(CFS) =      75.94

****************************************************************************
  FLOW PROCESS FROM NODE  50006.00 TO NODE  50007.00 IS CODE =  41
----------------------------------------------------------------------------
  >>>>>COMPUTE PIPE-FLOW TRAVEL TIME THRU SUBAREA<<<<<
  >>>>>USING USER-SPECIFIED PIPESIZE (EXISTING ELEMENT)<<<<<
============================================================================
  ELEVATION DATA: UPSTREAM(FEET) =  1241.00  DOWNSTREAM(FEET) =  1218.00
  FLOW LENGTH(FEET) =  1330.00   MANNING'S N =  0.013
  DEPTH OF FLOW IN  36.0 INCH PIPE IS  27.0 INCHES
  PIPE-FLOW VELOCITY(FEET/SEC.) =  13.34
  GIVEN PIPE DIAMETER(INCH) =  36.00    NUMBER OF PIPES =   1
  PIPE-FLOW(CFS) =      75.94
  PIPE TRAVEL TIME(MIN.) =   1.66    Tc(MIN.) =   17.56
  LONGEST FLOWPATH FROM NODE  50000.00 TO NODE  50007.00 =    5425.00 FEET.
```

```
****************************************************************************
  FLOW PROCESS FROM NODE  50007.00 TO NODE  50007.00 IS CODE =  81
----------------------------------------------------------------------------
  >>>>>ADDITION OF SUBAREA TO MAINLINE PEAK FLOW<<<<<
============================================================================
  MAINLINE Tc(MIN.) =   17.56
  * 100 YEAR RAINFALL INTENSITY(INCH/HR) =  2.613
  SUBAREA LOSS RATE DATA(AMC III):
   DEVELOPMENT TYPE/      SCS SOIL   AREA      Fp         Ap     SCS
       LAND USE            GROUP   (ACRES)  (INCH/HR)  (DECIMAL)  CN
  COMMERCIAL                 B        9.30      0.42     0.100    76
  SUBAREA AVERAGE PERVIOUS LOSS RATE, Fp(INCH/HR) =  0.42
  SUBAREA AVERAGE PERVIOUS AREA FRACTION, Ap =  0.100
  SUBAREA AREA(ACRES) =    9.30      SUBAREA RUNOFF(CFS) =   21.51
  EFFECTIVE AREA(ACRES) =     40.20   AREA-AVERAGED Fm(INCH/HR) =  0.04
  AREA-AVERAGED Fp(INCH/HR) =  0.42  AREA-AVERAGED Ap =  0.10
  TOTAL AREA(ACRES) =       40.2       PEAK FLOW RATE(CFS) =      92.99

****************************************************************************
  FLOW PROCESS FROM NODE  50007.00 TO NODE  50008.00 IS CODE =  51
----------------------------------------------------------------------------
  >>>>>COMPUTE TRAPEZOIDAL CHANNEL FLOW<<<<<
  >>>>>TRAVELTIME THRU SUBAREA (EXISTING ELEMENT)<<<<<
============================================================================
  ELEVATION DATA: UPSTREAM(FEET) =   1218.00  DOWNSTREAM(FEET) =   1192.00
  CHANNEL LENGTH THRU SUBAREA(FEET) =  1316.00   CHANNEL SLOPE =  0.0198
  CHANNEL BASE(FEET) =    2.00   "Z" FACTOR =   4.000
  MANNING'S FACTOR = 0.015   MAXIMUM DEPTH(FEET) =   3.00
  * 100 YEAR RAINFALL INTENSITY(INCH/HR) =  2.451
  SUBAREA LOSS RATE DATA(AMC III):
   DEVELOPMENT TYPE/      SCS SOIL   AREA      Fp         Ap     SCS
       LAND USE            GROUP   (ACRES)  (INCH/HR)  (DECIMAL)  CN
  COMMERCIAL                 B        5.90      0.42     0.100    76
  SUBAREA AVERAGE PERVIOUS LOSS RATE, Fp(INCH/HR) =  0.42
  SUBAREA AVERAGE PERVIOUS AREA FRACTION, Ap =  0.100
  TRAVEL TIME COMPUTED USING ESTIMATED FLOW(CFS) =      99.39
  TRAVEL TIME THRU SUBAREA BASED ON VELOCITY(FEET/SEC.) =  11.15
  AVERAGE FLOW DEPTH(FEET) =   1.26   TRAVEL TIME(MIN.) =   1.97
  Tc(MIN.) =   19.53
  SUBAREA AREA(ACRES) =     5.90       SUBAREA RUNOFF(CFS) =   12.79
  EFFECTIVE AREA(ACRES) =     46.10     AREA-AVERAGED Fm(INCH/HR) =   0.04
  AREA-AVERAGED Fp(INCH/HR) =   0.42  AREA-AVERAGED Ap =   0.10
  TOTAL AREA(ACRES) =       46.1         PEAK FLOW RATE(CFS) =      99.95

  END OF SUBAREA CHANNEL FLOW HYDRAULICS:
  DEPTH(FEET) =  1.26   FLOW VELOCITY(FEET/SEC.) =  11.21
  LONGEST FLOWPATH FROM NODE  50000.00 TO NODE  50008.00 =    6741.00 FEET.

****************************************************************************
  FLOW PROCESS FROM NODE  50008.00 TO NODE  50008.00 IS CODE =   1
----------------------------------------------------------------------------
  >>>>>DESIGNATE INDEPENDENT STREAM FOR CONFLUENCE<<<<<
============================================================================
  TOTAL NUMBER OF STREAMS =  2
  CONFLUENCE VALUES USED FOR INDEPENDENT STREAM  1 ARE:
  TIME OF CONCENTRATION(MIN.) =   19.53
  RAINFALL INTENSITY(INCH/HR) =   2.45
  AREA-AVERAGED Fm(INCH/HR) =  0.04
  AREA-AVERAGED Fp(INCH/HR) =  0.42
  AREA-AVERAGED Ap =  0.10
  EFFECTIVE STREAM AREA(ACRES) =      46.10
  TOTAL STREAM AREA(ACRES) =      46.10
  PEAK FLOW RATE(CFS) AT CONFLUENCE =      99.95

****************************************************************************
  FLOW PROCESS FROM NODE  52000.00 TO NODE  52005.00 IS CODE =  21
----------------------------------------------------------------------------
  >>>>>RATIONAL METHOD INITIAL SUBAREA ANALYSIS<<<<<
  >>USE TIME-OF-CONCENTRATION NOMOGRAPH FOR INITIAL SUBAREA<<
============================================================================
  INITIAL SUBAREA FLOW-LENGTH(FEET) =   480.00
```

```
  ELEVATION DATA: UPSTREAM(FEET) =   1240.00  DOWNSTREAM(FEET) =   1237.00

  Tc = K*[(LENGTH** 3.00)/(ELEVATION CHANGE)]**0.20
  SUBAREA ANALYSIS USED MINIMUM Tc(MIN.) =    9.913
  * 100 YEAR RAINFALL INTENSITY(INCH/HR) =  3.682
  SUBAREA Tc AND LOSS RATE DATA(AMC III):
   DEVELOPMENT TYPE/      SCS SOIL   AREA      Fp         Ap     SCS   Tc
       LAND USE            GROUP   (ACRES)  (INCH/HR)  (DECIMAL)  CN  (MIN.)
  COMMERCIAL                 B        1.50      0.42     0.100    76    9.91
  SUBAREA AVERAGE PERVIOUS LOSS RATE, Fp(INCH/HR) =  0.42
  SUBAREA AVERAGE PERVIOUS AREA FRACTION, Ap =  0.100
  SUBAREA RUNOFF(CFS) =      4.91
  TOTAL AREA(ACRES) =      1.50   PEAK FLOW RATE(CFS) =      4.91

****************************************************************************
  FLOW PROCESS FROM NODE  52005.00 TO NODE  52010.00 IS CODE =  51
----------------------------------------------------------------------------
  >>>>>COMPUTE TRAPEZOIDAL CHANNEL FLOW<<<<<
  >>>>>TRAVELTIME THRU SUBAREA (EXISTING ELEMENT)<<<<<
============================================================================
  ELEVATION DATA: UPSTREAM(FEET) =   1237.00  DOWNSTREAM(FEET) =   1228.00
  CHANNEL LENGTH THRU SUBAREA(FEET) =   635.00   CHANNEL SLOPE =  0.0142
  CHANNEL BASE(FEET) =    2.00   "Z" FACTOR =   4.000
  MANNING'S FACTOR = 0.030   MAXIMUM DEPTH(FEET) =   1.00
  * 100 YEAR RAINFALL INTENSITY(INCH/HR) =  3.030
  SUBAREA LOSS RATE DATA(AMC III):
   DEVELOPMENT TYPE/      SCS SOIL   AREA      Fp         Ap     SCS
       LAND USE            GROUP   (ACRES)  (INCH/HR)  (DECIMAL)  CN
  RESIDENTIAL
  "3-4 DWELLINGS/ACRE"       B        0.40      0.42     0.600    76
  SUBAREA AVERAGE PERVIOUS LOSS RATE, Fp(INCH/HR) =  0.42
  SUBAREA AVERAGE PERVIOUS AREA FRACTION, Ap =  0.600
  TRAVEL TIME COMPUTED USING ESTIMATED FLOW(CFS) =       5.41
  TRAVEL TIME THRU SUBAREA BASED ON VELOCITY(FEET/SEC.) =   2.78
  AVERAGE FLOW DEPTH(FEET) =   0.49   TRAVEL TIME(MIN.) =   3.81
  Tc(MIN.) =   13.72
  SUBAREA AREA(ACRES) =     0.40       SUBAREA RUNOFF(CFS) =    1.00
  EFFECTIVE AREA(ACRES) =      1.90     AREA-AVERAGED Fm(INCH/HR) =   0.09
  AREA-AVERAGED Fp(INCH/HR) =   0.42  AREA-AVERAGED Ap =   0.21
  TOTAL AREA(ACRES) =        1.9         PEAK FLOW RATE(CFS) =       5.03

  END OF SUBAREA CHANNEL FLOW HYDRAULICS:
  DEPTH(FEET) =  0.48   FLOW VELOCITY(FEET/SEC.) =   2.71
  LONGEST FLOWPATH FROM NODE  52000.00 TO NODE  52010.00 =    1115.00 FEET.

****************************************************************************
  FLOW PROCESS FROM NODE  52010.00 TO NODE  52010.00 IS CODE =  81
----------------------------------------------------------------------------
  >>>>>ADDITION OF SUBAREA TO MAINLINE PEAK FLOW<<<<<
============================================================================
  MAINLINE Tc(MIN.) =   13.72
  * 100 YEAR RAINFALL INTENSITY(INCH/HR) =  3.030
  SUBAREA LOSS RATE DATA(AMC III):
   DEVELOPMENT TYPE/      SCS SOIL   AREA      Fp         Ap     SCS
       LAND USE            GROUP   (ACRES)  (INCH/HR)  (DECIMAL)  CN
  COMMERCIAL                 B        2.90      0.42     0.100    76
  SUBAREA AVERAGE PERVIOUS LOSS RATE, Fp(INCH/HR) =  0.42
  SUBAREA AVERAGE PERVIOUS AREA FRACTION, Ap =  0.100
  SUBAREA AREA(ACRES) =    2.90      SUBAREA RUNOFF(CFS) =    7.80
  EFFECTIVE AREA(ACRES) =      4.80   AREA-AVERAGED Fm(INCH/HR) =  0.06
  AREA-AVERAGED Fp(INCH/HR) =  0.42  AREA-AVERAGED Ap =  0.14
  TOTAL AREA(ACRES) =        4.8       PEAK FLOW RATE(CFS) =      12.83

****************************************************************************
  FLOW PROCESS FROM NODE  52010.00 TO NODE  52015.00 IS CODE =  51
----------------------------------------------------------------------------
  >>>>>COMPUTE TRAPEZOIDAL CHANNEL FLOW<<<<<
  >>>>>TRAVELTIME THRU SUBAREA (EXISTING ELEMENT)<<<<<
============================================================================
  ELEVATION DATA: UPSTREAM(FEET) =   1228.00  DOWNSTREAM(FEET) =   1218.00
  CHANNEL LENGTH THRU SUBAREA(FEET) =   520.00   CHANNEL SLOPE =  0.0192
```

```
  CHANNEL BASE(FEET) =    2.00   "Z" FACTOR =   4.000
  MANNING'S FACTOR = 0.030   MAXIMUM DEPTH(FEET) =   2.00
  * 100 YEAR RAINFALL INTENSITY(INCH/HR) =  2.770
  SUBAREA LOSS RATE DATA(AMC III):
   DEVELOPMENT TYPE/      SCS SOIL   AREA      Fp         Ap     SCS
       LAND USE            GROUP   (ACRES)  (INCH/HR)  (DECIMAL)  CN
  RESIDENTIAL
  "3-4 DWELLINGS/ACRE"       B        0.30      0.42     0.600    76
  SUBAREA AVERAGE PERVIOUS LOSS RATE, Fp(INCH/HR) =  0.42
  SUBAREA AVERAGE PERVIOUS AREA FRACTION, Ap =  0.600
  TRAVEL TIME COMPUTED USING ESTIMATED FLOW(CFS) =      13.17
  TRAVEL TIME THRU SUBAREA BASED ON VELOCITY(FEET/SEC.) =   3.93
  AVERAGE FLOW DEPTH(FEET) =   0.70   TRAVEL TIME(MIN.) =   2.21
  Tc(MIN.) =   15.93
  SUBAREA AREA(ACRES) =     0.30       SUBAREA RUNOFF(CFS) =    0.68
  EFFECTIVE AREA(ACRES) =      5.10     AREA-AVERAGED Fm(INCH/HR) =   0.07
  AREA-AVERAGED Fp(INCH/HR) =   0.42  AREA-AVERAGED Ap =   0.17
  TOTAL AREA(ACRES) =        5.1         PEAK FLOW RATE(CFS) =      12.83
  NOTE: PEAK FLOW RATE DEFAULTED TO UPSTREAM VALUE

  END OF SUBAREA CHANNEL FLOW HYDRAULICS:
  DEPTH(FEET) =  0.69   FLOW VELOCITY(FEET/SEC.) =   3.89
  LONGEST FLOWPATH FROM NODE  52000.00 TO NODE  52015.00 =    1635.00 FEET.

****************************************************************************
  FLOW PROCESS FROM NODE  52015.00 TO NODE  52015.00 IS CODE =  81
----------------------------------------------------------------------------
  >>>>>ADDITION OF SUBAREA TO MAINLINE PEAK FLOW<<<<<
============================================================================
  MAINLINE Tc(MIN.) =   15.93
  * 100 YEAR RAINFALL INTENSITY(INCH/HR) =  2.770
  SUBAREA LOSS RATE DATA(AMC III):
   DEVELOPMENT TYPE/      SCS SOIL   AREA      Fp         Ap     SCS
       LAND USE            GROUP   (ACRES)  (INCH/HR)  (DECIMAL)  CN
  RESIDENTIAL
  "3-4 DWELLINGS/ACRE"       B        4.10      0.42     0.600    76
  SUBAREA AVERAGE PERVIOUS LOSS RATE, Fp(INCH/HR) =  0.42
  SUBAREA AVERAGE PERVIOUS AREA FRACTION, Ap =  0.600
  SUBAREA AREA(ACRES) =    4.10      SUBAREA RUNOFF(CFS) =    9.29
  EFFECTIVE AREA(ACRES) =      9.20   AREA-AVERAGED Fm(INCH/HR) =  0.15
  AREA-AVERAGED Fp(INCH/HR) =  0.42  AREA-AVERAGED Ap =  0.36
  TOTAL AREA(ACRES) =        9.2       PEAK FLOW RATE(CFS) =      21.67

****************************************************************************
  FLOW PROCESS FROM NODE  52015.00 TO NODE  52025.00 IS CODE =  51
----------------------------------------------------------------------------
  >>>>>COMPUTE TRAPEZOIDAL CHANNEL FLOW<<<<<
  >>>>>TRAVELTIME THRU SUBAREA (EXISTING ELEMENT)<<<<<
============================================================================
  ELEVATION DATA: UPSTREAM(FEET) =    1218.00  DOWNSTREAM(FEET) =   1209.00
  CHANNEL LENGTH THRU SUBAREA(FEET) =   610.00   CHANNEL SLOPE =  0.0148
  CHANNEL BASE(FEET) =    2.00   "Z" FACTOR =   4.000
  MANNING'S FACTOR = 0.030   MAXIMUM DEPTH(FEET) =   2.00
  * 100 YEAR RAINFALL INTENSITY(INCH/HR) =  2.538
  SUBAREA LOSS RATE DATA(AMC III):
   DEVELOPMENT TYPE/      SCS SOIL   AREA      Fp         Ap     SCS
       LAND USE            GROUP   (ACRES)  (INCH/HR)  (DECIMAL)  CN
  RESIDENTIAL
  "3-4 DWELLINGS/ACRE"       B        0.40      0.42     0.600    76
  SUBAREA AVERAGE PERVIOUS LOSS RATE, Fp(INCH/HR) =  0.42
  SUBAREA AVERAGE PERVIOUS AREA FRACTION, Ap =  0.600
  TRAVEL TIME COMPUTED USING ESTIMATED FLOW(CFS) =      22.09
  TRAVEL TIME THRU SUBAREA BASED ON VELOCITY(FEET/SEC.) =   4.07
  AVERAGE FLOW DEPTH(FEET) =   0.94   TRAVEL TIME(MIN.) =   2.50
  Tc(MIN.) =   18.42
  SUBAREA AREA(ACRES) =     0.40       SUBAREA RUNOFF(CFS) =    0.82
  EFFECTIVE AREA(ACRES) =      9.60     AREA-AVERAGED Fm(INCH/HR) =   0.16
  AREA-AVERAGED Fp(INCH/HR) =   0.42  AREA-AVERAGED Ap =   0.37
  TOTAL AREA(ACRES) =        9.6         PEAK FLOW RATE(CFS) =      21.67
  NOTE: PEAK FLOW RATE DEFAULTED TO UPSTREAM VALUE
```

```
  END OF SUBAREA CHANNEL FLOW HYDRAULICS:
  DEPTH(FEET) =  0.93   FLOW VELOCITY(FEET/SEC.) =   4.05
  LONGEST FLOWPATH FROM NODE  52000.00 TO NODE  52025.00 =    2245.00 FEET.

****************************************************************************
  FLOW PROCESS FROM NODE  52025.00 TO NODE  52035.00 IS CODE =  51
----------------------------------------------------------------------------
  >>>>>COMPUTE TRAPEZOIDAL CHANNEL FLOW<<<<<
  >>>>>TRAVELTIME THRU SUBAREA (EXISTING ELEMENT)<<<<<
============================================================================
  ELEVATION DATA: UPSTREAM(FEET) =   1209.00  DOWNSTREAM(FEET) =   1199.00
  CHANNEL LENGTH THRU SUBAREA(FEET) =   938.00   CHANNEL SLOPE =  0.0107
  CHANNEL BASE(FEET) =    2.00   "Z" FACTOR =   4.000
  MANNING'S FACTOR = 0.030   MAXIMUM DEPTH(FEET) =   2.00
  * 100 YEAR RAINFALL INTENSITY(INCH/HR) =  2.236
  SUBAREA LOSS RATE DATA(AMC III):
   DEVELOPMENT TYPE/      SCS SOIL   AREA      Fp         Ap     SCS
       LAND USE            GROUP   (ACRES)  (INCH/HR)  (DECIMAL)  CN
  RESIDENTIAL
  "3-4 DWELLINGS/ACRE"       B        0.40      0.42     0.600    76
  SUBAREA AVERAGE PERVIOUS LOSS RATE, Fp(INCH/HR) =  0.42
  SUBAREA AVERAGE PERVIOUS AREA FRACTION, Ap =  0.600
  TRAVEL TIME COMPUTED USING ESTIMATED FLOW(CFS) =      22.03
  TRAVEL TIME THRU SUBAREA BASED ON VELOCITY(FEET/SEC.) =   3.60
  AVERAGE FLOW DEPTH(FEET) =   1.01   TRAVEL TIME(MIN.) =   4.34
  Tc(MIN.) =   22.77
  SUBAREA AREA(ACRES) =     0.40       SUBAREA RUNOFF(CFS) =    0.71
  EFFECTIVE AREA(ACRES) =     10.00     AREA-AVERAGED Fm(INCH/HR) =   0.16
  AREA-AVERAGED Fp(INCH/HR) =   0.42  AREA-AVERAGED Ap =   0.38
  TOTAL AREA(ACRES) =       10.0         PEAK FLOW RATE(CFS) =      21.67
  NOTE: PEAK FLOW RATE DEFAULTED TO UPSTREAM VALUE

  END OF SUBAREA CHANNEL FLOW HYDRAULICS:
  DEPTH(FEET) =  1.00   FLOW VELOCITY(FEET/SEC.) =   3.59
  LONGEST FLOWPATH FROM NODE  52000.00 TO NODE  52035.00 =    3183.00 FEET.

****************************************************************************
  FLOW PROCESS FROM NODE  52035.00 TO NODE  52040.00 IS CODE =  62
----------------------------------------------------------------------------
  >>>>>COMPUTE STREET FLOW TRAVEL TIME THRU SUBAREA<<<<<
  >>>>>(STREET TABLE SECTION #  1 USED)<<<<<
============================================================================
  UPSTREAM ELEVATION(FEET) = 1199.00  DOWNSTREAM ELEVATION(FEET) = 1198.00
  STREET LENGTH(FEET) =   180.00   CURB HEIGHT(INCHES) =  8.0
  STREET HALFWIDTH(FEET) = 30.00

  DISTANCE FROM CROWN TO CROSSFALL GRADEBREAK(FEET) =  20.00
  INSIDE STREET CROSSFALL(DECIMAL) =  0.018
  OUTSIDE STREET CROSSFALL(DECIMAL)  =  0.018

  SPECIFIED NUMBER OF HALFSTREETS CARRYING RUNOFF =  1
  STREET PARKWAY CROSSFALL(DECIMAL)  =  0.020
  Manning's FRICTION FACTOR for Streetflow Section(curb-to-curb) =   0.0150
  Manning's FRICTION FACTOR for Back-of-Walk Flow Section =   0.0200

    **TRAVEL TIME COMPUTED USING ESTIMATED FLOW(CFS) =      21.77
    STREETFLOW MODEL RESULTS USING ESTIMATED FLOW:
    STREET FLOW DEPTH(FEET) =  0.67
    HALFSTREET FLOOD WIDTH(FEET) =   28.40
    AVERAGE FLOW VELOCITY(FEET/SEC.) =    2.96
    PRODUCT OF DEPTH&VELOCITY(FT*FT/SEC.) =    1.98
  STREET FLOW TRAVEL TIME(MIN.) =   1.01   Tc(MIN.) =   23.78
  * 100 YEAR RAINFALL INTENSITY(INCH/HR) =  2.178
  SUBAREA LOSS RATE DATA(AMC III):
   DEVELOPMENT TYPE/      SCS SOIL   AREA      Fp         Ap     SCS
       LAND USE            GROUP   (ACRES)  (INCH/HR)  (DECIMAL)  CN
  COMMERCIAL                 B        0.10      0.42     0.100    76
  SUBAREA AVERAGE PERVIOUS LOSS RATE, Fp(INCH/HR) =  0.42
  SUBAREA AVERAGE PERVIOUS AREA FRACTION, Ap =  0.100
  SUBAREA AREA(ACRES) =    0.10      SUBAREA RUNOFF(CFS) =    0.19
  EFFECTIVE AREA(ACRES) =     10.10    AREA-AVERAGED Fm(INCH/HR) =  0.16
```

```
  AREA-AVERAGED Fp(INCH/HR) =  0.42  AREA-AVERAGED Ap =  0.38
  TOTAL AREA(ACRES) =       10.1        PEAK FLOW RATE(CFS) =      21.67
  NOTE: PEAK FLOW RATE DEFAULTED TO UPSTREAM VALUE

  END OF SUBAREA STREET FLOW HYDRAULICS:
  DEPTH(FEET) = 0.67   HALFSTREET FLOOD WIDTH(FEET) =  28.40
  FLOW VELOCITY(FEET/SEC.) =  2.95   DEPTH*VELOCITY(FT*FT/SEC.) =   1.97
  LONGEST FLOWPATH FROM NODE  52000.00 TO NODE  52040.00 =    3363.00 FEET.

****************************************************************************
  FLOW PROCESS FROM NODE  52040.00 TO NODE  52040.00 IS CODE =  81
----------------------------------------------------------------------------
  >>>>>ADDITION OF SUBAREA TO MAINLINE PEAK FLOW<<<<<
============================================================================
  MAINLINE Tc(MIN.) =   23.78
  * 100 YEAR RAINFALL INTENSITY(INCH/HR) =  2.178
  SUBAREA LOSS RATE DATA(AMC III):
   DEVELOPMENT TYPE/      SCS SOIL   AREA      Fp         Ap     SCS
       LAND USE            GROUP   (ACRES)  (INCH/HR)  (DECIMAL)  CN
  COMMERCIAL                 B        4.60      0.42     0.100    76
  COMMERCIAL                 B       12.30      0.42     0.100    76
  SUBAREA AVERAGE PERVIOUS LOSS RATE, Fp(INCH/HR) =  0.42
  SUBAREA AVERAGE PERVIOUS AREA FRACTION, Ap =  0.100
  SUBAREA AREA(ACRES) =   16.90      SUBAREA RUNOFF(CFS) =   32.49
  EFFECTIVE AREA(ACRES) =     27.00   AREA-AVERAGED Fm(INCH/HR) =  0.09
  AREA-AVERAGED Fp(INCH/HR) =  0.42  AREA-AVERAGED Ap =  0.20
  TOTAL AREA(ACRES) =       27.0       PEAK FLOW RATE(CFS) =      50.83

****************************************************************************
  FLOW PROCESS FROM NODE  52040.00 TO NODE  50008.00 IS CODE =  41
----------------------------------------------------------------------------
  >>>>>COMPUTE PIPE-FLOW TRAVEL TIME THRU SUBAREA<<<<<
  >>>>>USING USER-SPECIFIED PIPESIZE (EXISTING ELEMENT)<<<<<
============================================================================
  ELEVATION DATA: UPSTREAM(FEET) =  1198.00  DOWNSTREAM(FEET) =  1192.00
  FLOW LENGTH(FEET) =    45.00   MANNING'S N =  0.013
  DEPTH OF FLOW IN  24.0 INCH PIPE IS  14.1 INCHES
  PIPE-FLOW VELOCITY(FEET/SEC.) =  26.54
  GIVEN PIPE DIAMETER(INCH) =  24.00    NUMBER OF PIPES =   1
  PIPE-FLOW(CFS) =      50.83
  PIPE TRAVEL TIME(MIN.) =   0.03    Tc(MIN.) =   23.81
  LONGEST FLOWPATH FROM NODE  52000.00 TO NODE  50008.00 =    3408.00 FEET.

****************************************************************************
  FLOW PROCESS FROM NODE  50008.00 TO NODE  50008.00 IS CODE =   1
----------------------------------------------------------------------------
  >>>>>DESIGNATE INDEPENDENT STREAM FOR CONFLUENCE<<<<<
  >>>>>AND COMPUTE VARIOUS CONFLUENCED STREAM VALUES<<<<<
============================================================================
  TOTAL NUMBER OF STREAMS =  2
  CONFLUENCE VALUES USED FOR INDEPENDENT STREAM  2 ARE:
  TIME OF CONCENTRATION(MIN.) =   23.81
  RAINFALL INTENSITY(INCH/HR) =   2.18
  AREA-AVERAGED Fm(INCH/HR) =  0.09
  AREA-AVERAGED Fp(INCH/HR) =  0.42
  AREA-AVERAGED Ap =  0.20
  EFFECTIVE STREAM AREA(ACRES) =      27.00
  TOTAL STREAM AREA(ACRES) =      27.00
  PEAK FLOW RATE(CFS) AT CONFLUENCE =      50.83

  ** CONFLUENCE DATA **
   STREAM       Q      Tc   Intensity   Fp(Fm)     Ap     Ae     HEADWATER
   NUMBER     (CFS)  (MIN.) (INCH/HR) (INCH/HR)         (ACRES)    NODE
      1       99.95   19.53    2.451  0.42( 0.04) 0.10      46.1   50000.00
      2       50.83   23.81    2.177  0.42( 0.09) 0.20      27.0   52000.00

  RAINFALL INTENSITY AND TIME OF CONCENTRATION RATIO
  CONFLUENCE FORMULA USED FOR  2 STREAMS.

  ** PEAK FLOW RATE TABLE **
   STREAM       Q      Tc   Intensity   Fp(Fm)     Ap     Ae     HEADWATER
```

```
 NUMBER     (CFS)  (MIN.) (INCH/HR) (INCH/HR)         (ACRES)    NODE
    1      147.13   19.53    2.451  0.42( 0.06) 0.13      68.2   50000.00
    2      139.39   23.81    2.177  0.42( 0.06) 0.14      73.1   52000.00

COMPUTED CONFLUENCE ESTIMATES ARE AS FOLLOWS:
PEAK FLOW RATE(CFS) =     147.13    Tc(MIN.) =    19.53
EFFECTIVE AREA(ACRES) =      68.25   AREA-AVERAGED Fm(INCH/HR) =  0.06
AREA-AVERAGED Fp(INCH/HR) =  0.42  AREA-AVERAGED Ap =  0.13
TOTAL AREA(ACRES) =       73.1
LONGEST FLOWPATH FROM NODE  50000.00 TO NODE  50008.00 =    6741.00 FEET.

****************************************************************************
FLOW PROCESS FROM NODE  50008.00 TO NODE  50035.00 IS CODE =  41
----------------------------------------------------------------------------
>>>>>COMPUTE PIPE-FLOW TRAVEL TIME THRU SUBAREA<<<<<
>>>>>USING USER-SPECIFIED PIPESIZE (EXISTING ELEMENT)<<<<<
============================================================================
ELEVATION DATA: UPSTREAM(FEET) =  1192.00  DOWNSTREAM(FEET) =  1190.60
FLOW LENGTH(FEET) =   140.00   MANNING'S N =  0.013
ASSUME FULL-FLOWING PIPELINE
PIPE-FLOW VELOCITY(FEET/SEC.) =  11.71
PIPE FLOW VELOCITY = (TOTAL FLOW)/(PIPE CROSS SECTION AREA)
GIVEN PIPE DIAMETER(INCH) =  48.00    NUMBER OF PIPES =   1
PIPE-FLOW(CFS) =     147.13
PIPE TRAVEL TIME(MIN.) =   0.20    Tc(MIN.) =   19.73
LONGEST FLOWPATH FROM NODE  50000.00 TO NODE  50035.00 =    6881.00 FEET.

****************************************************************************
FLOW PROCESS FROM NODE  50035.00 TO NODE  50035.00 IS CODE =  81
----------------------------------------------------------------------------
>>>>>ADDITION OF SUBAREA TO MAINLINE PEAK FLOW<<<<<
============================================================================
MAINLINE Tc(MIN.) =   19.73
* 100 YEAR RAINFALL INTENSITY(INCH/HR) =  2.436
SUBAREA LOSS RATE DATA(AMC III):
 DEVELOPMENT TYPE/      SCS SOIL   AREA      Fp         Ap     SCS
     LAND USE            GROUP   (ACRES)  (INCH/HR)  (DECIMAL)  CN
COMMERCIAL                 B      69.30      0.42     0.100    76
SUBAREA AVERAGE PERVIOUS LOSS RATE, Fp(INCH/HR) =  0.42
SUBAREA AVERAGE PERVIOUS AREA FRACTION, Ap =  0.100
SUBAREA AREA(ACRES) =   69.30      SUBAREA RUNOFF(CFS) =  149.32
EFFECTIVE AREA(ACRES) =    137.55   AREA-AVERAGED Fm(INCH/HR) =  0.05
AREA-AVERAGED Fp(INCH/HR) =  0.42  AREA-AVERAGED Ap =  0.12
TOTAL AREA(ACRES) =      142.4       PEAK FLOW RATE(CFS) =     295.51

****************************************************************************
FLOW PROCESS FROM NODE  50035.00 TO NODE  50015.00 IS CODE =  51
----------------------------------------------------------------------------
>>>>>COMPUTE TRAPEZOIDAL CHANNEL FLOW<<<<<
>>>>>TRAVELTIME THRU SUBAREA (EXISTING ELEMENT)<<<<<
============================================================================
ELEVATION DATA: UPSTREAM(FEET) =   1190.60  DOWNSTREAM(FEET) =   1162.00
CHANNEL LENGTH THRU SUBAREA(FEET) =  2460.00   CHANNEL SLOPE =  0.0116
CHANNEL BASE(FEET) =    2.00   "Z" FACTOR =   2.000
MANNING'S FACTOR = 0.015   MAXIMUM DEPTH(FEET) =   4.00
* 100 YEAR RAINFALL INTENSITY(INCH/HR) =  2.241
SUBAREA LOSS RATE DATA(AMC III):
 DEVELOPMENT TYPE/      SCS SOIL   AREA      Fp         Ap     SCS
     LAND USE            GROUP   (ACRES)  (INCH/HR)  (DECIMAL)  CN
COMMERCIAL                 B      10.00      0.42     0.100    76
SUBAREA AVERAGE PERVIOUS LOSS RATE, Fp(INCH/HR) =  0.42
SUBAREA AVERAGE PERVIOUS AREA FRACTION, Ap =  0.100
TRAVEL TIME COMPUTED USING ESTIMATED FLOW(CFS) =     305.40
TRAVEL TIME THRU SUBAREA BASED ON VELOCITY(FEET/SEC.) =  13.93
AVERAGE FLOW DEPTH(FEET) =   2.85   TRAVEL TIME(MIN.) =   2.94
Tc(MIN.) =   22.67
SUBAREA AREA(ACRES) =    10.00       SUBAREA RUNOFF(CFS) =   19.79
EFFECTIVE AREA(ACRES) =    147.55     AREA-AVERAGED Fm(INCH/HR) =   0.05
AREA-AVERAGED Fp(INCH/HR) =   0.42  AREA-AVERAGED Ap =   0.12
TOTAL AREA(ACRES) =      152.4         PEAK FLOW RATE(CFS) =     295.51
NOTE: PEAK FLOW RATE DEFAULTED TO UPSTREAM VALUE
```

```
  END OF SUBAREA CHANNEL FLOW HYDRAULICS:
  DEPTH(FEET) =  2.81   FLOW VELOCITY(FEET/SEC.) =  13.80
  LONGEST FLOWPATH FROM NODE  50000.00 TO NODE  50015.00 =    9341.00 FEET.

****************************************************************************
  FLOW PROCESS FROM NODE  50015.00 TO NODE  50015.00 IS CODE =   1
----------------------------------------------------------------------------
  >>>>>DESIGNATE INDEPENDENT STREAM FOR CONFLUENCE<<<<<
============================================================================
  TOTAL NUMBER OF STREAMS =  3
  CONFLUENCE VALUES USED FOR INDEPENDENT STREAM  1 ARE:
  TIME OF CONCENTRATION(MIN.) =   22.67
  RAINFALL INTENSITY(INCH/HR) =   2.24
  AREA-AVERAGED Fm(INCH/HR) =  0.05
  AREA-AVERAGED Fp(INCH/HR) =  0.42
  AREA-AVERAGED Ap =  0.12
  EFFECTIVE STREAM AREA(ACRES) =     147.55
  TOTAL STREAM AREA(ACRES) =     152.40
  PEAK FLOW RATE(CFS) AT CONFLUENCE =     295.51

****************************************************************************
  FLOW PROCESS FROM NODE  50005.00 TO NODE  50010.00 IS CODE =  21
----------------------------------------------------------------------------
  >>>>>RATIONAL METHOD INITIAL SUBAREA ANALYSIS<<<<<
  >>USE TIME-OF-CONCENTRATION NOMOGRAPH FOR INITIAL SUBAREA<<
============================================================================
  INITIAL SUBAREA FLOW-LENGTH(FEET) =   418.80
  ELEVATION DATA: UPSTREAM(FEET) =   1188.00  DOWNSTREAM(FEET) =   1183.00

  Tc = K*[(LENGTH** 3.00)/(ELEVATION CHANGE)]**0.20
  SUBAREA ANALYSIS USED MINIMUM Tc(MIN.) =   13.103
  * 100 YEAR RAINFALL INTENSITY(INCH/HR) =  3.114
  SUBAREA Tc AND LOSS RATE DATA(AMC III):
   DEVELOPMENT TYPE/      SCS SOIL   AREA      Fp         Ap     SCS   Tc
       LAND USE            GROUP   (ACRES)  (INCH/HR)  (DECIMAL)  CN  (MIN.)
  PUBLIC PARK                B        1.10      0.42     0.850    76   13.10
  SUBAREA AVERAGE PERVIOUS LOSS RATE, Fp(INCH/HR) =  0.42
  SUBAREA AVERAGE PERVIOUS AREA FRACTION, Ap =  0.850
  SUBAREA RUNOFF(CFS) =      2.73
  TOTAL AREA(ACRES) =      1.10   PEAK FLOW RATE(CFS) =      2.73

****************************************************************************
  FLOW PROCESS FROM NODE  50010.00 TO NODE  50015.00 IS CODE =  51
----------------------------------------------------------------------------
  >>>>>COMPUTE TRAPEZOIDAL CHANNEL FLOW<<<<<
  >>>>>TRAVELTIME THRU SUBAREA (EXISTING ELEMENT)<<<<<
============================================================================
  ELEVATION DATA: UPSTREAM(FEET) =   1183.00  DOWNSTREAM(FEET) =   1162.00
  CHANNEL LENGTH THRU SUBAREA(FEET) =  1592.70   CHANNEL SLOPE =  0.0132
  CHANNEL BASE(FEET) =    5.00   "Z" FACTOR =   4.000
  MANNING'S FACTOR = 0.030   MAXIMUM DEPTH(FEET) =   1.00
  * 100 YEAR RAINFALL INTENSITY(INCH/HR) =  2.153
  SUBAREA LOSS RATE DATA(AMC III):
   DEVELOPMENT TYPE/      SCS SOIL   AREA      Fp         Ap     SCS
       LAND USE            GROUP   (ACRES)  (INCH/HR)  (DECIMAL)  CN
  PUBLIC PARK                B        2.90      0.42     0.850    76
  SUBAREA AVERAGE PERVIOUS LOSS RATE, Fp(INCH/HR) =  0.42
  SUBAREA AVERAGE PERVIOUS AREA FRACTION, Ap =  0.850
  TRAVEL TIME COMPUTED USING ESTIMATED FLOW(CFS) =       5.12
  TRAVEL TIME THRU SUBAREA BASED ON VELOCITY(FEET/SEC.) =   2.38
  AVERAGE FLOW DEPTH(FEET) =   0.34   TRAVEL TIME(MIN.) =  11.14
  Tc(MIN.) =   24.25
  SUBAREA AREA(ACRES) =     2.90       SUBAREA RUNOFF(CFS) =    4.68
  EFFECTIVE AREA(ACRES) =      4.00     AREA-AVERAGED Fm(INCH/HR) =   0.36
  AREA-AVERAGED Fp(INCH/HR) =   0.42  AREA-AVERAGED Ap =   0.85
  TOTAL AREA(ACRES) =        4.0         PEAK FLOW RATE(CFS) =       6.46

  END OF SUBAREA CHANNEL FLOW HYDRAULICS:
  DEPTH(FEET) =  0.38   FLOW VELOCITY(FEET/SEC.) =   2.57
  LONGEST FLOWPATH FROM NODE  50005.00 TO NODE  50015.00 =    2011.50 FEET.
```

```
****************************************************************************
  FLOW PROCESS FROM NODE  50015.00 TO NODE  50015.00 IS CODE =  81
----------------------------------------------------------------------------
  >>>>>ADDITION OF SUBAREA TO MAINLINE PEAK FLOW<<<<<
============================================================================
  MAINLINE Tc(MIN.) =   24.25
  * 100 YEAR RAINFALL INTENSITY(INCH/HR) =  2.153
  SUBAREA LOSS RATE DATA(AMC III):
   DEVELOPMENT TYPE/      SCS SOIL   AREA      Fp         Ap     SCS
       LAND USE            GROUP   (ACRES)  (INCH/HR)  (DECIMAL)  CN
  PUBLIC PARK                B        3.80      0.42     0.850    76
  SUBAREA AVERAGE PERVIOUS LOSS RATE, Fp(INCH/HR) =  0.42
  SUBAREA AVERAGE PERVIOUS AREA FRACTION, Ap =  0.850
  SUBAREA AREA(ACRES) =    3.80      SUBAREA RUNOFF(CFS) =    6.13
  EFFECTIVE AREA(ACRES) =      7.80   AREA-AVERAGED Fm(INCH/HR) =  0.36
  AREA-AVERAGED Fp(INCH/HR) =  0.42  AREA-AVERAGED Ap =  0.85
  TOTAL AREA(ACRES) =        7.8       PEAK FLOW RATE(CFS) =      12.59

****************************************************************************
  FLOW PROCESS FROM NODE  50015.00 TO NODE  50015.00 IS CODE =   1
----------------------------------------------------------------------------
  >>>>>DESIGNATE INDEPENDENT STREAM FOR CONFLUENCE<<<<<
============================================================================
  TOTAL NUMBER OF STREAMS =  3
  CONFLUENCE VALUES USED FOR INDEPENDENT STREAM  2 ARE:
  TIME OF CONCENTRATION(MIN.) =   24.25
  RAINFALL INTENSITY(INCH/HR) =   2.15
  AREA-AVERAGED Fm(INCH/HR) =  0.36
  AREA-AVERAGED Fp(INCH/HR) =  0.42
  AREA-AVERAGED Ap =  0.85
  EFFECTIVE STREAM AREA(ACRES) =       7.80
  TOTAL STREAM AREA(ACRES) =       7.80
  PEAK FLOW RATE(CFS) AT CONFLUENCE =      12.59

****************************************************************************
  FLOW PROCESS FROM NODE  50020.00 TO NODE  50025.00 IS CODE =  21
----------------------------------------------------------------------------
  >>>>>RATIONAL METHOD INITIAL SUBAREA ANALYSIS<<<<<
  >>USE TIME-OF-CONCENTRATION NOMOGRAPH FOR INITIAL SUBAREA<<
============================================================================
  INITIAL SUBAREA FLOW-LENGTH(FEET) =   544.10
  ELEVATION DATA: UPSTREAM(FEET) =   1198.00  DOWNSTREAM(FEET) =   1190.00

  Tc = K*[(LENGTH** 3.00)/(ELEVATION CHANGE)]**0.20
  SUBAREA ANALYSIS USED MINIMUM Tc(MIN.) =   13.955
  * 100 YEAR RAINFALL INTENSITY(INCH/HR) =  2.999
  SUBAREA Tc AND LOSS RATE DATA(AMC III):
   DEVELOPMENT TYPE/      SCS SOIL   AREA      Fp         Ap     SCS   Tc
       LAND USE            GROUP   (ACRES)  (INCH/HR)  (DECIMAL)  CN  (MIN.)
  PUBLIC PARK                B        0.40      0.42     0.850    76   13.96
  SUBAREA AVERAGE PERVIOUS LOSS RATE, Fp(INCH/HR) =  0.42
  SUBAREA AVERAGE PERVIOUS AREA FRACTION, Ap =  0.850
  SUBAREA RUNOFF(CFS) =      0.95
  TOTAL AREA(ACRES) =      0.40   PEAK FLOW RATE(CFS) =      0.95

****************************************************************************
  FLOW PROCESS FROM NODE  50025.00 TO NODE  50015.00 IS CODE =  51
----------------------------------------------------------------------------
  >>>>>COMPUTE TRAPEZOIDAL CHANNEL FLOW<<<<<
  >>>>>TRAVELTIME THRU SUBAREA (EXISTING ELEMENT)<<<<<
============================================================================
  ELEVATION DATA: UPSTREAM(FEET) =   1190.00  DOWNSTREAM(FEET) =   1162.00
  CHANNEL LENGTH THRU SUBAREA(FEET) =  2131.40   CHANNEL SLOPE =  0.0131
  CHANNEL BASE(FEET) =    5.00   "Z" FACTOR =   4.000
  MANNING'S FACTOR = 0.030   MAXIMUM DEPTH(FEET) =   1.00
  * 100 YEAR RAINFALL INTENSITY(INCH/HR) =  1.739
  SUBAREA LOSS RATE DATA(AMC III):
   DEVELOPMENT TYPE/      SCS SOIL   AREA      Fp         Ap     SCS
       LAND USE            GROUP   (ACRES)  (INCH/HR)  (DECIMAL)  CN
  PUBLIC PARK                B        1.40      0.42     0.850    76
```

```
  SUBAREA AVERAGE PERVIOUS LOSS RATE, Fp(INCH/HR) =  0.42
  SUBAREA AVERAGE PERVIOUS AREA FRACTION, Ap =  0.850
  TRAVEL TIME COMPUTED USING ESTIMATED FLOW(CFS) =       1.86
  TRAVEL TIME THRU SUBAREA BASED ON VELOCITY(FEET/SEC.) =   1.72
  AVERAGE FLOW DEPTH(FEET) =   0.19   TRAVEL TIME(MIN.) =  20.65
  Tc(MIN.) =   34.61
  SUBAREA AREA(ACRES) =     1.40       SUBAREA RUNOFF(CFS) =    1.74
  EFFECTIVE AREA(ACRES) =      1.80     AREA-AVERAGED Fm(INCH/HR) =   0.36
  AREA-AVERAGED Fp(INCH/HR) =   0.42  AREA-AVERAGED Ap =   0.85
  TOTAL AREA(ACRES) =        1.8         PEAK FLOW RATE(CFS) =       2.23

  END OF SUBAREA CHANNEL FLOW HYDRAULICS:
  DEPTH(FEET) =  0.21   FLOW VELOCITY(FEET/SEC.) =   1.81
  LONGEST FLOWPATH FROM NODE  50020.00 TO NODE  50015.00 =    2675.50 FEET.

****************************************************************************
  FLOW PROCESS FROM NODE  50015.00 TO NODE  50015.00 IS CODE =   1
----------------------------------------------------------------------------
  >>>>>DESIGNATE INDEPENDENT STREAM FOR CONFLUENCE<<<<<
  >>>>>AND COMPUTE VARIOUS CONFLUENCED STREAM VALUES<<<<<
============================================================================
  TOTAL NUMBER OF STREAMS =  3
  CONFLUENCE VALUES USED FOR INDEPENDENT STREAM  3 ARE:
  TIME OF CONCENTRATION(MIN.) =   34.61
  RAINFALL INTENSITY(INCH/HR) =   1.74
  AREA-AVERAGED Fm(INCH/HR) =  0.36
  AREA-AVERAGED Fp(INCH/HR) =  0.42
  AREA-AVERAGED Ap =  0.85
  EFFECTIVE STREAM AREA(ACRES) =       1.80
  TOTAL STREAM AREA(ACRES) =       1.80
  PEAK FLOW RATE(CFS) AT CONFLUENCE =       2.23

  ** CONFLUENCE DATA **
   STREAM       Q      Tc   Intensity   Fp(Fm)     Ap     Ae     HEADWATER
   NUMBER     (CFS)  (MIN.) (INCH/HR) (INCH/HR)         (ACRES)    NODE
      1      295.51   22.67    2.241  0.42( 0.05) 0.12     147.5   50000.00
      1      270.99   27.03    2.017  0.42( 0.05) 0.12     152.4   52000.00
      2       12.59   24.25    2.153  0.42( 0.36) 0.85       7.8   50005.00
      3        2.23   34.61    1.739  0.42( 0.36) 0.85       1.8   50020.00

  RAINFALL INTENSITY AND TIME OF CONCENTRATION RATIO
  CONFLUENCE FORMULA USED FOR  3 STREAMS.

  ** PEAK FLOW RATE TABLE **
   STREAM       Q      Tc   Intensity   Fp(Fm)     Ap     Ae     HEADWATER
   NUMBER     (CFS)  (MIN.) (INCH/HR) (INCH/HR)         (ACRES)    NODE
      1      309.85   22.67    2.241  0.42( 0.07) 0.16     156.0   50000.00
      2      301.26   24.25    2.153  0.42( 0.07) 0.16     158.4   50005.00
      3      284.73   27.03    2.017  0.42( 0.07) 0.16     161.6   52000.00
      4      244.60   34.61    1.739  0.42( 0.07) 0.16     162.0   50020.00

  COMPUTED CONFLUENCE ESTIMATES ARE AS FOLLOWS:
  PEAK FLOW RATE(CFS) =     309.85    Tc(MIN.) =    22.67
  EFFECTIVE AREA(ACRES) =     156.02   AREA-AVERAGED Fm(INCH/HR) =  0.07
  AREA-AVERAGED Fp(INCH/HR) =  0.42  AREA-AVERAGED Ap =  0.16
  TOTAL AREA(ACRES) =      162.0
  LONGEST FLOWPATH FROM NODE  50000.00 TO NODE  50015.00 =    9341.00 FEET.

****************************************************************************
  FLOW PROCESS FROM NODE  50015.00 TO NODE  50020.00 IS CODE =  41
----------------------------------------------------------------------------
  >>>>>COMPUTE PIPE-FLOW TRAVEL TIME THRU SUBAREA<<<<<
  >>>>>USING USER-SPECIFIED PIPESIZE (EXISTING ELEMENT)<<<<<
============================================================================
  ELEVATION DATA: UPSTREAM(FEET) =  1162.00  DOWNSTREAM(FEET) =  1160.00
  FLOW LENGTH(FEET) =   140.00   MANNING'S N =  0.013
  ASSUME FULL-FLOWING PIPELINE
  PIPE-FLOW VELOCITY(FEET/SEC.) =  43.84
  PIPE FLOW VELOCITY = (TOTAL FLOW)/(PIPE CROSS SECTION AREA)
  GIVEN PIPE DIAMETER(INCH) =  36.00    NUMBER OF PIPES =   1
  PIPE-FLOW(CFS) =     309.85
```

```
  PIPE TRAVEL TIME(MIN.) =   0.05    Tc(MIN.) =   22.72
  LONGEST FLOWPATH FROM NODE  50000.00 TO NODE  50020.00 =    9481.00 FEET.

****************************************************************************
  FLOW PROCESS FROM NODE  50020.00 TO NODE  50020.00 IS CODE =  81
----------------------------------------------------------------------------
  >>>>>ADDITION OF SUBAREA TO MAINLINE PEAK FLOW<<<<<
============================================================================
  MAINLINE Tc(MIN.) =   22.72
  * 100 YEAR RAINFALL INTENSITY(INCH/HR) =  2.238
  SUBAREA LOSS RATE DATA(AMC III):
   DEVELOPMENT TYPE/      SCS SOIL   AREA      Fp         Ap     SCS
       LAND USE            GROUP   (ACRES)  (INCH/HR)  (DECIMAL)  CN
  COMMERCIAL                 B       10.70      0.42     0.100    76
  SUBAREA AVERAGE PERVIOUS LOSS RATE, Fp(INCH/HR) =  0.42
  SUBAREA AVERAGE PERVIOUS AREA FRACTION, Ap =  0.100
  SUBAREA AREA(ACRES) =   10.70      SUBAREA RUNOFF(CFS) =   21.15
  EFFECTIVE AREA(ACRES) =    166.72   AREA-AVERAGED Fm(INCH/HR) =  0.06
  AREA-AVERAGED Fp(INCH/HR) =  0.42  AREA-AVERAGED Ap =  0.15
  TOTAL AREA(ACRES) =      172.7       PEAK FLOW RATE(CFS) =     326.20

****************************************************************************
  FLOW PROCESS FROM NODE  50020.00 TO NODE  50025.00 IS CODE =  51
----------------------------------------------------------------------------
  >>>>>COMPUTE TRAPEZOIDAL CHANNEL FLOW<<<<<
  >>>>>TRAVELTIME THRU SUBAREA (EXISTING ELEMENT)<<<<<
============================================================================
  ELEVATION DATA: UPSTREAM(FEET) =   1160.00  DOWNSTREAM(FEET) =   1128.00
  CHANNEL LENGTH THRU SUBAREA(FEET) =  2940.00   CHANNEL SLOPE =  0.0109
  CHANNEL BASE(FEET) =    2.00   "Z" FACTOR =   2.000
  MANNING'S FACTOR = 0.015   MAXIMUM DEPTH(FEET) =   4.00
  * 100 YEAR RAINFALL INTENSITY(INCH/HR) =  2.053
  SUBAREA LOSS RATE DATA(AMC III):
   DEVELOPMENT TYPE/      SCS SOIL   AREA      Fp         Ap     SCS
       LAND USE            GROUP   (ACRES)  (INCH/HR)  (DECIMAL)  CN
  RESIDENTIAL
  "3-4 DWELLINGS/ACRE"       B       12.40      0.42     0.600    76
  SUBAREA AVERAGE PERVIOUS LOSS RATE, Fp(INCH/HR) =  0.42
  SUBAREA AVERAGE PERVIOUS AREA FRACTION, Ap =  0.600
  TRAVEL TIME COMPUTED USING ESTIMATED FLOW(CFS) =     336.24
  TRAVEL TIME THRU SUBAREA BASED ON VELOCITY(FEET/SEC.) =  13.92
  AVERAGE FLOW DEPTH(FEET) =   3.01   TRAVEL TIME(MIN.) =   3.52
  Tc(MIN.) =   26.24
  SUBAREA AREA(ACRES) =    12.40       SUBAREA RUNOFF(CFS) =   20.08
  EFFECTIVE AREA(ACRES) =    179.12     AREA-AVERAGED Fm(INCH/HR) =   0.08
  AREA-AVERAGED Fp(INCH/HR) =   0.42  AREA-AVERAGED Ap =   0.18
  TOTAL AREA(ACRES) =      185.1         PEAK FLOW RATE(CFS) =     326.20
  NOTE: PEAK FLOW RATE DEFAULTED TO UPSTREAM VALUE

  END OF SUBAREA CHANNEL FLOW HYDRAULICS:
  DEPTH(FEET) =  2.97   FLOW VELOCITY(FEET/SEC.) =  13.81
  LONGEST FLOWPATH FROM NODE  50000.00 TO NODE  50025.00 =   12421.00 FEET.

****************************************************************************
  FLOW PROCESS FROM NODE  50025.00 TO NODE  50025.00 IS CODE =  82
----------------------------------------------------------------------------
  >>>>>ADD SUBAREA RUNOFF TO MAINLINE, AT MAINLINE Tc,<<<<<
  >>>>>(AND COMPUTE INITIAL SUBAREA RUNOFF)<<<<<
============================================================================
  INITIAL SUBAREA FLOW-LENGTH(FEET) =  2970.00
  ELEVATION DATA: UPSTREAM(FEET) =   1165.00  DOWNSTREAM(FEET) =   1129.00

  Tc = K*[(LENGTH** 3.00)/(ELEVATION CHANGE)]**0.20
  SUBAREA ANALYSIS USED MINIMUM Tc(MIN.) =   28.598
  * 100 YEAR RAINFALL INTENSITY(INCH/HR) =  1.950
  SUBAREA Tc AND LOSS RATE DATA(AMC III):
   DEVELOPMENT TYPE/      SCS SOIL   AREA      Fp         Ap     SCS   Tc
       LAND USE            GROUP   (ACRES)  (INCH/HR)  (DECIMAL)  CN  (MIN.)
  PUBLIC PARK                B        8.70      0.42     0.850    76   28.60
  SUBAREA AVERAGE PERVIOUS LOSS RATE, Fp(INCH/HR) =  0.42
  SUBAREA AVERAGE PERVIOUS AREA FRACTION, Ap =  0.850
```

```
 SUBAREA AREA(ACRES) =    8.70   INITIAL SUBAREA RUNOFF(CFS) =   12.45

 ** ADD SUBAREA RUNOFF TO MAINLINE AT MAINLINE Tc:
 MAINLINE Tc(MIN.) =   26.24
 * 100 YEAR RAINFALL INTENSITY(INCH/HR) =  2.053
 SUBAREA AREA(ACRES) =    8.70      SUBAREA RUNOFF(CFS) =   13.26
 EFFECTIVE AREA(ACRES) =    187.82   AREA-AVERAGED Fm(INCH/HR) =  0.09
 AREA-AVERAGED Fp(INCH/HR) =  0.42  AREA-AVERAGED Ap =  0.21
 TOTAL AREA(ACRES) =      193.8       PEAK FLOW RATE(CFS) =     331.74
============================================================================
 END OF STUDY SUMMARY:
 TOTAL AREA(ACRES)     =      193.8  TC(MIN.) =     26.24
 EFFECTIVE AREA(ACRES) =    187.82  AREA-AVERAGED Fm(INCH/HR)=  0.09
 AREA-AVERAGED Fp(INCH/HR) =  0.42  AREA-AVERAGED Ap = 0.214
 PEAK FLOW RATE(CFS)   =     331.74

 ** PEAK FLOW RATE TABLE **
  STREAM       Q      Tc   Intensity   Fp(Fm)     Ap     Ae     HEADWATER
  NUMBER     (CFS)  (MIN.) (INCH/HR) (INCH/HR)         (ACRES)    NODE
     1      331.74   26.24    2.053  0.42( 0.09) 0.21     187.8   50000.00
     2      323.50   27.84    1.981  0.42( 0.09) 0.22     190.2   50005.00
     3      309.53   30.67    1.870  0.42( 0.09) 0.22     193.4   52000.00
     4      268.92   38.40    1.634  0.42( 0.09) 0.22     193.8   50020.00
============================================================================
============================================================================
 END OF RATIONAL METHOD ANALYSIS
```

```
****************************************************************************
             RATIONAL METHOD HYDROLOGY COMPUTER PROGRAM PACKAGE
          (Reference: 1986 SAN BERNARDINO CO. HYDROLOGY CRITERION)
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             Ver. 15.0  Release Date: 04/01/2008  License ID 1555

                           Analysis prepared by:




 ************************** DESCRIPTION OF STUDY **************************
* REDLANDS PASSENGER RAIL PROJECT                                          *
* EXISTING 100 YEAR ANALYSIS                                               *
* DRAINAGE AREA 55000                                                      *
 **************************************************************************

  FILE NAME: C:\RPRP\55000.DAT
  TIME/DATE OF STUDY: 15:38 11/08/2012
============================================================================
  USER SPECIFIED HYDROLOGY AND HYDRAULIC MODEL INFORMATION:
============================================================================
                    --*TIME-OF-CONCENTRATION MODEL*--

  USER SPECIFIED STORM EVENT(YEAR) =  100.00
  SPECIFIED MINIMUM PIPE SIZE(INCH) =  12.00
  SPECIFIED PERCENT OF GRADIENTS(DECIMAL) TO USE FOR FRICTION SLOPE = 0.90
  *USER-DEFINED LOGARITHMIC INTERPOLATION USED FOR RAINFALL*

  SLOPE OF INTENSITY DURATION CURVE(LOG(I;IN/HR) vs. LOG(Tc;MIN)) = 0.6000
  USER SPECIFIED 1-HOUR INTENSITY(INCH/HOUR) = 1.2500

  *ANTECEDENT MOISTURE CONDITION (AMC) III ASSUMED FOR RATIONAL METHOD*

  *USER-DEFINED STREET-SECTIONS FOR COUPLED PIPEFLOW AND STREETFLOW MODEL*
     HALF-  CROWN TO   STREET-CROSSFALL:   CURB  GUTTER-GEOMETRIES:  MANNING
     WIDTH  CROSSFALL  IN-  / OUT-/PARK-  HEIGHT  WIDTH  LIP   HIKE  FACTOR
NO.   (FT)     (FT)    SIDE / SIDE/ WAY    (FT)    (FT)  (FT)  (FT)    (n)
===  =====  =========  =================  ======  ===== ====== ===== =======
  1   30.0     20.0    0.018/0.018/0.020   0.67    2.00 0.0313 0.167 0.0150
  2   20.0     15.0    0.020/0.020/0.020   0.50    1.50 0.0313 0.125 0.0170

  GLOBAL STREET FLOW-DEPTH CONSTRAINTS:
    1. Relative Flow-Depth =  0.20 FEET
       as (Maximum Allowable Street Flow Depth) - (Top-of-Curb)
    2. (Depth)*(Velocity) Constraint = 10.0 (FT*FT/S)
  *SIZE PIPE WITH A FLOW CAPACITY GREATER THAN
   OR EQUAL TO THE UPSTREAM TRIBUTARY PIPE.*
  *USER-SPECIFIED MINIMUM TOPOGRAPHIC SLOPE ADJUSTMENT NOT SELECTED

****************************************************************************
  FLOW PROCESS FROM NODE  55000.00 TO NODE  55005.00 IS CODE =  21
----------------------------------------------------------------------------
  >>>>>RATIONAL METHOD INITIAL SUBAREA ANALYSIS<<<<<
  >>USE TIME-OF-CONCENTRATION NOMOGRAPH FOR INITIAL SUBAREA<<
============================================================================
  INITIAL SUBAREA FLOW-LENGTH(FEET) =   330.00
  ELEVATION DATA: UPSTREAM(FEET) =   1275.00  DOWNSTREAM(FEET) =   1270.00

  Tc = K*[(LENGTH** 3.00)/(ELEVATION CHANGE)]**0.20
  SUBAREA ANALYSIS USED MINIMUM Tc(MIN.) =    7.148
  * 100 YEAR RAINFALL INTENSITY(INCH/HR) =  4.480
  SUBAREA Tc AND LOSS RATE DATA(AMC III):
   DEVELOPMENT TYPE/      SCS SOIL   AREA      Fp         Ap     SCS   Tc
       LAND USE            GROUP   (ACRES)  (INCH/HR)  (DECIMAL)  CN  (MIN.)
  COMMERCIAL                 B        1.20      0.42      0.100    76    7.15
  SUBAREA AVERAGE PERVIOUS LOSS RATE, Fp(INCH/HR) =  0.42
  SUBAREA AVERAGE PERVIOUS AREA FRACTION, Ap =  0.100
```

```
  SUBAREA RUNOFF(CFS) =      4.79
  TOTAL AREA(ACRES) =      1.20   PEAK FLOW RATE(CFS) =      4.79

****************************************************************************
  FLOW PROCESS FROM NODE  55005.00 TO NODE  55010.00 IS CODE =  62
----------------------------------------------------------------------------
  >>>>>COMPUTE STREET FLOW TRAVEL TIME THRU SUBAREA<<<<<
  >>>>>(STREET TABLE SECTION #  1 USED)<<<<<
============================================================================
  UPSTREAM ELEVATION(FEET) = 1270.00  DOWNSTREAM ELEVATION(FEET) = 1261.00
  STREET LENGTH(FEET) =   580.00   CURB HEIGHT(INCHES) =  8.0
  STREET HALFWIDTH(FEET) = 30.00

  DISTANCE FROM CROWN TO CROSSFALL GRADEBREAK(FEET) =  20.00
  INSIDE STREET CROSSFALL(DECIMAL) =  0.018
  OUTSIDE STREET CROSSFALL(DECIMAL)  =  0.018

  SPECIFIED NUMBER OF HALFSTREETS CARRYING RUNOFF =  1
  STREET PARKWAY CROSSFALL(DECIMAL)  =  0.020
  Manning's FRICTION FACTOR for Streetflow Section(curb-to-curb) =   0.0150
  Manning's FRICTION FACTOR for Back-of-Walk Flow Section =   0.0200

    **TRAVEL TIME COMPUTED USING ESTIMATED FLOW(CFS) =      11.95
    STREETFLOW MODEL RESULTS USING ESTIMATED FLOW:
    STREET FLOW DEPTH(FEET) =  0.49
    HALFSTREET FLOOD WIDTH(FEET) =   18.24
    AVERAGE FLOW VELOCITY(FEET/SEC.) =    3.78
    PRODUCT OF DEPTH&VELOCITY(FT*FT/SEC.) =    1.84
  STREET FLOW TRAVEL TIME(MIN.) =   2.56   Tc(MIN.) =    9.71
  * 100 YEAR RAINFALL INTENSITY(INCH/HR) =  3.728
  SUBAREA LOSS RATE DATA(AMC III):
   DEVELOPMENT TYPE/      SCS SOIL   AREA      Fp         Ap     SCS
       LAND USE            GROUP   (ACRES)  (INCH/HR)  (DECIMAL)  CN
  COMMERCIAL                 B        4.30      0.42     0.100    76
  SUBAREA AVERAGE PERVIOUS LOSS RATE, Fp(INCH/HR) =  0.42
  SUBAREA AVERAGE PERVIOUS AREA FRACTION, Ap =  0.100
  SUBAREA AREA(ACRES) =    4.30      SUBAREA RUNOFF(CFS) =   14.27
  EFFECTIVE AREA(ACRES) =      5.50    AREA-AVERAGED Fm(INCH/HR) =  0.04
  AREA-AVERAGED Fp(INCH/HR) =  0.42  AREA-AVERAGED Ap =  0.10
  TOTAL AREA(ACRES) =        5.5        PEAK FLOW RATE(CFS) =      18.25

  END OF SUBAREA STREET FLOW HYDRAULICS:
  DEPTH(FEET) = 0.55   HALFSTREET FLOOD WIDTH(FEET) =  21.60
  FLOW VELOCITY(FEET/SEC.) =  4.18   DEPTH*VELOCITY(FT*FT/SEC.) =   2.29
  LONGEST FLOWPATH FROM NODE  55000.00 TO NODE  55010.00 =     910.00 FEET.

****************************************************************************
  FLOW PROCESS FROM NODE  55010.00 TO NODE  55015.00 IS CODE =  62
----------------------------------------------------------------------------
  >>>>>COMPUTE STREET FLOW TRAVEL TIME THRU SUBAREA<<<<<
  >>>>>(STREET TABLE SECTION #  2 USED)<<<<<
============================================================================
  UPSTREAM ELEVATION(FEET) = 1261.00  DOWNSTREAM ELEVATION(FEET) = 1252.00
  STREET LENGTH(FEET) =   511.00   CURB HEIGHT(INCHES) =  6.0
  STREET HALFWIDTH(FEET) = 20.00

  DISTANCE FROM CROWN TO CROSSFALL GRADEBREAK(FEET) =  15.00
  INSIDE STREET CROSSFALL(DECIMAL) =  0.020
  OUTSIDE STREET CROSSFALL(DECIMAL)  =  0.020

  SPECIFIED NUMBER OF HALFSTREETS CARRYING RUNOFF =  1
  STREET PARKWAY CROSSFALL(DECIMAL)  =  0.020
  Manning's FRICTION FACTOR for Streetflow Section(curb-to-curb) =   0.0170
  Manning's FRICTION FACTOR for Back-of-Walk Flow Section =   0.0170

    **TRAVEL TIME COMPUTED USING ESTIMATED FLOW(CFS) =      28.82
    ***STREET FLOW SPLITS OVER STREET-CROWN***
    FULL DEPTH(FEET) =    0.53   FLOOD WIDTH(FEET) =   21.31
    FULL HALF-STREET VELOCITY(FEET/SEC.) =    3.96
    SPLIT DEPTH(FEET) =    0.49   SPLIT FLOOD WIDTH(FEET) =   17.98
    SPLIT FLOW(CFS) =   12.45   SPLIT VELOCITY(FEET/SEC.) =    3.71
```

```
    STREETFLOW MODEL RESULTS USING ESTIMATED FLOW:
    STREET FLOW DEPTH(FEET) =  0.53
    HALFSTREET FLOOD WIDTH(FEET) =   21.31
    AVERAGE FLOW VELOCITY(FEET/SEC.) =    3.96
    PRODUCT OF DEPTH&VELOCITY(FT*FT/SEC.) =    2.08
  STREET FLOW TRAVEL TIME(MIN.) =   2.15   Tc(MIN.) =   11.86
  * 100 YEAR RAINFALL INTENSITY(INCH/HR) =  3.307
  SUBAREA LOSS RATE DATA(AMC III):
   DEVELOPMENT TYPE/      SCS SOIL   AREA      Fp         Ap     SCS
      LAND USE            GROUP   (ACRES)  (INCH/HR)  (DECIMAL)  CN
  COMMERCIAL                B        7.20      0.42     0.100    76
  SUBAREA AVERAGE PERVIOUS LOSS RATE, Fp(INCH/HR) =  0.42
  SUBAREA AVERAGE PERVIOUS AREA FRACTION, Ap =  0.100
  SUBAREA AREA(ACRES) =    7.20      SUBAREA RUNOFF(CFS) =   21.15
  EFFECTIVE AREA(ACRES) =     12.70    AREA-AVERAGED Fm(INCH/HR) =  0.04
  AREA-AVERAGED Fp(INCH/HR) =  0.42  AREA-AVERAGED Ap =  0.10
  TOTAL AREA(ACRES) =       12.7        PEAK FLOW RATE(CFS) =      37.31

  END OF SUBAREA STREET FLOW HYDRAULICS:
  DEPTH(FEET) = 0.54   HALFSTREET FLOOD WIDTH(FEET) =  22.14
  FLOW VELOCITY(FEET/SEC.) =  4.15   DEPTH*VELOCITY(FT*FT/SEC.) =   2.25
  *NOTE: INITIAL SUBAREA NOMOGRAPH WITH SUBAREA PARAMETERS,
         AND L =  511.0 FT WITH ELEVATION-DROP =   9.0 FT, IS   26.3 CFS,
         WHICH EXCEEDS THE TOP-OF-CURB STREET CAPACITY AT NODE  55015.00
  LONGEST FLOWPATH FROM NODE  55000.00 TO NODE  55015.00 =    1421.00 FEET.

****************************************************************************
  FLOW PROCESS FROM NODE  55015.00 TO NODE  55020.00 IS CODE =  62
----------------------------------------------------------------------------
  >>>>>COMPUTE STREET FLOW TRAVEL TIME THRU SUBAREA<<<<<
  >>>>>(STREET TABLE SECTION #  2 USED)<<<<<
============================================================================
  UPSTREAM ELEVATION(FEET) = 1252.00  DOWNSTREAM ELEVATION(FEET) = 1239.00
  STREET LENGTH(FEET) =   980.00   CURB HEIGHT(INCHES) =  6.0
  STREET HALFWIDTH(FEET) = 20.00

  DISTANCE FROM CROWN TO CROSSFALL GRADEBREAK(FEET) =  15.00
  INSIDE STREET CROSSFALL(DECIMAL) =  0.020
  OUTSIDE STREET CROSSFALL(DECIMAL)  =  0.020

  SPECIFIED NUMBER OF HALFSTREETS CARRYING RUNOFF =  1
  STREET PARKWAY CROSSFALL(DECIMAL)  =  0.020
  Manning's FRICTION FACTOR for Streetflow Section(curb-to-curb) =   0.0170
  Manning's FRICTION FACTOR for Back-of-Walk Flow Section =   0.0170

    **TRAVEL TIME COMPUTED USING ESTIMATED FLOW(CFS) =      50.81
    ***STREET FLOWING FULL***
    STREETFLOW MODEL RESULTS USING ESTIMATED FLOW:
    STREET FLOW DEPTH(FEET) =  0.61
    HALFSTREET FLOOD WIDTH(FEET) =   25.43
    AVERAGE FLOW VELOCITY(FEET/SEC.) =    4.19
    PRODUCT OF DEPTH&VELOCITY(FT*FT/SEC.) =    2.55
  STREET FLOW TRAVEL TIME(MIN.) =   3.90   Tc(MIN.) =   15.76
  * 100 YEAR RAINFALL INTENSITY(INCH/HR) =  2.788
  SUBAREA LOSS RATE DATA(AMC III):
   DEVELOPMENT TYPE/      SCS SOIL   AREA      Fp         Ap     SCS
      LAND USE            GROUP   (ACRES)  (INCH/HR)  (DECIMAL)  CN
  COMMERCIAL                B       10.90      0.42     0.100    76
  SUBAREA AVERAGE PERVIOUS LOSS RATE, Fp(INCH/HR) =  0.42
  SUBAREA AVERAGE PERVIOUS AREA FRACTION, Ap =  0.100
  SUBAREA AREA(ACRES) =   10.90      SUBAREA RUNOFF(CFS) =   26.94
  EFFECTIVE AREA(ACRES) =     23.60    AREA-AVERAGED Fm(INCH/HR) =  0.04
  AREA-AVERAGED Fp(INCH/HR) =  0.42  AREA-AVERAGED Ap =  0.10
  TOTAL AREA(ACRES) =       23.6        PEAK FLOW RATE(CFS) =      58.33

  END OF SUBAREA STREET FLOW HYDRAULICS:
  DEPTH(FEET) = 0.63   HALFSTREET FLOOD WIDTH(FEET) =  26.65
  FLOW VELOCITY(FEET/SEC.) =  4.35   DEPTH*VELOCITY(FT*FT/SEC.) =   2.76
  *NOTE: INITIAL SUBAREA NOMOGRAPH WITH SUBAREA PARAMETERS,
         AND L =  980.0 FT WITH ELEVATION-DROP =  13.0 FT, IS   32.9 CFS,
         WHICH EXCEEDS THE TOP-OF-CURB STREET CAPACITY AT NODE  55020.00
```

```
  LONGEST FLOWPATH FROM NODE  55000.00 TO NODE  55020.00 =    2401.00 FEET.

****************************************************************************
  FLOW PROCESS FROM NODE  55020.00 TO NODE  55020.00 IS CODE =   1
----------------------------------------------------------------------------
  >>>>>DESIGNATE INDEPENDENT STREAM FOR CONFLUENCE<<<<<
============================================================================
  TOTAL NUMBER OF STREAMS =  2
  CONFLUENCE VALUES USED FOR INDEPENDENT STREAM  1 ARE:
  TIME OF CONCENTRATION(MIN.) =   15.76
  RAINFALL INTENSITY(INCH/HR) =   2.79
  AREA-AVERAGED Fm(INCH/HR) =  0.04
  AREA-AVERAGED Fp(INCH/HR) =  0.42
  AREA-AVERAGED Ap =  0.10
  EFFECTIVE STREAM AREA(ACRES) =      23.60
  TOTAL STREAM AREA(ACRES) =      23.60
  PEAK FLOW RATE(CFS) AT CONFLUENCE =      58.33

****************************************************************************
  FLOW PROCESS FROM NODE  55025.00 TO NODE  55030.00 IS CODE =  21
----------------------------------------------------------------------------
  >>>>>RATIONAL METHOD INITIAL SUBAREA ANALYSIS<<<<<
  >>USE TIME-OF-CONCENTRATION NOMOGRAPH FOR INITIAL SUBAREA<<
============================================================================
  INITIAL SUBAREA FLOW-LENGTH(FEET) =   230.00
  ELEVATION DATA: UPSTREAM(FEET) =   1273.00  DOWNSTREAM(FEET) =   1270.00

  Tc = K*[(LENGTH** 3.00)/(ELEVATION CHANGE)]**0.20
  SUBAREA ANALYSIS USED MINIMUM Tc(MIN.) =    6.375
  * 100 YEAR RAINFALL INTENSITY(INCH/HR) =  4.799
  SUBAREA Tc AND LOSS RATE DATA(AMC III):
   DEVELOPMENT TYPE/      SCS SOIL   AREA      Fp         Ap     SCS   Tc
       LAND USE            GROUP   (ACRES)  (INCH/HR)  (DECIMAL)  CN  (MIN.)
  COMMERCIAL                 B       0.50      0.42     0.100    76    6.38
  SUBAREA AVERAGE PERVIOUS LOSS RATE, Fp(INCH/HR) =  0.42
  SUBAREA AVERAGE PERVIOUS AREA FRACTION, Ap =  0.100
  SUBAREA RUNOFF(CFS) =      2.14
  TOTAL AREA(ACRES) =      0.50   PEAK FLOW RATE(CFS) =      2.14

****************************************************************************
  FLOW PROCESS FROM NODE  55030.00 TO NODE  55035.00 IS CODE =  62
----------------------------------------------------------------------------
  >>>>>COMPUTE STREET FLOW TRAVEL TIME THRU SUBAREA<<<<<
  >>>>>(STREET TABLE SECTION #  1 USED)<<<<<
============================================================================
  UPSTREAM ELEVATION(FEET) = 1270.00  DOWNSTREAM ELEVATION(FEET) = 1251.00
  STREET LENGTH(FEET) =  1140.00   CURB HEIGHT(INCHES) =  8.0
  STREET HALFWIDTH(FEET) = 30.00

  DISTANCE FROM CROWN TO CROSSFALL GRADEBREAK(FEET) =  20.00
  INSIDE STREET CROSSFALL(DECIMAL) =  0.018
  OUTSIDE STREET CROSSFALL(DECIMAL)  =  0.018

  SPECIFIED NUMBER OF HALFSTREETS CARRYING RUNOFF =  1
  STREET PARKWAY CROSSFALL(DECIMAL)  =  0.020
  Manning's FRICTION FACTOR for Streetflow Section(curb-to-curb) =   0.0150
  Manning's FRICTION FACTOR for Back-of-Walk Flow Section =   0.0200

    **TRAVEL TIME COMPUTED USING ESTIMATED FLOW(CFS) =      12.33
    STREETFLOW MODEL RESULTS USING ESTIMATED FLOW:
    STREET FLOW DEPTH(FEET) =  0.49
    HALFSTREET FLOOD WIDTH(FEET) =   18.24
    AVERAGE FLOW VELOCITY(FEET/SEC.) =    3.90
    PRODUCT OF DEPTH&VELOCITY(FT*FT/SEC.) =    1.90
  STREET FLOW TRAVEL TIME(MIN.) =   4.88   Tc(MIN.) =   11.25
  * 100 YEAR RAINFALL INTENSITY(INCH/HR) =  3.412
  SUBAREA LOSS RATE DATA(AMC III):
   DEVELOPMENT TYPE/      SCS SOIL   AREA      Fp         Ap     SCS
       LAND USE            GROUP   (ACRES)  (INCH/HR)  (DECIMAL)  CN
  COMMERCIAL                 B       6.60      0.42     0.100    76
  SUBAREA AVERAGE PERVIOUS LOSS RATE, Fp(INCH/HR) =  0.42
```

```
  SUBAREA AVERAGE PERVIOUS AREA FRACTION, Ap =  0.100
  SUBAREA AREA(ACRES) =    6.60      SUBAREA RUNOFF(CFS) =   20.02
  EFFECTIVE AREA(ACRES) =      7.10    AREA-AVERAGED Fm(INCH/HR) =  0.04
  AREA-AVERAGED Fp(INCH/HR) =  0.42  AREA-AVERAGED Ap =  0.10
  TOTAL AREA(ACRES) =        7.1        PEAK FLOW RATE(CFS) =      21.54

  END OF SUBAREA STREET FLOW HYDRAULICS:
  DEPTH(FEET) = 0.57   HALFSTREET FLOOD WIDTH(FEET) =  22.77
  FLOW VELOCITY(FEET/SEC.) =  4.46   DEPTH*VELOCITY(FT*FT/SEC.) =   2.54
  LONGEST FLOWPATH FROM NODE  55025.00 TO NODE  55035.00 =    1370.00 FEET.

****************************************************************************
  FLOW PROCESS FROM NODE  55035.00 TO NODE  55040.00 IS CODE =  62
----------------------------------------------------------------------------
  >>>>>COMPUTE STREET FLOW TRAVEL TIME THRU SUBAREA<<<<<
  >>>>>(STREET TABLE SECTION #  1 USED)<<<<<
============================================================================
  UPSTREAM ELEVATION(FEET) = 1251.00  DOWNSTREAM ELEVATION(FEET) = 1242.50
  STREET LENGTH(FEET) =   590.00   CURB HEIGHT(INCHES) =  8.0
  STREET HALFWIDTH(FEET) = 30.00

  DISTANCE FROM CROWN TO CROSSFALL GRADEBREAK(FEET) =  20.00
  INSIDE STREET CROSSFALL(DECIMAL) =  0.018
  OUTSIDE STREET CROSSFALL(DECIMAL)  =  0.018

  SPECIFIED NUMBER OF HALFSTREETS CARRYING RUNOFF =  1
  STREET PARKWAY CROSSFALL(DECIMAL)  =  0.020
  Manning's FRICTION FACTOR for Streetflow Section(curb-to-curb) =   0.0150
  Manning's FRICTION FACTOR for Back-of-Walk Flow Section =   0.0200

    **TRAVEL TIME COMPUTED USING ESTIMATED FLOW(CFS) =      29.31
    STREETFLOW MODEL RESULTS USING ESTIMATED FLOW:
    STREET FLOW DEPTH(FEET) =  0.63
    HALFSTREET FLOOD WIDTH(FEET) =   26.45
    AVERAGE FLOW VELOCITY(FEET/SEC.) =    4.55
    PRODUCT OF DEPTH&VELOCITY(FT*FT/SEC.) =    2.89
  STREET FLOW TRAVEL TIME(MIN.) =   2.16   Tc(MIN.) =   13.41
  * 100 YEAR RAINFALL INTENSITY(INCH/HR) =  3.071
  SUBAREA LOSS RATE DATA(AMC III):
   DEVELOPMENT TYPE/      SCS SOIL   AREA      Fp         Ap     SCS
       LAND USE            GROUP   (ACRES)  (INCH/HR)  (DECIMAL)  CN
  COMMERCIAL                 B        5.70      0.42     0.100    76
  SUBAREA AVERAGE PERVIOUS LOSS RATE, Fp(INCH/HR) =  0.42
  SUBAREA AVERAGE PERVIOUS AREA FRACTION, Ap =  0.100
  SUBAREA AREA(ACRES) =    5.70      SUBAREA RUNOFF(CFS) =   15.54
  EFFECTIVE AREA(ACRES) =     12.80    AREA-AVERAGED Fm(INCH/HR) =  0.04
  AREA-AVERAGED Fp(INCH/HR) =  0.42  AREA-AVERAGED Ap =  0.10
  TOTAL AREA(ACRES) =       12.8        PEAK FLOW RATE(CFS) =      34.89

  END OF SUBAREA STREET FLOW HYDRAULICS:
  DEPTH(FEET) = 0.67   HALFSTREET FLOOD WIDTH(FEET) =  28.26
  FLOW VELOCITY(FEET/SEC.) =  4.77   DEPTH*VELOCITY(FT*FT/SEC.) =   3.18
  LONGEST FLOWPATH FROM NODE  55025.00 TO NODE  55040.00 =    1960.00 FEET.

****************************************************************************
  FLOW PROCESS FROM NODE  55040.00 TO NODE  55020.00 IS CODE =  62
----------------------------------------------------------------------------
  >>>>>COMPUTE STREET FLOW TRAVEL TIME THRU SUBAREA<<<<<
  >>>>>(STREET TABLE SECTION #  1 USED)<<<<<
============================================================================
  UPSTREAM ELEVATION(FEET) = 1242.50  DOWNSTREAM ELEVATION(FEET) = 1239.00
  STREET LENGTH(FEET) =   330.00   CURB HEIGHT(INCHES) =  8.0
  STREET HALFWIDTH(FEET) = 30.00

  DISTANCE FROM CROWN TO CROSSFALL GRADEBREAK(FEET) =  20.00
  INSIDE STREET CROSSFALL(DECIMAL) =  0.018
  OUTSIDE STREET CROSSFALL(DECIMAL)  =  0.018

  SPECIFIED NUMBER OF HALFSTREETS CARRYING RUNOFF =  1
  STREET PARKWAY CROSSFALL(DECIMAL)  =  0.020
  Manning's FRICTION FACTOR for Streetflow Section(curb-to-curb) =   0.0150
```

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 Manning's FRICTION FACTOR for Back-of-Walk Flow Section =   0.0200

   **TRAVEL TIME COMPUTED USING ESTIMATED FLOW(CFS) =      36.82
   ***STREET FLOW SPLITS OVER STREET-CROWN***
   FULL DEPTH(FEET) =    0.70   FLOOD WIDTH(FEET) =   31.58
   FULL HALF-STREET VELOCITY(FEET/SEC.) =    4.23
   SPLIT DEPTH(FEET) =    0.32   SPLIT FLOOD WIDTH(FEET) =    8.78
   SPLIT FLOW(CFS) =    1.91   SPLIT VELOCITY(FEET/SEC.) =    2.16
   STREETFLOW MODEL RESULTS USING ESTIMATED FLOW:
   STREET FLOW DEPTH(FEET) =  0.70
   HALFSTREET FLOOD WIDTH(FEET) =   31.58
   AVERAGE FLOW VELOCITY(FEET/SEC.) =    4.23
   PRODUCT OF DEPTH&VELOCITY(FT*FT/SEC.) =    2.95
 STREET FLOW TRAVEL TIME(MIN.) =   1.30   Tc(MIN.) =   14.71
 * 100 YEAR RAINFALL INTENSITY(INCH/HR) =  2.905
 SUBAREA LOSS RATE DATA(AMC III):
  DEVELOPMENT TYPE/      SCS SOIL   AREA      Fp         Ap     SCS
      LAND USE            GROUP   (ACRES)  (INCH/HR)  (DECIMAL)  CN
 COMMERCIAL                 B        1.50      0.42     0.100    76
 SUBAREA AVERAGE PERVIOUS LOSS RATE, Fp(INCH/HR) =  0.42
 SUBAREA AVERAGE PERVIOUS AREA FRACTION, Ap =  0.100
 SUBAREA AREA(ACRES) =    1.50      SUBAREA RUNOFF(CFS) =    3.86
 EFFECTIVE AREA(ACRES) =     14.30    AREA-AVERAGED Fm(INCH/HR) =  0.04
 AREA-AVERAGED Fp(INCH/HR) =  0.42  AREA-AVERAGED Ap =  0.10
 TOTAL AREA(ACRES) =       14.3        PEAK FLOW RATE(CFS) =      36.85

 END OF SUBAREA STREET FLOW HYDRAULICS:
 DEPTH(FEET) = 0.70   HALFSTREET FLOOD WIDTH(FEET) =  31.58
 FLOW VELOCITY(FEET/SEC.) =  4.23   DEPTH*VELOCITY(FT*FT/SEC.) =   2.95
 LONGEST FLOWPATH FROM NODE  55025.00 TO NODE  55020.00 =    2290.00 FEET.

****************************************************************************
 FLOW PROCESS FROM NODE  55020.00 TO NODE  55020.00 IS CODE =   1
----------------------------------------------------------------------------
 >>>>>DESIGNATE INDEPENDENT STREAM FOR CONFLUENCE<<<<<
 >>>>>AND COMPUTE VARIOUS CONFLUENCED STREAM VALUES<<<<<
============================================================================
 TOTAL NUMBER OF STREAMS =  2
 CONFLUENCE VALUES USED FOR INDEPENDENT STREAM  2 ARE:
 TIME OF CONCENTRATION(MIN.) =   14.71
 RAINFALL INTENSITY(INCH/HR) =   2.91
 AREA-AVERAGED Fm(INCH/HR) =  0.04
 AREA-AVERAGED Fp(INCH/HR) =  0.42
 AREA-AVERAGED Ap =  0.10
 EFFECTIVE STREAM AREA(ACRES) =      14.30
 TOTAL STREAM AREA(ACRES) =      14.30
 PEAK FLOW RATE(CFS) AT CONFLUENCE =      36.85

 ** CONFLUENCE DATA **
  STREAM       Q      Tc   Intensity   Fp(Fm)     Ap     Ae     HEADWATER
  NUMBER     (CFS)  (MIN.) (INCH/HR) (INCH/HR)         (ACRES)    NODE
     1       58.33   15.76    2.788  0.42( 0.04) 0.10      23.6   55000.00
     2       36.85   14.71    2.905  0.42( 0.04) 0.10      14.3   55025.00

 RAINFALL INTENSITY AND TIME OF CONCENTRATION RATIO
 CONFLUENCE FORMULA USED FOR  2 STREAMS.

 ** PEAK FLOW RATE TABLE **
  STREAM       Q      Tc   Intensity   Fp(Fm)     Ap     Ae     HEADWATER
  NUMBER     (CFS)  (MIN.) (INCH/HR) (INCH/HR)         (ACRES)    NODE
     1       93.63   14.71    2.905  0.42( 0.04) 0.10      36.3   55025.00
     2       93.67   15.76    2.788  0.42( 0.04) 0.10      37.9   55000.00

 COMPUTED CONFLUENCE ESTIMATES ARE AS FOLLOWS:
 PEAK FLOW RATE(CFS) =      93.67    Tc(MIN.) =    15.76
 EFFECTIVE AREA(ACRES) =      37.90   AREA-AVERAGED Fm(INCH/HR) =  0.04
 AREA-AVERAGED Fp(INCH/HR) =  0.42  AREA-AVERAGED Ap =  0.10
 TOTAL AREA(ACRES) =       37.9
 LONGEST FLOWPATH FROM NODE  55000.00 TO NODE  55020.00 =    2401.00 FEET.

****************************************************************************
```

```
  FLOW PROCESS FROM NODE  55020.00 TO NODE  55025.00 IS CODE =  41
----------------------------------------------------------------------------
  >>>>>COMPUTE PIPE-FLOW TRAVEL TIME THRU SUBAREA<<<<<
  >>>>>USING USER-SPECIFIED PIPESIZE (EXISTING ELEMENT)<<<<<
============================================================================
  ELEVATION DATA: UPSTREAM(FEET) =  1226.00  DOWNSTREAM(FEET) =  1224.80
  FLOW LENGTH(FEET) =   301.00   MANNING'S N =  0.013
  ASSUME FULL-FLOWING PIPELINE
  PIPE-FLOW VELOCITY(FEET/SEC.) =  11.29
  PIPE FLOW VELOCITY = (TOTAL FLOW)/(PIPE CROSS SECTION AREA)
  GIVEN PIPE DIAMETER(INCH) =  39.00    NUMBER OF PIPES =   1
  PIPE-FLOW(CFS) =      93.67
  PIPE TRAVEL TIME(MIN.) =   0.44    Tc(MIN.) =   16.20
  LONGEST FLOWPATH FROM NODE  55000.00 TO NODE  55025.00 =    2702.00 FEET.

****************************************************************************
  FLOW PROCESS FROM NODE  55025.00 TO NODE  55025.00 IS CODE =  81
----------------------------------------------------------------------------
  >>>>>ADDITION OF SUBAREA TO MAINLINE PEAK FLOW<<<<<
============================================================================
  MAINLINE Tc(MIN.) =   16.20
  * 100 YEAR RAINFALL INTENSITY(INCH/HR) =  2.742
  SUBAREA LOSS RATE DATA(AMC III):
   DEVELOPMENT TYPE/      SCS SOIL   AREA      Fp         Ap     SCS
       LAND USE            GROUP   (ACRES)  (INCH/HR)  (DECIMAL)  CN
  COMMERCIAL                 B       3.40      0.42     0.100    76
  RESIDENTIAL
  "3-4 DWELLINGS/ACRE"       B       0.30      0.42     0.600    76
  SUBAREA AVERAGE PERVIOUS LOSS RATE, Fp(INCH/HR) =  0.42
  SUBAREA AVERAGE PERVIOUS AREA FRACTION, Ap =  0.141
  SUBAREA AREA(ACRES) =    3.70      SUBAREA RUNOFF(CFS) =    8.93
  EFFECTIVE AREA(ACRES) =     41.60   AREA-AVERAGED Fm(INCH/HR) =  0.04
  AREA-AVERAGED Fp(INCH/HR) =  0.42  AREA-AVERAGED Ap =  0.10
  TOTAL AREA(ACRES) =       41.6       PEAK FLOW RATE(CFS) =     101.03

  ** PEAK FLOW RATE TABLE **
   STREAM       Q      Tc   Intensity   Fp(Fm)     Ap     Ae     HEADWATER
   NUMBER     (CFS)  (MIN.) (INCH/HR) (INCH/HR)         (ACRES)    NODE
      1      101.26   15.16    2.854  0.42( 0.04) 0.10      40.0   55025.00
      2      101.03   16.20    2.742  0.42( 0.04) 0.10      41.6   55000.00
  NEW PEAK FLOW DATA ARE:
  PEAK FLOW RATE(CFS) =     101.26  Tc(MIN.) =   15.16
  AREA-AVERAGED Fm(INCH/HR) =  0.04  AREA-AVERAGED Fp(INCH/HR) =  0.42
  AREA-AVERAGED Ap =  0.10  EFFECTIVE AREA(ACRES) =      40.04
============================================================================
  END OF STUDY SUMMARY:
  TOTAL AREA(ACRES)     =       41.6  TC(MIN.) =     15.16
  EFFECTIVE AREA(ACRES) =     40.04  AREA-AVERAGED Fm(INCH/HR)=  0.04
  AREA-AVERAGED Fp(INCH/HR) =  0.42  AREA-AVERAGED Ap = 0.104
  PEAK FLOW RATE(CFS)   =     101.26

  ** PEAK FLOW RATE TABLE **
   STREAM       Q      Tc   Intensity   Fp(Fm)     Ap     Ae     HEADWATER
   NUMBER     (CFS)  (MIN.) (INCH/HR) (INCH/HR)         (ACRES)    NODE
      1      101.26   15.16    2.854  0.42( 0.04) 0.10      40.0   55025.00
      2      101.03   16.20    2.742  0.42( 0.04) 0.10      41.6   55000.00
============================================================================
============================================================================
  END OF RATIONAL METHOD ANALYSIS
```

```
****************************************************************************
             RATIONAL METHOD HYDROLOGY COMPUTER PROGRAM PACKAGE
          (Reference: 1986 SAN BERNARDINO CO. HYDROLOGY CRITERION)
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             Ver. 15.0  Release Date: 04/01/2008  License ID 1555

                           Analysis prepared by:




 ************************** DESCRIPTION OF STUDY **************************
* REDLANDS PASSENGER RAIL                                                  *
* EXISTING HYDROLOGY 100 YEAR EVENT                                        *
* BASIN 60000                                                              *
 **************************************************************************

  FILE NAME: C:\RPRP\60000.DAT
  TIME/DATE OF STUDY: 14:16 11/09/2012
============================================================================
  USER SPECIFIED HYDROLOGY AND HYDRAULIC MODEL INFORMATION:
============================================================================
                    --*TIME-OF-CONCENTRATION MODEL*--

  USER SPECIFIED STORM EVENT(YEAR) =  100.00
  SPECIFIED MINIMUM PIPE SIZE(INCH) =  12.00
  SPECIFIED PERCENT OF GRADIENTS(DECIMAL) TO USE FOR FRICTION SLOPE = 0.90
  *USER-DEFINED LOGARITHMIC INTERPOLATION USED FOR RAINFALL*

  SLOPE OF INTENSITY DURATION CURVE(LOG(I;IN/HR) vs. LOG(Tc;MIN)) = 0.6000
  USER SPECIFIED 1-HOUR INTENSITY(INCH/HOUR) = 1.2500

  *ANTECEDENT MOISTURE CONDITION (AMC) III ASSUMED FOR RATIONAL METHOD*

  *USER-DEFINED STREET-SECTIONS FOR COUPLED PIPEFLOW AND STREETFLOW MODEL*
     HALF-  CROWN TO   STREET-CROSSFALL:   CURB  GUTTER-GEOMETRIES:  MANNING
     WIDTH  CROSSFALL  IN-  / OUT-/PARK-  HEIGHT  WIDTH  LIP   HIKE  FACTOR
NO.   (FT)     (FT)    SIDE / SIDE/ WAY    (FT)    (FT)  (FT)  (FT)    (n)
===  =====  =========  =================  ======   ===== ====== ===== =======
  1   30.0     20.0    0.018/0.018/0.020   0.67    2.00 0.0313 0.167 0.0150
  2   20.0     15.0    0.020/0.020/0.020   0.50    1.50 0.0313 0.125 0.0170
  3  100.0     40.0    0.020/0.050/0.050   0.67    2.00 0.0313 0.167 0.0150

  GLOBAL STREET FLOW-DEPTH CONSTRAINTS:
    1. Relative Flow-Depth =  0.20 FEET
       as (Maximum Allowable Street Flow Depth) - (Top-of-Curb)
    2. (Depth)*(Velocity) Constraint = 10.0 (FT*FT/S)
  *SIZE PIPE WITH A FLOW CAPACITY GREATER THAN
   OR EQUAL TO THE UPSTREAM TRIBUTARY PIPE.*
  *USER-SPECIFIED MINIMUM TOPOGRAPHIC SLOPE ADJUSTMENT NOT SELECTED

****************************************************************************
  FLOW PROCESS FROM NODE  60000.00 TO NODE  60005.00 IS CODE =  21
----------------------------------------------------------------------------
  >>>>>RATIONAL METHOD INITIAL SUBAREA ANALYSIS<<<<<
  >>USE TIME-OF-CONCENTRATION NOMOGRAPH FOR INITIAL SUBAREA<<
============================================================================
  INITIAL SUBAREA FLOW-LENGTH(FEET) =   337.00
  ELEVATION DATA: UPSTREAM(FEET) =   1321.00  DOWNSTREAM(FEET) =   1315.00

  Tc = K*[(LENGTH** 3.00)/(ELEVATION CHANGE)]**0.20
  SUBAREA ANALYSIS USED MINIMUM Tc(MIN.) =    6.979
  * 100 YEAR RAINFALL INTENSITY(INCH/HR) =  4.545
  SUBAREA Tc AND LOSS RATE DATA(AMC III):
   DEVELOPMENT TYPE/      SCS SOIL   AREA      Fp         Ap     SCS   Tc
       LAND USE            GROUP   (ACRES)  (INCH/HR)  (DECIMAL)  CN  (MIN.)
  COMMERCIAL                 B       1.30      0.42     0.100    76    6.98
  SUBAREA AVERAGE PERVIOUS LOSS RATE, Fp(INCH/HR) =  0.42
```

```
  SUBAREA AVERAGE PERVIOUS AREA FRACTION, Ap =  0.100
  SUBAREA RUNOFF(CFS) =      5.27
  TOTAL AREA(ACRES) =      1.30   PEAK FLOW RATE(CFS) =      5.27

****************************************************************************
  FLOW PROCESS FROM NODE  60005.00 TO NODE  60010.00 IS CODE =  51
----------------------------------------------------------------------------
  >>>>>COMPUTE TRAPEZOIDAL CHANNEL FLOW<<<<<
  >>>>>TRAVELTIME THRU SUBAREA (EXISTING ELEMENT)<<<<<
============================================================================
  ELEVATION DATA: UPSTREAM(FEET) =   1315.00  DOWNSTREAM(FEET) =   1298.00
  CHANNEL LENGTH THRU SUBAREA(FEET) =   680.00   CHANNEL SLOPE =  0.0250
  CHANNEL BASE(FEET) =    5.00   "Z" FACTOR =   4.000
  MANNING'S FACTOR = 0.030   MAXIMUM DEPTH(FEET) =   4.00
  * 100 YEAR RAINFALL INTENSITY(INCH/HR) =  3.673
  SUBAREA LOSS RATE DATA(AMC III):
   DEVELOPMENT TYPE/      SCS SOIL   AREA      Fp         Ap     SCS
       LAND USE            GROUP   (ACRES)  (INCH/HR)  (DECIMAL)  CN
  PUBLIC PARK                B        3.70      0.42     0.850    76
  SUBAREA AVERAGE PERVIOUS LOSS RATE, Fp(INCH/HR) =  0.42
  SUBAREA AVERAGE PERVIOUS AREA FRACTION, Ap =  0.850
  TRAVEL TIME COMPUTED USING ESTIMATED FLOW(CFS) =      10.83
  TRAVEL TIME THRU SUBAREA BASED ON VELOCITY(FEET/SEC.) =   3.81
  AVERAGE FLOW DEPTH(FEET) =   0.42   TRAVEL TIME(MIN.) =   2.97
  Tc(MIN.) =    9.95
  SUBAREA AREA(ACRES) =     3.70       SUBAREA RUNOFF(CFS) =   11.03
  EFFECTIVE AREA(ACRES) =      5.00     AREA-AVERAGED Fm(INCH/HR) =   0.28
  AREA-AVERAGED Fp(INCH/HR) =   0.42  AREA-AVERAGED Ap =   0.66
  TOTAL AREA(ACRES) =        5.0         PEAK FLOW RATE(CFS) =      15.28

  END OF SUBAREA CHANNEL FLOW HYDRAULICS:
  DEPTH(FEET) =  0.51   FLOW VELOCITY(FEET/SEC.) =   4.21
  LONGEST FLOWPATH FROM NODE  60000.00 TO NODE  60010.00 =    1017.00 FEET.

****************************************************************************
  FLOW PROCESS FROM NODE  60010.00 TO NODE  60010.00 IS CODE =   1
----------------------------------------------------------------------------
  >>>>>DESIGNATE INDEPENDENT STREAM FOR CONFLUENCE<<<<<
============================================================================
  TOTAL NUMBER OF STREAMS =  2
  CONFLUENCE VALUES USED FOR INDEPENDENT STREAM  1 ARE:
  TIME OF CONCENTRATION(MIN.) =    9.95
  RAINFALL INTENSITY(INCH/HR) =   3.67
  AREA-AVERAGED Fm(INCH/HR) =  0.28
  AREA-AVERAGED Fp(INCH/HR) =  0.42
  AREA-AVERAGED Ap =  0.66
  EFFECTIVE STREAM AREA(ACRES) =       5.00
  TOTAL STREAM AREA(ACRES) =       5.00
  PEAK FLOW RATE(CFS) AT CONFLUENCE =      15.28

****************************************************************************
  FLOW PROCESS FROM NODE  60015.00 TO NODE  60020.00 IS CODE =  21
----------------------------------------------------------------------------
  >>>>>RATIONAL METHOD INITIAL SUBAREA ANALYSIS<<<<<
  >>USE TIME-OF-CONCENTRATION NOMOGRAPH FOR INITIAL SUBAREA<<
============================================================================
  INITIAL SUBAREA FLOW-LENGTH(FEET) =  1000.00
  ELEVATION DATA: UPSTREAM(FEET) =   1326.00  DOWNSTREAM(FEET) =   1307.00

  Tc = K*[(LENGTH** 3.00)/(ELEVATION CHANGE)]**0.20
  SUBAREA ANALYSIS USED MINIMUM Tc(MIN.) =   10.644
  * 100 YEAR RAINFALL INTENSITY(INCH/HR) =  3.528
  SUBAREA Tc AND LOSS RATE DATA(AMC III):
   DEVELOPMENT TYPE/      SCS SOIL   AREA      Fp         Ap     SCS   Tc
       LAND USE            GROUP   (ACRES)  (INCH/HR)  (DECIMAL)  CN  (MIN.)
  COMMERCIAL                 B        1.20      0.42     0.100    76   10.64
  SUBAREA AVERAGE PERVIOUS LOSS RATE, Fp(INCH/HR) =  0.42
  SUBAREA AVERAGE PERVIOUS AREA FRACTION, Ap =  0.100
  SUBAREA RUNOFF(CFS) =      3.76
  TOTAL AREA(ACRES) =      1.20   PEAK FLOW RATE(CFS) =      3.76
```

```
****************************************************************************
  FLOW PROCESS FROM NODE  60020.00 TO NODE  60020.00 IS CODE =  81
----------------------------------------------------------------------------
  >>>>>ADDITION OF SUBAREA TO MAINLINE PEAK FLOW<<<<<
============================================================================
  MAINLINE Tc(MIN.) =   10.64
  * 100 YEAR RAINFALL INTENSITY(INCH/HR) =  3.528
  SUBAREA LOSS RATE DATA(AMC III):
   DEVELOPMENT TYPE/      SCS SOIL   AREA      Fp         Ap     SCS
       LAND USE            GROUP   (ACRES)  (INCH/HR)  (DECIMAL)  CN
  COMMERCIAL                 B       5.19      0.42     0.100    76
  SUBAREA AVERAGE PERVIOUS LOSS RATE, Fp(INCH/HR) =  0.42
  SUBAREA AVERAGE PERVIOUS AREA FRACTION, Ap =  0.100
  SUBAREA AREA(ACRES) =    5.19      SUBAREA RUNOFF(CFS) =   16.28
  EFFECTIVE AREA(ACRES) =      6.39   AREA-AVERAGED Fm(INCH/HR) =  0.04
  AREA-AVERAGED Fp(INCH/HR) =  0.42  AREA-AVERAGED Ap =  0.10
  TOTAL AREA(ACRES) =        6.4       PEAK FLOW RATE(CFS) =      20.05

****************************************************************************
  FLOW PROCESS FROM NODE  60020.00 TO NODE  60025.00 IS CODE =  62
----------------------------------------------------------------------------
  >>>>>COMPUTE STREET FLOW TRAVEL TIME THRU SUBAREA<<<<<
  >>>>>(STREET TABLE SECTION #  1 USED)<<<<<
============================================================================
  UPSTREAM ELEVATION(FEET) = 1307.00  DOWNSTREAM ELEVATION(FEET) = 1301.00
  STREET LENGTH(FEET) =   450.00   CURB HEIGHT(INCHES) =  8.0
  STREET HALFWIDTH(FEET) = 30.00

  DISTANCE FROM CROWN TO CROSSFALL GRADEBREAK(FEET) =  20.00
  INSIDE STREET CROSSFALL(DECIMAL) =  0.018
  OUTSIDE STREET CROSSFALL(DECIMAL)  =  0.018

  SPECIFIED NUMBER OF HALFSTREETS CARRYING RUNOFF =  1
  STREET PARKWAY CROSSFALL(DECIMAL)  =  0.020
  Manning's FRICTION FACTOR for Streetflow Section(curb-to-curb) =   0.0150
  Manning's FRICTION FACTOR for Back-of-Walk Flow Section =   0.0200

    **TRAVEL TIME COMPUTED USING ESTIMATED FLOW(CFS) =      20.06
    STREETFLOW MODEL RESULTS USING ESTIMATED FLOW:
    STREET FLOW DEPTH(FEET) =  0.58
    HALFSTREET FLOOD WIDTH(FEET) =   23.16
    AVERAGE FLOW VELOCITY(FEET/SEC.) =    4.02
    PRODUCT OF DEPTH&VELOCITY(FT*FT/SEC.) =    2.32
  STREET FLOW TRAVEL TIME(MIN.) =   1.86   Tc(MIN.) =   12.51
  * 100 YEAR RAINFALL INTENSITY(INCH/HR) =  3.202
  SUBAREA LOSS RATE DATA(AMC III):
   DEVELOPMENT TYPE/      SCS SOIL   AREA      Fp         Ap     SCS
       LAND USE            GROUP   (ACRES)  (INCH/HR)  (DECIMAL)  CN
  MOBILE HOME PARK           B       0.01      0.42     0.250    76
  SUBAREA AVERAGE PERVIOUS LOSS RATE, Fp(INCH/HR) =  0.42
  SUBAREA AVERAGE PERVIOUS AREA FRACTION, Ap =  0.250
  SUBAREA AREA(ACRES) =    0.01      SUBAREA RUNOFF(CFS) =    0.03
  EFFECTIVE AREA(ACRES) =      6.40    AREA-AVERAGED Fm(INCH/HR) =  0.04
  AREA-AVERAGED Fp(INCH/HR) =  0.42  AREA-AVERAGED Ap =  0.10
  TOTAL AREA(ACRES) =        6.4        PEAK FLOW RATE(CFS) =      20.05
  NOTE: PEAK FLOW RATE DEFAULTED TO UPSTREAM VALUE

  END OF SUBAREA STREET FLOW HYDRAULICS:
  DEPTH(FEET) = 0.58   HALFSTREET FLOOD WIDTH(FEET) =  23.16
  FLOW VELOCITY(FEET/SEC.) =  4.02   DEPTH*VELOCITY(FT*FT/SEC.) =   2.32
  LONGEST FLOWPATH FROM NODE  60015.00 TO NODE  60025.00 =    1450.00 FEET.

****************************************************************************
  FLOW PROCESS FROM NODE  60025.00 TO NODE  60010.00 IS CODE =  62
----------------------------------------------------------------------------
  >>>>>COMPUTE STREET FLOW TRAVEL TIME THRU SUBAREA<<<<<
  >>>>>(STREET TABLE SECTION #  1 USED)<<<<<
============================================================================
  UPSTREAM ELEVATION(FEET) = 1301.00  DOWNSTREAM ELEVATION(FEET) = 1298.00
  STREET LENGTH(FEET) =   520.00   CURB HEIGHT(INCHES) =  8.0
  STREET HALFWIDTH(FEET) = 30.00
```

```
 DISTANCE FROM CROWN TO CROSSFALL GRADEBREAK(FEET) =  20.00
 INSIDE STREET CROSSFALL(DECIMAL) =  0.018
 OUTSIDE STREET CROSSFALL(DECIMAL)  =  0.018

 SPECIFIED NUMBER OF HALFSTREETS CARRYING RUNOFF =  2
 STREET PARKWAY CROSSFALL(DECIMAL)  =  0.020
 Manning's FRICTION FACTOR for Streetflow Section(curb-to-curb) =   0.0150
 Manning's FRICTION FACTOR for Back-of-Walk Flow Section =   0.0200

   **TRAVEL TIME COMPUTED USING ESTIMATED FLOW(CFS) =      27.48
   STREETFLOW MODEL RESULTS USING ESTIMATED FLOW:
   STREET FLOW DEPTH(FEET) =  0.58
   HALFSTREET FLOOD WIDTH(FEET) =   23.48
   AVERAGE FLOW VELOCITY(FEET/SEC.) =    2.69
   PRODUCT OF DEPTH&VELOCITY(FT*FT/SEC.) =    1.56
 STREET FLOW TRAVEL TIME(MIN.) =   3.23   Tc(MIN.) =   15.74
 * 100 YEAR RAINFALL INTENSITY(INCH/HR) =  2.790
 SUBAREA LOSS RATE DATA(AMC III):
  DEVELOPMENT TYPE/      SCS SOIL   AREA      Fp         Ap     SCS
      LAND USE            GROUP   (ACRES)  (INCH/HR)  (DECIMAL)  CN
 COMMERCIAL                 B       6.00      0.42     0.100    76
 SUBAREA AVERAGE PERVIOUS LOSS RATE, Fp(INCH/HR) =  0.42
 SUBAREA AVERAGE PERVIOUS AREA FRACTION, Ap =  0.100
 SUBAREA AREA(ACRES) =    6.00      SUBAREA RUNOFF(CFS) =   14.84
 EFFECTIVE AREA(ACRES) =     12.40    AREA-AVERAGED Fm(INCH/HR) =  0.04
 AREA-AVERAGED Fp(INCH/HR) =  0.42  AREA-AVERAGED Ap =  0.10
 TOTAL AREA(ACRES) =       12.4       PEAK FLOW RATE(CFS) =      30.67

 END OF SUBAREA STREET FLOW HYDRAULICS:
 DEPTH(FEET) = 0.60   HALFSTREET FLOOD WIDTH(FEET) =  24.57
 FLOW VELOCITY(FEET/SEC.) =  2.75   DEPTH*VELOCITY(FT*FT/SEC.) =   1.65
 LONGEST FLOWPATH FROM NODE  60015.00 TO NODE  60010.00 =    1970.00 FEET.

****************************************************************************
 FLOW PROCESS FROM NODE  60010.00 TO NODE  60010.00 IS CODE =   1
----------------------------------------------------------------------------
 >>>>>DESIGNATE INDEPENDENT STREAM FOR CONFLUENCE<<<<<
 >>>>>AND COMPUTE VARIOUS CONFLUENCED STREAM VALUES<<<<<
============================================================================
 TOTAL NUMBER OF STREAMS =  2
 CONFLUENCE VALUES USED FOR INDEPENDENT STREAM  2 ARE:
 TIME OF CONCENTRATION(MIN.) =   15.74
 RAINFALL INTENSITY(INCH/HR) =   2.79
 AREA-AVERAGED Fm(INCH/HR) =  0.04
 AREA-AVERAGED Fp(INCH/HR) =  0.42
 AREA-AVERAGED Ap =  0.10
 EFFECTIVE STREAM AREA(ACRES) =      12.40
 TOTAL STREAM AREA(ACRES) =      12.40
 PEAK FLOW RATE(CFS) AT CONFLUENCE =      30.67

 ** CONFLUENCE DATA **
  STREAM       Q      Tc   Intensity   Fp(Fm)     Ap     Ae     HEADWATER
  NUMBER     (CFS)  (MIN.) (INCH/HR) (INCH/HR)         (ACRES)    NODE
     1       15.28    9.95    3.673  0.42( 0.28) 0.66       5.0   60000.00
     2       30.67   15.74    2.790  0.42( 0.04) 0.10      12.4   60015.00

 RAINFALL INTENSITY AND TIME OF CONCENTRATION RATIO
 CONFLUENCE FORMULA USED FOR  2 STREAMS.

 ** PEAK FLOW RATE TABLE **
  STREAM       Q      Tc   Intensity   Fp(Fm)     Ap     Ae     HEADWATER
  NUMBER     (CFS)  (MIN.) (INCH/HR) (INCH/HR)         (ACRES)    NODE
     1       40.91    9.95    3.673  0.42( 0.13) 0.32      12.8   60000.00
     2       41.98   15.74    2.790  0.42( 0.11) 0.26      17.4   60015.00

 COMPUTED CONFLUENCE ESTIMATES ARE AS FOLLOWS:
 PEAK FLOW RATE(CFS) =      41.98    Tc(MIN.) =    15.74
 EFFECTIVE AREA(ACRES) =      17.40   AREA-AVERAGED Fm(INCH/HR) =  0.11
 AREA-AVERAGED Fp(INCH/HR) =  0.42  AREA-AVERAGED Ap =  0.26
 TOTAL AREA(ACRES) =       17.4
```

```
  LONGEST FLOWPATH FROM NODE  60015.00 TO NODE  60010.00 =    1970.00 FEET.

****************************************************************************
  FLOW PROCESS FROM NODE  60010.00 TO NODE  60030.00 IS CODE =  62
----------------------------------------------------------------------------
  >>>>>COMPUTE STREET FLOW TRAVEL TIME THRU SUBAREA<<<<<
  >>>>>(STREET TABLE SECTION #  1 USED)<<<<<
============================================================================
  UPSTREAM ELEVATION(FEET) = 1298.00  DOWNSTREAM ELEVATION(FEET) = 1297.00
  STREET LENGTH(FEET) =   225.00   CURB HEIGHT(INCHES) =  8.0
  STREET HALFWIDTH(FEET) = 30.00

  DISTANCE FROM CROWN TO CROSSFALL GRADEBREAK(FEET) =  20.00
  INSIDE STREET CROSSFALL(DECIMAL) =  0.018
  OUTSIDE STREET CROSSFALL(DECIMAL)  =  0.018

  SPECIFIED NUMBER OF HALFSTREETS CARRYING RUNOFF =  2
  STREET PARKWAY CROSSFALL(DECIMAL)  =  0.020
  Manning's FRICTION FACTOR for Streetflow Section(curb-to-curb) =   0.0150
  Manning's FRICTION FACTOR for Back-of-Walk Flow Section =   0.0200

   **TRAVEL TIME COMPUTED USING ESTIMATED FLOW(CFS) =      42.10
    STREETFLOW MODEL RESULTS USING ESTIMATED FLOW:
    STREET FLOW DEPTH(FEET) =  0.68
    HALFSTREET FLOOD WIDTH(FEET) =   30.03
    AVERAGE FLOW VELOCITY(FEET/SEC.) =    2.70
    PRODUCT OF DEPTH&VELOCITY(FT*FT/SEC.) =    1.84
  STREET FLOW TRAVEL TIME(MIN.) =   1.39   Tc(MIN.) =   17.13
  * 100 YEAR RAINFALL INTENSITY(INCH/HR) =  2.652
  SUBAREA LOSS RATE DATA(AMC III):
   DEVELOPMENT TYPE/      SCS SOIL   AREA      Fp         Ap     SCS
       LAND USE            GROUP   (ACRES)  (INCH/HR)  (DECIMAL)  CN
  COMMERCIAL                  B        0.10      0.42     0.100    76
  SUBAREA AVERAGE PERVIOUS LOSS RATE, Fp(INCH/HR) =  0.42
  SUBAREA AVERAGE PERVIOUS AREA FRACTION, Ap =  0.100
  SUBAREA AREA(ACRES) =    0.10      SUBAREA RUNOFF(CFS) =    0.23
  EFFECTIVE AREA(ACRES) =     17.50    AREA-AVERAGED Fm(INCH/HR) =  0.11
  AREA-AVERAGED Fp(INCH/HR) =  0.42  AREA-AVERAGED Ap =  0.26
  TOTAL AREA(ACRES) =       17.5        PEAK FLOW RATE(CFS) =      41.98
  NOTE: PEAK FLOW RATE DEFAULTED TO UPSTREAM VALUE

  END OF SUBAREA STREET FLOW HYDRAULICS:
  DEPTH(FEET) = 0.68   HALFSTREET FLOOD WIDTH(FEET) =  30.03
  FLOW VELOCITY(FEET/SEC.) =  2.69   DEPTH*VELOCITY(FT*FT/SEC.) =   1.84
  LONGEST FLOWPATH FROM NODE  60015.00 TO NODE  60030.00 =    2195.00 FEET.

****************************************************************************
  FLOW PROCESS FROM NODE  60030.00 TO NODE  60030.00 IS CODE =   1
----------------------------------------------------------------------------
  >>>>>DESIGNATE INDEPENDENT STREAM FOR CONFLUENCE<<<<<
============================================================================
  TOTAL NUMBER OF STREAMS =  2
  CONFLUENCE VALUES USED FOR INDEPENDENT STREAM  1 ARE:
  TIME OF CONCENTRATION(MIN.) =   17.13
  RAINFALL INTENSITY(INCH/HR) =   2.65
  AREA-AVERAGED Fm(INCH/HR) =  0.11
  AREA-AVERAGED Fp(INCH/HR) =  0.42
  AREA-AVERAGED Ap =  0.26
  EFFECTIVE STREAM AREA(ACRES) =      17.50
  TOTAL STREAM AREA(ACRES) =      17.50
  PEAK FLOW RATE(CFS) AT CONFLUENCE =      41.98

****************************************************************************
  FLOW PROCESS FROM NODE  60100.00 TO NODE  60105.00 IS CODE =  21
----------------------------------------------------------------------------
  >>>>>RATIONAL METHOD INITIAL SUBAREA ANALYSIS<<<<<
  >>USE TIME-OF-CONCENTRATION NOMOGRAPH FOR INITIAL SUBAREA<<
============================================================================
  INITIAL SUBAREA FLOW-LENGTH(FEET) =   230.00
  ELEVATION DATA: UPSTREAM(FEET) =   1320.00  DOWNSTREAM(FEET) =   1317.00
```

```
  Tc = K*[(LENGTH** 3.00)/(ELEVATION CHANGE)]**0.20
  SUBAREA ANALYSIS USED MINIMUM Tc(MIN.) =    8.640
  * 100 YEAR RAINFALL INTENSITY(INCH/HR) =  3.998
  SUBAREA Tc AND LOSS RATE DATA(AMC III):
   DEVELOPMENT TYPE/      SCS SOIL   AREA      Fp         Ap     SCS   Tc
       LAND USE            GROUP   (ACRES)  (INCH/HR)  (DECIMAL)  CN  (MIN.)
  SCHOOL                     B        0.60      0.42     0.600    76    8.64
  SUBAREA AVERAGE PERVIOUS LOSS RATE, Fp(INCH/HR) =  0.42
  SUBAREA AVERAGE PERVIOUS AREA FRACTION, Ap =  0.600
  SUBAREA RUNOFF(CFS) =      2.02
  TOTAL AREA(ACRES) =      0.60   PEAK FLOW RATE(CFS) =      2.02

****************************************************************************
  FLOW PROCESS FROM NODE  60105.00 TO NODE  60110.00 IS CODE =  51
----------------------------------------------------------------------------
  >>>>>COMPUTE TRAPEZOIDAL CHANNEL FLOW<<<<<
  >>>>>TRAVELTIME THRU SUBAREA (EXISTING ELEMENT)<<<<<
============================================================================
  ELEVATION DATA: UPSTREAM(FEET) =   1317.00  DOWNSTREAM(FEET) =   1306.00
  CHANNEL LENGTH THRU SUBAREA(FEET) =   590.00   CHANNEL SLOPE =  0.0186
  CHANNEL BASE(FEET) =   10.00   "Z" FACTOR =   4.000
  MANNING'S FACTOR = 0.030   MAXIMUM DEPTH(FEET) =   0.50
  * 100 YEAR RAINFALL INTENSITY(INCH/HR) =  3.276
  SUBAREA LOSS RATE DATA(AMC III):
   DEVELOPMENT TYPE/      SCS SOIL   AREA      Fp         Ap     SCS
       LAND USE            GROUP   (ACRES)  (INCH/HR)  (DECIMAL)  CN
  SCHOOL                     B        6.00      0.42     0.600    76
  SUBAREA AVERAGE PERVIOUS LOSS RATE, Fp(INCH/HR) =  0.42
  SUBAREA AVERAGE PERVIOUS AREA FRACTION, Ap =  0.600
  TRAVEL TIME COMPUTED USING ESTIMATED FLOW(CFS) =      10.28
  TRAVEL TIME THRU SUBAREA BASED ON VELOCITY(FEET/SEC.) =   2.89
  AVERAGE FLOW DEPTH(FEET) =   0.32   TRAVEL TIME(MIN.) =   3.40
  Tc(MIN.) =   12.04
  SUBAREA AREA(ACRES) =     6.00       SUBAREA RUNOFF(CFS) =   16.32
  EFFECTIVE AREA(ACRES) =      6.60     AREA-AVERAGED Fm(INCH/HR) =   0.25
  AREA-AVERAGED Fp(INCH/HR) =   0.42  AREA-AVERAGED Ap =   0.60
  TOTAL AREA(ACRES) =        6.6         PEAK FLOW RATE(CFS) =      17.95

  END OF SUBAREA CHANNEL FLOW HYDRAULICS:
  DEPTH(FEET) =  0.43   FLOW VELOCITY(FEET/SEC.) =   3.54
  LONGEST FLOWPATH FROM NODE  60100.00 TO NODE  60110.00 =     820.00 FEET.

****************************************************************************
  FLOW PROCESS FROM NODE  60110.00 TO NODE  60030.00 IS CODE =  62
----------------------------------------------------------------------------
  >>>>>COMPUTE STREET FLOW TRAVEL TIME THRU SUBAREA<<<<<
  >>>>>(STREET TABLE SECTION #  1 USED)<<<<<
============================================================================
  UPSTREAM ELEVATION(FEET) = 1306.00  DOWNSTREAM ELEVATION(FEET) = 1297.00
  STREET LENGTH(FEET) =   750.00   CURB HEIGHT(INCHES) =  8.0
  STREET HALFWIDTH(FEET) = 30.00

  DISTANCE FROM CROWN TO CROSSFALL GRADEBREAK(FEET) =  20.00
  INSIDE STREET CROSSFALL(DECIMAL) =  0.018
  OUTSIDE STREET CROSSFALL(DECIMAL)  =  0.018

  SPECIFIED NUMBER OF HALFSTREETS CARRYING RUNOFF =  2
  STREET PARKWAY CROSSFALL(DECIMAL)  =  0.020
  Manning's FRICTION FACTOR for Streetflow Section(curb-to-curb) =   0.0150
  Manning's FRICTION FACTOR for Back-of-Walk Flow Section =   0.0200

    **TRAVEL TIME COMPUTED USING ESTIMATED FLOW(CFS) =      24.21
    STREETFLOW MODEL RESULTS USING ESTIMATED FLOW:
    STREET FLOW DEPTH(FEET) =  0.51
    HALFSTREET FLOOD WIDTH(FEET) =   19.34
    AVERAGE FLOW VELOCITY(FEET/SEC.) =    3.43
    PRODUCT OF DEPTH&VELOCITY(FT*FT/SEC.) =    1.74
  STREET FLOW TRAVEL TIME(MIN.) =   3.65   Tc(MIN.) =   15.69
  * 100 YEAR RAINFALL INTENSITY(INCH/HR) =  2.795
  SUBAREA LOSS RATE DATA(AMC III):
   DEVELOPMENT TYPE/      SCS SOIL   AREA      Fp         Ap     SCS
```

```
     LAND USE            GROUP   (ACRES)  (INCH/HR)  (DECIMAL)  CN
 COMMERCIAL                B        0.70      0.42     0.100    76
 PUBLIC PARK               B        4.90      0.42     0.850    76
 SUBAREA AVERAGE PERVIOUS LOSS RATE, Fp(INCH/HR) =  0.42
 SUBAREA AVERAGE PERVIOUS AREA FRACTION, Ap =  0.756
 SUBAREA AREA(ACRES) =    5.60      SUBAREA RUNOFF(CFS) =   12.48
 EFFECTIVE AREA(ACRES) =     12.20    AREA-AVERAGED Fm(INCH/HR) =  0.28
 AREA-AVERAGED Fp(INCH/HR) =  0.42  AREA-AVERAGED Ap =  0.67
 TOTAL AREA(ACRES) =       12.2        PEAK FLOW RATE(CFS) =      27.57

 END OF SUBAREA STREET FLOW HYDRAULICS:
 DEPTH(FEET) = 0.53   HALFSTREET FLOOD WIDTH(FEET) =  20.35
 FLOW VELOCITY(FEET/SEC.) =  3.54   DEPTH*VELOCITY(FT*FT/SEC.) =   1.86
 LONGEST FLOWPATH FROM NODE  60100.00 TO NODE  60030.00 =    1570.00 FEET.

****************************************************************************
 FLOW PROCESS FROM NODE  60030.00 TO NODE  60030.00 IS CODE =   1
----------------------------------------------------------------------------
 >>>>>DESIGNATE INDEPENDENT STREAM FOR CONFLUENCE<<<<<
 >>>>>AND COMPUTE VARIOUS CONFLUENCED STREAM VALUES<<<<<
============================================================================
 TOTAL NUMBER OF STREAMS =  2
 CONFLUENCE VALUES USED FOR INDEPENDENT STREAM  2 ARE:
 TIME OF CONCENTRATION(MIN.) =   15.69
 RAINFALL INTENSITY(INCH/HR) =   2.80
 AREA-AVERAGED Fm(INCH/HR) =  0.28
 AREA-AVERAGED Fp(INCH/HR) =  0.42
 AREA-AVERAGED Ap =  0.67
 EFFECTIVE STREAM AREA(ACRES) =      12.20
 TOTAL STREAM AREA(ACRES) =      12.20
 PEAK FLOW RATE(CFS) AT CONFLUENCE =      27.57

 ** CONFLUENCE DATA **
  STREAM       Q      Tc   Intensity   Fp(Fm)     Ap     Ae     HEADWATER
  NUMBER     (CFS)  (MIN.) (INCH/HR) (INCH/HR)         (ACRES)    NODE
     1       40.91   11.36    3.393  0.42( 0.13) 0.31      12.9   60000.00
     1       41.98   17.13    2.652  0.42( 0.11) 0.26      17.5   60015.00
     2       27.57   15.69    2.795  0.42( 0.28) 0.67      12.2   60100.00

 RAINFALL INTENSITY AND TIME OF CONCENTRATION RATIO
 CONFLUENCE FORMULA USED FOR  2 STREAMS.

 ** PEAK FLOW RATE TABLE **
  STREAM       Q      Tc   Intensity   Fp(Fm)     Ap     Ae     HEADWATER
  NUMBER     (CFS)  (MIN.) (INCH/HR) (INCH/HR)         (ACRES)    NODE
     1       65.62   11.36    3.393  0.42( 0.19) 0.46      21.8   60000.00
     2       69.29   15.69    2.795  0.42( 0.19) 0.44      28.6   60100.00
     3       67.98   17.13    2.652  0.42( 0.18) 0.43      29.7   60015.00

 COMPUTED CONFLUENCE ESTIMATES ARE AS FOLLOWS:
 PEAK FLOW RATE(CFS) =      69.29    Tc(MIN.) =    15.69
 EFFECTIVE AREA(ACRES) =      28.57    AREA-AVERAGED Fm(INCH/HR) =  0.19
 AREA-AVERAGED Fp(INCH/HR) =  0.42  AREA-AVERAGED Ap =  0.44
 TOTAL AREA(ACRES) =       29.7
 LONGEST FLOWPATH FROM NODE  60015.00 TO NODE  60030.00 =    2195.00 FEET.

****************************************************************************
 FLOW PROCESS FROM NODE  60030.00 TO NODE  60040.00 IS CODE =  41
----------------------------------------------------------------------------
 >>>>>COMPUTE PIPE-FLOW TRAVEL TIME THRU SUBAREA<<<<<
 >>>>>USING USER-SPECIFIED PIPESIZE (EXISTING ELEMENT)<<<<<
============================================================================
 ELEVATION DATA: UPSTREAM(FEET) =  1297.00  DOWNSTREAM(FEET) =  1296.00
 FLOW LENGTH(FEET) =    40.00   MANNING'S N =  0.010
 DEPTH OF FLOW IN  36.0 INCH PIPE IS  18.7 INCHES
 PIPE-FLOW VELOCITY(FEET/SEC.) =  18.69
 GIVEN PIPE DIAMETER(INCH) =  36.00    NUMBER OF PIPES =   1
 PIPE-FLOW(CFS) =      69.29
 PIPE TRAVEL TIME(MIN.) =   0.04    Tc(MIN.) =   15.73
 LONGEST FLOWPATH FROM NODE  60015.00 TO NODE  60040.00 =    2235.00 FEET.
```

```
****************************************************************************
  FLOW PROCESS FROM NODE  60040.00 TO NODE  60040.00 IS CODE =  81
----------------------------------------------------------------------------
  >>>>>ADDITION OF SUBAREA TO MAINLINE PEAK FLOW<<<<<
============================================================================
  MAINLINE Tc(MIN.) =   15.73
  * 100 YEAR RAINFALL INTENSITY(INCH/HR) =  2.791
  SUBAREA LOSS RATE DATA(AMC III):
   DEVELOPMENT TYPE/      SCS SOIL   AREA      Fp         Ap     SCS
       LAND USE            GROUP   (ACRES)  (INCH/HR)  (DECIMAL)  CN
  COMMERCIAL                 B        1.00      0.42     0.100    76
  SUBAREA AVERAGE PERVIOUS LOSS RATE, Fp(INCH/HR) =  0.42
  SUBAREA AVERAGE PERVIOUS AREA FRACTION, Ap =  0.100
  SUBAREA AREA(ACRES) =    1.00      SUBAREA RUNOFF(CFS) =    2.47
  EFFECTIVE AREA(ACRES) =     29.57   AREA-AVERAGED Fm(INCH/HR) =  0.18
  AREA-AVERAGED Fp(INCH/HR) =  0.42  AREA-AVERAGED Ap =  0.43
  TOTAL AREA(ACRES) =       30.7       PEAK FLOW RATE(CFS) =      69.42

****************************************************************************
  FLOW PROCESS FROM NODE  60040.00 TO NODE  60045.00 IS CODE =  41
----------------------------------------------------------------------------
  >>>>>COMPUTE PIPE-FLOW TRAVEL TIME THRU SUBAREA<<<<<
  >>>>>USING USER-SPECIFIED PIPESIZE (EXISTING ELEMENT)<<<<<
============================================================================
  ELEVATION DATA: UPSTREAM(FEET) =  1297.00  DOWNSTREAM(FEET) =  1293.00
  FLOW LENGTH(FEET) =   158.80   MANNING'S N =  0.013
  DEPTH OF FLOW IN  36.0 INCH PIPE IS  22.0 INCHES
  PIPE-FLOW VELOCITY(FEET/SEC.) =  15.33
  GIVEN PIPE DIAMETER(INCH) =  36.00    NUMBER OF PIPES =   1
  PIPE-FLOW(CFS) =      69.42
  PIPE TRAVEL TIME(MIN.) =   0.17    Tc(MIN.) =   15.90
  LONGEST FLOWPATH FROM NODE  60015.00 TO NODE  60045.00 =    2393.80 FEET.

****************************************************************************
  FLOW PROCESS FROM NODE  60045.00 TO NODE  60045.00 IS CODE =   1
----------------------------------------------------------------------------
  >>>>>DESIGNATE INDEPENDENT STREAM FOR CONFLUENCE<<<<<
============================================================================
  TOTAL NUMBER OF STREAMS =  2
  CONFLUENCE VALUES USED FOR INDEPENDENT STREAM  1 ARE:
  TIME OF CONCENTRATION(MIN.) =   15.90
  RAINFALL INTENSITY(INCH/HR) =   2.77
  AREA-AVERAGED Fm(INCH/HR) =  0.18
  AREA-AVERAGED Fp(INCH/HR) =  0.42
  AREA-AVERAGED Ap =  0.43
  EFFECTIVE STREAM AREA(ACRES) =      29.57
  TOTAL STREAM AREA(ACRES) =      30.70
  PEAK FLOW RATE(CFS) AT CONFLUENCE =      69.42

****************************************************************************
  FLOW PROCESS FROM NODE  60200.00 TO NODE  60205.00 IS CODE =  21
----------------------------------------------------------------------------
  >>>>>RATIONAL METHOD INITIAL SUBAREA ANALYSIS<<<<<
  >>USE TIME-OF-CONCENTRATION NOMOGRAPH FOR INITIAL SUBAREA<<
============================================================================
  INITIAL SUBAREA FLOW-LENGTH(FEET) =   230.00
  ELEVATION DATA: UPSTREAM(FEET) =   1315.00  DOWNSTREAM(FEET) =   1312.00

  Tc = K*[(LENGTH** 3.00)/(ELEVATION CHANGE)]**0.20
  SUBAREA ANALYSIS USED MINIMUM Tc(MIN.) =   10.129
  * 100 YEAR RAINFALL INTENSITY(INCH/HR) =  3.635
  SUBAREA Tc AND LOSS RATE DATA(AMC III):
   DEVELOPMENT TYPE/      SCS SOIL   AREA      Fp         Ap     SCS   Tc
       LAND USE            GROUP   (ACRES)  (INCH/HR)  (DECIMAL)  CN  (MIN.)
  PUBLIC PARK                B        0.70      0.42     0.850    76   10.13
  SUBAREA AVERAGE PERVIOUS LOSS RATE, Fp(INCH/HR) =  0.42
  SUBAREA AVERAGE PERVIOUS AREA FRACTION, Ap =  0.850
  SUBAREA RUNOFF(CFS) =      2.06
  TOTAL AREA(ACRES) =      0.70   PEAK FLOW RATE(CFS) =      2.06

****************************************************************************
```

```
  FLOW PROCESS FROM NODE  60205.00 TO NODE  60210.00 IS CODE =  51
----------------------------------------------------------------------------
  >>>>>COMPUTE TRAPEZOIDAL CHANNEL FLOW<<<<<
  >>>>>TRAVELTIME THRU SUBAREA (EXISTING ELEMENT)<<<<<
============================================================================
  ELEVATION DATA: UPSTREAM(FEET) =   1312.00  DOWNSTREAM(FEET) =   1301.00
  CHANNEL LENGTH THRU SUBAREA(FEET) =   692.00   CHANNEL SLOPE =  0.0159
  CHANNEL BASE(FEET) =    5.00   "Z" FACTOR =   4.000
  MANNING'S FACTOR = 0.030   MAXIMUM DEPTH(FEET) =   1.00
  * 100 YEAR RAINFALL INTENSITY(INCH/HR) =  2.854
  SUBAREA LOSS RATE DATA(AMC III):
   DEVELOPMENT TYPE/      SCS SOIL   AREA      Fp         Ap     SCS
      LAND USE             GROUP   (ACRES)  (INCH/HR)  (DECIMAL)  CN
  PUBLIC PARK                B        1.50      0.42     0.850    76
  SUBAREA AVERAGE PERVIOUS LOSS RATE, Fp(INCH/HR) =  0.42
  SUBAREA AVERAGE PERVIOUS AREA FRACTION, Ap =  0.850
  TRAVEL TIME COMPUTED USING ESTIMATED FLOW(CFS) =       3.77
  TRAVEL TIME THRU SUBAREA BASED ON VELOCITY(FEET/SEC.) =   2.30
  AVERAGE FLOW DEPTH(FEET) =   0.27   TRAVEL TIME(MIN.) =   5.02
  Tc(MIN.) =   15.15
  SUBAREA AREA(ACRES) =     1.50       SUBAREA RUNOFF(CFS) =    3.37
  EFFECTIVE AREA(ACRES) =      2.20     AREA-AVERAGED Fm(INCH/HR) =   0.36
  AREA-AVERAGED Fp(INCH/HR) =   0.42  AREA-AVERAGED Ap =   0.85
  TOTAL AREA(ACRES) =        2.2         PEAK FLOW RATE(CFS) =       4.94

  END OF SUBAREA CHANNEL FLOW HYDRAULICS:
  DEPTH(FEET) =  0.31   FLOW VELOCITY(FEET/SEC.) =   2.55
  LONGEST FLOWPATH FROM NODE  60200.00 TO NODE  60210.00 =     922.00 FEET.

****************************************************************************
  FLOW PROCESS FROM NODE  60210.00 TO NODE  60215.00 IS CODE =  41
----------------------------------------------------------------------------
  >>>>>COMPUTE PIPE-FLOW TRAVEL TIME THRU SUBAREA<<<<<
  >>>>>USING USER-SPECIFIED PIPESIZE (EXISTING ELEMENT)<<<<<
============================================================================
  ELEVATION DATA: UPSTREAM(FEET) =  1301.00  DOWNSTREAM(FEET) =  1300.00
  FLOW LENGTH(FEET) =    59.00   MANNING'S N =  0.013
  DEPTH OF FLOW IN  24.0 INCH PIPE IS   6.8 INCHES
  PIPE-FLOW VELOCITY(FEET/SEC.) =   6.70
  GIVEN PIPE DIAMETER(INCH) =  24.00    NUMBER OF PIPES =   1
  PIPE-FLOW(CFS) =       4.94
  PIPE TRAVEL TIME(MIN.) =   0.15    Tc(MIN.) =   15.30
  LONGEST FLOWPATH FROM NODE  60200.00 TO NODE  60215.00 =     981.00 FEET.

****************************************************************************
  FLOW PROCESS FROM NODE  60215.00 TO NODE  60220.00 IS CODE =  51
----------------------------------------------------------------------------
  >>>>>COMPUTE TRAPEZOIDAL CHANNEL FLOW<<<<<
  >>>>>TRAVELTIME THRU SUBAREA (EXISTING ELEMENT)<<<<<
============================================================================
  ELEVATION DATA: UPSTREAM(FEET) =   1301.00  DOWNSTREAM(FEET) =   1297.00
  CHANNEL LENGTH THRU SUBAREA(FEET) =   322.00   CHANNEL SLOPE =  0.0124
  CHANNEL BASE(FEET) =    5.00   "Z" FACTOR =   4.000
  MANNING'S FACTOR = 0.030   MAXIMUM DEPTH(FEET) =   1.00
  * 100 YEAR RAINFALL INTENSITY(INCH/HR) =  2.617
  SUBAREA LOSS RATE DATA(AMC III):
   DEVELOPMENT TYPE/      SCS SOIL   AREA      Fp         Ap     SCS
      LAND USE             GROUP   (ACRES)  (INCH/HR)  (DECIMAL)  CN
  PUBLIC PARK                B        0.60      0.42     0.850    76
  SUBAREA AVERAGE PERVIOUS LOSS RATE, Fp(INCH/HR) =  0.42
  SUBAREA AVERAGE PERVIOUS AREA FRACTION, Ap =  0.850
  TRAVEL TIME COMPUTED USING ESTIMATED FLOW(CFS) =       5.55
  TRAVEL TIME THRU SUBAREA BASED ON VELOCITY(FEET/SEC.) =   2.43
  AVERAGE FLOW DEPTH(FEET) =   0.36   TRAVEL TIME(MIN.) =   2.21
  Tc(MIN.) =   17.51
  SUBAREA AREA(ACRES) =     0.60       SUBAREA RUNOFF(CFS) =    1.22
  EFFECTIVE AREA(ACRES) =      2.80     AREA-AVERAGED Fm(INCH/HR) =   0.36
  AREA-AVERAGED Fp(INCH/HR) =   0.42  AREA-AVERAGED Ap =   0.85
  TOTAL AREA(ACRES) =        2.8         PEAK FLOW RATE(CFS) =       5.69

  END OF SUBAREA CHANNEL FLOW HYDRAULICS:
```

```
  DEPTH(FEET) =  0.36   FLOW VELOCITY(FEET/SEC.) =   2.43
  LONGEST FLOWPATH FROM NODE  60200.00 TO NODE  60220.00 =    1303.00 FEET.

****************************************************************************
  FLOW PROCESS FROM NODE  60020.00 TO NODE  60045.00 IS CODE =  41
----------------------------------------------------------------------------
  >>>>>COMPUTE PIPE-FLOW TRAVEL TIME THRU SUBAREA<<<<<
  >>>>>USING USER-SPECIFIED PIPESIZE (EXISTING ELEMENT)<<<<<
============================================================================
  ELEVATION DATA: UPSTREAM(FEET) =  1297.00  DOWNSTREAM(FEET) =  1293.00
  FLOW LENGTH(FEET) =    41.00   MANNING'S N =  0.013
  DEPTH OF FLOW IN  36.0 INCH PIPE IS   4.2 INCHES
  PIPE-FLOW VELOCITY(FEET/SEC.) =  12.36
  GIVEN PIPE DIAMETER(INCH) =  36.00    NUMBER OF PIPES =   1
  PIPE-FLOW(CFS) =       5.69
  PIPE TRAVEL TIME(MIN.) =   0.06    Tc(MIN.) =   17.56
  LONGEST FLOWPATH FROM NODE  60200.00 TO NODE  60045.00 =    1344.00 FEET.

****************************************************************************
  FLOW PROCESS FROM NODE  60045.00 TO NODE  60045.00 IS CODE =   1
----------------------------------------------------------------------------
  >>>>>DESIGNATE INDEPENDENT STREAM FOR CONFLUENCE<<<<<
  >>>>>AND COMPUTE VARIOUS CONFLUENCED STREAM VALUES<<<<<
============================================================================
  TOTAL NUMBER OF STREAMS =  2
  CONFLUENCE VALUES USED FOR INDEPENDENT STREAM  2 ARE:
  TIME OF CONCENTRATION(MIN.) =   17.56
  RAINFALL INTENSITY(INCH/HR) =   2.61
  AREA-AVERAGED Fm(INCH/HR) =  0.36
  AREA-AVERAGED Fp(INCH/HR) =  0.42
  AREA-AVERAGED Ap =  0.85
  EFFECTIVE STREAM AREA(ACRES) =       2.80
  TOTAL STREAM AREA(ACRES) =       2.80
  PEAK FLOW RATE(CFS) AT CONFLUENCE =       5.69

  ** CONFLUENCE DATA **
   STREAM       Q      Tc   Intensity   Fp(Fm)     Ap     Ae     HEADWATER
   NUMBER     (CFS)  (MIN.) (INCH/HR) (INCH/HR)         (ACRES)    NODE
      1       65.62   11.57    3.356  0.42( 0.19) 0.44      22.8   60000.00
      1       69.42   15.90    2.773  0.42( 0.18) 0.43      29.6   60100.00
      1       68.31   17.33    2.633  0.42( 0.18) 0.42      30.7   60015.00
      2        5.69   17.56    2.612  0.42( 0.36) 0.85       2.8   60200.00

  RAINFALL INTENSITY AND TIME OF CONCENTRATION RATIO
  CONFLUENCE FORMULA USED FOR  2 STREAMS.

  ** PEAK FLOW RATE TABLE **
   STREAM       Q      Tc   Intensity   Fp(Fm)     Ap     Ae     HEADWATER
   NUMBER     (CFS)  (MIN.) (INCH/HR) (INCH/HR)         (ACRES)    NODE
      1       70.61   11.57    3.356  0.42( 0.20) 0.47      24.6   60000.00
      2       74.94   15.90    2.773  0.42( 0.20) 0.46      32.1   60100.00
      3       73.97   17.33    2.633  0.42( 0.19) 0.45      33.5   60015.00
      4       73.42   17.56    2.612  0.42( 0.19) 0.45      33.5   60200.00

  COMPUTED CONFLUENCE ESTIMATES ARE AS FOLLOWS:
  PEAK FLOW RATE(CFS) =      74.94    Tc(MIN.) =    15.90
  EFFECTIVE AREA(ACRES) =      32.10   AREA-AVERAGED Fm(INCH/HR) =  0.20
  AREA-AVERAGED Fp(INCH/HR) =  0.42  AREA-AVERAGED Ap =  0.46
  TOTAL AREA(ACRES) =       33.5
  LONGEST FLOWPATH FROM NODE  60015.00 TO NODE  60045.00 =    2393.80 FEET.

****************************************************************************
  FLOW PROCESS FROM NODE  60045.00 TO NODE  60050.00 IS CODE =  51
----------------------------------------------------------------------------
  >>>>>COMPUTE TRAPEZOIDAL CHANNEL FLOW<<<<<
  >>>>>TRAVELTIME THRU SUBAREA (EXISTING ELEMENT)<<<<<
============================================================================
  ELEVATION DATA: UPSTREAM(FEET) =   1293.00  DOWNSTREAM(FEET) =   1287.00
  CHANNEL LENGTH THRU SUBAREA(FEET) =   625.30   CHANNEL SLOPE =  0.0096
  CHANNEL BASE(FEET) =    5.00   "Z" FACTOR =   4.000
  MANNING'S FACTOR = 0.030   MAXIMUM DEPTH(FEET) =   4.00
```

```
 * 100 YEAR RAINFALL INTENSITY(INCH/HR) =  2.568
 SUBAREA LOSS RATE DATA(AMC III):
  DEVELOPMENT TYPE/      SCS SOIL   AREA      Fp         Ap     SCS
      LAND USE            GROUP   (ACRES)  (INCH/HR)  (DECIMAL)  CN
 PUBLIC PARK                B       9.80      0.42     0.850    76
 SUBAREA AVERAGE PERVIOUS LOSS RATE, Fp(INCH/HR) =  0.42
 SUBAREA AVERAGE PERVIOUS AREA FRACTION, Ap =  0.850
 TRAVEL TIME COMPUTED USING ESTIMATED FLOW(CFS) =      84.69
 TRAVEL TIME THRU SUBAREA BASED ON VELOCITY(FEET/SEC.) =   4.80
 AVERAGE FLOW DEPTH(FEET) =   1.57   TRAVEL TIME(MIN.) =   2.17
 Tc(MIN.) =   18.07
 SUBAREA AREA(ACRES) =     9.80       SUBAREA RUNOFF(CFS) =   19.48
 EFFECTIVE AREA(ACRES) =     41.90     AREA-AVERAGED Fm(INCH/HR) =   0.23
 AREA-AVERAGED Fp(INCH/HR) =   0.42  AREA-AVERAGED Ap =   0.55
 TOTAL AREA(ACRES) =       43.3         PEAK FLOW RATE(CFS) =      88.00

 END OF SUBAREA CHANNEL FLOW HYDRAULICS:
 DEPTH(FEET) =  1.59   FLOW VELOCITY(FEET/SEC.) =   4.86
 LONGEST FLOWPATH FROM NODE  60015.00 TO NODE  60050.00 =    3019.10 FEET.

****************************************************************************
 FLOW PROCESS FROM NODE  60050.00 TO NODE  60055.00 IS CODE =  51
----------------------------------------------------------------------------
 >>>>>COMPUTE TRAPEZOIDAL CHANNEL FLOW<<<<<
 >>>>>TRAVELTIME THRU SUBAREA (EXISTING ELEMENT)<<<<<
============================================================================
 ELEVATION DATA: UPSTREAM(FEET) =   1287.00  DOWNSTREAM(FEET) =   1283.00
 CHANNEL LENGTH THRU SUBAREA(FEET) =    96.50   CHANNEL SLOPE =  0.0415
 CHANNEL BASE(FEET) =    5.00   "Z" FACTOR =   4.000
 MANNING'S FACTOR = 0.030   MAXIMUM DEPTH(FEET) =   4.00
 * 100 YEAR RAINFALL INTENSITY(INCH/HR) =  2.552
 SUBAREA LOSS RATE DATA(AMC III):
  DEVELOPMENT TYPE/      SCS SOIL   AREA      Fp         Ap     SCS
      LAND USE            GROUP   (ACRES)  (INCH/HR)  (DECIMAL)  CN
 PUBLIC PARK                B       1.80      0.42     0.850    76
 SUBAREA AVERAGE PERVIOUS LOSS RATE, Fp(INCH/HR) =  0.42
 SUBAREA AVERAGE PERVIOUS AREA FRACTION, Ap =  0.850
 TRAVEL TIME COMPUTED USING ESTIMATED FLOW(CFS) =      89.77
 TRAVEL TIME THRU SUBAREA BASED ON VELOCITY(FEET/SEC.) =   8.32
 AVERAGE FLOW DEPTH(FEET) =   1.13   TRAVEL TIME(MIN.) =   0.19
 Tc(MIN.) =   18.26
 SUBAREA AREA(ACRES) =     1.80       SUBAREA RUNOFF(CFS) =    3.55
 EFFECTIVE AREA(ACRES) =     43.70     AREA-AVERAGED Fm(INCH/HR) =   0.24
 AREA-AVERAGED Fp(INCH/HR) =   0.42  AREA-AVERAGED Ap =   0.57
 TOTAL AREA(ACRES) =       45.1         PEAK FLOW RATE(CFS) =      90.93

 END OF SUBAREA CHANNEL FLOW HYDRAULICS:
 DEPTH(FEET) =  1.14   FLOW VELOCITY(FEET/SEC.) =   8.35
 LONGEST FLOWPATH FROM NODE  60015.00 TO NODE  60055.00 =    3115.60 FEET.

****************************************************************************
 FLOW PROCESS FROM NODE  60055.00 TO NODE  60055.00 IS CODE =  81
----------------------------------------------------------------------------
 >>>>>ADDITION OF SUBAREA TO MAINLINE PEAK FLOW<<<<<
============================================================================
 MAINLINE Tc(MIN.) =   18.26
 * 100 YEAR RAINFALL INTENSITY(INCH/HR) =  2.552
 SUBAREA LOSS RATE DATA(AMC III):
  DEVELOPMENT TYPE/      SCS SOIL   AREA      Fp         Ap     SCS
      LAND USE            GROUP   (ACRES)  (INCH/HR)  (DECIMAL)  CN
 COMMERCIAL                 B       1.10      0.42     0.100    76
 PUBLIC PARK                B       1.30      0.42     0.850    76
 SUBAREA AVERAGE PERVIOUS LOSS RATE, Fp(INCH/HR) =  0.42
 SUBAREA AVERAGE PERVIOUS AREA FRACTION, Ap =  0.506
 SUBAREA AREA(ACRES) =    2.40      SUBAREA RUNOFF(CFS) =    5.05
 EFFECTIVE AREA(ACRES) =     46.10   AREA-AVERAGED Fm(INCH/HR) =  0.24
 AREA-AVERAGED Fp(INCH/HR) =  0.42  AREA-AVERAGED Ap =  0.56
 TOTAL AREA(ACRES) =       47.5       PEAK FLOW RATE(CFS) =      95.98

****************************************************************************
 FLOW PROCESS FROM NODE  60055.00 TO NODE  60060.00 IS CODE =  61
```

```
----------------------------------------------------------------------------
  >>>>>COMPUTE STREET FLOW TRAVEL TIME THRU SUBAREA<<<<<
  >>>>>(STANDARD CURB SECTION USED)<<<<<
============================================================================
  UPSTREAM ELEVATION(FEET) = 1283.00  DOWNSTREAM ELEVATION(FEET) = 1247.00
  STREET LENGTH(FEET) =  2626.47   CURB HEIGHT(INCHES) =  6.0
  STREET HALFWIDTH(FEET) = 30.00

  DISTANCE FROM CROWN TO CROSSFALL GRADEBREAK(FEET) =   2.00
  INSIDE STREET CROSSFALL(DECIMAL) =  0.100
  OUTSIDE STREET CROSSFALL(DECIMAL)  =  0.100

  SPECIFIED NUMBER OF HALFSTREETS CARRYING RUNOFF =  1
  STREET PARKWAY CROSSFALL(DECIMAL)  =  0.005
  Manning's FRICTION FACTOR for Streetflow Section(curb-to-curb) =   0.0130
  Manning's FRICTION FACTOR for Back-of-Walk Flow Section =   0.0200

    **TRAVEL TIME COMPUTED USING ESTIMATED FLOW(CFS) =      98.36
    STREETFLOW MODEL RESULTS USING ESTIMATED FLOW:
    STREET FLOW DEPTH(FEET) =  0.95
    HALFSTREET FLOOD WIDTH(FEET) =   98.64
    AVERAGE FLOW VELOCITY(FEET/SEC.) =    4.04
    PRODUCT OF DEPTH&VELOCITY(FT*FT/SEC.) =    3.82
  STREET FLOW TRAVEL TIME(MIN.) =  10.84   Tc(MIN.) =   29.10
  * 100 YEAR RAINFALL INTENSITY(INCH/HR) =  1.929
  SUBAREA LOSS RATE DATA(AMC III):
   DEVELOPMENT TYPE/      SCS SOIL   AREA      Fp         Ap     SCS
       LAND USE             GROUP   (ACRES)  (INCH/HR)  (DECIMAL)  CN
  COMMERCIAL                  B        2.80      0.42     0.100    76
  SUBAREA AVERAGE PERVIOUS LOSS RATE, Fp(INCH/HR) =  0.42
  SUBAREA AVERAGE PERVIOUS AREA FRACTION, Ap =  0.100
  SUBAREA AREA(ACRES) =    2.80      SUBAREA RUNOFF(CFS) =    4.76
  EFFECTIVE AREA(ACRES) =     48.90    AREA-AVERAGED Fm(INCH/HR) =  0.23
  AREA-AVERAGED Fp(INCH/HR) =  0.42  AREA-AVERAGED Ap =  0.54
  TOTAL AREA(ACRES) =       50.3        PEAK FLOW RATE(CFS) =      95.98
  NOTE: PEAK FLOW RATE DEFAULTED TO UPSTREAM VALUE

  END OF SUBAREA STREET FLOW HYDRAULICS:
  DEPTH(FEET) = 0.94   HALFSTREET FLOOD WIDTH(FEET) =  97.55
  FLOW VELOCITY(FEET/SEC.) =  4.02   DEPTH*VELOCITY(FT*FT/SEC.) =   3.79
  *NOTE: INITIAL SUBAREA NOMOGRAPH WITH SUBAREA PARAMETERS,
         AND L = 2626.5 FT WITH ELEVATION-DROP =  36.0 FT, IS    6.7 CFS,
         WHICH EXCEEDS THE TOP-OF-CURB STREET CAPACITY AT NODE  60060.00
  LONGEST FLOWPATH FROM NODE  60015.00 TO NODE  60060.00 =    5742.07 FEET.

****************************************************************************
  FLOW PROCESS FROM NODE  60060.00 TO NODE  60060.00 IS CODE =  81
----------------------------------------------------------------------------
  >>>>>ADDITION OF SUBAREA TO MAINLINE PEAK FLOW<<<<<
============================================================================
  MAINLINE Tc(MIN.) =   29.10
  * 100 YEAR RAINFALL INTENSITY(INCH/HR) =  1.929
  SUBAREA LOSS RATE DATA(AMC III):
   DEVELOPMENT TYPE/      SCS SOIL   AREA      Fp         Ap     SCS
       LAND USE             GROUP   (ACRES)  (INCH/HR)  (DECIMAL)  CN
  PUBLIC PARK                 B        2.50      0.42     0.850    76
  PUBLIC PARK                 B        0.60      0.42     0.850    76
  PUBLIC PARK                 B        0.40      0.42     0.850    76
  COMMERCIAL                  B       16.40      0.42     0.100    76
  SUBAREA AVERAGE PERVIOUS LOSS RATE, Fp(INCH/HR) =  0.42
  SUBAREA AVERAGE PERVIOUS AREA FRACTION, Ap =  0.232
  SUBAREA AREA(ACRES) =   19.90      SUBAREA RUNOFF(CFS) =   32.80
  EFFECTIVE AREA(ACRES) =     68.80   AREA-AVERAGED Fm(INCH/HR) =  0.19
  AREA-AVERAGED Fp(INCH/HR) =  0.42  AREA-AVERAGED Ap =  0.45
  TOTAL AREA(ACRES) =       70.2       PEAK FLOW RATE(CFS) =     107.72

****************************************************************************
  FLOW PROCESS FROM NODE  60060.00 TO NODE  60060.00 IS CODE =   1
----------------------------------------------------------------------------
  >>>>>DESIGNATE INDEPENDENT STREAM FOR CONFLUENCE<<<<<
============================================================================
```

```
  TOTAL NUMBER OF STREAMS =  2
  CONFLUENCE VALUES USED FOR INDEPENDENT STREAM  1 ARE:
  TIME OF CONCENTRATION(MIN.) =   29.10
  RAINFALL INTENSITY(INCH/HR) =   1.93
  AREA-AVERAGED Fm(INCH/HR) =  0.19
  AREA-AVERAGED Fp(INCH/HR) =  0.42
  AREA-AVERAGED Ap =  0.45
  EFFECTIVE STREAM AREA(ACRES) =      68.80
  TOTAL STREAM AREA(ACRES) =      70.20
  PEAK FLOW RATE(CFS) AT CONFLUENCE =     107.72

****************************************************************************
  FLOW PROCESS FROM NODE  60300.00 TO NODE  60305.00 IS CODE =  21
----------------------------------------------------------------------------
  >>>>>RATIONAL METHOD INITIAL SUBAREA ANALYSIS<<<<<
  >>USE TIME-OF-CONCENTRATION NOMOGRAPH FOR INITIAL SUBAREA<<
============================================================================
  INITIAL SUBAREA FLOW-LENGTH(FEET) =  1346.00
  ELEVATION DATA: UPSTREAM(FEET) =   1266.00  DOWNSTREAM(FEET) =   1248.00

  Tc = K*[(LENGTH** 3.00)/(ELEVATION CHANGE)]**0.20
  SUBAREA ANALYSIS USED MINIMUM Tc(MIN.) =   20.432
  * 100 YEAR RAINFALL INTENSITY(INCH/HR) =  2.386
  SUBAREA Tc AND LOSS RATE DATA(AMC III):
   DEVELOPMENT TYPE/      SCS SOIL   AREA      Fp         Ap     SCS   Tc
       LAND USE            GROUP   (ACRES)  (INCH/HR)  (DECIMAL)  CN  (MIN.)
  PUBLIC PARK                B        1.50      0.42     0.850    76   20.43
  SUBAREA AVERAGE PERVIOUS LOSS RATE, Fp(INCH/HR) =  0.42
  SUBAREA AVERAGE PERVIOUS AREA FRACTION, Ap =  0.850
  SUBAREA RUNOFF(CFS) =      2.74
  TOTAL AREA(ACRES) =      1.50   PEAK FLOW RATE(CFS) =      2.74

****************************************************************************
  FLOW PROCESS FROM NODE  60305.00 TO NODE  60305.00 IS CODE =  81
----------------------------------------------------------------------------
  >>>>>ADDITION OF SUBAREA TO MAINLINE PEAK FLOW<<<<<
============================================================================
  MAINLINE Tc(MIN.) =   20.43
  * 100 YEAR RAINFALL INTENSITY(INCH/HR) =  2.386
  SUBAREA LOSS RATE DATA(AMC III):
   DEVELOPMENT TYPE/      SCS SOIL   AREA      Fp         Ap     SCS
       LAND USE            GROUP   (ACRES)  (INCH/HR)  (DECIMAL)  CN
  COMMERCIAL                 B       11.60      0.42     0.100    76
  SUBAREA AVERAGE PERVIOUS LOSS RATE, Fp(INCH/HR) =  0.42
  SUBAREA AVERAGE PERVIOUS AREA FRACTION, Ap =  0.100
  SUBAREA AREA(ACRES) =   11.60      SUBAREA RUNOFF(CFS) =   24.46
  EFFECTIVE AREA(ACRES) =     13.10   AREA-AVERAGED Fm(INCH/HR) =  0.08
  AREA-AVERAGED Fp(INCH/HR) =  0.42  AREA-AVERAGED Ap =  0.19
  TOTAL AREA(ACRES) =       13.1       PEAK FLOW RATE(CFS) =      27.20

****************************************************************************
  FLOW PROCESS FROM NODE  60305.00 TO NODE  60310.00 IS CODE =  41
----------------------------------------------------------------------------
  >>>>>COMPUTE PIPE-FLOW TRAVEL TIME THRU SUBAREA<<<<<
  >>>>>USING USER-SPECIFIED PIPESIZE (EXISTING ELEMENT)<<<<<
============================================================================
  ELEVATION DATA: UPSTREAM(FEET) =  1248.00  DOWNSTREAM(FEET) =  1247.00
  FLOW LENGTH(FEET) =    20.00   MANNING'S N =  0.013
  ASSUME FULL-FLOWING PIPELINE
  PIPE-FLOW VELOCITY(FEET/SEC.) =  15.39
  PIPE FLOW VELOCITY = (TOTAL FLOW)/(PIPE CROSS SECTION AREA)
  GIVEN PIPE DIAMETER(INCH) =  18.00    NUMBER OF PIPES =   1
  PIPE-FLOW(CFS) =      27.20
  PIPE TRAVEL TIME(MIN.) =   0.02    Tc(MIN.) =   20.45
  LONGEST FLOWPATH FROM NODE  60300.00 TO NODE  60310.00 =    1366.00 FEET.

****************************************************************************
  FLOW PROCESS FROM NODE  60310.00 TO NODE  60060.00 IS CODE =  51
----------------------------------------------------------------------------
  >>>>>COMPUTE TRAPEZOIDAL CHANNEL FLOW<<<<<
  >>>>>TRAVELTIME THRU SUBAREA (EXISTING ELEMENT)<<<<<
```

```
============================================================================
  ELEVATION DATA: UPSTREAM(FEET) =   1247.00  DOWNSTREAM(FEET) =   1245.00
  CHANNEL LENGTH THRU SUBAREA(FEET) =   116.40   CHANNEL SLOPE =  0.0172
  CHANNEL BASE(FEET) =    5.00   "Z" FACTOR =   4.000
  MANNING'S FACTOR = 0.030   MAXIMUM DEPTH(FEET) =   1.00
  * 100 YEAR RAINFALL INTENSITY(INCH/HR) =  2.354
  SUBAREA LOSS RATE DATA(AMC III):
   DEVELOPMENT TYPE/      SCS SOIL   AREA      Fp         Ap     SCS
       LAND USE            GROUP   (ACRES)  (INCH/HR)  (DECIMAL)  CN
  PUBLIC PARK                B        0.10      0.42     0.850    76
  SUBAREA AVERAGE PERVIOUS LOSS RATE, Fp(INCH/HR) =  0.42
  SUBAREA AVERAGE PERVIOUS AREA FRACTION, Ap =  0.850
  TRAVEL TIME COMPUTED USING ESTIMATED FLOW(CFS) =      27.29
  TRAVEL TIME THRU SUBAREA BASED ON VELOCITY(FEET/SEC.) =   4.36
  AVERAGE FLOW DEPTH(FEET) =   0.77   TRAVEL TIME(MIN.) =   0.45
  Tc(MIN.) =   20.90
  SUBAREA AREA(ACRES) =     0.10       SUBAREA RUNOFF(CFS) =    0.18
  EFFECTIVE AREA(ACRES) =     13.20     AREA-AVERAGED Fm(INCH/HR) =   0.08
  AREA-AVERAGED Fp(INCH/HR) =   0.42  AREA-AVERAGED Ap =   0.19
  TOTAL AREA(ACRES) =       13.2         PEAK FLOW RATE(CFS) =      27.20
  NOTE: PEAK FLOW RATE DEFAULTED TO UPSTREAM VALUE

  END OF SUBAREA CHANNEL FLOW HYDRAULICS:
  DEPTH(FEET) =  0.77   FLOW VELOCITY(FEET/SEC.) =   4.35
  LONGEST FLOWPATH FROM NODE  60300.00 TO NODE  60060.00 =    1482.40 FEET.

****************************************************************************
  FLOW PROCESS FROM NODE  60060.00 TO NODE  60060.00 IS CODE =   1
----------------------------------------------------------------------------
  >>>>>DESIGNATE INDEPENDENT STREAM FOR CONFLUENCE<<<<<
  >>>>>AND COMPUTE VARIOUS CONFLUENCED STREAM VALUES<<<<<
============================================================================
  TOTAL NUMBER OF STREAMS =  2
  CONFLUENCE VALUES USED FOR INDEPENDENT STREAM  2 ARE:
  TIME OF CONCENTRATION(MIN.) =   20.90
  RAINFALL INTENSITY(INCH/HR) =   2.35
  AREA-AVERAGED Fm(INCH/HR) =  0.08
  AREA-AVERAGED Fp(INCH/HR) =  0.42
  AREA-AVERAGED Ap =  0.19
  EFFECTIVE STREAM AREA(ACRES) =      13.20
  TOTAL STREAM AREA(ACRES) =      13.20
  PEAK FLOW RATE(CFS) AT CONFLUENCE =      27.20

  ** CONFLUENCE DATA **
   STREAM       Q      Tc   Intensity   Fp(Fm)     Ap     Ae     HEADWATER
   NUMBER     (CFS)  (MIN.) (INCH/HR) (INCH/HR)         (ACRES)    NODE
      1      106.68   24.80    2.124  0.42( 0.19) 0.45      61.3   60000.00
      1      107.72   29.10    1.929  0.42( 0.19) 0.45      68.8   60100.00
      1      106.39   30.59    1.873  0.42( 0.19) 0.44      70.2   60015.00
      1      105.87   30.84    1.864  0.42( 0.19) 0.44      70.2   60200.00
      2       27.20   20.90    2.354  0.42( 0.08) 0.19      13.2   60300.00

  RAINFALL INTENSITY AND TIME OF CONCENTRATION RATIO
  CONFLUENCE FORMULA USED FOR  2 STREAMS.

  ** PEAK FLOW RATE TABLE **
   STREAM       Q      Tc   Intensity   Fp(Fm)     Ap     Ae     HEADWATER
   NUMBER     (CFS)  (MIN.) (INCH/HR) (INCH/HR)         (ACRES)    NODE
      1      127.78   20.90    2.354  0.42( 0.17) 0.40      64.9   60300.00
      2      131.13   24.80    2.124  0.42( 0.17) 0.40      74.5   60000.00
      3      129.84   29.10    1.929  0.42( 0.17) 0.41      82.0   60100.00
      4      127.84   30.59    1.873  0.42( 0.17) 0.40      83.4   60015.00
      5      127.21   30.84    1.864  0.42( 0.17) 0.40      83.4   60200.00

  COMPUTED CONFLUENCE ESTIMATES ARE AS FOLLOWS:
  PEAK FLOW RATE(CFS) =     131.13    Tc(MIN.) =    24.80
  EFFECTIVE AREA(ACRES) =      74.52   AREA-AVERAGED Fm(INCH/HR) =  0.17
  AREA-AVERAGED Fp(INCH/HR) =  0.42  AREA-AVERAGED Ap =  0.40
  TOTAL AREA(ACRES) =       83.4
  LONGEST FLOWPATH FROM NODE  60015.00 TO NODE  60060.00 =    5742.07 FEET.
```

```
****************************************************************************
  FLOW PROCESS FROM NODE  60060.00 TO NODE  60065.00 IS CODE =  41
----------------------------------------------------------------------------
  >>>>>COMPUTE PIPE-FLOW TRAVEL TIME THRU SUBAREA<<<<<
  >>>>>USING USER-SPECIFIED PIPESIZE (EXISTING ELEMENT)<<<<<
============================================================================
  ELEVATION DATA: UPSTREAM(FEET) =  1245.00  DOWNSTREAM(FEET) =  1244.00
  FLOW LENGTH(FEET) =   124.00   MANNING'S N =  0.013
  ASSUME FULL-FLOWING PIPELINE
  PIPE-FLOW VELOCITY(FEET/SEC.) =  93.92
  PIPE FLOW VELOCITY = (TOTAL FLOW)/(PIPE CROSS SECTION AREA)
  GIVEN PIPE DIAMETER(INCH) =  16.00    NUMBER OF PIPES =   1
  PIPE-FLOW(CFS) =     131.13
  PIPE TRAVEL TIME(MIN.) =   0.02    Tc(MIN.) =   24.82
  LONGEST FLOWPATH FROM NODE  60015.00 TO NODE  60065.00 =    5866.07 FEET.

****************************************************************************
  FLOW PROCESS FROM NODE  60065.00 TO NODE  60065.00 IS CODE =   1
----------------------------------------------------------------------------
  >>>>>DESIGNATE INDEPENDENT STREAM FOR CONFLUENCE<<<<<
============================================================================
  TOTAL NUMBER OF STREAMS =  2
  CONFLUENCE VALUES USED FOR INDEPENDENT STREAM  1 ARE:
  TIME OF CONCENTRATION(MIN.) =   24.82
  RAINFALL INTENSITY(INCH/HR) =   2.12
  AREA-AVERAGED Fm(INCH/HR) =  0.17
  AREA-AVERAGED Fp(INCH/HR) =  0.42
  AREA-AVERAGED Ap =  0.40
  EFFECTIVE STREAM AREA(ACRES) =      74.52
  TOTAL STREAM AREA(ACRES) =      83.40
  PEAK FLOW RATE(CFS) AT CONFLUENCE =     131.13

****************************************************************************
  FLOW PROCESS FROM NODE  60400.00 TO NODE  60405.00 IS CODE =  21
----------------------------------------------------------------------------
  >>>>>RATIONAL METHOD INITIAL SUBAREA ANALYSIS<<<<<
  >>USE TIME-OF-CONCENTRATION NOMOGRAPH FOR INITIAL SUBAREA<<
============================================================================
  INITIAL SUBAREA FLOW-LENGTH(FEET) =   652.70
  ELEVATION DATA: UPSTREAM(FEET) =   1300.00  DOWNSTREAM(FEET) =   1288.00

  Tc = K*[(LENGTH** 3.00)/(ELEVATION CHANGE)]**0.20
  SUBAREA ANALYSIS USED MINIMUM Tc(MIN.) =    9.034
  * 100 YEAR RAINFALL INTENSITY(INCH/HR) =  3.893
  SUBAREA Tc AND LOSS RATE DATA(AMC III):
   DEVELOPMENT TYPE/      SCS SOIL   AREA      Fp         Ap     SCS   Tc
       LAND USE            GROUP   (ACRES)  (INCH/HR)  (DECIMAL)  CN  (MIN.)
  COMMERCIAL                 B       0.70      0.42     0.100    76    9.03
  SUBAREA AVERAGE PERVIOUS LOSS RATE, Fp(INCH/HR) =  0.42
  SUBAREA AVERAGE PERVIOUS AREA FRACTION, Ap =  0.100
  SUBAREA RUNOFF(CFS) =      2.43
  TOTAL AREA(ACRES) =      0.70   PEAK FLOW RATE(CFS) =      2.43

****************************************************************************
  FLOW PROCESS FROM NODE  60405.00 TO NODE  60410.00 IS CODE =  51
----------------------------------------------------------------------------
  >>>>>COMPUTE TRAPEZOIDAL CHANNEL FLOW<<<<<
  >>>>>TRAVELTIME THRU SUBAREA (EXISTING ELEMENT)<<<<<
============================================================================
  ELEVATION DATA: UPSTREAM(FEET) =   1288.00  DOWNSTREAM(FEET) =   1245.00
  CHANNEL LENGTH THRU SUBAREA(FEET) =  2654.10   CHANNEL SLOPE =  0.0162
  CHANNEL BASE(FEET) =    5.00   "Z" FACTOR =   4.000
  MANNING'S FACTOR = 0.017   MAXIMUM DEPTH(FEET) =   1.00
  * 100 YEAR RAINFALL INTENSITY(INCH/HR) =  2.686
  SUBAREA LOSS RATE DATA(AMC III):
   DEVELOPMENT TYPE/      SCS SOIL   AREA      Fp         Ap     SCS
       LAND USE            GROUP   (ACRES)  (INCH/HR)  (DECIMAL)  CN
  COMMERCIAL                 B      13.20      0.42     0.100    76
  SUBAREA AVERAGE PERVIOUS LOSS RATE, Fp(INCH/HR) =  0.42
  SUBAREA AVERAGE PERVIOUS AREA FRACTION, Ap =  0.100
  TRAVEL TIME COMPUTED USING ESTIMATED FLOW(CFS) =      18.51
```

TRAVEL TIME THRU SUBAREA BASED ON VELOCITY(FEET/SEC.) = 5.72
AVERAGE FLOW DEPTH(FEET) = 0.47 TRAVEL TIME(MIN.) = 7.73
Tc(MIN.) = 16.76
SUBAREA AREA(ACRES) = 13.20 SUBAREA RUNOFF(CFS) = 31.41
EFFECTIVE AREA(ACRES) = 13.90 AREA-AVERAGED Fm(INCH/HR) = 0.04
AREA-AVERAGED Fp(INCH/HR) = 0.42 AREA-AVERAGED Ap = 0.10
TOTAL AREA(ACRES) = 13.9 PEAK FLOW RATE(CFS) = 33.08

END OF SUBAREA CHANNEL FLOW HYDRAULICS:
DEPTH(FEET) = 0.65 FLOW VELOCITY(FEET/SEC.) = 6.76
LONGEST FLOWPATH FROM NODE 60400.00 TO NODE 60410.00 = 3306.80 FEET.

****************************************************************************
FLOW PROCESS FROM NODE 60410.00 TO NODE 60065.00 IS CODE = 46
----------------------------------------------------------------------------
>>>>>COMPUTE BOX-FLOW TRAVEL TIME THRU SUBAREA<<<<<
>>>>>USING USER-SPECIFIED BOX SIZE (EXISTING ELEMENT)<<<<<
============================================================================
ELEVATION DATA: UPSTREAM(FEET) = 1245.00 DOWNSTREAM(FEET) = 1244.00
FLOW LENGTH(FEET) = 68.00 MANNING'S N = 0.030
GIVEN BOX BASEWIDTH(FEET) = 24.00 GIVEN BOX HEIGHT(FEET) = 18.00
FLOWDEPTH IN BOX IS 0.42 FEET BOX-FLOW VELOCITY(FEET/SEC.) = 3.31
BOX-FLOW(CFS) = 33.08
BOX-FLOW TRAVEL TIME(MIN.) = 0.34 Tc(MIN.) = 17.11
LONGEST FLOWPATH FROM NODE 60400.00 TO NODE 60065.00 = 3374.80 FEET.

****************************************************************************
FLOW PROCESS FROM NODE 60065.00 TO NODE 60065.00 IS CODE = 1
----------------------------------------------------------------------------
>>>>>DESIGNATE INDEPENDENT STREAM FOR CONFLUENCE<<<<<
>>>>>AND COMPUTE VARIOUS CONFLUENCED STREAM VALUES<<<<<
============================================================================
TOTAL NUMBER OF STREAMS = 2
CONFLUENCE VALUES USED FOR INDEPENDENT STREAM 2 ARE:
TIME OF CONCENTRATION(MIN.) = 17.11
RAINFALL INTENSITY(INCH/HR) = 2.65
AREA-AVERAGED Fm(INCH/HR) = 0.04
AREA-AVERAGED Fp(INCH/HR) = 0.42
AREA-AVERAGED Ap = 0.10
EFFECTIVE STREAM AREA(ACRES) = 13.90
TOTAL STREAM AREA(ACRES) = 13.90
PEAK FLOW RATE(CFS) AT CONFLUENCE = 33.08

** CONFLUENCE DATA **

| STREAM NUMBER | Q (CFS) | Tc (MIN.) | Intensity (INCH/HR) | Fp(Fm) (INCH/HR) | Ap | Ae (ACRES) | HEADWATER NODE |
|---|---|---|---|---|---|---|---|
| 1 | 127.78 | 20.92 | 2.352 | 0.42( 0.17) | 0.40 | 64.9 | 60300.00 |
| 1 | 131.13 | 24.82 | 2.123 | 0.42( 0.17) | 0.40 | 74.5 | 60000.00 |
| 1 | 129.84 | 29.13 | 1.929 | 0.42( 0.17) | 0.41 | 82.0 | 60100.00 |
| 1 | 127.84 | 30.61 | 1.872 | 0.42( 0.17) | 0.40 | 83.4 | 60015.00 |
| 1 | 127.21 | 30.86 | 1.863 | 0.42( 0.17) | 0.40 | 83.4 | 60200.00 |
| 2 | 33.08 | 17.11 | 2.654 | 0.42( 0.04) | 0.10 | 13.9 | 60400.00 |

RAINFALL INTENSITY AND TIME OF CONCENTRATION RATIO
CONFLUENCE FORMULA USED FOR 2 STREAMS.

** PEAK FLOW RATE TABLE **

| STREAM NUMBER | Q (CFS) | Tc (MIN.) | Intensity (INCH/HR) | Fp(Fm) (INCH/HR) | Ap | Ae (ACRES) | HEADWATER NODE |
|---|---|---|---|---|---|---|---|
| 1 | 152.00 | 17.11 | 2.654 | 0.42( 0.14) | 0.34 | 66.9 | 60400.00 |
| 2 | 157.03 | 20.92 | 2.352 | 0.42( 0.15) | 0.35 | 78.8 | 60300.00 |
| 3 | 157.48 | 24.82 | 2.123 | 0.42( 0.15) | 0.36 | 88.4 | 60000.00 |
| 4 | 153.73 | 29.13 | 1.929 | 0.42( 0.15) | 0.36 | 95.9 | 60100.00 |
| 5 | 151.01 | 30.61 | 1.872 | 0.42( 0.15) | 0.36 | 97.3 | 60015.00 |
| 6 | 150.27 | 30.86 | 1.863 | 0.42( 0.15) | 0.36 | 97.3 | 60200.00 |

COMPUTED CONFLUENCE ESTIMATES ARE AS FOLLOWS:
PEAK FLOW RATE(CFS) = 157.48 Tc(MIN.) = 24.82
EFFECTIVE AREA(ACRES) = 88.42 AREA-AVERAGED Fm(INCH/HR) = 0.15
AREA-AVERAGED Fp(INCH/HR) = 0.42 AREA-AVERAGED Ap = 0.36
TOTAL AREA(ACRES) = 97.3

```
  LONGEST FLOWPATH FROM NODE  60015.00 TO NODE  60065.00 =    5866.07 FEET.
============================================================================
  END OF STUDY SUMMARY:
  TOTAL AREA(ACRES)      =       97.3  TC(MIN.) =     24.82
  EFFECTIVE AREA(ACRES) =     88.42  AREA-AVERAGED Fm(INCH/HR)=  0.15
  AREA-AVERAGED Fp(INCH/HR) =  0.42  AREA-AVERAGED Ap = 0.357
  PEAK FLOW RATE(CFS)    =     157.48

  ** PEAK FLOW RATE TABLE **
   STREAM       Q      Tc   Intensity   Fp(Fm)     Ap     Ae     HEADWATER
   NUMBER     (CFS)  (MIN.) (INCH/HR) (INCH/HR)         (ACRES)    NODE
      1      152.00   17.11    2.654  0.42( 0.14) 0.34      66.9   60400.00
      2      157.03   20.92    2.352  0.42( 0.15) 0.35      78.8   60300.00
      3      157.48   24.82    2.123  0.42( 0.15) 0.36      88.4   60000.00
      4      153.73   29.13    1.929  0.42( 0.15) 0.36      95.9   60100.00
      5      151.01   30.61    1.872  0.42( 0.15) 0.36      97.3   60015.00
      6      150.27   30.86    1.863  0.42( 0.15) 0.36      97.3   60200.00
============================================================================
============================================================================
  END OF RATIONAL METHOD ANALYSIS
```

```
****************************************************************************
              RATIONAL METHOD HYDROLOGY COMPUTER PROGRAM PACKAGE
           (Reference: 1986 SAN BERNARDINO CO. HYDROLOGY CRITERION)
          (c) Copyright 1983-2008 Advanced Engineering Software (aes)
              Ver. 15.0  Release Date: 04/01/2008  License ID 1555

                            Analysis prepared by:




 ************************** DESCRIPTION OF STUDY **************************
* REDLANDS PASSENGER RAIL                                                  *
* EXISTING HYDROLOGY 100 YEAR EVENT                                        *
* BASIN 70000                                                              *
 **************************************************************************

  FILE NAME: C:\RPRP\70000.DAT
  TIME/DATE OF STUDY: 16:14 11/09/2012
============================================================================
  USER SPECIFIED HYDROLOGY AND HYDRAULIC MODEL INFORMATION:
============================================================================
                      --*TIME-OF-CONCENTRATION MODEL*--

  USER SPECIFIED STORM EVENT(YEAR) =  100.00
  SPECIFIED MINIMUM PIPE SIZE(INCH) =  12.00
  SPECIFIED PERCENT OF GRADIENTS(DECIMAL) TO USE FOR FRICTION SLOPE = 0.90
  *USER-DEFINED LOGARITHMIC INTERPOLATION USED FOR RAINFALL*

  SLOPE OF INTENSITY DURATION CURVE(LOG(I;IN/HR) vs. LOG(Tc;MIN)) = 0.6000
  USER SPECIFIED 1-HOUR INTENSITY(INCH/HOUR) = 1.2500

  *ANTECEDENT MOISTURE CONDITION (AMC) III ASSUMED FOR RATIONAL METHOD*

  *USER-DEFINED STREET-SECTIONS FOR COUPLED PIPEFLOW AND STREETFLOW MODEL*
     HALF-  CROWN TO   STREET-CROSSFALL:   CURB  GUTTER-GEOMETRIES:  MANNING
     WIDTH  CROSSFALL  IN-  / OUT-/PARK-  HEIGHT  WIDTH  LIP   HIKE  FACTOR
NO.   (FT)     (FT)    SIDE / SIDE/ WAY    (FT)    (FT)  (FT)  (FT)    (n)
===  =====  =========  =================  ======  ===== ====== ===== =======
  1   30.0     20.0    0.018/0.018/0.020   0.67    2.00 0.0313 0.167 0.0150
  2   13.0      8.0    0.018/0.018/0.020   0.67    2.00 0.0313 0.167 0.0150
  3   25.0     15.0    0.018/0.018/0.020   0.67    2.00 0.0313 0.167 0.0150
  4   35.0     25.0    0.018/0.018/0.020   0.67    2.00 0.0313 0.167 0.0150
  5   20.0     15.0    0.018/0.018/0.020   0.67    2.00 0.0313 0.167 0.0150

  GLOBAL STREET FLOW-DEPTH CONSTRAINTS:
    1. Relative Flow-Depth =  0.20 FEET
       as (Maximum Allowable Street Flow Depth) - (Top-of-Curb)
    2. (Depth)*(Velocity) Constraint = 10.0 (FT*FT/S)
  *SIZE PIPE WITH A FLOW CAPACITY GREATER THAN
   OR EQUAL TO THE UPSTREAM TRIBUTARY PIPE.*
  *USER-SPECIFIED MINIMUM TOPOGRAPHIC SLOPE ADJUSTMENT NOT SELECTED

****************************************************************************
  FLOW PROCESS FROM NODE  70005.00 TO NODE  70010.00 IS CODE =  21
----------------------------------------------------------------------------
  >>>>>RATIONAL METHOD INITIAL SUBAREA ANALYSIS<<<<<
  >>USE TIME-OF-CONCENTRATION NOMOGRAPH FOR INITIAL SUBAREA<<
============================================================================
  INITIAL SUBAREA FLOW-LENGTH(FEET) =   752.00
  ELEVATION DATA: UPSTREAM(FEET) =   1416.00  DOWNSTREAM(FEET) =   1406.00

  Tc = K*[(LENGTH** 3.00)/(ELEVATION CHANGE)]**0.20
  SUBAREA ANALYSIS USED MINIMUM Tc(MIN.) =   10.200
  * 100 YEAR RAINFALL INTENSITY(INCH/HR) =  3.619
  SUBAREA Tc AND LOSS RATE DATA(AMC III):
   DEVELOPMENT TYPE/      SCS SOIL   AREA      Fp         Ap     SCS   Tc
       LAND USE            GROUP   (ACRES)  (INCH/HR)  (DECIMAL)  CN  (MIN.)
```

```
  COMMERCIAL                 B        1.10      0.42     0.100    76   10.20
  SUBAREA AVERAGE PERVIOUS LOSS RATE, Fp(INCH/HR) =  0.42
  SUBAREA AVERAGE PERVIOUS AREA FRACTION, Ap =  0.100
  SUBAREA RUNOFF(CFS) =      3.54
  TOTAL AREA(ACRES) =      1.10   PEAK FLOW RATE(CFS) =      3.54

****************************************************************************
  FLOW PROCESS FROM NODE  70010.00 TO NODE  70015.00 IS CODE =  51
----------------------------------------------------------------------------
  >>>>>COMPUTE TRAPEZOIDAL CHANNEL FLOW<<<<<
  >>>>>TRAVELTIME THRU SUBAREA (EXISTING ELEMENT)<<<<<
============================================================================
  ELEVATION DATA: UPSTREAM(FEET) =   1406.00  DOWNSTREAM(FEET) =   1372.00
  CHANNEL LENGTH THRU SUBAREA(FEET) =  1477.00   CHANNEL SLOPE =  0.0230
  CHANNEL BASE(FEET) =    2.00   "Z" FACTOR =   3.000
  MANNING'S FACTOR = 0.015   MAXIMUM DEPTH(FEET) =   1.00
  * 100 YEAR RAINFALL INTENSITY(INCH/HR) =  2.921
  SUBAREA LOSS RATE DATA(AMC III):
   DEVELOPMENT TYPE/      SCS SOIL   AREA      Fp         Ap     SCS
       LAND USE            GROUP   (ACRES)  (INCH/HR)  (DECIMAL)  CN
  COMMERCIAL                 B        1.20      0.42     0.100    76
  SUBAREA AVERAGE PERVIOUS LOSS RATE, Fp(INCH/HR) =  0.42
  SUBAREA AVERAGE PERVIOUS AREA FRACTION, Ap =  0.100
  TRAVEL TIME COMPUTED USING ESTIMATED FLOW(CFS) =      5.10
  TRAVEL TIME THRU SUBAREA BASED ON VELOCITY(FEET/SEC.) =   5.62
  AVERAGE FLOW DEPTH(FEET) =   0.31   TRAVEL TIME(MIN.) =   4.38
  Tc(MIN.) =   14.58
  SUBAREA AREA(ACRES) =     1.20       SUBAREA RUNOFF(CFS) =    3.11
  EFFECTIVE AREA(ACRES) =      2.30     AREA-AVERAGED Fm(INCH/HR) =   0.04
  AREA-AVERAGED Fp(INCH/HR) =   0.42  AREA-AVERAGED Ap =   0.10
  TOTAL AREA(ACRES) =        2.3         PEAK FLOW RATE(CFS) =       5.96

  END OF SUBAREA CHANNEL FLOW HYDRAULICS:
  DEPTH(FEET) =  0.34   FLOW VELOCITY(FEET/SEC.) =   5.84
  LONGEST FLOWPATH FROM NODE  70005.00 TO NODE  70015.00 =    2229.00 FEET.

****************************************************************************
  FLOW PROCESS FROM NODE  70015.00 TO NODE  70015.00 IS CODE =  81
----------------------------------------------------------------------------
  >>>>>ADDITION OF SUBAREA TO MAINLINE PEAK FLOW<<<<<
============================================================================
  MAINLINE Tc(MIN.) =   14.58
  * 100 YEAR RAINFALL INTENSITY(INCH/HR) =  2.921
  SUBAREA LOSS RATE DATA(AMC III):
   DEVELOPMENT TYPE/      SCS SOIL   AREA      Fp         Ap     SCS
       LAND USE            GROUP   (ACRES)  (INCH/HR)  (DECIMAL)  CN
  COMMERCIAL                 B        1.10      0.42     0.100    76
  CONDOMINIUMS               B        1.90      0.42     0.350    76
  PUBLIC PARK                B        1.00      0.42     0.850    76
  COMMERCIAL                 B        3.90      0.42     0.100    76
  SUBAREA AVERAGE PERVIOUS LOSS RATE, Fp(INCH/HR) =  0.42
  SUBAREA AVERAGE PERVIOUS AREA FRACTION, Ap =  0.255
  SUBAREA AREA(ACRES) =    7.90      SUBAREA RUNOFF(CFS) =   20.00
  EFFECTIVE AREA(ACRES) =     10.20   AREA-AVERAGED Fm(INCH/HR) =  0.09
  AREA-AVERAGED Fp(INCH/HR) =  0.42  AREA-AVERAGED Ap =  0.22
  TOTAL AREA(ACRES) =       10.2       PEAK FLOW RATE(CFS) =      25.96

****************************************************************************
  FLOW PROCESS FROM NODE  70015.00 TO NODE  70020.00 IS CODE =  41
----------------------------------------------------------------------------
  >>>>>COMPUTE PIPE-FLOW TRAVEL TIME THRU SUBAREA<<<<<
  >>>>>USING USER-SPECIFIED PIPESIZE (EXISTING ELEMENT)<<<<<
============================================================================
  ELEVATION DATA: UPSTREAM(FEET) =   100.00  DOWNSTREAM(FEET) =    99.40
  FLOW LENGTH(FEET) =    60.00   MANNING'S N =  0.013
  DEPTH OF FLOW IN  36.0 INCH PIPE IS  16.1 INCHES
  PIPE-FLOW VELOCITY(FEET/SEC.) =   8.51
  GIVEN PIPE DIAMETER(INCH) =  36.00    NUMBER OF PIPES =   1
  PIPE-FLOW(CFS) =      25.96
  PIPE TRAVEL TIME(MIN.) =   0.12    Tc(MIN.) =   14.70
  LONGEST FLOWPATH FROM NODE  70005.00 TO NODE  70020.00 =    2289.00 FEET.
```

```
****************************************************************************
  FLOW PROCESS FROM NODE  70020.00 TO NODE  70020.00 IS CODE =  81
----------------------------------------------------------------------------
  >>>>>ADDITION OF SUBAREA TO MAINLINE PEAK FLOW<<<<<
============================================================================
  MAINLINE Tc(MIN.) =   14.70
  * 100 YEAR RAINFALL INTENSITY(INCH/HR) =  2.907
  SUBAREA LOSS RATE DATA(AMC III):
   DEVELOPMENT TYPE/      SCS SOIL   AREA      Fp         Ap     SCS
       LAND USE            GROUP   (ACRES)  (INCH/HR)  (DECIMAL)  CN
  COMMERCIAL                 B       0.40      0.42     0.100    76
  SUBAREA AVERAGE PERVIOUS LOSS RATE, Fp(INCH/HR) =  0.42
  SUBAREA AVERAGE PERVIOUS AREA FRACTION, Ap =  0.100
  SUBAREA AREA(ACRES) =    0.40      SUBAREA RUNOFF(CFS) =    1.03
  EFFECTIVE AREA(ACRES) =     10.60   AREA-AVERAGED Fm(INCH/HR) =  0.09
  AREA-AVERAGED Fp(INCH/HR) =  0.42  AREA-AVERAGED Ap =  0.22
  TOTAL AREA(ACRES) =       10.6       PEAK FLOW RATE(CFS) =      26.86

****************************************************************************
  FLOW PROCESS FROM NODE  70020.00 TO NODE  70025.00 IS CODE =  41
----------------------------------------------------------------------------
  >>>>>COMPUTE PIPE-FLOW TRAVEL TIME THRU SUBAREA<<<<<
  >>>>>USING USER-SPECIFIED PIPESIZE (EXISTING ELEMENT)<<<<<
============================================================================
  ELEVATION DATA: UPSTREAM(FEET) =   100.00  DOWNSTREAM(FEET) =    99.50
  FLOW LENGTH(FEET) =    50.00   MANNING'S N =  0.013
  DEPTH OF FLOW IN  36.0 INCH PIPE IS  16.4 INCHES
  PIPE-FLOW VELOCITY(FEET/SEC.) =   8.58
  GIVEN PIPE DIAMETER(INCH) =  36.00    NUMBER OF PIPES =   1
  PIPE-FLOW(CFS) =      26.86
  PIPE TRAVEL TIME(MIN.) =   0.10    Tc(MIN.) =   14.80
  LONGEST FLOWPATH FROM NODE  70005.00 TO NODE  70025.00 =    2339.00 FEET.

****************************************************************************
  FLOW PROCESS FROM NODE  70025.00 TO NODE  70025.00 IS CODE =   1
----------------------------------------------------------------------------
  >>>>>DESIGNATE INDEPENDENT STREAM FOR CONFLUENCE<<<<<
============================================================================
  TOTAL NUMBER OF STREAMS =  2
  CONFLUENCE VALUES USED FOR INDEPENDENT STREAM  1 ARE:
  TIME OF CONCENTRATION(MIN.) =   14.80
  RAINFALL INTENSITY(INCH/HR) =   2.90
  AREA-AVERAGED Fm(INCH/HR) =  0.09
  AREA-AVERAGED Fp(INCH/HR) =  0.42
  AREA-AVERAGED Ap =  0.22
  EFFECTIVE STREAM AREA(ACRES) =      10.60
  TOTAL STREAM AREA(ACRES) =      10.60
  PEAK FLOW RATE(CFS) AT CONFLUENCE =      26.86

****************************************************************************
  FLOW PROCESS FROM NODE  71005.00 TO NODE  71010.00 IS CODE =  21
----------------------------------------------------------------------------
  >>>>>RATIONAL METHOD INITIAL SUBAREA ANALYSIS<<<<<
  >>USE TIME-OF-CONCENTRATION NOMOGRAPH FOR INITIAL SUBAREA<<
============================================================================
  INITIAL SUBAREA FLOW-LENGTH(FEET) =   290.00
  ELEVATION DATA: UPSTREAM(FEET) =   1420.00  DOWNSTREAM(FEET) =   1407.00

  Tc = K*[(LENGTH** 3.00)/(ELEVATION CHANGE)]**0.20
  SUBAREA ANALYSIS USED MINIMUM Tc(MIN.) =    5.464
  * 100 YEAR RAINFALL INTENSITY(INCH/HR) =  5.264
  SUBAREA Tc AND LOSS RATE DATA(AMC III):
   DEVELOPMENT TYPE/      SCS SOIL   AREA      Fp         Ap     SCS   Tc
       LAND USE            GROUP   (ACRES)  (INCH/HR)  (DECIMAL)  CN  (MIN.)
  COMMERCIAL                 B       0.70      0.42     0.100    76    5.46
  SUBAREA AVERAGE PERVIOUS LOSS RATE, Fp(INCH/HR) =  0.42
  SUBAREA AVERAGE PERVIOUS AREA FRACTION, Ap =  0.100
  SUBAREA RUNOFF(CFS) =      3.29
  TOTAL AREA(ACRES) =      0.70   PEAK FLOW RATE(CFS) =      3.29
```

```
****************************************************************************
  FLOW PROCESS FROM NODE  71010.00 TO NODE  71015.00 IS CODE =  51
----------------------------------------------------------------------------
  >>>>>COMPUTE TRAPEZOIDAL CHANNEL FLOW<<<<<
  >>>>>TRAVELTIME THRU SUBAREA (EXISTING ELEMENT)<<<<<
============================================================================
  ELEVATION DATA: UPSTREAM(FEET) =   1407.00  DOWNSTREAM(FEET) =   1387.00
  CHANNEL LENGTH THRU SUBAREA(FEET) =   977.00   CHANNEL SLOPE =  0.0205
  CHANNEL BASE(FEET) =    2.00   "Z" FACTOR =   3.000
  MANNING'S FACTOR = 0.015   MAXIMUM DEPTH(FEET) =   1.00
  * 100 YEAR RAINFALL INTENSITY(INCH/HR) =  3.989
  SUBAREA LOSS RATE DATA(AMC III):
   DEVELOPMENT TYPE/      SCS SOIL   AREA      Fp         Ap     SCS
       LAND USE            GROUP   (ACRES)  (INCH/HR)  (DECIMAL)  CN
  PUBLIC PARK                B       0.60      0.42     0.850    76
  SUBAREA AVERAGE PERVIOUS LOSS RATE, Fp(INCH/HR) =  0.42
  SUBAREA AVERAGE PERVIOUS AREA FRACTION, Ap =  0.850
  TRAVEL TIME COMPUTED USING ESTIMATED FLOW(CFS) =       4.28
  TRAVEL TIME THRU SUBAREA BASED ON VELOCITY(FEET/SEC.) =   5.07
  AVERAGE FLOW DEPTH(FEET) =   0.29   TRAVEL TIME(MIN.) =   3.21
  Tc(MIN.) =    8.67
  SUBAREA AREA(ACRES) =     0.60       SUBAREA RUNOFF(CFS) =    1.96
  EFFECTIVE AREA(ACRES) =      1.30     AREA-AVERAGED Fm(INCH/HR) =   0.19
  AREA-AVERAGED Fp(INCH/HR) =   0.42  AREA-AVERAGED Ap =   0.45
  TOTAL AREA(ACRES) =        1.3         PEAK FLOW RATE(CFS) =       4.45

  END OF SUBAREA CHANNEL FLOW HYDRAULICS:
  DEPTH(FEET) =  0.29   FLOW VELOCITY(FEET/SEC.) =   5.23
  LONGEST FLOWPATH FROM NODE  71005.00 TO NODE  71015.00 =    1267.00 FEET.

****************************************************************************
  FLOW PROCESS FROM NODE  71015.00 TO NODE  71020.00 IS CODE =  51
----------------------------------------------------------------------------
  >>>>>COMPUTE TRAPEZOIDAL CHANNEL FLOW<<<<<
  >>>>>TRAVELTIME THRU SUBAREA (EXISTING ELEMENT)<<<<<
============================================================================
  ELEVATION DATA: UPSTREAM(FEET) =   1387.00  DOWNSTREAM(FEET) =   1385.00
  CHANNEL LENGTH THRU SUBAREA(FEET) =   193.10   CHANNEL SLOPE =  0.0104
  CHANNEL BASE(FEET) =    2.00   "Z" FACTOR =   3.000
  MANNING'S FACTOR = 0.015   MAXIMUM DEPTH(FEET) =   1.00
  * 100 YEAR RAINFALL INTENSITY(INCH/HR) =  3.790
  SUBAREA LOSS RATE DATA(AMC III):
   DEVELOPMENT TYPE/      SCS SOIL   AREA      Fp         Ap     SCS
       LAND USE            GROUP   (ACRES)  (INCH/HR)  (DECIMAL)  CN
  COMMERCIAL                 B       0.20      0.42     0.100    76
  SUBAREA AVERAGE PERVIOUS LOSS RATE, Fp(INCH/HR) =  0.42
  SUBAREA AVERAGE PERVIOUS AREA FRACTION, Ap =  0.100
  TRAVEL TIME COMPUTED USING ESTIMATED FLOW(CFS) =       4.78
  TRAVEL TIME THRU SUBAREA BASED ON VELOCITY(FEET/SEC.) =   4.17
  AVERAGE FLOW DEPTH(FEET) =   0.37   TRAVEL TIME(MIN.) =   0.77
  Tc(MIN.) =    9.44
  SUBAREA AREA(ACRES) =     0.20       SUBAREA RUNOFF(CFS) =    0.67
  EFFECTIVE AREA(ACRES) =      1.50     AREA-AVERAGED Fm(INCH/HR) =   0.17
  AREA-AVERAGED Fp(INCH/HR) =   0.42  AREA-AVERAGED Ap =   0.40
  TOTAL AREA(ACRES) =        1.5         PEAK FLOW RATE(CFS) =       4.89

  END OF SUBAREA CHANNEL FLOW HYDRAULICS:
  DEPTH(FEET) =  0.38   FLOW VELOCITY(FEET/SEC.) =   4.15
  LONGEST FLOWPATH FROM NODE  71005.00 TO NODE  71020.00 =    1460.10 FEET.

****************************************************************************
  FLOW PROCESS FROM NODE  71020.00 TO NODE  71020.00 IS CODE =  81
----------------------------------------------------------------------------
  >>>>>ADDITION OF SUBAREA TO MAINLINE PEAK FLOW<<<<<
============================================================================
  MAINLINE Tc(MIN.) =    9.44
  * 100 YEAR RAINFALL INTENSITY(INCH/HR) =  3.790
  SUBAREA LOSS RATE DATA(AMC III):
   DEVELOPMENT TYPE/      SCS SOIL   AREA      Fp         Ap     SCS
       LAND USE            GROUP   (ACRES)  (INCH/HR)  (DECIMAL)  CN
  COMMERCIAL                 B       9.70      0.42     0.100    76
```

```
  COMMERCIAL                 B        2.20      0.42     0.100    76
  COMMERCIAL                 B        3.10      0.42     0.100    76
  COMMERCIAL                 B        0.20      0.42     0.100    76
  COMMERCIAL                 B        1.10      0.42     0.100    76
  COMMERCIAL                 B        0.20      0.42     0.100    76
  SUBAREA AVERAGE PERVIOUS LOSS RATE, Fp(INCH/HR) =  0.42
  SUBAREA AVERAGE PERVIOUS AREA FRACTION, Ap =  0.100
  SUBAREA AREA(ACRES) =   16.50      SUBAREA RUNOFF(CFS) =   55.66
  EFFECTIVE AREA(ACRES) =     18.00   AREA-AVERAGED Fm(INCH/HR) =  0.05
  AREA-AVERAGED Fp(INCH/HR) =  0.42  AREA-AVERAGED Ap =  0.12
  TOTAL AREA(ACRES) =       18.0       PEAK FLOW RATE(CFS) =      60.55

****************************************************************************
  FLOW PROCESS FROM NODE  71020.00 TO NODE  71020.00 IS CODE =  81
----------------------------------------------------------------------------
  >>>>>ADDITION OF SUBAREA TO MAINLINE PEAK FLOW<<<<<
============================================================================
  MAINLINE Tc(MIN.) =    9.44
  * 100 YEAR RAINFALL INTENSITY(INCH/HR) =  3.790
  SUBAREA LOSS RATE DATA(AMC III):
   DEVELOPMENT TYPE/      SCS SOIL   AREA      Fp         Ap     SCS
      LAND USE             GROUP   (ACRES)  (INCH/HR)  (DECIMAL)  CN
  PUBLIC PARK                B        0.50      0.42     0.850    76
  SUBAREA AVERAGE PERVIOUS LOSS RATE, Fp(INCH/HR) =  0.42
  SUBAREA AVERAGE PERVIOUS AREA FRACTION, Ap =  0.850
  SUBAREA AREA(ACRES) =    0.50      SUBAREA RUNOFF(CFS) =    1.54
  EFFECTIVE AREA(ACRES) =     18.50   AREA-AVERAGED Fm(INCH/HR) =  0.06
  AREA-AVERAGED Fp(INCH/HR) =  0.42  AREA-AVERAGED Ap =  0.14
  TOTAL AREA(ACRES) =       18.5       PEAK FLOW RATE(CFS) =      62.09

****************************************************************************
  FLOW PROCESS FROM NODE  71020.00 TO NODE  71025.00 IS CODE =  51
----------------------------------------------------------------------------
  >>>>>COMPUTE TRAPEZOIDAL CHANNEL FLOW<<<<<
  >>>>>TRAVELTIME THRU SUBAREA (EXISTING ELEMENT)<<<<<
============================================================================
  ELEVATION DATA: UPSTREAM(FEET) =   1385.00  DOWNSTREAM(FEET) =   1366.00
  CHANNEL LENGTH THRU SUBAREA(FEET) =  1265.00   CHANNEL SLOPE =  0.0150
  CHANNEL BASE(FEET) =    2.00   "Z" FACTOR =   3.000
  MANNING'S FACTOR = 0.015   MAXIMUM DEPTH(FEET) =   2.00
  * 100 YEAR RAINFALL INTENSITY(INCH/HR) =  3.342
  SUBAREA LOSS RATE DATA(AMC III):
   DEVELOPMENT TYPE/      SCS SOIL   AREA      Fp         Ap     SCS
      LAND USE             GROUP   (ACRES)  (INCH/HR)  (DECIMAL)  CN
  COMMERCIAL                 B        1.50      0.42     0.100    76
  SUBAREA AVERAGE PERVIOUS LOSS RATE, Fp(INCH/HR) =  0.42
  SUBAREA AVERAGE PERVIOUS AREA FRACTION, Ap =  0.100
  TRAVEL TIME COMPUTED USING ESTIMATED FLOW(CFS) =      64.32
  TRAVEL TIME THRU SUBAREA BASED ON VELOCITY(FEET/SEC.) =   9.56
  AVERAGE FLOW DEPTH(FEET) =   1.20   TRAVEL TIME(MIN.) =   2.20
  Tc(MIN.) =   11.65
  SUBAREA AREA(ACRES) =     1.50       SUBAREA RUNOFF(CFS) =    4.45
  EFFECTIVE AREA(ACRES) =     20.00     AREA-AVERAGED Fm(INCH/HR) =   0.06
  AREA-AVERAGED Fp(INCH/HR) =   0.42  AREA-AVERAGED Ap =   0.14
  TOTAL AREA(ACRES) =       20.0         PEAK FLOW RATE(CFS) =      62.09
  NOTE: PEAK FLOW RATE DEFAULTED TO UPSTREAM VALUE

  END OF SUBAREA CHANNEL FLOW HYDRAULICS:
  DEPTH(FEET) =  1.18   FLOW VELOCITY(FEET/SEC.) =  9.50
  LONGEST FLOWPATH FROM NODE  71005.00 TO NODE  71025.00 =    2725.10 FEET.

****************************************************************************
  FLOW PROCESS FROM NODE  71025.00 TO NODE  70025.00 IS CODE =  41
----------------------------------------------------------------------------
  >>>>>COMPUTE PIPE-FLOW TRAVEL TIME THRU SUBAREA<<<<<
  >>>>>USING USER-SPECIFIED PIPESIZE (EXISTING ELEMENT)<<<<<
============================================================================
  ELEVATION DATA: UPSTREAM(FEET) =   100.00  DOWNSTREAM(FEET) =    97.00
  FLOW LENGTH(FEET) =   300.00   MANNING'S N =  0.013
  DEPTH OF FLOW IN  36.0 INCH PIPE IS  28.9 INCHES
  PIPE-FLOW VELOCITY(FEET/SEC.) =  10.20
```

```
  GIVEN PIPE DIAMETER(INCH) =  36.00    NUMBER OF PIPES =   1
  PIPE-FLOW(CFS) =      62.09
  PIPE TRAVEL TIME(MIN.) =   0.49    Tc(MIN.) =   12.14
  LONGEST FLOWPATH FROM NODE  71005.00 TO NODE  70025.00 =    3025.10 FEET.

****************************************************************************
  FLOW PROCESS FROM NODE  70025.00 TO NODE  70025.00 IS CODE =   1
----------------------------------------------------------------------------
  >>>>>DESIGNATE INDEPENDENT STREAM FOR CONFLUENCE<<<<<
  >>>>>AND COMPUTE VARIOUS CONFLUENCED STREAM VALUES<<<<<
============================================================================
  TOTAL NUMBER OF STREAMS =  2
  CONFLUENCE VALUES USED FOR INDEPENDENT STREAM  2 ARE:
  TIME OF CONCENTRATION(MIN.) =   12.14
  RAINFALL INTENSITY(INCH/HR) =   3.26
  AREA-AVERAGED Fm(INCH/HR) =  0.06
  AREA-AVERAGED Fp(INCH/HR) =  0.42
  AREA-AVERAGED Ap =  0.14
  EFFECTIVE STREAM AREA(ACRES) =      20.00
  TOTAL STREAM AREA(ACRES) =      20.00
  PEAK FLOW RATE(CFS) AT CONFLUENCE =      62.09

  ** CONFLUENCE DATA **
   STREAM       Q      Tc   Intensity   Fp(Fm)     Ap     Ae     HEADWATER
   NUMBER     (CFS)  (MIN.) (INCH/HR) (INCH/HR)         (ACRES)    NODE
      1       26.86   14.80    2.895  0.42( 0.09) 0.22      10.6   70005.00
      2       62.09   12.14    3.260  0.42( 0.06) 0.14      20.0   71005.00

  RAINFALL INTENSITY AND TIME OF CONCENTRATION RATIO
  CONFLUENCE FORMULA USED FOR  2 STREAMS.

  ** PEAK FLOW RATE TABLE **
   STREAM       Q      Tc   Intensity   Fp(Fm)     Ap     Ae     HEADWATER
   NUMBER     (CFS)  (MIN.) (INCH/HR) (INCH/HR)         (ACRES)    NODE
      1       87.00   12.14    3.260  0.42( 0.07) 0.16      28.7   71005.00
      2       81.87   14.80    2.895  0.42( 0.07) 0.17      30.6   70005.00

  COMPUTED CONFLUENCE ESTIMATES ARE AS FOLLOWS:
  PEAK FLOW RATE(CFS) =      87.00    Tc(MIN.) =    12.14
  EFFECTIVE AREA(ACRES) =      28.70   AREA-AVERAGED Fm(INCH/HR) =  0.07
  AREA-AVERAGED Fp(INCH/HR) =  0.42  AREA-AVERAGED Ap =  0.16
  TOTAL AREA(ACRES) =       30.6
  LONGEST FLOWPATH FROM NODE  71005.00 TO NODE  70025.00 =    3025.10 FEET.

****************************************************************************
  FLOW PROCESS FROM NODE  70025.00 TO NODE  70025.00 IS CODE =  81
----------------------------------------------------------------------------
  >>>>>ADDITION OF SUBAREA TO MAINLINE PEAK FLOW<<<<<
============================================================================
  MAINLINE Tc(MIN.) =   12.14
  * 100 YEAR RAINFALL INTENSITY(INCH/HR) =  3.260
  SUBAREA LOSS RATE DATA(AMC III):
   DEVELOPMENT TYPE/      SCS SOIL   AREA      Fp         Ap     SCS
       LAND USE            GROUP   (ACRES)  (INCH/HR)  (DECIMAL)  CN
  COMMERCIAL                 B        2.40      0.42     0.100    76
  COMMERCIAL                 B        3.70      0.42     0.100    76
  RESIDENTIAL
  "5-7 DWELLINGS/ACRE"       B        2.00      0.42     0.500    76
  COMMERCIAL                 B        9.40      0.42     0.100    76
  CONDOMINIUMS               B        9.60      0.42     0.350    76
  SUBAREA AVERAGE PERVIOUS LOSS RATE, Fp(INCH/HR) =  0.42
  SUBAREA AVERAGE PERVIOUS AREA FRACTION, Ap =  0.218
  SUBAREA AREA(ACRES) =   27.10      SUBAREA RUNOFF(CFS) =   77.27
  EFFECTIVE AREA(ACRES) =      55.80   AREA-AVERAGED Fm(INCH/HR) =  0.08
  AREA-AVERAGED Fp(INCH/HR) =  0.42  AREA-AVERAGED Ap =  0.19
  TOTAL AREA(ACRES) =       57.7       PEAK FLOW RATE(CFS) =     159.69

****************************************************************************
  FLOW PROCESS FROM NODE  70025.00 TO NODE  70030.00 IS CODE =  41
----------------------------------------------------------------------------
  >>>>>COMPUTE PIPE-FLOW TRAVEL TIME THRU SUBAREA<<<<<
```

```
  >>>>>USING USER-SPECIFIED PIPESIZE (EXISTING ELEMENT)<<<<<
==============================================================================
  ELEVATION DATA: UPSTREAM(FEET) =   100.00  DOWNSTREAM(FEET) =    95.00
  FLOW LENGTH(FEET) =   530.00   MANNING'S N =  0.013
  ASSUME FULL-FLOWING PIPELINE
  PIPE-FLOW VELOCITY(FEET/SEC.) =  22.59
  PIPE FLOW VELOCITY = (TOTAL FLOW)/(PIPE CROSS SECTION AREA)
  GIVEN PIPE DIAMETER(INCH) =  36.00    NUMBER OF PIPES =   1
  PIPE-FLOW(CFS) =     159.69
  PIPE TRAVEL TIME(MIN.) =   0.39    Tc(MIN.) =   12.53
  LONGEST FLOWPATH FROM NODE  71005.00 TO NODE  70030.00 =    3555.10 FEET.

******************************************************************************
  FLOW PROCESS FROM NODE  70030.00 TO NODE  70030.00 IS CODE =  81
------------------------------------------------------------------------------
  >>>>>ADDITION OF SUBAREA TO MAINLINE PEAK FLOW<<<<<
==============================================================================
  MAINLINE Tc(MIN.) =   12.53
  * 100 YEAR RAINFALL INTENSITY(INCH/HR) =  3.199
  SUBAREA LOSS RATE DATA(AMC III):
   DEVELOPMENT TYPE/      SCS SOIL   AREA      Fp         Ap     SCS
       LAND USE            GROUP   (ACRES)  (INCH/HR)  (DECIMAL)  CN
  COMMERCIAL                 B        0.90      0.42     0.100    76
  COMMERCIAL                 B        2.40      0.42     0.100    76
  COMMERCIAL                 B        8.80      0.42     0.100    76
  SUBAREA AVERAGE PERVIOUS LOSS RATE, Fp(INCH/HR) =  0.42
  SUBAREA AVERAGE PERVIOUS AREA FRACTION, Ap =  0.100
  SUBAREA AREA(ACRES) =   12.10      SUBAREA RUNOFF(CFS) =   34.38
  EFFECTIVE AREA(ACRES) =     67.90   AREA-AVERAGED Fm(INCH/HR) =  0.07
  AREA-AVERAGED Fp(INCH/HR) =  0.42  AREA-AVERAGED Ap =  0.17
  TOTAL AREA(ACRES) =       69.8       PEAK FLOW RATE(CFS) =     190.98

******************************************************************************
  FLOW PROCESS FROM NODE  70030.00 TO NODE  70035.00 IS CODE =  41
------------------------------------------------------------------------------
  >>>>>COMPUTE PIPE-FLOW TRAVEL TIME THRU SUBAREA<<<<<
  >>>>>USING USER-SPECIFIED PIPESIZE (EXISTING ELEMENT)<<<<<
==============================================================================
  ELEVATION DATA: UPSTREAM(FEET) =   100.00  DOWNSTREAM(FEET) =    99.60
  FLOW LENGTH(FEET) =   135.00   MANNING'S N =  0.013
  ASSUME FULL-FLOWING PIPELINE
  PIPE-FLOW VELOCITY(FEET/SEC.) =  27.02
  PIPE FLOW VELOCITY = (TOTAL FLOW)/(PIPE CROSS SECTION AREA)
  GIVEN PIPE DIAMETER(INCH) =  36.00    NUMBER OF PIPES =   1
  PIPE-FLOW(CFS) =     190.98
  PIPE TRAVEL TIME(MIN.) =   0.08    Tc(MIN.) =   12.61
  LONGEST FLOWPATH FROM NODE  71005.00 TO NODE  70035.00 =    3690.10 FEET.

******************************************************************************
  FLOW PROCESS FROM NODE  70035.00 TO NODE  70035.00 IS CODE =  81
------------------------------------------------------------------------------
  >>>>>ADDITION OF SUBAREA TO MAINLINE PEAK FLOW<<<<<
==============================================================================
  MAINLINE Tc(MIN.) =   12.61
  * 100 YEAR RAINFALL INTENSITY(INCH/HR) =  3.186
  SUBAREA LOSS RATE DATA(AMC III):
   DEVELOPMENT TYPE/      SCS SOIL   AREA      Fp         Ap     SCS
       LAND USE            GROUP   (ACRES)  (INCH/HR)  (DECIMAL)  CN
  COMMERCIAL                 B        3.00      0.42     0.100    76
  COMMERCIAL                 B        0.60      0.42     0.100    76
  COMMERCIAL                 B        1.30      0.42     0.100    76
  COMMERCIAL                 B        0.80      0.42     0.100    76
  COMMERCIAL                 B        0.60      0.42     0.100    76
  COMMERCIAL                 B        1.20      0.42     0.100    76
  SUBAREA AVERAGE PERVIOUS LOSS RATE, Fp(INCH/HR) =  0.42
  SUBAREA AVERAGE PERVIOUS AREA FRACTION, Ap =  0.100
  SUBAREA AREA(ACRES) =    7.50      SUBAREA RUNOFF(CFS) =   21.22
  EFFECTIVE AREA(ACRES) =     75.40   AREA-AVERAGED Fm(INCH/HR) =  0.07
  AREA-AVERAGED Fp(INCH/HR) =  0.42  AREA-AVERAGED Ap =  0.17
  TOTAL AREA(ACRES) =       77.3       PEAK FLOW RATE(CFS) =     211.43
```

```
****************************************************************************
  FLOW PROCESS FROM NODE  70035.00 TO NODE  70040.00 IS CODE =  41
----------------------------------------------------------------------------
  >>>>>COMPUTE PIPE-FLOW TRAVEL TIME THRU SUBAREA<<<<<
  >>>>>USING USER-SPECIFIED PIPESIZE (EXISTING ELEMENT)<<<<<
============================================================================
  ELEVATION DATA: UPSTREAM(FEET) =   100.00  DOWNSTREAM(FEET) =    97.00
  FLOW LENGTH(FEET) =   310.00   MANNING'S N =  0.013
  ASSUME FULL-FLOWING PIPELINE
  PIPE-FLOW VELOCITY(FEET/SEC.) =  29.91
  PIPE FLOW VELOCITY = (TOTAL FLOW)/(PIPE CROSS SECTION AREA)
  GIVEN PIPE DIAMETER(INCH) =  36.00    NUMBER OF PIPES =   1
  PIPE-FLOW(CFS) =     211.43
  PIPE TRAVEL TIME(MIN.) =   0.17    Tc(MIN.) =   12.79
  LONGEST FLOWPATH FROM NODE  71005.00 TO NODE  70040.00 =    4000.10 FEET.

****************************************************************************
  FLOW PROCESS FROM NODE  70040.00 TO NODE  70040.00 IS CODE =  81
----------------------------------------------------------------------------
  >>>>>ADDITION OF SUBAREA TO MAINLINE PEAK FLOW<<<<<
============================================================================
  MAINLINE Tc(MIN.) =   12.79
  * 100 YEAR RAINFALL INTENSITY(INCH/HR) =  3.160
  SUBAREA LOSS RATE DATA(AMC III):
   DEVELOPMENT TYPE/      SCS SOIL   AREA      Fp         Ap     SCS
       LAND USE            GROUP   (ACRES)  (INCH/HR)  (DECIMAL)  CN
  COMMERCIAL                 B        3.10      0.42     0.100    76
  SUBAREA AVERAGE PERVIOUS LOSS RATE, Fp(INCH/HR) =  0.42
  SUBAREA AVERAGE PERVIOUS AREA FRACTION, Ap =  0.100
  SUBAREA AREA(ACRES) =    3.10      SUBAREA RUNOFF(CFS) =    8.70
  EFFECTIVE AREA(ACRES) =     78.50   AREA-AVERAGED Fm(INCH/HR) =  0.07
  AREA-AVERAGED Fp(INCH/HR) =  0.42  AREA-AVERAGED Ap =  0.16
  TOTAL AREA(ACRES) =       80.4       PEAK FLOW RATE(CFS) =     218.37

****************************************************************************
  FLOW PROCESS FROM NODE  70040.00 TO NODE  70045.00 IS CODE =  41
----------------------------------------------------------------------------
  >>>>>COMPUTE PIPE-FLOW TRAVEL TIME THRU SUBAREA<<<<<
  >>>>>USING USER-SPECIFIED PIPESIZE (EXISTING ELEMENT)<<<<<
============================================================================
  ELEVATION DATA: UPSTREAM(FEET) =   100.00  DOWNSTREAM(FEET) =    98.00
  FLOW LENGTH(FEET) =   200.00   MANNING'S N =  0.013
  ASSUME FULL-FLOWING PIPELINE
  PIPE-FLOW VELOCITY(FEET/SEC.) =  30.89
  PIPE FLOW VELOCITY = (TOTAL FLOW)/(PIPE CROSS SECTION AREA)
  GIVEN PIPE DIAMETER(INCH) =  36.00    NUMBER OF PIPES =   1
  PIPE-FLOW(CFS) =     218.37
  PIPE TRAVEL TIME(MIN.) =   0.11    Tc(MIN.) =   12.89
  LONGEST FLOWPATH FROM NODE  71005.00 TO NODE  70045.00 =    4200.10 FEET.

****************************************************************************
  FLOW PROCESS FROM NODE  70045.00 TO NODE  70045.00 IS CODE =  81
----------------------------------------------------------------------------
  >>>>>ADDITION OF SUBAREA TO MAINLINE PEAK FLOW<<<<<
============================================================================
  MAINLINE Tc(MIN.) =   12.89
  * 100 YEAR RAINFALL INTENSITY(INCH/HR) =  3.145
  SUBAREA LOSS RATE DATA(AMC III):
   DEVELOPMENT TYPE/      SCS SOIL   AREA      Fp         Ap     SCS
       LAND USE            GROUP   (ACRES)  (INCH/HR)  (DECIMAL)  CN
  RESIDENTIAL
  "1 DWELLING/ACRE"          B        1.00      0.42     0.800    76
  COMMERCIAL                 B        2.60      0.42     0.100    76
  SUBAREA AVERAGE PERVIOUS LOSS RATE, Fp(INCH/HR) =  0.42
  SUBAREA AVERAGE PERVIOUS AREA FRACTION, Ap =  0.294
  SUBAREA AREA(ACRES) =    3.60      SUBAREA RUNOFF(CFS) =    9.78
  EFFECTIVE AREA(ACRES) =     82.10   AREA-AVERAGED Fm(INCH/HR) =  0.07
  AREA-AVERAGED Fp(INCH/HR) =  0.42  AREA-AVERAGED Ap =  0.17
  TOTAL AREA(ACRES) =       84.0       PEAK FLOW RATE(CFS) =     227.03

****************************************************************************
```

```
  FLOW PROCESS FROM NODE  70045.00 TO NODE  70050.00 IS CODE =  41
----------------------------------------------------------------------------
  >>>>>COMPUTE PIPE-FLOW TRAVEL TIME THRU SUBAREA<<<<<
  >>>>>USING USER-SPECIFIED PIPESIZE (EXISTING ELEMENT)<<<<<
============================================================================
  ELEVATION DATA: UPSTREAM(FEET) =   100.00  DOWNSTREAM(FEET) =    98.70
  FLOW LENGTH(FEET) =   125.00   MANNING'S N =  0.013
  ASSUME FULL-FLOWING PIPELINE
  PIPE-FLOW VELOCITY(FEET/SEC.) =  32.12
  PIPE FLOW VELOCITY = (TOTAL FLOW)/(PIPE CROSS SECTION AREA)
  GIVEN PIPE DIAMETER(INCH) =  36.00    NUMBER OF PIPES =   1
  PIPE-FLOW(CFS) =     227.03
  PIPE TRAVEL TIME(MIN.) =   0.06    Tc(MIN.) =   12.96
  LONGEST FLOWPATH FROM NODE  71005.00 TO NODE  70050.00 =    4325.10 FEET.

****************************************************************************
  FLOW PROCESS FROM NODE  70050.00 TO NODE  70050.00 IS CODE =  81
----------------------------------------------------------------------------
  >>>>>ADDITION OF SUBAREA TO MAINLINE PEAK FLOW<<<<<
============================================================================
  MAINLINE Tc(MIN.) =   12.96
  * 100 YEAR RAINFALL INTENSITY(INCH/HR) =  3.135
  SUBAREA LOSS RATE DATA(AMC III):
   DEVELOPMENT TYPE/      SCS SOIL   AREA      Fp         Ap     SCS
       LAND USE            GROUP   (ACRES)  (INCH/HR)  (DECIMAL)  CN
  COMMERCIAL                 B        2.70      0.42     0.100    76
  SUBAREA AVERAGE PERVIOUS LOSS RATE, Fp(INCH/HR) =  0.42
  SUBAREA AVERAGE PERVIOUS AREA FRACTION, Ap =  0.100
  SUBAREA AREA(ACRES) =    2.70      SUBAREA RUNOFF(CFS) =    7.52
  EFFECTIVE AREA(ACRES) =     84.80   AREA-AVERAGED Fm(INCH/HR) =  0.07
  AREA-AVERAGED Fp(INCH/HR) =  0.42  AREA-AVERAGED Ap =  0.17
  TOTAL AREA(ACRES) =       86.7       PEAK FLOW RATE(CFS) =     233.85

****************************************************************************
  FLOW PROCESS FROM NODE  70050.00 TO NODE  70055.00 IS CODE =  41
----------------------------------------------------------------------------
  >>>>>COMPUTE PIPE-FLOW TRAVEL TIME THRU SUBAREA<<<<<
  >>>>>USING USER-SPECIFIED PIPESIZE (EXISTING ELEMENT)<<<<<
============================================================================
  ELEVATION DATA: UPSTREAM(FEET) =   100.00  DOWNSTREAM(FEET) =    98.00
  FLOW LENGTH(FEET) =   210.00   MANNING'S N =  0.013
  ASSUME FULL-FLOWING PIPELINE
  PIPE-FLOW VELOCITY(FEET/SEC.) =  33.08
  PIPE FLOW VELOCITY = (TOTAL FLOW)/(PIPE CROSS SECTION AREA)
  GIVEN PIPE DIAMETER(INCH) =  36.00    NUMBER OF PIPES =   1
  PIPE-FLOW(CFS) =     233.85
  PIPE TRAVEL TIME(MIN.) =   0.11    Tc(MIN.) =   13.07
  LONGEST FLOWPATH FROM NODE  71005.00 TO NODE  70055.00 =    4535.10 FEET.

****************************************************************************
  FLOW PROCESS FROM NODE  70055.00 TO NODE  70055.00 IS CODE =  81
----------------------------------------------------------------------------
  >>>>>ADDITION OF SUBAREA TO MAINLINE PEAK FLOW<<<<<
============================================================================
  MAINLINE Tc(MIN.) =   13.07
  * 100 YEAR RAINFALL INTENSITY(INCH/HR) =  3.120
  SUBAREA LOSS RATE DATA(AMC III):
   DEVELOPMENT TYPE/      SCS SOIL   AREA      Fp         Ap     SCS
       LAND USE            GROUP   (ACRES)  (INCH/HR)  (DECIMAL)  CN
  RESIDENTIAL
  "5-7 DWELLINGS/ACRE"       B        1.40      0.42     0.500    76
  COMMERCIAL                 B        2.20      0.42     0.100    76
  SUBAREA AVERAGE PERVIOUS LOSS RATE, Fp(INCH/HR) =  0.42
  SUBAREA AVERAGE PERVIOUS AREA FRACTION, Ap =  0.256
  SUBAREA AREA(ACRES) =    3.60      SUBAREA RUNOFF(CFS) =    9.76
  EFFECTIVE AREA(ACRES) =     88.40   AREA-AVERAGED Fm(INCH/HR) =  0.07
  AREA-AVERAGED Fp(INCH/HR) =  0.42  AREA-AVERAGED Ap =  0.17
  TOTAL AREA(ACRES) =       90.3       PEAK FLOW RATE(CFS) =     242.44

****************************************************************************
  FLOW PROCESS FROM NODE  70055.00 TO NODE  70060.00 IS CODE =  41
```

```
----------------------------------------------------------------------------
  >>>>>COMPUTE PIPE-FLOW TRAVEL TIME THRU SUBAREA<<<<<
  >>>>>USING USER-SPECIFIED PIPESIZE (EXISTING ELEMENT)<<<<<
============================================================================
  ELEVATION DATA: UPSTREAM(FEET) =   100.00  DOWNSTREAM(FEET) =    98.60
  FLOW LENGTH(FEET) =   140.00   MANNING'S N =  0.013
  ASSUME FULL-FLOWING PIPELINE
  PIPE-FLOW VELOCITY(FEET/SEC.) =  34.30
  PIPE FLOW VELOCITY = (TOTAL FLOW)/(PIPE CROSS SECTION AREA)
  GIVEN PIPE DIAMETER(INCH) =  36.00    NUMBER OF PIPES =   1
  PIPE-FLOW(CFS) =     242.44
  PIPE TRAVEL TIME(MIN.) =   0.07    Tc(MIN.) =   13.13
  LONGEST FLOWPATH FROM NODE  71005.00 TO NODE  70060.00 =    4675.10 FEET.

****************************************************************************
  FLOW PROCESS FROM NODE  70060.00 TO NODE  70060.00 IS CODE =  81
----------------------------------------------------------------------------
  >>>>>ADDITION OF SUBAREA TO MAINLINE PEAK FLOW<<<<<
============================================================================
  MAINLINE Tc(MIN.) =   13.13
  * 100 YEAR RAINFALL INTENSITY(INCH/HR) =  3.110
  SUBAREA LOSS RATE DATA(AMC III):
   DEVELOPMENT TYPE/      SCS SOIL   AREA      Fp         Ap     SCS
       LAND USE            GROUP   (ACRES)  (INCH/HR)  (DECIMAL)  CN
  COMMERCIAL                 B        2.00      0.42     0.100    76
  SUBAREA AVERAGE PERVIOUS LOSS RATE, Fp(INCH/HR) =  0.42
  SUBAREA AVERAGE PERVIOUS AREA FRACTION, Ap =  0.100
  SUBAREA AREA(ACRES) =    2.00      SUBAREA RUNOFF(CFS) =    5.52
  EFFECTIVE AREA(ACRES) =     90.40   AREA-AVERAGED Fm(INCH/HR) =  0.07
  AREA-AVERAGED Fp(INCH/HR) =  0.42  AREA-AVERAGED Ap =  0.17
  TOTAL AREA(ACRES) =       92.3       PEAK FLOW RATE(CFS) =     247.19

****************************************************************************
  FLOW PROCESS FROM NODE  70060.00 TO NODE  70065.00 IS CODE =  41
----------------------------------------------------------------------------
  >>>>>COMPUTE PIPE-FLOW TRAVEL TIME THRU SUBAREA<<<<<
  >>>>>USING USER-SPECIFIED PIPESIZE (EXISTING ELEMENT)<<<<<
============================================================================
  ELEVATION DATA: UPSTREAM(FEET) =   100.00  DOWNSTREAM(FEET) =    99.80
  FLOW LENGTH(FEET) =   120.00   MANNING'S N =  0.013
  ASSUME FULL-FLOWING PIPELINE
  PIPE-FLOW VELOCITY(FEET/SEC.) =  34.97
  PIPE FLOW VELOCITY = (TOTAL FLOW)/(PIPE CROSS SECTION AREA)
  GIVEN PIPE DIAMETER(INCH) =  36.00    NUMBER OF PIPES =   1
  PIPE-FLOW(CFS) =     247.19
  PIPE TRAVEL TIME(MIN.) =   0.06    Tc(MIN.) =   13.19
  LONGEST FLOWPATH FROM NODE  71005.00 TO NODE  70065.00 =    4795.10 FEET.

****************************************************************************
  FLOW PROCESS FROM NODE  70065.00 TO NODE  70065.00 IS CODE =  81
----------------------------------------------------------------------------
  >>>>>ADDITION OF SUBAREA TO MAINLINE PEAK FLOW<<<<<
============================================================================
  MAINLINE Tc(MIN.) =   13.19
  * 100 YEAR RAINFALL INTENSITY(INCH/HR) =  3.102
  SUBAREA LOSS RATE DATA(AMC III):
   DEVELOPMENT TYPE/      SCS SOIL   AREA      Fp         Ap     SCS
       LAND USE            GROUP   (ACRES)  (INCH/HR)  (DECIMAL)  CN
  COMMERCIAL                 B        0.60      0.42     0.100    76
  COMMERCIAL                 B        9.10      0.42     0.100    76
  SUBAREA AVERAGE PERVIOUS LOSS RATE, Fp(INCH/HR) =  0.42
  SUBAREA AVERAGE PERVIOUS AREA FRACTION, Ap =  0.100
  SUBAREA AREA(ACRES) =    9.70      SUBAREA RUNOFF(CFS) =   26.71
  EFFECTIVE AREA(ACRES) =    100.10   AREA-AVERAGED Fm(INCH/HR) =  0.07
  AREA-AVERAGED Fp(INCH/HR) =  0.42  AREA-AVERAGED Ap =  0.16
  TOTAL AREA(ACRES) =      102.0       PEAK FLOW RATE(CFS) =     273.25

****************************************************************************
  FLOW PROCESS FROM NODE  70065.00 TO NODE  70070.00 IS CODE =  41
----------------------------------------------------------------------------
  >>>>>COMPUTE PIPE-FLOW TRAVEL TIME THRU SUBAREA<<<<<
```

```
  >>>>>USING USER-SPECIFIED PIPESIZE (EXISTING ELEMENT)<<<<<
============================================================================
  ELEVATION DATA: UPSTREAM(FEET) =   100.00  DOWNSTREAM(FEET) =    98.10
  FLOW LENGTH(FEET) =   190.00   MANNING'S N =  0.013
  ASSUME FULL-FLOWING PIPELINE
  PIPE-FLOW VELOCITY(FEET/SEC.) =  38.66
  PIPE FLOW VELOCITY = (TOTAL FLOW)/(PIPE CROSS SECTION AREA)
  GIVEN PIPE DIAMETER(INCH) =  36.00    NUMBER OF PIPES =   1
  PIPE-FLOW(CFS) =     273.25
  PIPE TRAVEL TIME(MIN.) =   0.08    Tc(MIN.) =   13.27
  LONGEST FLOWPATH FROM NODE  71005.00 TO NODE  70070.00 =    4985.10 FEET.

****************************************************************************
  FLOW PROCESS FROM NODE  70070.00 TO NODE  70070.00 IS CODE =  81
----------------------------------------------------------------------------
  >>>>>ADDITION OF SUBAREA TO MAINLINE PEAK FLOW<<<<<
============================================================================
  MAINLINE Tc(MIN.) =   13.27
  * 100 YEAR RAINFALL INTENSITY(INCH/HR) =  3.091
  SUBAREA LOSS RATE DATA(AMC III):
   DEVELOPMENT TYPE/      SCS SOIL   AREA      Fp         Ap     SCS
       LAND USE            GROUP   (ACRES)  (INCH/HR)  (DECIMAL)  CN
  COMMERCIAL                 B        0.60      0.42     0.100    76
  COMMERCIAL                 B        1.70      0.42     0.100    76
  RESIDENTIAL
  "5-7 DWELLINGS/ACRE"       B        1.00      0.42     0.500    76
  PUBLIC PARK                B        1.20      0.42     0.850    76
  COMMERCIAL                 B        1.00      0.42     0.100    76
  SUBAREA AVERAGE PERVIOUS LOSS RATE, Fp(INCH/HR) =  0.42
  SUBAREA AVERAGE PERVIOUS AREA FRACTION, Ap =  0.336
  SUBAREA AREA(ACRES) =    5.50      SUBAREA RUNOFF(CFS) =   14.59
  EFFECTIVE AREA(ACRES) =    105.60   AREA-AVERAGED Fm(INCH/HR) =  0.07
  AREA-AVERAGED Fp(INCH/HR) =  0.42  AREA-AVERAGED Ap =  0.17
  TOTAL AREA(ACRES) =      107.5       PEAK FLOW RATE(CFS) =     286.80

****************************************************************************
  FLOW PROCESS FROM NODE  70070.00 TO NODE  72005.00 IS CODE =  41
----------------------------------------------------------------------------
  >>>>>COMPUTE PIPE-FLOW TRAVEL TIME THRU SUBAREA<<<<<
  >>>>>USING USER-SPECIFIED PIPESIZE (EXISTING ELEMENT)<<<<<
============================================================================
  ELEVATION DATA: UPSTREAM(FEET) =   100.00  DOWNSTREAM(FEET) =    95.70
  FLOW LENGTH(FEET) =   430.00   MANNING'S N =  0.013
  ASSUME FULL-FLOWING PIPELINE
  PIPE-FLOW VELOCITY(FEET/SEC.) =  40.57
  PIPE FLOW VELOCITY = (TOTAL FLOW)/(PIPE CROSS SECTION AREA)
  GIVEN PIPE DIAMETER(INCH) =  36.00    NUMBER OF PIPES =   1
  PIPE-FLOW(CFS) =     286.80
  PIPE TRAVEL TIME(MIN.) =   0.18    Tc(MIN.) =   13.45
  LONGEST FLOWPATH FROM NODE  71005.00 TO NODE  72005.00 =    5415.10 FEET.

****************************************************************************
  FLOW PROCESS FROM NODE  72005.00 TO NODE  72005.00 IS CODE =  81
----------------------------------------------------------------------------
  >>>>>ADDITION OF SUBAREA TO MAINLINE PEAK FLOW<<<<<
============================================================================
  MAINLINE Tc(MIN.) =   13.45
  * 100 YEAR RAINFALL INTENSITY(INCH/HR) =  3.066
  SUBAREA LOSS RATE DATA(AMC III):
   DEVELOPMENT TYPE/      SCS SOIL   AREA      Fp         Ap     SCS
       LAND USE            GROUP   (ACRES)  (INCH/HR)  (DECIMAL)  CN
  COMMERCIAL                 B        0.80      0.42     0.100    76
  COMMERCIAL                 B        2.40      0.42     0.100    76
  PUBLIC PARK                B        3.00      0.42     0.850    76
  SUBAREA AVERAGE PERVIOUS LOSS RATE, Fp(INCH/HR) =  0.42
  SUBAREA AVERAGE PERVIOUS AREA FRACTION, Ap =  0.463
  SUBAREA AREA(ACRES) =    6.20      SUBAREA RUNOFF(CFS) =   16.02
  EFFECTIVE AREA(ACRES) =    111.80   AREA-AVERAGED Fm(INCH/HR) =  0.08
  AREA-AVERAGED Fp(INCH/HR) =  0.42  AREA-AVERAGED Ap =  0.19
  TOTAL AREA(ACRES) =      113.7       PEAK FLOW RATE(CFS) =     300.50
```

```
****************************************************************************
  FLOW PROCESS FROM NODE  72005.00 TO NODE  72010.00 IS CODE =  41
----------------------------------------------------------------------------
  >>>>>COMPUTE PIPE-FLOW TRAVEL TIME THRU SUBAREA<<<<<
  >>>>>USING USER-SPECIFIED PIPESIZE (EXISTING ELEMENT)<<<<<
============================================================================
  ELEVATION DATA: UPSTREAM(FEET) =   100.00  DOWNSTREAM(FEET) =    85.20
  FLOW LENGTH(FEET) =  1420.00   MANNING'S N =  0.013
  ASSUME FULL-FLOWING PIPELINE
  PIPE-FLOW VELOCITY(FEET/SEC.) =  42.51
  PIPE FLOW VELOCITY = (TOTAL FLOW)/(PIPE CROSS SECTION AREA)
  GIVEN PIPE DIAMETER(INCH) =  36.00    NUMBER OF PIPES =   1
  PIPE-FLOW(CFS) =     300.50
  PIPE TRAVEL TIME(MIN.) =   0.56    Tc(MIN.) =   14.01
  LONGEST FLOWPATH FROM NODE  71005.00 TO NODE  72010.00 =    6835.10 FEET.

****************************************************************************
  FLOW PROCESS FROM NODE  72010.00 TO NODE  72010.00 IS CODE =  81
----------------------------------------------------------------------------
  >>>>>ADDITION OF SUBAREA TO MAINLINE PEAK FLOW<<<<<
============================================================================
  MAINLINE Tc(MIN.) =   14.01
  * 100 YEAR RAINFALL INTENSITY(INCH/HR) =  2.992
  SUBAREA LOSS RATE DATA(AMC III):
   DEVELOPMENT TYPE/      SCS SOIL   AREA      Fp         Ap     SCS
       LAND USE            GROUP   (ACRES)  (INCH/HR)  (DECIMAL)  CN
  COMMERCIAL                 B        7.50      0.42     0.100    76
  PUBLIC PARK                B        9.30      0.42     0.850    76
  COMMERCIAL                 B        1.70      0.42     0.100    76
  COMMERCIAL                 B       11.00      0.42     0.100    76
  COMMERCIAL                 B        4.60      0.42     0.100    76
  COMMERCIAL                 B        5.60      0.42     0.100    76
  SUBAREA AVERAGE PERVIOUS LOSS RATE, Fp(INCH/HR) =  0.42
  SUBAREA AVERAGE PERVIOUS AREA FRACTION, Ap =  0.276
  SUBAREA AREA(ACRES) =   39.70      SUBAREA RUNOFF(CFS) =  102.75
  EFFECTIVE AREA(ACRES) =    151.50   AREA-AVERAGED Fm(INCH/HR) =  0.09
  AREA-AVERAGED Fp(INCH/HR) =  0.42  AREA-AVERAGED Ap =  0.21
  TOTAL AREA(ACRES) =      153.4       PEAK FLOW RATE(CFS) =     395.83

****************************************************************************
  FLOW PROCESS FROM NODE  72010.00 TO NODE  72010.00 IS CODE =  81
----------------------------------------------------------------------------
  >>>>>ADDITION OF SUBAREA TO MAINLINE PEAK FLOW<<<<<
============================================================================
  MAINLINE Tc(MIN.) =   14.01
  * 100 YEAR RAINFALL INTENSITY(INCH/HR) =  2.992
  SUBAREA LOSS RATE DATA(AMC III):
   DEVELOPMENT TYPE/      SCS SOIL   AREA      Fp         Ap     SCS
       LAND USE            GROUP   (ACRES)  (INCH/HR)  (DECIMAL)  CN
  COMMERCIAL                 B        1.80      0.42     0.100    76
  SUBAREA AVERAGE PERVIOUS LOSS RATE, Fp(INCH/HR) =  0.42
  SUBAREA AVERAGE PERVIOUS AREA FRACTION, Ap =  0.100
  SUBAREA AREA(ACRES) =    1.80      SUBAREA RUNOFF(CFS) =    4.78
  EFFECTIVE AREA(ACRES) =    153.30   AREA-AVERAGED Fm(INCH/HR) =  0.09
  AREA-AVERAGED Fp(INCH/HR) =  0.42  AREA-AVERAGED Ap =  0.21
  TOTAL AREA(ACRES) =      155.2       PEAK FLOW RATE(CFS) =     400.61

****************************************************************************
  FLOW PROCESS FROM NODE  72010.00 TO NODE  72015.00 IS CODE =  41
----------------------------------------------------------------------------
  >>>>>COMPUTE PIPE-FLOW TRAVEL TIME THRU SUBAREA<<<<<
  >>>>>USING USER-SPECIFIED PIPESIZE (EXISTING ELEMENT)<<<<<
============================================================================
  ELEVATION DATA: UPSTREAM(FEET) =   100.00  DOWNSTREAM(FEET) =    98.80
  FLOW LENGTH(FEET) =   120.00   MANNING'S N =  0.013
  ASSUME FULL-FLOWING PIPELINE
  PIPE-FLOW VELOCITY(FEET/SEC.) =  41.64
  PIPE FLOW VELOCITY = (TOTAL FLOW)/(PIPE CROSS SECTION AREA)
  GIVEN PIPE DIAMETER(INCH) =  42.00    NUMBER OF PIPES =   1
  PIPE-FLOW(CFS) =     400.61
  PIPE TRAVEL TIME(MIN.) =   0.05    Tc(MIN.) =   14.05
```

```
  LONGEST FLOWPATH FROM NODE  71005.00 TO NODE  72015.00 =    6955.10 FEET.

****************************************************************************
  FLOW PROCESS FROM NODE  72015.00 TO NODE  72015.00 IS CODE =   1
----------------------------------------------------------------------------
  >>>>>DESIGNATE INDEPENDENT STREAM FOR CONFLUENCE<<<<<
============================================================================
  TOTAL NUMBER OF STREAMS =  2
  CONFLUENCE VALUES USED FOR INDEPENDENT STREAM  1 ARE:
  TIME OF CONCENTRATION(MIN.) =   14.05
  RAINFALL INTENSITY(INCH/HR) =   2.99
  AREA-AVERAGED Fm(INCH/HR) =  0.09
  AREA-AVERAGED Fp(INCH/HR) =  0.42
  AREA-AVERAGED Ap =  0.21
  EFFECTIVE STREAM AREA(ACRES) =     153.30
  TOTAL STREAM AREA(ACRES) =     155.20
  PEAK FLOW RATE(CFS) AT CONFLUENCE =     400.61

****************************************************************************
  FLOW PROCESS FROM NODE  73000.00 TO NODE  73005.00 IS CODE =  21
----------------------------------------------------------------------------
  >>>>>RATIONAL METHOD INITIAL SUBAREA ANALYSIS<<<<<
  >>USE TIME-OF-CONCENTRATION NOMOGRAPH FOR INITIAL SUBAREA<<
============================================================================
  INITIAL SUBAREA FLOW-LENGTH(FEET) =   330.00
  ELEVATION DATA: UPSTREAM(FEET) =   1337.00  DOWNSTREAM(FEET) =   1332.00

  Tc = K*[(LENGTH** 3.00)/(ELEVATION CHANGE)]**0.20
  SUBAREA ANALYSIS USED MINIMUM Tc(MIN.) =   11.357
  * 100 YEAR RAINFALL INTENSITY(INCH/HR) =  3.393
  SUBAREA Tc AND LOSS RATE DATA(AMC III):
   DEVELOPMENT TYPE/      SCS SOIL   AREA      Fp         Ap     SCS   Tc
       LAND USE            GROUP   (ACRES)  (INCH/HR)  (DECIMAL)  CN  (MIN.)
  PUBLIC PARK                B       0.90      0.42     0.850    76   11.36
  SUBAREA AVERAGE PERVIOUS LOSS RATE, Fp(INCH/HR) =  0.42
  SUBAREA AVERAGE PERVIOUS AREA FRACTION, Ap =  0.850
  SUBAREA RUNOFF(CFS) =      2.46
  TOTAL AREA(ACRES) =      0.90   PEAK FLOW RATE(CFS) =      2.46

****************************************************************************
  FLOW PROCESS FROM NODE  73005.00 TO NODE  73010.00 IS CODE =  51
----------------------------------------------------------------------------
  >>>>>COMPUTE TRAPEZOIDAL CHANNEL FLOW<<<<<
  >>>>>TRAVELTIME THRU SUBAREA (EXISTING ELEMENT)<<<<<
============================================================================
  ELEVATION DATA: UPSTREAM(FEET) =   1332.00  DOWNSTREAM(FEET) =   1327.00
  CHANNEL LENGTH THRU SUBAREA(FEET) =   240.00   CHANNEL SLOPE =  0.0208
  CHANNEL BASE(FEET) =    2.00   "Z" FACTOR =   3.000
  MANNING'S FACTOR = 0.015   MAXIMUM DEPTH(FEET) =   1.00
  * 100 YEAR RAINFALL INTENSITY(INCH/HR) =  3.257
  SUBAREA LOSS RATE DATA(AMC III):
   DEVELOPMENT TYPE/      SCS SOIL   AREA      Fp         Ap     SCS
       LAND USE            GROUP   (ACRES)  (INCH/HR)  (DECIMAL)  CN
  COMMERCIAL                 B       0.90      0.42     0.100    76
  SUBAREA AVERAGE PERVIOUS LOSS RATE, Fp(INCH/HR) =  0.42
  SUBAREA AVERAGE PERVIOUS AREA FRACTION, Ap =  0.100
  TRAVEL TIME COMPUTED USING ESTIMATED FLOW(CFS) =       3.76
  TRAVEL TIME THRU SUBAREA BASED ON VELOCITY(FEET/SEC.) =   4.96
  AVERAGE FLOW DEPTH(FEET) =   0.27   TRAVEL TIME(MIN.) =   0.81
  Tc(MIN.) =   12.16
  SUBAREA AREA(ACRES) =     0.90       SUBAREA RUNOFF(CFS) =    2.60
  EFFECTIVE AREA(ACRES) =      1.80     AREA-AVERAGED Fm(INCH/HR) =   0.20
  AREA-AVERAGED Fp(INCH/HR) =   0.42  AREA-AVERAGED Ap =   0.47
  TOTAL AREA(ACRES) =        1.8         PEAK FLOW RATE(CFS) =       4.95

  END OF SUBAREA CHANNEL FLOW HYDRAULICS:
  DEPTH(FEET) =  0.32   FLOW VELOCITY(FEET/SEC.) =   5.32
  LONGEST FLOWPATH FROM NODE  73000.00 TO NODE  73010.00 =     570.00 FEET.

****************************************************************************
  FLOW PROCESS FROM NODE  73010.00 TO NODE  73015.00 IS CODE =  51
```

```
----------------------------------------------------------------------------
  >>>>>COMPUTE TRAPEZOIDAL CHANNEL FLOW<<<<<
  >>>>>TRAVELTIME THRU SUBAREA (EXISTING ELEMENT)<<<<<
============================================================================
  ELEVATION DATA: UPSTREAM(FEET) =   1327.00  DOWNSTREAM(FEET) =   1318.00
  CHANNEL LENGTH THRU SUBAREA(FEET) =   477.00   CHANNEL SLOPE =  0.0189
  CHANNEL BASE(FEET) =    2.00   "Z" FACTOR =   3.000
  MANNING'S FACTOR = 0.015   MAXIMUM DEPTH(FEET) =   1.00
  * 100 YEAR RAINFALL INTENSITY(INCH/HR) =  3.054
  SUBAREA LOSS RATE DATA(AMC III):
   DEVELOPMENT TYPE/      SCS SOIL   AREA      Fp         Ap     SCS
       LAND USE            GROUP   (ACRES)  (INCH/HR)  (DECIMAL)  CN
  PUBLIC PARK                B       1.90      0.42      0.850    76
  SUBAREA AVERAGE PERVIOUS LOSS RATE, Fp(INCH/HR) =  0.42
  SUBAREA AVERAGE PERVIOUS AREA FRACTION, Ap =  0.850
  TRAVEL TIME COMPUTED USING ESTIMATED FLOW(CFS) =       7.26
  TRAVEL TIME THRU SUBAREA BASED ON VELOCITY(FEET/SEC.) =   5.79
  AVERAGE FLOW DEPTH(FEET) =   0.39   TRAVEL TIME(MIN.) =   1.37
  Tc(MIN.) =   13.54
  SUBAREA AREA(ACRES) =     1.90       SUBAREA RUNOFF(CFS) =    4.61
  EFFECTIVE AREA(ACRES) =      3.70     AREA-AVERAGED Fm(INCH/HR) =   0.28
  AREA-AVERAGED Fp(INCH/HR) =   0.42  AREA-AVERAGED Ap =   0.67
  TOTAL AREA(ACRES) =        3.7         PEAK FLOW RATE(CFS) =       9.23

  END OF SUBAREA CHANNEL FLOW HYDRAULICS:
  DEPTH(FEET) =  0.45   FLOW VELOCITY(FEET/SEC.) =   6.21
  LONGEST FLOWPATH FROM NODE  73000.00 TO NODE  73015.00 =    1047.00 FEET.

****************************************************************************
  FLOW PROCESS FROM NODE  73015.00 TO NODE  72015.00 IS CODE =  51
----------------------------------------------------------------------------
  >>>>>COMPUTE TRAPEZOIDAL CHANNEL FLOW<<<<<
  >>>>>TRAVELTIME THRU SUBAREA (EXISTING ELEMENT)<<<<<
============================================================================
  ELEVATION DATA: UPSTREAM(FEET) =   1318.00  DOWNSTREAM(FEET) =   1315.00
  CHANNEL LENGTH THRU SUBAREA(FEET) =   410.00   CHANNEL SLOPE =  0.0073
  CHANNEL BASE(FEET) =    2.00   "Z" FACTOR =   3.000
  MANNING'S FACTOR = 0.015   MAXIMUM DEPTH(FEET) =   2.00
  * 100 YEAR RAINFALL INTENSITY(INCH/HR) =  2.872
  SUBAREA LOSS RATE DATA(AMC III):
   DEVELOPMENT TYPE/      SCS SOIL   AREA      Fp         Ap     SCS
       LAND USE            GROUP   (ACRES)  (INCH/HR)  (DECIMAL)  CN
  COMMERCIAL                 B       1.70      0.42      0.100    76
  SUBAREA AVERAGE PERVIOUS LOSS RATE, Fp(INCH/HR) =  0.42
  SUBAREA AVERAGE PERVIOUS AREA FRACTION, Ap =  0.100
  TRAVEL TIME COMPUTED USING ESTIMATED FLOW(CFS) =      11.39
  TRAVEL TIME THRU SUBAREA BASED ON VELOCITY(FEET/SEC.) =   4.67
  AVERAGE FLOW DEPTH(FEET) =   0.63   TRAVEL TIME(MIN.) =   1.46
  Tc(MIN.) =   15.00
  SUBAREA AREA(ACRES) =     1.70       SUBAREA RUNOFF(CFS) =    4.33
  EFFECTIVE AREA(ACRES) =      5.40     AREA-AVERAGED Fm(INCH/HR) =   0.21
  AREA-AVERAGED Fp(INCH/HR) =   0.42  AREA-AVERAGED Ap =   0.49
  TOTAL AREA(ACRES) =        5.4         PEAK FLOW RATE(CFS) =      12.95

  END OF SUBAREA CHANNEL FLOW HYDRAULICS:
  DEPTH(FEET) =  0.67   FLOW VELOCITY(FEET/SEC.) =   4.84
  LONGEST FLOWPATH FROM NODE  73000.00 TO NODE  72015.00 =    1457.00 FEET.

****************************************************************************
  FLOW PROCESS FROM NODE  72015.00 TO NODE  72015.00 IS CODE =   1
----------------------------------------------------------------------------
  >>>>>DESIGNATE INDEPENDENT STREAM FOR CONFLUENCE<<<<<
  >>>>>AND COMPUTE VARIOUS CONFLUENCED STREAM VALUES<<<<<
============================================================================
  TOTAL NUMBER OF STREAMS =  2
  CONFLUENCE VALUES USED FOR INDEPENDENT STREAM  2 ARE:
  TIME OF CONCENTRATION(MIN.) =   15.00
  RAINFALL INTENSITY(INCH/HR) =   2.87
  AREA-AVERAGED Fm(INCH/HR) =  0.21
  AREA-AVERAGED Fp(INCH/HR) =  0.42
  AREA-AVERAGED Ap =  0.49
```

```
  EFFECTIVE STREAM AREA(ACRES) =       5.40
  TOTAL STREAM AREA(ACRES) =       5.40
  PEAK FLOW RATE(CFS) AT CONFLUENCE =      12.95

  ** CONFLUENCE DATA **
   STREAM       Q      Tc   Intensity   Fp(Fm)     Ap     Ae     HEADWATER
   NUMBER     (CFS)  (MIN.) (INCH/HR) (INCH/HR)         (ACRES)    NODE
      1      400.61   14.05    2.986  0.42( 0.09) 0.21     153.3   71005.00
      1      361.68   16.90    2.673  0.42( 0.09) 0.21     155.2   70005.00
      2       12.95   15.00    2.872  0.42( 0.21) 0.49       5.4   73000.00

  RAINFALL INTENSITY AND TIME OF CONCENTRATION RATIO
  CONFLUENCE FORMULA USED FOR  2 STREAMS.

  ** PEAK FLOW RATE TABLE **
   STREAM       Q      Tc   Intensity   Fp(Fm)     Ap     Ae     HEADWATER
   NUMBER     (CFS)  (MIN.) (INCH/HR) (INCH/HR)         (ACRES)    NODE
      1      413.27   14.05    2.986  0.42( 0.09) 0.22     158.4   71005.00
      2      400.62   15.00    2.872  0.42( 0.09) 0.22     159.3   73000.00
      3      373.67   16.90    2.673  0.42( 0.09) 0.22     160.6   70005.00

  COMPUTED CONFLUENCE ESTIMATES ARE AS FOLLOWS:
  PEAK FLOW RATE(CFS) =     413.27    Tc(MIN.) =    14.05
  EFFECTIVE AREA(ACRES) =     158.35   AREA-AVERAGED Fm(INCH/HR) =  0.09
  AREA-AVERAGED Fp(INCH/HR) =  0.42  AREA-AVERAGED Ap =  0.22
  TOTAL AREA(ACRES) =      160.6
  LONGEST FLOWPATH FROM NODE  71005.00 TO NODE  72015.00 =    6955.10 FEET.

****************************************************************************
  FLOW PROCESS FROM NODE  72015.00 TO NODE  72020.00 IS CODE =  41
----------------------------------------------------------------------------
  >>>>>COMPUTE PIPE-FLOW TRAVEL TIME THRU SUBAREA<<<<<
  >>>>>USING USER-SPECIFIED PIPESIZE (EXISTING ELEMENT)<<<<<
============================================================================
  ELEVATION DATA: UPSTREAM(FEET) =   100.00  DOWNSTREAM(FEET) =    97.90
  FLOW LENGTH(FEET) =   210.00   MANNING'S N =  0.013
  ASSUME FULL-FLOWING PIPELINE
  PIPE-FLOW VELOCITY(FEET/SEC.) =  42.95
  PIPE FLOW VELOCITY = (TOTAL FLOW)/(PIPE CROSS SECTION AREA)
  GIVEN PIPE DIAMETER(INCH) =  42.00    NUMBER OF PIPES =   1
  PIPE-FLOW(CFS) =     413.27
  PIPE TRAVEL TIME(MIN.) =   0.08    Tc(MIN.) =   14.14
  LONGEST FLOWPATH FROM NODE  71005.00 TO NODE  72020.00 =    7165.10 FEET.

****************************************************************************
  FLOW PROCESS FROM NODE  72020.00 TO NODE  72020.00 IS CODE =   1
----------------------------------------------------------------------------
  >>>>>DESIGNATE INDEPENDENT STREAM FOR CONFLUENCE<<<<<
============================================================================
  TOTAL NUMBER OF STREAMS =  2
  CONFLUENCE VALUES USED FOR INDEPENDENT STREAM  1 ARE:
  TIME OF CONCENTRATION(MIN.) =   14.14
  RAINFALL INTENSITY(INCH/HR) =   2.98
  AREA-AVERAGED Fm(INCH/HR) =  0.09
  AREA-AVERAGED Fp(INCH/HR) =  0.42
  AREA-AVERAGED Ap =  0.22
  EFFECTIVE STREAM AREA(ACRES) =     158.35
  TOTAL STREAM AREA(ACRES) =     160.60
  PEAK FLOW RATE(CFS) AT CONFLUENCE =     413.27

****************************************************************************
  FLOW PROCESS FROM NODE  74005.00 TO NODE  74010.00 IS CODE =  21
----------------------------------------------------------------------------
  >>>>>RATIONAL METHOD INITIAL SUBAREA ANALYSIS<<<<<
  >>USE TIME-OF-CONCENTRATION NOMOGRAPH FOR INITIAL SUBAREA<<
============================================================================
  INITIAL SUBAREA FLOW-LENGTH(FEET) =  1000.00
  ELEVATION DATA: UPSTREAM(FEET) =   1338.00  DOWNSTREAM(FEET) =   1320.00

  Tc = K*[(LENGTH** 3.00)/(ELEVATION CHANGE)]**0.20
  SUBAREA ANALYSIS USED MINIMUM Tc(MIN.) =   17.096
```

```
  * 100 YEAR RAINFALL INTENSITY(INCH/HR) =  2.655
  SUBAREA Tc AND LOSS RATE DATA(AMC III):
   DEVELOPMENT TYPE/      SCS SOIL   AREA      Fp         Ap     SCS   Tc
       LAND USE             GROUP   (ACRES)  (INCH/HR)  (DECIMAL)  CN  (MIN.)
  PUBLIC PARK                 B       2.50      0.42     0.850    76   17.10
  SUBAREA AVERAGE PERVIOUS LOSS RATE, Fp(INCH/HR) =  0.42
  SUBAREA AVERAGE PERVIOUS AREA FRACTION, Ap =  0.850
  SUBAREA RUNOFF(CFS) =      5.16
  TOTAL AREA(ACRES) =      2.50   PEAK FLOW RATE(CFS) =      5.16

****************************************************************************
  FLOW PROCESS FROM NODE  74010.00 TO NODE  72020.00 IS CODE =  51
----------------------------------------------------------------------------
  >>>>>COMPUTE TRAPEZOIDAL CHANNEL FLOW<<<<<
  >>>>>TRAVELTIME THRU SUBAREA (EXISTING ELEMENT)<<<<<
============================================================================
  ELEVATION DATA: UPSTREAM(FEET) =   1320.00  DOWNSTREAM(FEET) =   1314.00
  CHANNEL LENGTH THRU SUBAREA(FEET) =   570.00   CHANNEL SLOPE =  0.0105
  CHANNEL BASE(FEET) =    2.00   "Z" FACTOR =   3.000
  MANNING'S FACTOR = 0.015   MAXIMUM DEPTH(FEET) =   2.00
  * 100 YEAR RAINFALL INTENSITY(INCH/HR) =  2.488
  SUBAREA LOSS RATE DATA(AMC III):
   DEVELOPMENT TYPE/      SCS SOIL   AREA      Fp         Ap     SCS
       LAND USE             GROUP   (ACRES)  (INCH/HR)  (DECIMAL)  CN
  COMMERCIAL                  B       2.70      0.42     0.100    76
  SUBAREA AVERAGE PERVIOUS LOSS RATE, Fp(INCH/HR) =  0.42
  SUBAREA AVERAGE PERVIOUS AREA FRACTION, Ap =  0.100
  TRAVEL TIME COMPUTED USING ESTIMATED FLOW(CFS) =       8.14
  TRAVEL TIME THRU SUBAREA BASED ON VELOCITY(FEET/SEC.) =   4.85
  AVERAGE FLOW DEPTH(FEET) =   0.49   TRAVEL TIME(MIN.) =   1.96
  Tc(MIN.) =   19.05
  SUBAREA AREA(ACRES) =     2.70       SUBAREA RUNOFF(CFS) =    5.94
  EFFECTIVE AREA(ACRES) =      5.20     AREA-AVERAGED Fm(INCH/HR) =   0.19
  AREA-AVERAGED Fp(INCH/HR) =   0.42  AREA-AVERAGED Ap =   0.46
  TOTAL AREA(ACRES) =        5.2         PEAK FLOW RATE(CFS) =      10.73

  END OF SUBAREA CHANNEL FLOW HYDRAULICS:
  DEPTH(FEET) =  0.56   FLOW VELOCITY(FEET/SEC.) =   5.21
  LONGEST FLOWPATH FROM NODE  74005.00 TO NODE  72020.00 =    1570.00 FEET.

****************************************************************************
  FLOW PROCESS FROM NODE  72020.00 TO NODE  72020.00 IS CODE =   1
----------------------------------------------------------------------------
  >>>>>DESIGNATE INDEPENDENT STREAM FOR CONFLUENCE<<<<<
  >>>>>AND COMPUTE VARIOUS CONFLUENCED STREAM VALUES<<<<<
============================================================================
  TOTAL NUMBER OF STREAMS =  2
  CONFLUENCE VALUES USED FOR INDEPENDENT STREAM  2 ARE:
  TIME OF CONCENTRATION(MIN.) =   19.05
  RAINFALL INTENSITY(INCH/HR) =   2.49
  AREA-AVERAGED Fm(INCH/HR) =  0.19
  AREA-AVERAGED Fp(INCH/HR) =  0.42
  AREA-AVERAGED Ap =  0.46
  EFFECTIVE STREAM AREA(ACRES) =       5.20
  TOTAL STREAM AREA(ACRES) =       5.20
  PEAK FLOW RATE(CFS) AT CONFLUENCE =      10.73

  ** CONFLUENCE DATA **
   STREAM       Q      Tc   Intensity   Fp(Fm)     Ap     Ae     HEADWATER
   NUMBER     (CFS)  (MIN.) (INCH/HR) (INCH/HR)         (ACRES)    NODE
      1      413.27   14.14    2.976  0.42( 0.09) 0.22     158.4   71005.00
      1      400.62   15.09    2.862  0.42( 0.09) 0.22     159.3   73000.00
      1      373.67   16.99    2.665  0.42( 0.09) 0.22     160.6   70005.00
      2       10.73   19.05    2.488  0.42( 0.19) 0.46       5.2   74005.00

  RAINFALL INTENSITY AND TIME OF CONCENTRATION RATIO
  CONFLUENCE FORMULA USED FOR  2 STREAMS.

  ** PEAK FLOW RATE TABLE **
   STREAM       Q      Tc   Intensity   Fp(Fm)     Ap     Ae     HEADWATER
   NUMBER     (CFS)  (MIN.) (INCH/HR) (INCH/HR)         (ACRES)    NODE
```

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 1 | 422.92 | 14.14 | 2.976 | 0.42( 0.09) | 0.22 | 162.2 | 71005.00 |
| 2 | 410.51 | 15.09 | 2.862 | 0.42( 0.10) | 0.23 | 163.4 | 73000.00 |
| 3 | 383.98 | 16.99 | 2.665 | 0.42( 0.10) | 0.23 | 165.2 | 70005.00 |
| 4 | 358.71 | 19.05 | 2.488 | 0.42( 0.10) | 0.23 | 165.8 | 74005.00 |

```
 COMPUTED CONFLUENCE ESTIMATES ARE AS FOLLOWS:
 PEAK FLOW RATE(CFS) =     422.92    Tc(MIN.) =    14.14
 EFFECTIVE AREA(ACRES) =     162.21   AREA-AVERAGED Fm(INCH/HR) =  0.09
 AREA-AVERAGED Fp(INCH/HR) =  0.42  AREA-AVERAGED Ap =  0.22
 TOTAL AREA(ACRES) =      165.8
 LONGEST FLOWPATH FROM NODE  71005.00 TO NODE  72020.00 =    7165.10 FEET.
============================================================================
 END OF STUDY SUMMARY:
 TOTAL AREA(ACRES)     =      165.8  TC(MIN.) =     14.14
 EFFECTIVE AREA(ACRES) =    162.21  AREA-AVERAGED Fm(INCH/HR)=  0.09
 AREA-AVERAGED Fp(INCH/HR) =  0.42  AREA-AVERAGED Ap = 0.224
 PEAK FLOW RATE(CFS)   =     422.92

 ** PEAK FLOW RATE TABLE **
```

| STREAM NUMBER | Q (CFS) | Tc (MIN.) | Intensity (INCH/HR) | Fp(Fm) (INCH/HR) | Ap | Ae (ACRES) | HEADWATER NODE |
|---|---|---|---|---|---|---|---|
| 1 | 422.92 | 14.14 | 2.976 | 0.42( 0.09) | 0.22 | 162.2 | 71005.00 |
| 2 | 410.51 | 15.09 | 2.862 | 0.42( 0.10) | 0.23 | 163.4 | 73000.00 |
| 3 | 383.98 | 16.99 | 2.665 | 0.42( 0.10) | 0.23 | 165.2 | 70005.00 |
| 4 | 358.71 | 19.05 | 2.488 | 0.42( 0.10) | 0.23 | 165.8 | 74005.00 |

```
============================================================================
============================================================================
 END OF RATIONAL METHOD ANALYSIS
```

```
****************************************************************************
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            Ver. 15.0  Release Date: 04/01/2008  License ID 1555

                          Analysis prepared by:



 ************************** DESCRIPTION OF STUDY **************************
* REDLANDS PASSENGER RAIL                                                  *
* EXISTING HYDROLOGY 100 YEAR EVENT                                        *
* BASIN 80000                                                              *
 **************************************************************************

  FILE NAME: C:\RPRP\EPRP\80000.DAT
  TIME/DATE OF STUDY: 13:14 02/13/2012
============================================================================
  USER SPECIFIED HYDROLOGY AND HYDRAULIC MODEL INFORMATION:
============================================================================
                   --*TIME-OF-CONCENTRATION MODEL*--

  USER SPECIFIED STORM EVENT(YEAR) =  100.00
  SPECIFIED MINIMUM PIPE SIZE(INCH) =  12.00
  SPECIFIED PERCENT OF GRADIENTS(DECIMAL) TO USE FOR FRICTION SLOPE = 0.90
  *USER-DEFINED LOGARITHMIC INTERPOLATION USED FOR RAINFALL*

  SLOPE OF INTENSITY DURATION CURVE(LOG(I;IN/HR) vs. LOG(Tc;MIN)) = 0.6000
  USER SPECIFIED 1-HOUR INTENSITY(INCH/HOUR) = 1.2500

  *ANTECEDENT MOISTURE CONDITION (AMC) III ASSUMED FOR RATIONAL METHOD*

  *USER-DEFINED STREET-SECTIONS FOR COUPLED PIPEFLOW AND STREETFLOW MODEL*
```

| NO. | HALF- WIDTH (FT) | CROWN TO CROSSFALL (FT) | STREET-CROSSFALL: IN- / OUT-/PARK- SIDE / SIDE/ WAY | CURB HEIGHT (FT) | GUTTER-GEOMETRIES: WIDTH (FT) | LIP (FT) | HIKE (FT) | MANNING FACTOR (n) |
|---|---|---|---|---|---|---|---|---|
| 1 | 30.0 | 20.0 | 0.018/0.018/0.020 | 0.67 | 2.00 | 0.0312 | 0.167 | 0.0150 |
| 2 | 20.0 | 15.0 | 0.020/0.020/0.020 | 0.50 | 1.50 | 0.0312 | 0.125 | 0.0170 |

```
  GLOBAL STREET FLOW-DEPTH CONSTRAINTS:
    1. Relative Flow-Depth =  0.20 FEET
       as (Maximum Allowable Street Flow Depth) - (Top-of-Curb)
    2. (Depth)*(Velocity) Constraint = 10.0 (FT*FT/S)
  *SIZE PIPE WITH A FLOW CAPACITY GREATER THAN
   OR EQUAL TO THE UPSTREAM TRIBUTARY PIPE.*
  *USER-SPECIFIED MINIMUM TOPOGRAPHIC SLOPE ADJUSTMENT NOT SELECTED

****************************************************************************
  FLOW PROCESS FROM NODE  80005.00 TO NODE  80010.00 IS CODE =  21
----------------------------------------------------------------------------
  >>>>>RATIONAL METHOD INITIAL SUBAREA ANALYSIS<<<<<
  >>USE TIME-OF-CONCENTRATION NOMOGRAPH FOR INITIAL SUBAREA<<
============================================================================
  INITIAL SUBAREA FLOW-LENGTH(FEET) =   605.60
  ELEVATION DATA: UPSTREAM(FEET) =   1370.00  DOWNSTREAM(FEET) =   1358.00

  Tc = K*[(LENGTH** 3.00)/(ELEVATION CHANGE)]**0.20
  SUBAREA ANALYSIS USED MINIMUM Tc(MIN.) =   13.722
  * 100 YEAR RAINFALL INTENSITY(INCH/HR) =  3.029
  SUBAREA Tc AND LOSS RATE DATA(AMC III):
```

| DEVELOPMENT TYPE/ LAND USE | SCS SOIL GROUP | AREA (ACRES) | Fp (INCH/HR) | Ap (DECIMAL) | SCS CN | Tc (MIN.) |
|---|---|---|---|---|---|---|
| PUBLIC PARK | B | 0.30 | 0.42 | 0.850 | 76 | 13.72 |

```
  SUBAREA AVERAGE PERVIOUS LOSS RATE, Fp(INCH/HR) =  0.42
  SUBAREA AVERAGE PERVIOUS AREA FRACTION, Ap =  0.850
```

```
  SUBAREA RUNOFF(CFS) =      0.72
  TOTAL AREA(ACRES) =      0.30   PEAK FLOW RATE(CFS) =      0.72

****************************************************************************
  FLOW PROCESS FROM NODE  80010.00 TO NODE  80015.00 IS CODE =  51
----------------------------------------------------------------------------
  >>>>>COMPUTE TRAPEZOIDAL CHANNEL FLOW<<<<<
  >>>>>TRAVELTIME THRU SUBAREA (EXISTING ELEMENT)<<<<<
============================================================================
  ELEVATION DATA: UPSTREAM(FEET) =   1358.00  DOWNSTREAM(FEET) =   1357.00
  CHANNEL LENGTH THRU SUBAREA(FEET) =   116.80   CHANNEL SLOPE =  0.0086
  CHANNEL BASE(FEET) =    5.00   "Z" FACTOR =   4.000
  MANNING'S FACTOR = 0.017   MAXIMUM DEPTH(FEET) =   1.00
  * 100 YEAR RAINFALL INTENSITY(INCH/HR) =  2.896
  SUBAREA LOSS RATE DATA(AMC III):
   DEVELOPMENT TYPE/      SCS SOIL   AREA      Fp         Ap     SCS
       LAND USE            GROUP   (ACRES)  (INCH/HR)  (DECIMAL)  CN
  COMMERCIAL                 B        0.30      0.42     0.100    76
  SUBAREA AVERAGE PERVIOUS LOSS RATE, Fp(INCH/HR) =  0.42
  SUBAREA AVERAGE PERVIOUS AREA FRACTION, Ap =  0.100
  TRAVEL TIME COMPUTED USING ESTIMATED FLOW(CFS) =      1.11
  TRAVEL TIME THRU SUBAREA BASED ON VELOCITY(FEET/SEC.) =   1.82
  AVERAGE FLOW DEPTH(FEET) =   0.11   TRAVEL TIME(MIN.) =   1.07
  Tc(MIN.) =   14.79
  SUBAREA AREA(ACRES) =     0.30       SUBAREA RUNOFF(CFS) =    0.77
  EFFECTIVE AREA(ACRES) =      0.60     AREA-AVERAGED Fm(INCH/HR) =   0.20
  AREA-AVERAGED Fp(INCH/HR) =   0.42  AREA-AVERAGED Ap =   0.48
  TOTAL AREA(ACRES) =        0.6         PEAK FLOW RATE(CFS) =       1.46

  END OF SUBAREA CHANNEL FLOW HYDRAULICS:
  DEPTH(FEET) =  0.13   FLOW VELOCITY(FEET/SEC.) =   1.99
  LONGEST FLOWPATH FROM NODE  80005.00 TO NODE  80015.00 =     722.40 FEET.

****************************************************************************
  FLOW PROCESS FROM NODE  80015.00 TO NODE  80015.00 IS CODE =  81
----------------------------------------------------------------------------
  >>>>>ADDITION OF SUBAREA TO MAINLINE PEAK FLOW<<<<<
============================================================================
  MAINLINE Tc(MIN.) =   14.79
  * 100 YEAR RAINFALL INTENSITY(INCH/HR) =  2.896
  SUBAREA LOSS RATE DATA(AMC III):
   DEVELOPMENT TYPE/      SCS SOIL   AREA      Fp         Ap     SCS
       LAND USE            GROUP   (ACRES)  (INCH/HR)  (DECIMAL)  CN
  COMMERCIAL                 B        3.10      0.42     0.100    76
  SUBAREA AVERAGE PERVIOUS LOSS RATE, Fp(INCH/HR) =  0.42
  SUBAREA AVERAGE PERVIOUS AREA FRACTION, Ap =  0.100
  SUBAREA AREA(ACRES) =    3.10      SUBAREA RUNOFF(CFS) =    7.96
  EFFECTIVE AREA(ACRES) =      3.70   AREA-AVERAGED Fm(INCH/HR) =  0.07
  AREA-AVERAGED Fp(INCH/HR) =  0.42  AREA-AVERAGED Ap =  0.16
  TOTAL AREA(ACRES) =        3.7       PEAK FLOW RATE(CFS) =       9.42
============================================================================
  END OF STUDY SUMMARY:
  TOTAL AREA(ACRES)     =        3.7  TC(MIN.) =     14.79
  EFFECTIVE AREA(ACRES) =      3.70  AREA-AVERAGED Fm(INCH/HR)=  0.07
  AREA-AVERAGED Fp(INCH/HR) =  0.42  AREA-AVERAGED Ap = 0.161
  PEAK FLOW RATE(CFS)   =      9.42
============================================================================
============================================================================
  END OF RATIONAL METHOD ANALYSIS
```

```
____________________________________________________________________________
****************************************************************************
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                           Analysis prepared by:





 ************************** DESCRIPTION OF STUDY **************************
* REDLANDS PASSENGER RAIL                                                  *
* EXISTING HYDROLOGY 100 YEAR EVENT                                        *
* BASIN 90000                                                              *
 **************************************************************************

  FILE NAME: C:\RPRP\EPRP\90000.DAT
  TIME/DATE OF STUDY: 13:43 10/17/2012
============================================================================
  USER SPECIFIED HYDROLOGY AND HYDRAULIC MODEL INFORMATION:
============================================================================
                    --*TIME-OF-CONCENTRATION MODEL*--

  USER SPECIFIED STORM EVENT(YEAR) =  100.00
  SPECIFIED MINIMUM PIPE SIZE(INCH) =  12.00
  SPECIFIED PERCENT OF GRADIENTS(DECIMAL) TO USE FOR FRICTION SLOPE = 0.90
  *USER-DEFINED LOGARITHMIC INTERPOLATION USED FOR RAINFALL*

  SLOPE OF INTENSITY DURATION CURVE(LOG(I;IN/HR) vs. LOG(Tc;MIN)) = 0.6000
  USER SPECIFIED 1-HOUR INTENSITY(INCH/HOUR) = 1.2500

  *ANTECEDENT MOISTURE CONDITION (AMC) III ASSUMED FOR RATIONAL METHOD*

  *USER-DEFINED STREET-SECTIONS FOR COUPLED PIPEFLOW AND STREETFLOW MODEL*
     HALF-  CROWN TO   STREET-CROSSFALL:   CURB  GUTTER-GEOMETRIES:  MANNING
     WIDTH  CROSSFALL  IN-  / OUT-/PARK-  HEIGHT  WIDTH  LIP   HIKE  FACTOR
NO.   (FT)     (FT)    SIDE / SIDE/ WAY    (FT)    (FT)  (FT)  (FT)    (n)
===  =====  =========  =================  ======  ===== ====== ===== =======
  1   30.0     20.0    0.018/0.018/0.020   0.67    2.00 0.0312 0.167 0.0150
  2   20.0     15.0    0.020/0.020/0.020   0.50    1.50 0.0312 0.125 0.0170

  GLOBAL STREET FLOW-DEPTH CONSTRAINTS:
    1. Relative Flow-Depth =  0.20 FEET
       as (Maximum Allowable Street Flow Depth) - (Top-of-Curb)
    2. (Depth)*(Velocity) Constraint = 10.0 (FT*FT/S)
  *SIZE PIPE WITH A FLOW CAPACITY GREATER THAN
   OR EQUAL TO THE UPSTREAM TRIBUTARY PIPE.*
  *USER-SPECIFIED MINIMUM TOPOGRAPHIC SLOPE ADJUSTMENT NOT SELECTED

****************************************************************************
  FLOW PROCESS FROM NODE  90000.00 TO NODE  90005.00 IS CODE =  21
----------------------------------------------------------------------------
  >>>>>RATIONAL METHOD INITIAL SUBAREA ANALYSIS<<<<<
  >>USE TIME-OF-CONCENTRATION NOMOGRAPH FOR INITIAL SUBAREA<<
============================================================================
  INITIAL SUBAREA FLOW-LENGTH(FEET) =   238.50
  ELEVATION DATA: UPSTREAM(FEET) =   1500.00  DOWNSTREAM(FEET) =   1498.00

  Tc = K*[(LENGTH** 3.00)/(ELEVATION CHANGE)]**0.20
  SUBAREA ANALYSIS USED MINIMUM Tc(MIN.) =    7.810
  * 100 YEAR RAINFALL INTENSITY(INCH/HR) =  4.248
  SUBAREA Tc AND LOSS RATE DATA(AMC III):
   DEVELOPMENT TYPE/      SCS SOIL   AREA      Fp         Ap     SCS   Tc
       LAND USE            GROUP   (ACRES)  (INCH/HR)  (DECIMAL)  CN  (MIN.)
  MOBILE HOME PARK           B        0.50      0.42      0.250    76    7.81
  SUBAREA AVERAGE PERVIOUS LOSS RATE, Fp(INCH/HR) =  0.42
  SUBAREA AVERAGE PERVIOUS AREA FRACTION, Ap =  0.250
```

```
  SUBAREA RUNOFF(CFS) =      1.86
  TOTAL AREA(ACRES) =      0.50   PEAK FLOW RATE(CFS) =      1.86

****************************************************************************
  FLOW PROCESS FROM NODE  90005.00 TO NODE  90010.00 IS CODE =  62
----------------------------------------------------------------------------
  >>>>>COMPUTE STREET FLOW TRAVEL TIME THRU SUBAREA<<<<<
  >>>>>(STREET TABLE SECTION #  1 USED)<<<<<
============================================================================
  UPSTREAM ELEVATION(FEET) = 1498.00  DOWNSTREAM ELEVATION(FEET) = 1485.00
  STREET LENGTH(FEET) =   677.80   CURB HEIGHT(INCHES) =  8.0
  STREET HALFWIDTH(FEET) = 30.00

  DISTANCE FROM CROWN TO CROSSFALL GRADEBREAK(FEET) =  20.00
  INSIDE STREET CROSSFALL(DECIMAL) =  0.018
  OUTSIDE STREET CROSSFALL(DECIMAL)  =  0.018

  SPECIFIED NUMBER OF HALFSTREETS CARRYING RUNOFF =  1
  STREET PARKWAY CROSSFALL(DECIMAL)  =  0.020
  Manning's FRICTION FACTOR for Streetflow Section(curb-to-curb) =   0.0150
  Manning's FRICTION FACTOR for Back-of-Walk Flow Section =   0.0200

    **TRAVEL TIME COMPUTED USING ESTIMATED FLOW(CFS) =       8.78
    STREETFLOW MODEL RESULTS USING ESTIMATED FLOW:
    STREET FLOW DEPTH(FEET) =  0.44
    HALFSTREET FLOOD WIDTH(FEET) =   15.43
    AVERAGE FLOW VELOCITY(FEET/SEC.) =    3.78
    PRODUCT OF DEPTH&VELOCITY(FT*FT/SEC.) =    1.66
  STREET FLOW TRAVEL TIME(MIN.) =   2.99   Tc(MIN.) =   10.79
  * 100 YEAR RAINFALL INTENSITY(INCH/HR) =  3.498
  SUBAREA LOSS RATE DATA(AMC III):
   DEVELOPMENT TYPE/      SCS SOIL   AREA      Fp        Ap     SCS
       LAND USE            GROUP   (ACRES)  (INCH/HR)  (DECIMAL)  CN
  MOBILE HOME PARK           B       4.50      0.42     0.250    76
  SUBAREA AVERAGE PERVIOUS LOSS RATE, Fp(INCH/HR) =  0.42
  SUBAREA AVERAGE PERVIOUS AREA FRACTION, Ap =  0.250
  SUBAREA AREA(ACRES) =    4.50      SUBAREA RUNOFF(CFS) =   13.74
  EFFECTIVE AREA(ACRES) =      5.00    AREA-AVERAGED Fm(INCH/HR) =  0.11
  AREA-AVERAGED Fp(INCH/HR) =  0.42  AREA-AVERAGED Ap =  0.25
  TOTAL AREA(ACRES) =        5.0        PEAK FLOW RATE(CFS) =      15.27

  END OF SUBAREA STREET FLOW HYDRAULICS:
  DEPTH(FEET) = 0.51   HALFSTREET FLOOD WIDTH(FEET) =  19.34
  FLOW VELOCITY(FEET/SEC.) =  4.32   DEPTH*VELOCITY(FT*FT/SEC.) =   2.19
  LONGEST FLOWPATH FROM NODE  90000.00 TO NODE  90010.00 =     916.30 FEET.

****************************************************************************
  FLOW PROCESS FROM NODE  90010.00 TO NODE  90010.00 IS CODE =  81
----------------------------------------------------------------------------
  >>>>>ADDITION OF SUBAREA TO MAINLINE PEAK FLOW<<<<<
============================================================================
  MAINLINE Tc(MIN.) =   10.79
  * 100 YEAR RAINFALL INTENSITY(INCH/HR) =  3.498
  SUBAREA LOSS RATE DATA(AMC III):
   DEVELOPMENT TYPE/      SCS SOIL   AREA      Fp        Ap     SCS
       LAND USE            GROUP   (ACRES)  (INCH/HR)  (DECIMAL)  CN
  MOBILE HOME PARK           B       1.50      0.42     0.250    76
  SUBAREA AVERAGE PERVIOUS LOSS RATE, Fp(INCH/HR) =  0.42
  SUBAREA AVERAGE PERVIOUS AREA FRACTION, Ap =  0.250
  SUBAREA AREA(ACRES) =    1.50      SUBAREA RUNOFF(CFS) =    4.58
  EFFECTIVE AREA(ACRES) =      6.50   AREA-AVERAGED Fm(INCH/HR) =  0.11
  AREA-AVERAGED Fp(INCH/HR) =  0.42  AREA-AVERAGED Ap =  0.25
  TOTAL AREA(ACRES) =        6.5       PEAK FLOW RATE(CFS) =      19.85

****************************************************************************
  FLOW PROCESS FROM NODE  90010.00 TO NODE  90015.00 IS CODE =  51
----------------------------------------------------------------------------
  >>>>>COMPUTE TRAPEZOIDAL CHANNEL FLOW<<<<<
  >>>>>TRAVELTIME THRU SUBAREA (EXISTING ELEMENT)<<<<<
============================================================================
  ELEVATION DATA: UPSTREAM(FEET) =   1485.00  DOWNSTREAM(FEET) =   1464.00
```

```
  CHANNEL LENGTH THRU SUBAREA(FEET) =  1265.00   CHANNEL SLOPE =  0.0166
  CHANNEL BASE(FEET) =    5.00   "Z" FACTOR =   4.000
  MANNING'S FACTOR = 0.030   MAXIMUM DEPTH(FEET) =   4.00
  * 100 YEAR RAINFALL INTENSITY(INCH/HR) =  2.787
  SUBAREA LOSS RATE DATA(AMC III):
   DEVELOPMENT TYPE/      SCS SOIL   AREA      Fp         Ap     SCS
       LAND USE            GROUP   (ACRES)  (INCH/HR)  (DECIMAL)  CN
  PUBLIC PARK                B       5.20      0.42     0.850    76
  SUBAREA AVERAGE PERVIOUS LOSS RATE, Fp(INCH/HR) =  0.42
  SUBAREA AVERAGE PERVIOUS AREA FRACTION, Ap =  0.850
  TRAVEL TIME COMPUTED USING ESTIMATED FLOW(CFS) =      25.55
  TRAVEL TIME THRU SUBAREA BASED ON VELOCITY(FEET/SEC.) =   4.24
  AVERAGE FLOW DEPTH(FEET) =   0.75   TRAVEL TIME(MIN.) =   4.97
  Tc(MIN.) =   15.77
  SUBAREA AREA(ACRES) =     5.20       SUBAREA RUNOFF(CFS) =   11.36
  EFFECTIVE AREA(ACRES) =     11.70     AREA-AVERAGED Fm(INCH/HR) =   0.22
  AREA-AVERAGED Fp(INCH/HR) =   0.42  AREA-AVERAGED Ap =   0.52
  TOTAL AREA(ACRES) =       11.7         PEAK FLOW RATE(CFS) =      27.05

  END OF SUBAREA CHANNEL FLOW HYDRAULICS:
  DEPTH(FEET) =  0.78   FLOW VELOCITY(FEET/SEC.) =   4.31
  LONGEST FLOWPATH FROM NODE  90000.00 TO NODE  90015.00 =    2181.30 FEET.

****************************************************************************
  FLOW PROCESS FROM NODE  90015.00 TO NODE  90020.00 IS CODE =  41
----------------------------------------------------------------------------
  >>>>>COMPUTE PIPE-FLOW TRAVEL TIME THRU SUBAREA<<<<<
  >>>>>USING USER-SPECIFIED PIPESIZE (EXISTING ELEMENT)<<<<<
============================================================================
  ELEVATION DATA: UPSTREAM(FEET) =  1465.00  DOWNSTREAM(FEET) =  1464.00
  FLOW LENGTH(FEET) =    39.00   MANNING'S N =  0.013
  DEPTH OF FLOW IN  36.0 INCH PIPE IS  12.7 INCHES
  PIPE-FLOW VELOCITY(FEET/SEC.) =  12.13
  GIVEN PIPE DIAMETER(INCH) =  36.00    NUMBER OF PIPES =   1
  PIPE-FLOW(CFS) =      27.05
  PIPE TRAVEL TIME(MIN.) =   0.05    Tc(MIN.) =   15.82
  LONGEST FLOWPATH FROM NODE  90000.00 TO NODE  90020.00 =    2220.30 FEET.

****************************************************************************
  FLOW PROCESS FROM NODE  90020.00 TO NODE  90025.00 IS CODE =  51
----------------------------------------------------------------------------
  >>>>>COMPUTE TRAPEZOIDAL CHANNEL FLOW<<<<<
  >>>>>TRAVELTIME THRU SUBAREA (EXISTING ELEMENT)<<<<<
============================================================================
  ELEVATION DATA: UPSTREAM(FEET) =   1464.00  DOWNSTREAM(FEET) =   1455.00
  CHANNEL LENGTH THRU SUBAREA(FEET) =   548.00   CHANNEL SLOPE =  0.0164
  CHANNEL BASE(FEET) =    5.00   "Z" FACTOR =   1.000
  MANNING'S FACTOR = 0.030   MAXIMUM DEPTH(FEET) =   4.00
  * 100 YEAR RAINFALL INTENSITY(INCH/HR) =  2.612
  SUBAREA LOSS RATE DATA(AMC III):
   DEVELOPMENT TYPE/      SCS SOIL   AREA      Fp         Ap     SCS
       LAND USE            GROUP   (ACRES)  (INCH/HR)  (DECIMAL)  CN
  PUBLIC PARK                B       3.00      0.42     0.850    76
  SUBAREA AVERAGE PERVIOUS LOSS RATE, Fp(INCH/HR) =  0.42
  SUBAREA AVERAGE PERVIOUS AREA FRACTION, Ap =  0.850
  TRAVEL TIME COMPUTED USING ESTIMATED FLOW(CFS) =      30.09
  TRAVEL TIME THRU SUBAREA BASED ON VELOCITY(FEET/SEC.) =   5.22
  AVERAGE FLOW DEPTH(FEET) =   0.97   TRAVEL TIME(MIN.) =   1.75
  Tc(MIN.) =   17.57
  SUBAREA AREA(ACRES) =     3.00       SUBAREA RUNOFF(CFS) =    6.08
  EFFECTIVE AREA(ACRES) =     14.70     AREA-AVERAGED Fm(INCH/HR) =   0.25
  AREA-AVERAGED Fp(INCH/HR) =   0.42  AREA-AVERAGED Ap =   0.58
  TOTAL AREA(ACRES) =       14.7         PEAK FLOW RATE(CFS) =      31.28

  END OF SUBAREA CHANNEL FLOW HYDRAULICS:
  DEPTH(FEET) =  0.99   FLOW VELOCITY(FEET/SEC.) =   5.28
  LONGEST FLOWPATH FROM NODE  90000.00 TO NODE  90025.00 =    2768.30 FEET.

****************************************************************************
  FLOW PROCESS FROM NODE  90025.00 TO NODE  90030.00 IS CODE =  51
----------------------------------------------------------------------------
```

```
  >>>>>COMPUTE TRAPEZOIDAL CHANNEL FLOW<<<<<
  >>>>>TRAVELTIME THRU SUBAREA (EXISTING ELEMENT)<<<<<
============================================================================
  ELEVATION DATA: UPSTREAM(FEET) =   1455.00  DOWNSTREAM(FEET) =   1446.00
  CHANNEL LENGTH THRU SUBAREA(FEET) =   592.00   CHANNEL SLOPE =  0.0152
  CHANNEL BASE(FEET) =    5.00   "Z" FACTOR =   1.000
  MANNING'S FACTOR = 0.015   MAXIMUM DEPTH(FEET) =   4.00
  * 100 YEAR RAINFALL INTENSITY(INCH/HR) =  2.511
  SUBAREA LOSS RATE DATA(AMC III):
   DEVELOPMENT TYPE/      SCS SOIL   AREA      Fp         Ap     SCS
       LAND USE            GROUP   (ACRES)  (INCH/HR)  (DECIMAL)  CN
  COMMERCIAL                 B       1.00      0.42     0.100    76
  SUBAREA AVERAGE PERVIOUS LOSS RATE, Fp(INCH/HR) =  0.42
  SUBAREA AVERAGE PERVIOUS AREA FRACTION, Ap =  0.100
  TRAVEL TIME COMPUTED USING ESTIMATED FLOW(CFS) =      32.39
  TRAVEL TIME THRU SUBAREA BASED ON VELOCITY(FEET/SEC.) =   8.33
  AVERAGE FLOW DEPTH(FEET) =   0.68   TRAVEL TIME(MIN.) =   1.18
  Tc(MIN.) =   18.76
  SUBAREA AREA(ACRES) =     1.00       SUBAREA RUNOFF(CFS) =    2.22
  EFFECTIVE AREA(ACRES) =     15.70     AREA-AVERAGED Fm(INCH/HR) =   0.23
  AREA-AVERAGED Fp(INCH/HR) =   0.42  AREA-AVERAGED Ap =   0.55
  TOTAL AREA(ACRES) =       15.7         PEAK FLOW RATE(CFS) =      32.18

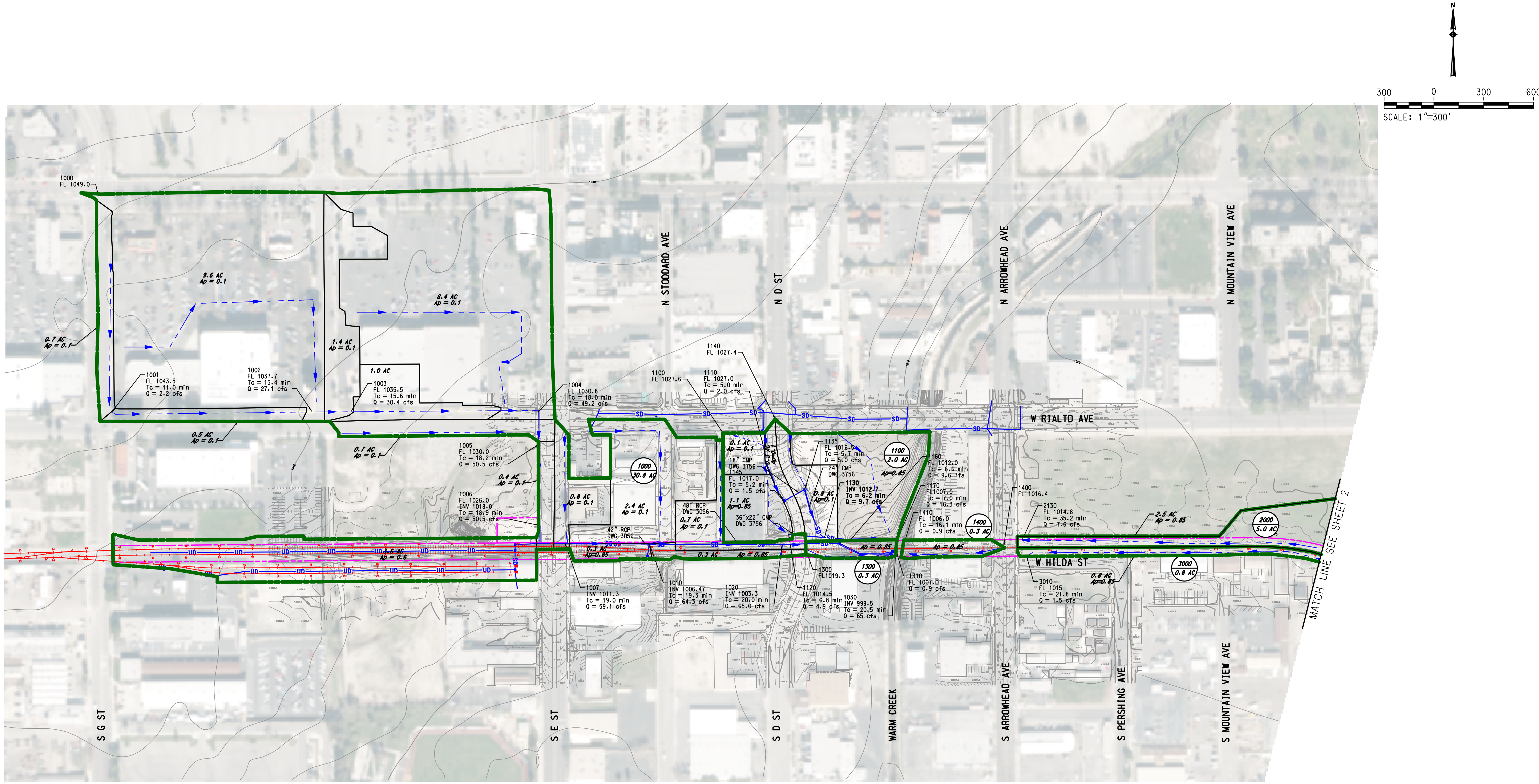
  END OF SUBAREA CHANNEL FLOW HYDRAULICS:
  DEPTH(FEET) =  0.68   FLOW VELOCITY(FEET/SEC.) =   8.31
  LONGEST FLOWPATH FROM NODE  90000.00 TO NODE  90030.00 =    3360.30 FEET.

****************************************************************************
  FLOW PROCESS FROM NODE  90030.00 TO NODE  90035.00 IS CODE =  51
----------------------------------------------------------------------------
  >>>>>COMPUTE TRAPEZOIDAL CHANNEL FLOW<<<<<
  >>>>>TRAVELTIME THRU SUBAREA (EXISTING ELEMENT)<<<<<
============================================================================
  ELEVATION DATA: UPSTREAM(FEET) =   1446.00  DOWNSTREAM(FEET) =   1412.00
  CHANNEL LENGTH THRU SUBAREA(FEET) =  1406.73   CHANNEL SLOPE =  0.0242
  CHANNEL BASE(FEET) =    5.00   "Z" FACTOR =   2.000
  MANNING'S FACTOR = 0.030   MAXIMUM DEPTH(FEET) =   1.00
  * 100 YEAR RAINFALL INTENSITY(INCH/HR) =  2.234
  SUBAREA LOSS RATE DATA(AMC III):
   DEVELOPMENT TYPE/      SCS SOIL   AREA      Fp         Ap     SCS
       LAND USE            GROUP   (ACRES)  (INCH/HR)  (DECIMAL)  CN
  PUBLIC PARK                B       1.60      0.42     0.850    76
  SUBAREA AVERAGE PERVIOUS LOSS RATE, Fp(INCH/HR) =  0.42
  SUBAREA AVERAGE PERVIOUS AREA FRACTION, Ap =  0.850
  TRAVEL TIME COMPUTED USING ESTIMATED FLOW(CFS) =      33.53
  TRAVEL TIME THRU SUBAREA BASED ON VELOCITY(FEET/SEC.) =   5.81
  AVERAGE FLOW DEPTH(FEET) =   0.86   TRAVEL TIME(MIN.) =   4.04
  Tc(MIN.) =   22.79
  SUBAREA AREA(ACRES) =     1.60       SUBAREA RUNOFF(CFS) =    2.70
  EFFECTIVE AREA(ACRES) =     17.30     AREA-AVERAGED Fm(INCH/HR) =   0.25
  AREA-AVERAGED Fp(INCH/HR) =   0.42  AREA-AVERAGED Ap =   0.58
  TOTAL AREA(ACRES) =       17.3         PEAK FLOW RATE(CFS) =      32.18
  NOTE: PEAK FLOW RATE DEFAULTED TO UPSTREAM VALUE

  END OF SUBAREA CHANNEL FLOW HYDRAULICS:
  DEPTH(FEET) =  0.84   FLOW VELOCITY(FEET/SEC.) =   5.72
  LONGEST FLOWPATH FROM NODE  90000.00 TO NODE  90035.00 =    4767.03 FEET.
============================================================================
  END OF STUDY SUMMARY:
  TOTAL AREA(ACRES)      =       17.3  TC(MIN.) =      22.79
  EFFECTIVE AREA(ACRES) =      17.30  AREA-AVERAGED Fm(INCH/HR)=  0.25
  AREA-AVERAGED Fp(INCH/HR) =  0.42  AREA-AVERAGED Ap = 0.581
  PEAK FLOW RATE(CFS)    =      32.18
============================================================================
============================================================================
  END OF RATIONAL METHOD ANALYSIS
```

# Appendix B

# Existing Conditions Hydrology Maps




## LEGEND

| | |
|---|---|
| (symbol) | RAIL TRACK |
| (symbol) | MAJOR DRAINAGE AREA |
| (symbol) | DRAINAGE SUB AREA |
| (symbol) | NODE LOCATION |
| (symbol) | FLOW PATH |
| —UD— | UNDER DRAIN |
| —SD— | STORM DRAIN |
| (symbol) | CONTOURS |
| 2300 / 1.6 AC | BASIN NAME / BASIN ACREAGE |

## ASSUMPTIONS

1. THE GENERAL SITE IS DRAINING SOUTHEAST, BASED OFF USGS AND AVAILABLE TOPO.
2. FOR PROPERTIES WHERE SURVEY OR TOPO IS NOT AVAILABLE, IT IS ASSUMED THE SITE DRAINS TOWARDS THE SOUTHEAST.
3. FOR PROPERTIES NEAR PUBLIC R/W AND NO AVAILABLE TOPO OR SURVEY, IT IS ASSUMED THE PROPERTY DRAINS TOWARDS THE NEAREST PUBLIC ROAD.
4. ALL Q VALUES SHOWN ARE FOR THE 100 YEAR EVENT, UNLESS OTHERWISE NOTED.

## ACRONYMS AND ABBREVIATIONS

- Ap - PERVIOUS AREA
- CB - CATCHBASIN
- CFS - CUBIC FEET PER SECOND
- CMP - CORRUGATED METAL PIPE
- DI - DRAIN INLET
- DWG - DRAWING AREA
- FL - ELEVATION AT SURFACE
- INV - PIPE FLOWLINE ELEVATION
- MIN - MINUTES
- Q - SUBAREA FLOW RATE IN CFS
- RCP - REINFORCED CONCRETE PIPE
- SQ - TOTAL FLOW RATE IN CFS
- Tc - TIME OF CONCENTRATION
- X.X AC - SUBAREA ACREAGE

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Governments SANBAG Working Together

SAN BERNARDINO ASSOCIATED GOVERNMENTS
REDLANDS PASSENGER RAIL PROJECT
EXISTING HYDROLOGY MAP
SHEET 1 OF 14

SCALE: 1"=300'
DATE: 07-09-2012

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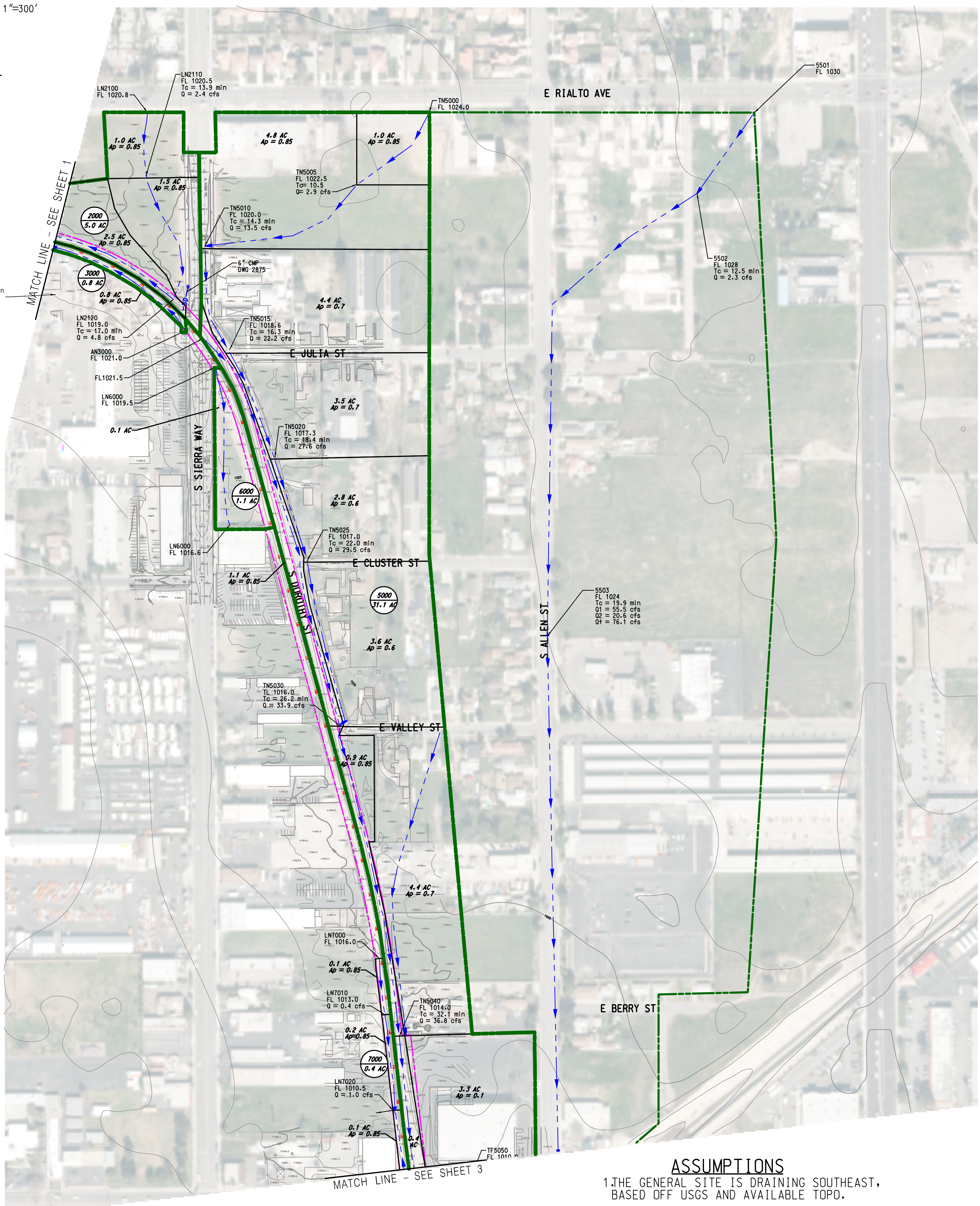


## LEGEND

RAIL TRACK
MAJOR DRAINAGE AREA
DRAINAGE SUB AREA
NODE LOCATION
FLOW PATH
UD — UNDER DRAIN
SD — STORM DRAIN
CONTOURS
2300 — BASIN NAME
1.6 AC — BASIN ACREAGE

## ASSUMPTIONS

1. THE GENERAL SITE IS DRAINING SOUTHEAST, BASED OFF USGS AND AVAILABLE TOPO.
2. FOR PROPERTIES WHERE SURVEY OR TOPO IS NOT AVAILABLE, IT IS ASSUMED THE SITE DRAINS TOWARDS THE SOUTHEAST.
3. FOR PROPERTIES NEAR PUBLIC R/W AND NO AVAILABLE TOPO OR SURVEY, IT IS ASSUMED THE PROPERTY DRAINS TOWARDS THE NEAREST PUBLIC ROAD.
4. ALL Q VALUES SHOWN ARE FOR THE 100 YEAR EVENT, UNLESS OTHERWISE NOTED.

## ACRONYMS AND ABBREVIATIONS

| | | |
|---|---|---|
| Ap - PERVIOUS AREA | DWG - DRAWING AREA | RCP - REINFORCED CONCRETE PIPE |
| CB - CATCHBASIN | FL - ELEVATION AT SURFACE | SQ - TOTAL FLOW RATE IN CFS |
| CFS - CUBIC FEET PER SECOND | INV - PIPE FLOWLINE ELEVATION | Tc - TIME OF CONCENTRATION |
| CMP - CORRUGATED METAL PIPE | MIN - MINUTES | X.X AC - SUBAREA ACREAGE |
| DI - DRAIN INLET | Q - SUBAREA FLOW RATE IN CFS | |

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**SAN BERNARDINO ASSOCIATED GOVERNMENTS**
**REDLANDS PASSENGER RAIL PROJECT**
EXISTING HYDROLOGY MAP
SHEET 2 OF 14

SCALE: 1"=300'
DATE: 07-09-2012

## LEGEND

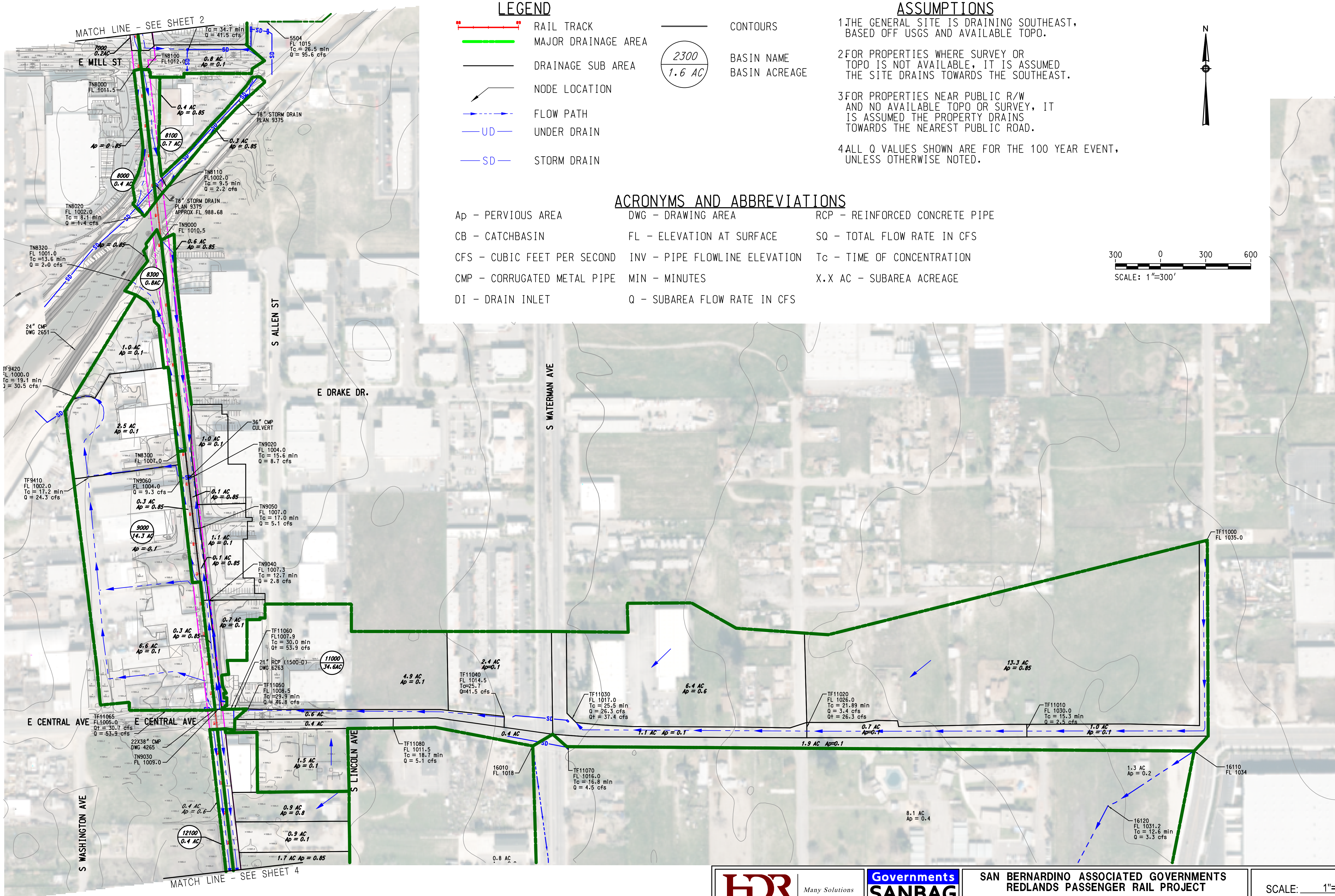
- RAIL TRACK
- MAJOR DRAINAGE AREA
- DRAINAGE SUB AREA
- NODE LOCATION
- FLOW PATH
- UD — UNDER DRAIN
- SD — STORM DRAIN
- CONTOURS
- 2300 — BASIN NAME
- 1.6 AC — BASIN ACREAGE

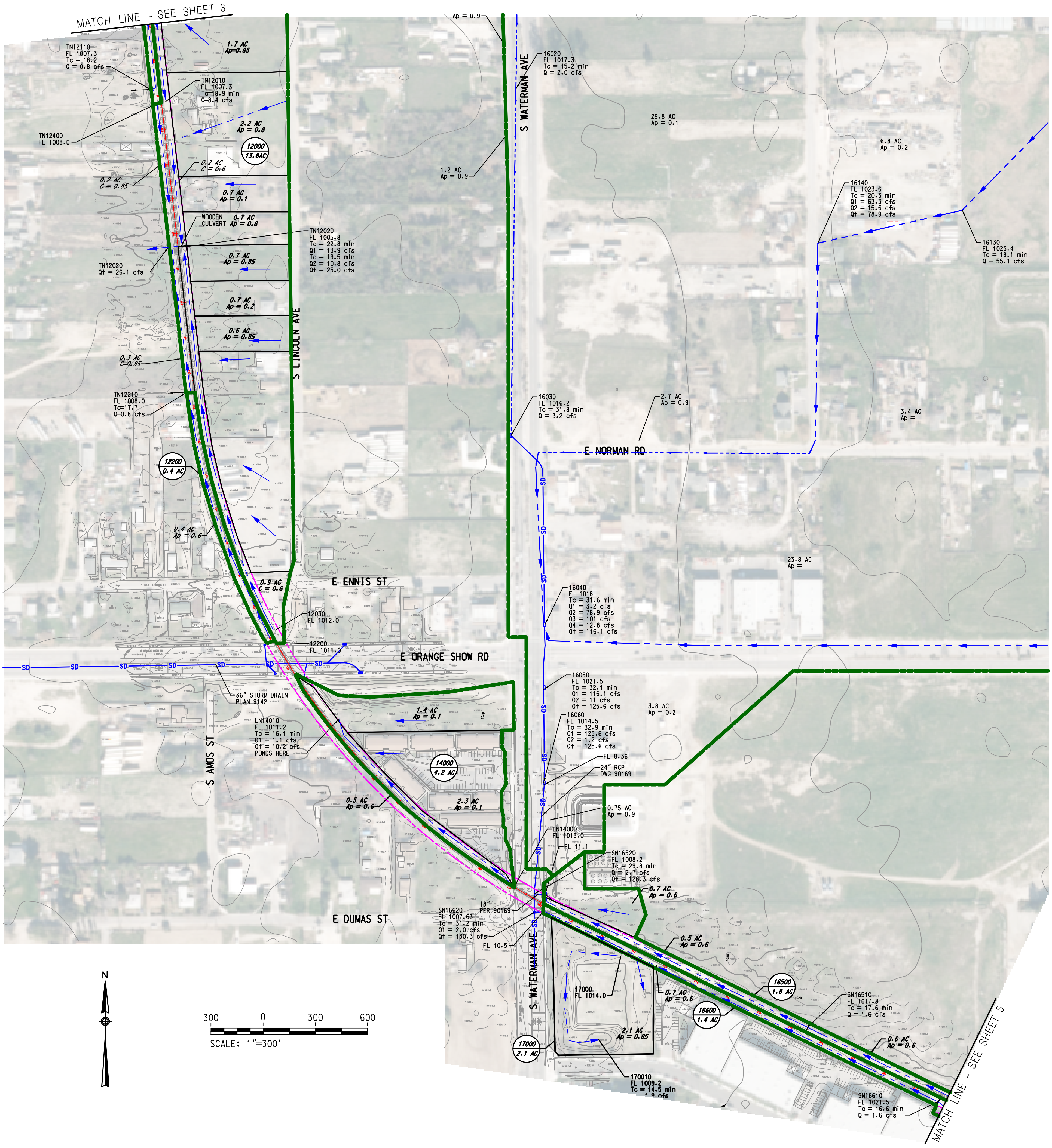
## ASSUMPTIONS

1. THE GENERAL SITE IS DRAINING SOUTHEAST, BASED OFF USGS AND AVAILABLE TOPO.
2. FOR PROPERTIES WHERE SURVEY OR TOPO IS NOT AVAILABLE, IT IS ASSUMED THE SITE DRAINS TOWARDS THE SOUTHEAST.
3. FOR PROPERTIES NEAR PUBLIC R/W AND NO AVAILABLE TOPO OR SURVEY, IT IS ASSUMED THE PROPERTY DRAINS TOWARDS THE NEAREST PUBLIC ROAD.
4. ALL Q VALUES SHOWN ARE FOR THE 100 YEAR EVENT, UNLESS OTHERWISE NOTED.

## ACRONYMS AND ABBREVIATIONS

| | | |
|---|---|---|
| Ap - PERVIOUS AREA | DWG - DRAWING AREA | RCP - REINFORCED CONCRETE PIPE |
| CB - CATCHBASIN | FL - ELEVATION AT SURFACE | SQ - TOTAL FLOW RATE IN CFS |
| CFS - CUBIC FEET PER SECOND | INV - PIPE FLOWLINE ELEVATION | Tc - TIME OF CONCENTRATION |
| CMP - CORRUGATED METAL PIPE | MIN - MINUTES | X.X AC - SUBAREA ACREAGE |
| DI - DRAIN INLET | Q - SUBAREA FLOW RATE IN CFS | |






## LEGEND

- RAIL TRACK
- MAJOR DRAINAGE AREA
- DRAINAGE SUB AREA
- NODE LOCATION
- FLOW PATH
- UD — UNDER DRAIN
- SD — STORM DRAIN
- CONTOURS
- 2300 / 1.6 AC — BASIN NAME / BASIN ACREAGE

## ASSUMPTIONS

1. THE GENERAL SITE IS DRAINING SOUTHEAST, BASED OFF USGS AND AVAILABLE TOPO.
2. FOR PROPERTIES WHERE SURVEY OR TOPO IS NOT AVAILABLE, IT IS ASSUMED THE SITE DRAINS TOWARDS THE SOUTHEAST.
3. FOR PROPERTIES NEAR PUBLIC R/W AND NO AVAILABLE TOPO OR SURVEY, IT IS ASSUMED THE PROPERTY DRAINS TOWARDS THE NEAREST PUBLIC ROAD.
4. ALL Q VALUES SHOWN ARE FOR THE 100 YEAR EVENT, UNLESS OTHERWISE NOTED.

## ACRONYMS AND ABBREVIATIONS

Ap - PERVIOUS AREA
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CMP - CORRUGATED METAL PIPE
DI - DRAIN INLET
DWG - DRAWING AREA
FL - ELEVATION AT SURFACE
INV - PIPE FLOWLINE ELEVATION
MIN - MINUTES
Q - SUBAREA FLOW RATE IN CFS
RCP - REINFORCED CONCRETE PIPE
SQ - TOTAL FLOW RATE IN CFS
Tc - TIME OF CONCENTRATION
X.X AC - SUBAREA ACREAGE

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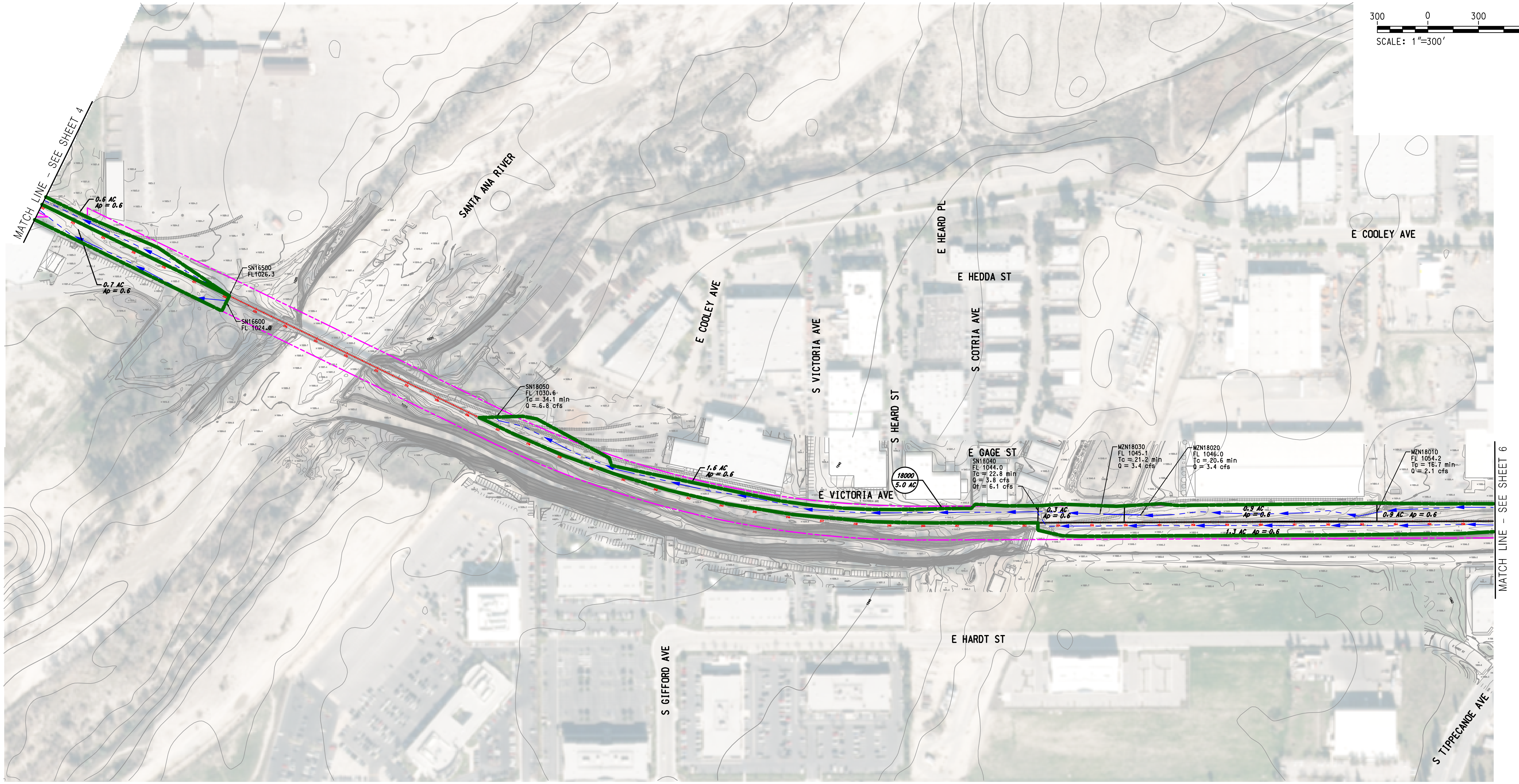
**SAN BERNARDINO ASSOCIATED GOVERNMENTS**
**REDLANDS PASSENGER RAIL PROJECT**
EXISTING HYDROLOGY MAP
SHEET 4 OF 14

SCALE: 1"=300'
DATE: 07-09-2012




## LEGEND

- RAIL TRACK
- MAJOR DRAINAGE AREA
- DRAINAGE SUB AREA
- NODE LOCATION
- FLOW PATH
- UD — UNDER DRAIN
- SD — STORM DRAIN
- CONTOURS
- 2300 / 1.6 AC — BASIN NAME / BASIN ACREAGE

## ASSUMPTIONS

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## ACRONYMS AND ABBREVIATIONS

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CMP - CORRUGATED METAL PIPE
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REDLANDS PASSENGER RAIL PROJECT
EXISTING HYDROLOGY MAP
SHEET 5 OF 14

SCALE: 1"=300'
DATE: 07-09-2012

7/12/2013 6:33:30 PM mgranado

## LEGEND

- RAIL TRACK
- MAJOR DRAINAGE AREA
- DRAINAGE SUB AREA
- NODE LOCATION
- FLOW PATH
- UD — UNDER DRAIN
- SD — STORM DRAIN
- CONTOURS
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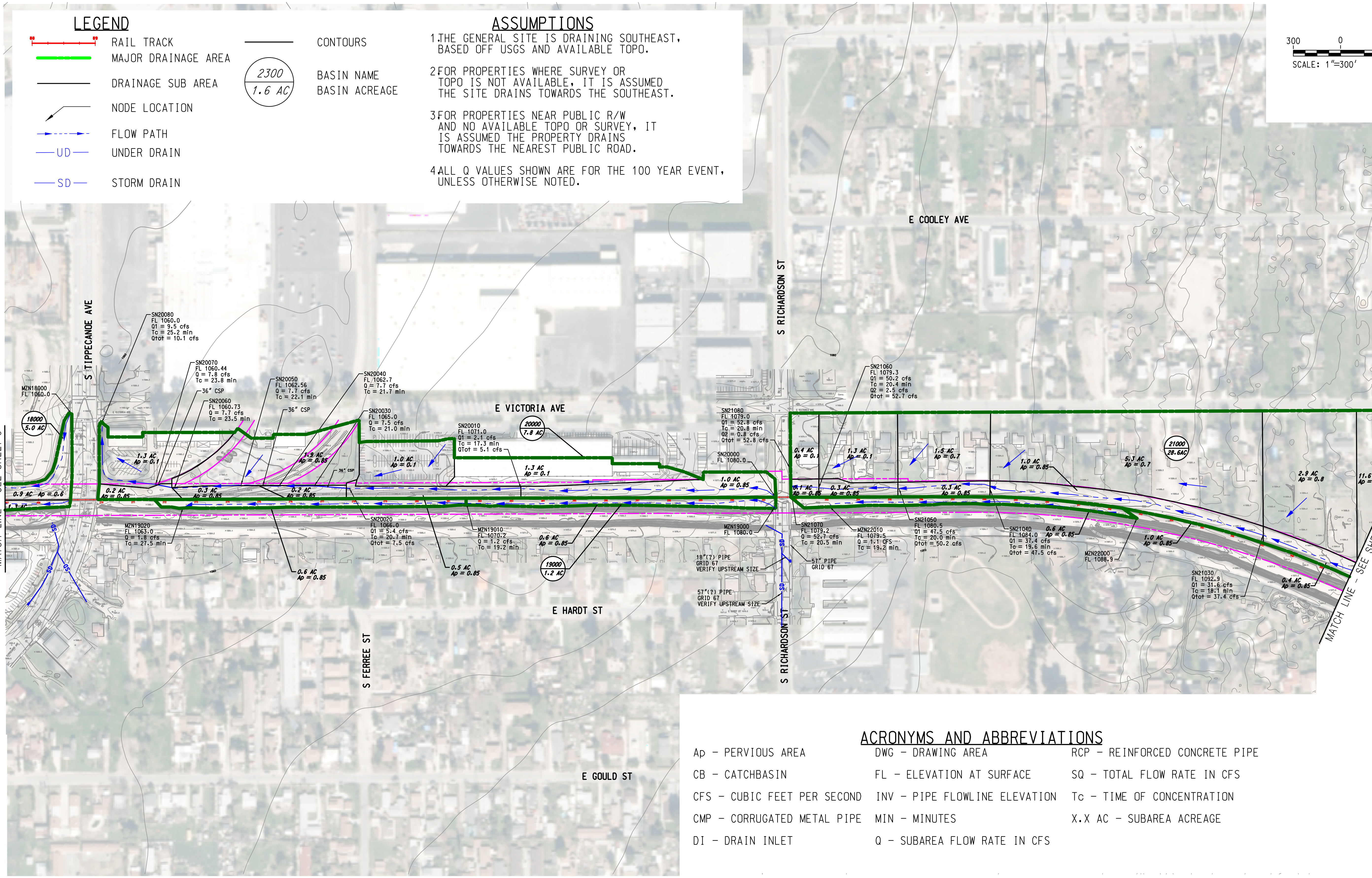


## ACRONYMS AND ABBREVIATIONS

| | | |
|---|---|---|
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| CFS - CUBIC FEET PER SECOND | INV - PIPE FLOWLINE ELEVATION | Tc - TIME OF CONCENTRATION |
| CMP - CORRUGATED METAL PIPE | MIN - MINUTES | X.X AC - SUBAREA ACREAGE |
| DI - DRAIN INLET | Q - SUBAREA FLOW RATE IN CFS | |

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EXISTING HYDROLOGY MAP
SHEET 6 OF 14

SCALE: 1"=300'
DATE: 07-09-2012

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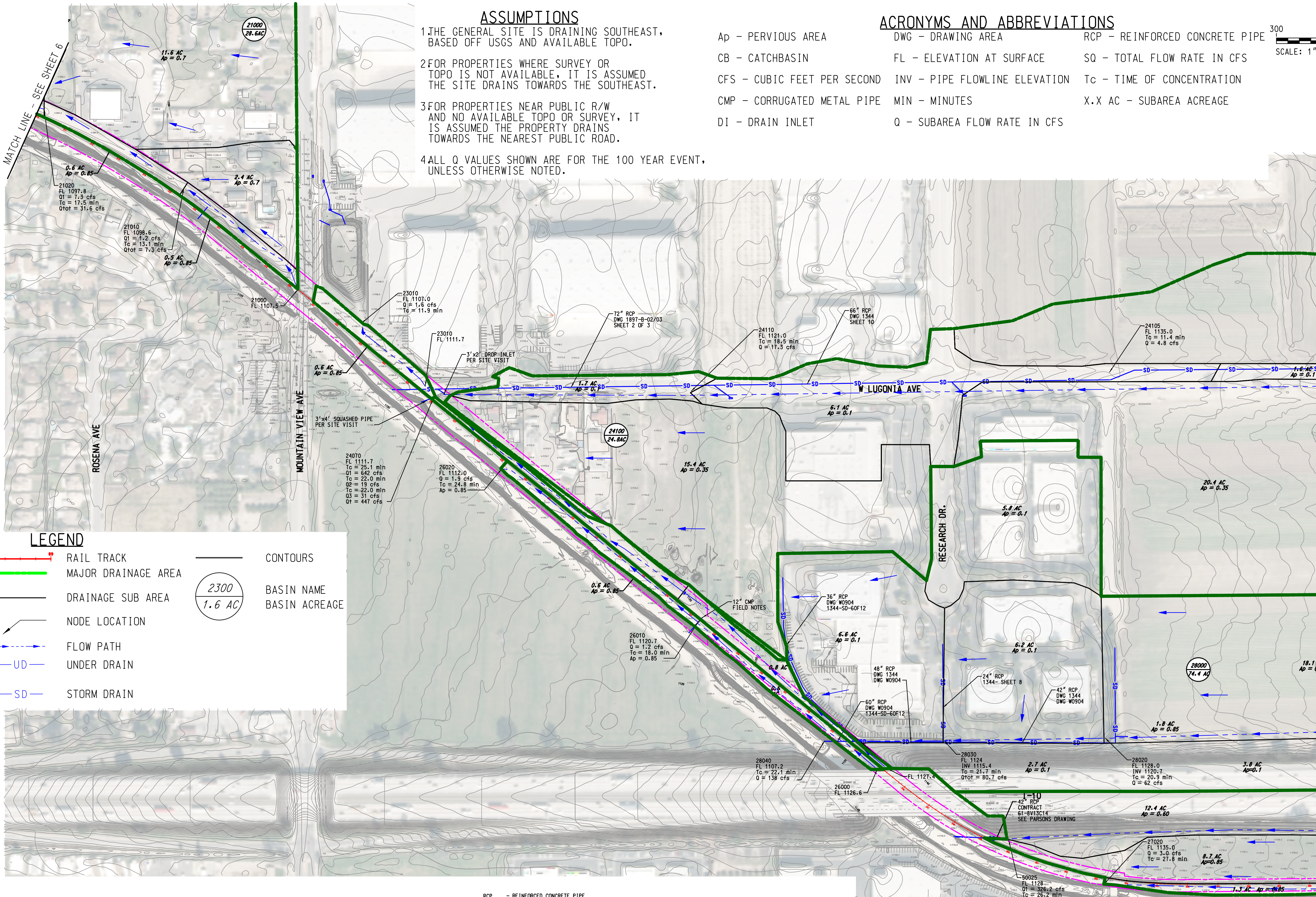


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SD — STORM DRAIN
CONTOURS
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EXISTING HYDROLOGY MAP
SHEET 7 OF 14

SCALE: 1"=300'
DATE: 07-09-2012

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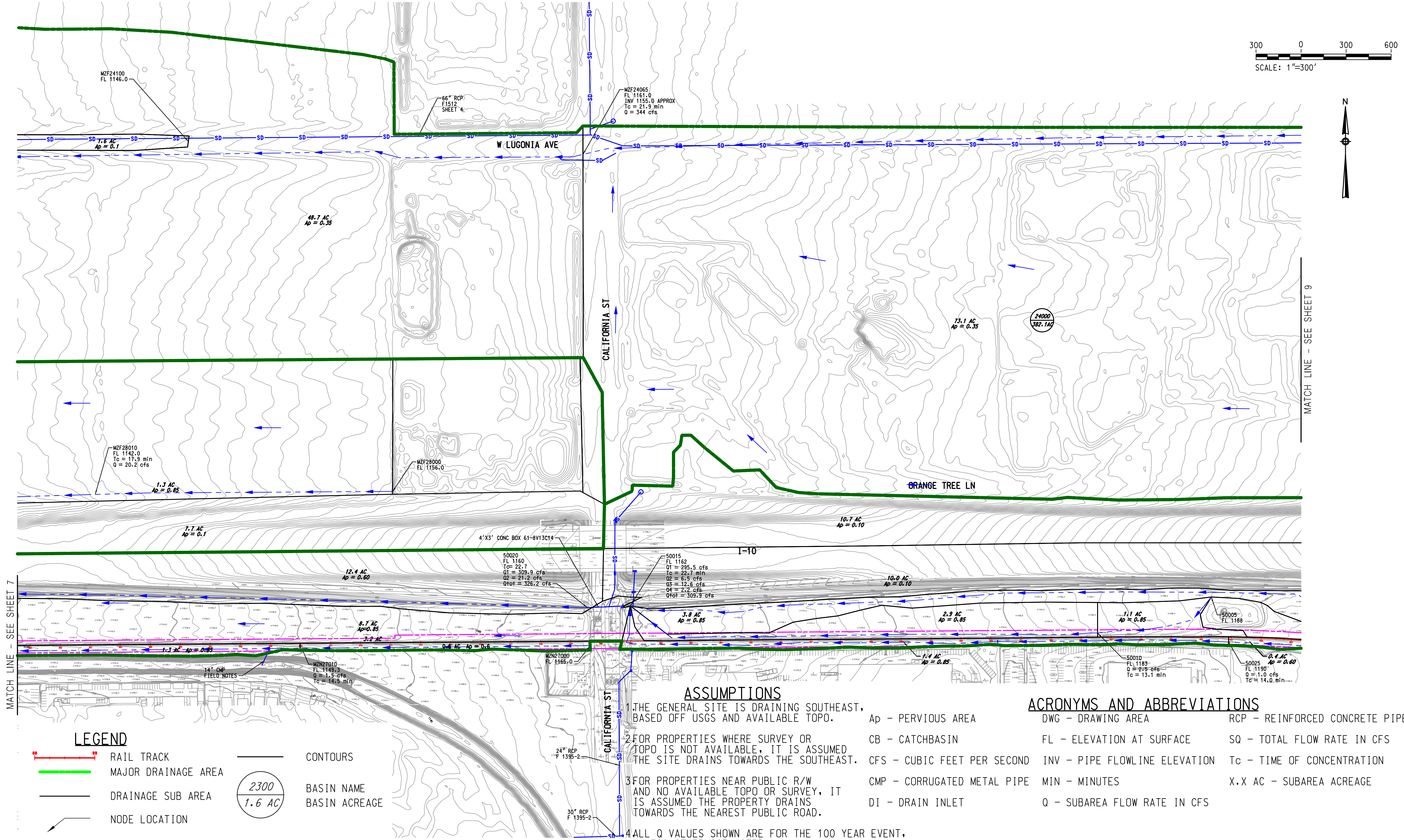


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EXISTING HYDROLOGY MAP
SHEET 8 OF 14

SCALE: 1"=300'
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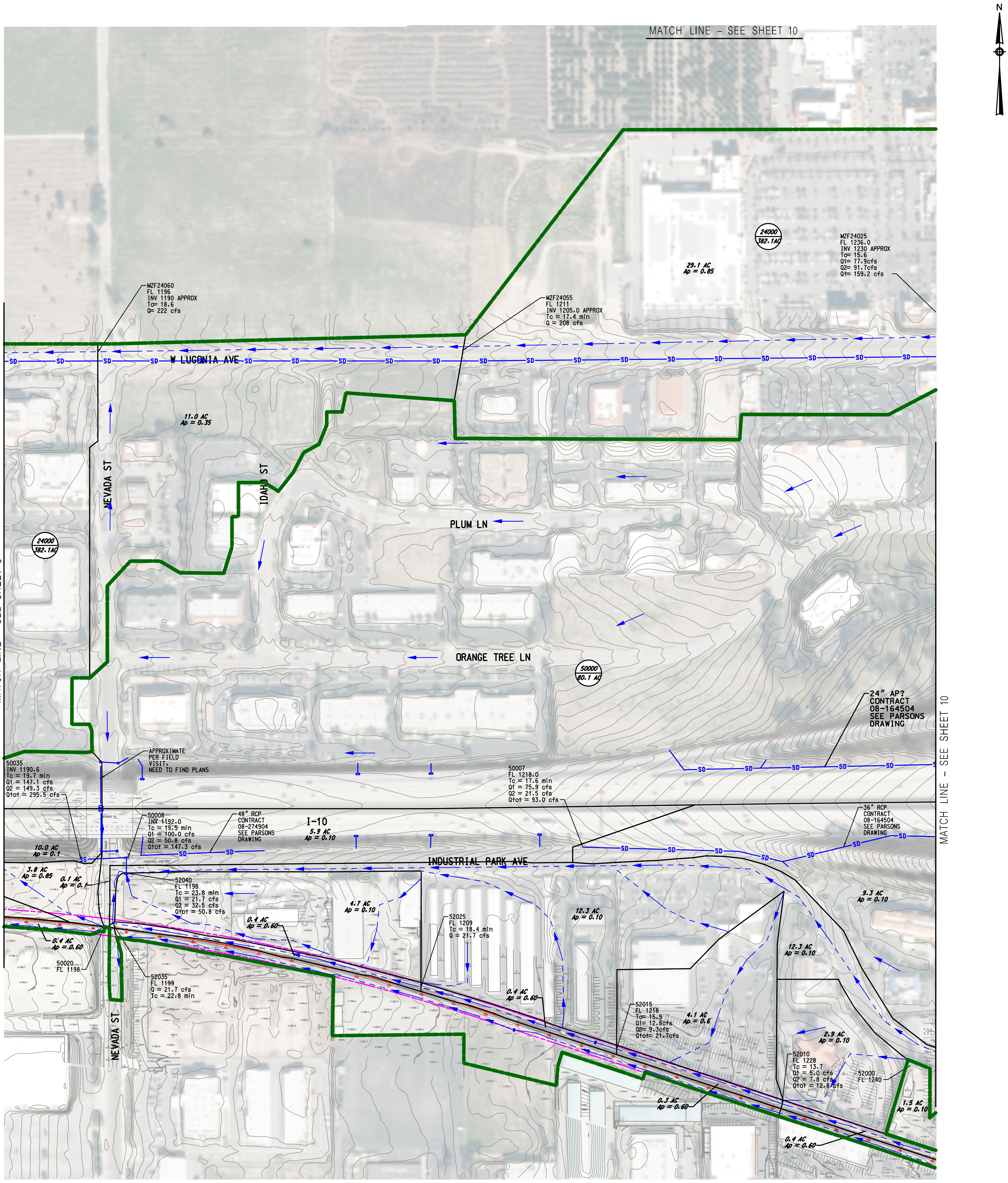


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300 0 300 600
SCALE: 1"=300'

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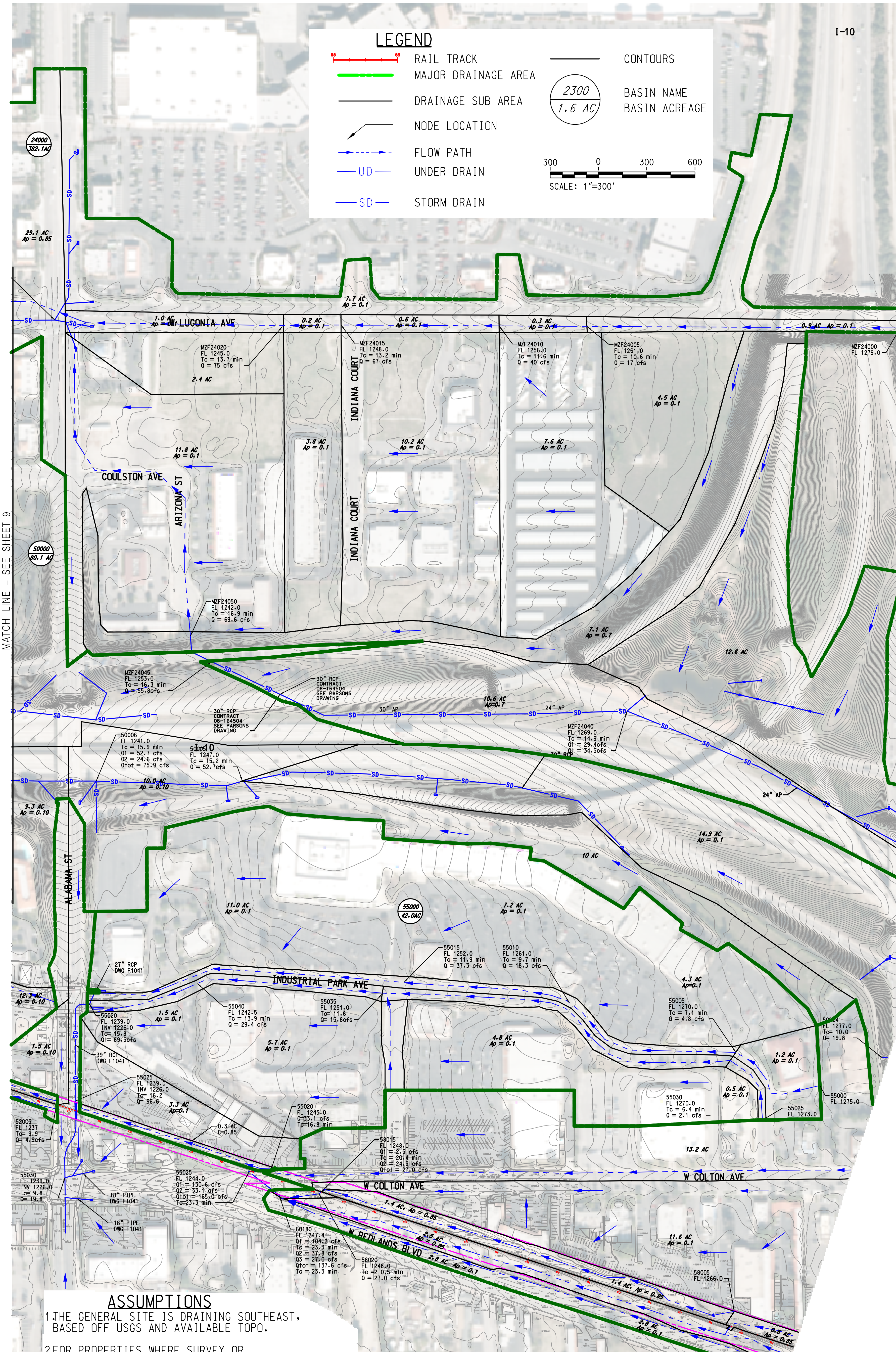
**SAN BERNARDINO ASSOCIATED GOVERNMENTS**
**REDLANDS PASSENGER RAIL PROJECT**
EXISTING HYDROLOGY MAP
SHEET 9 OF 14

SCALE: 1"=300'
DATE: 07-09-2012

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SHEET 10 OF 14

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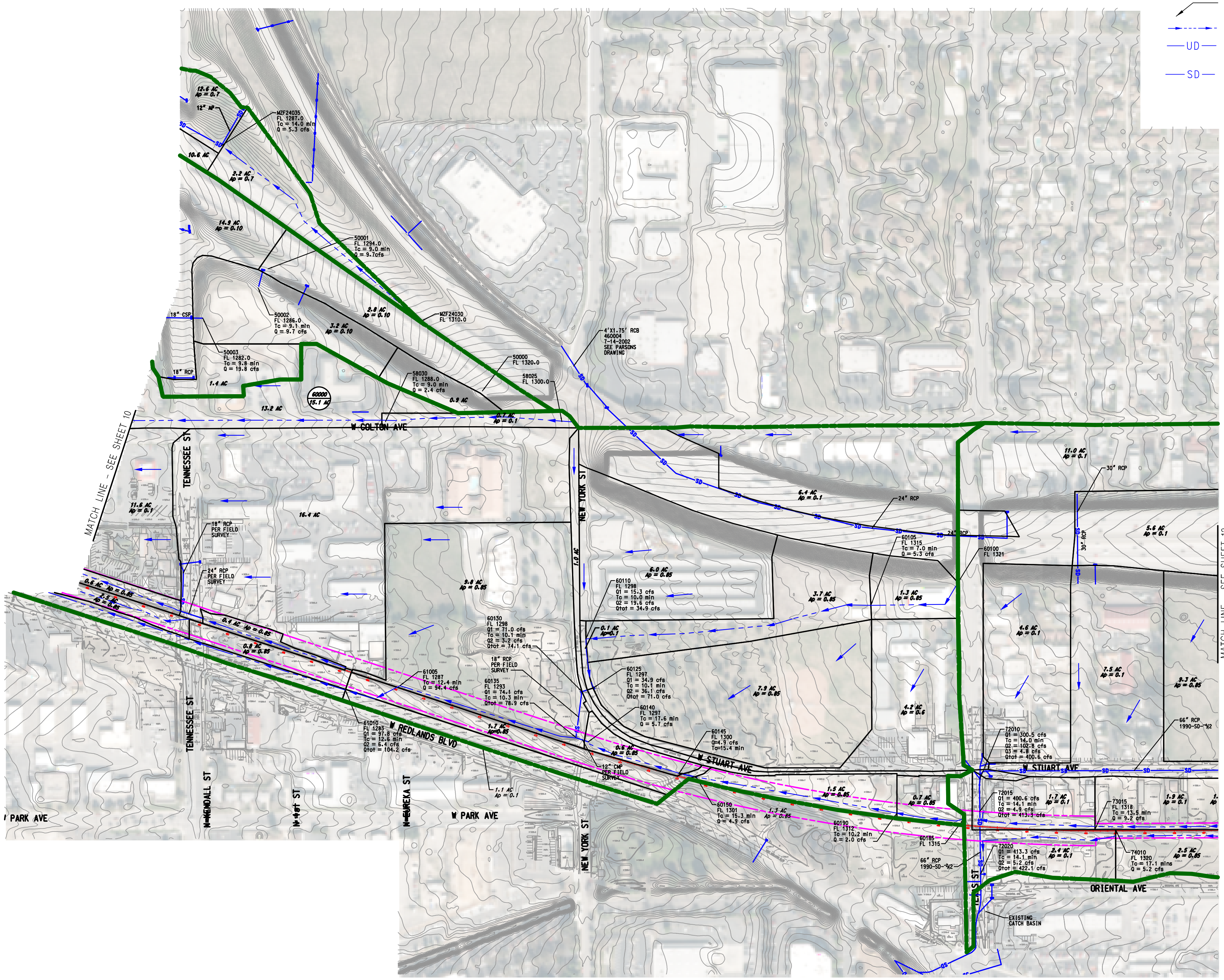


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EXISTING HYDROLOGY MAP
SHEET 11 OF 14

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SHEET 11 OF 14

SCALE: 1"=400'

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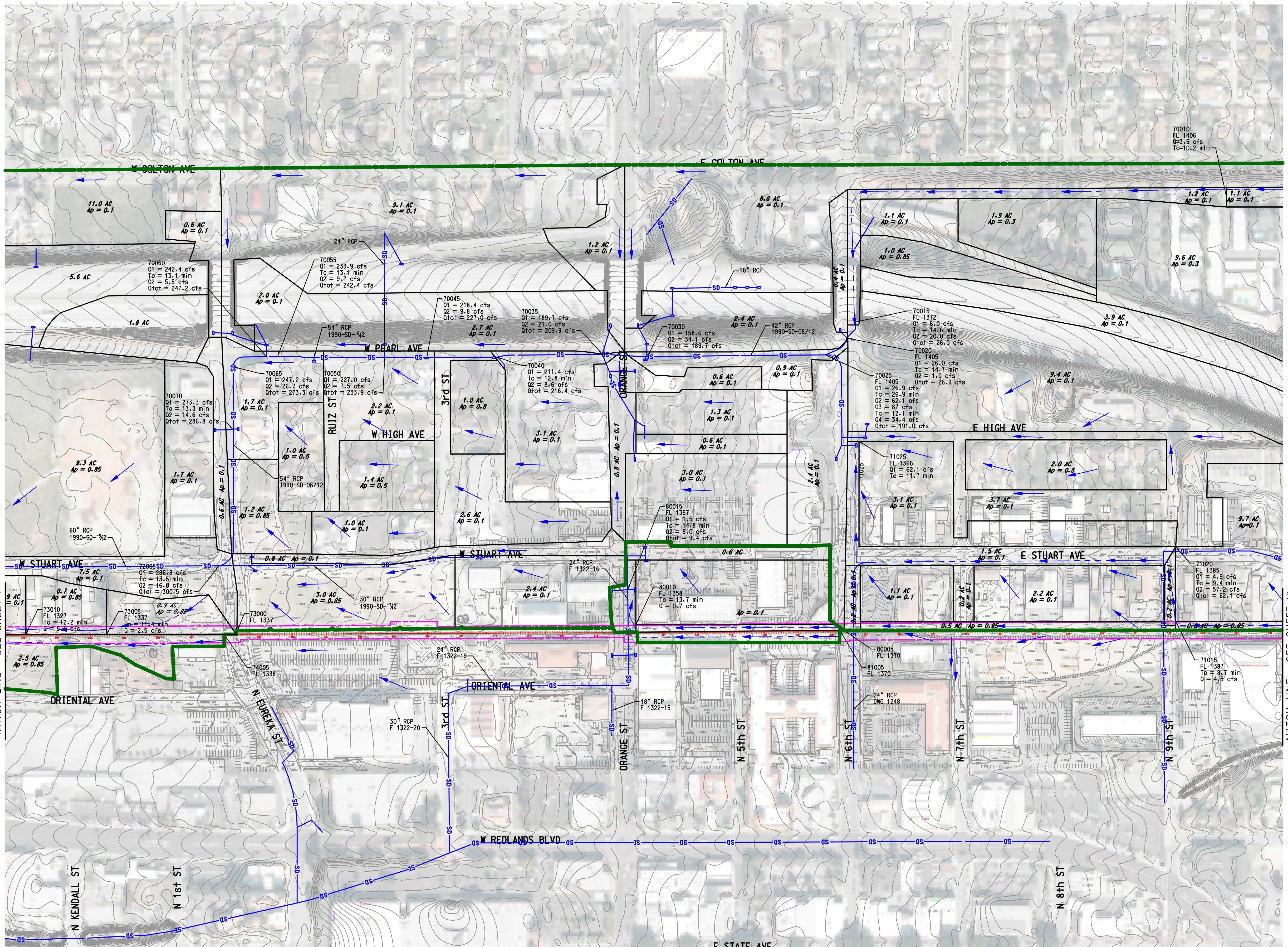


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SCALE: 1"=300'

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EXISTING HYDROLOGY MAP
SHEET 12 OF 14

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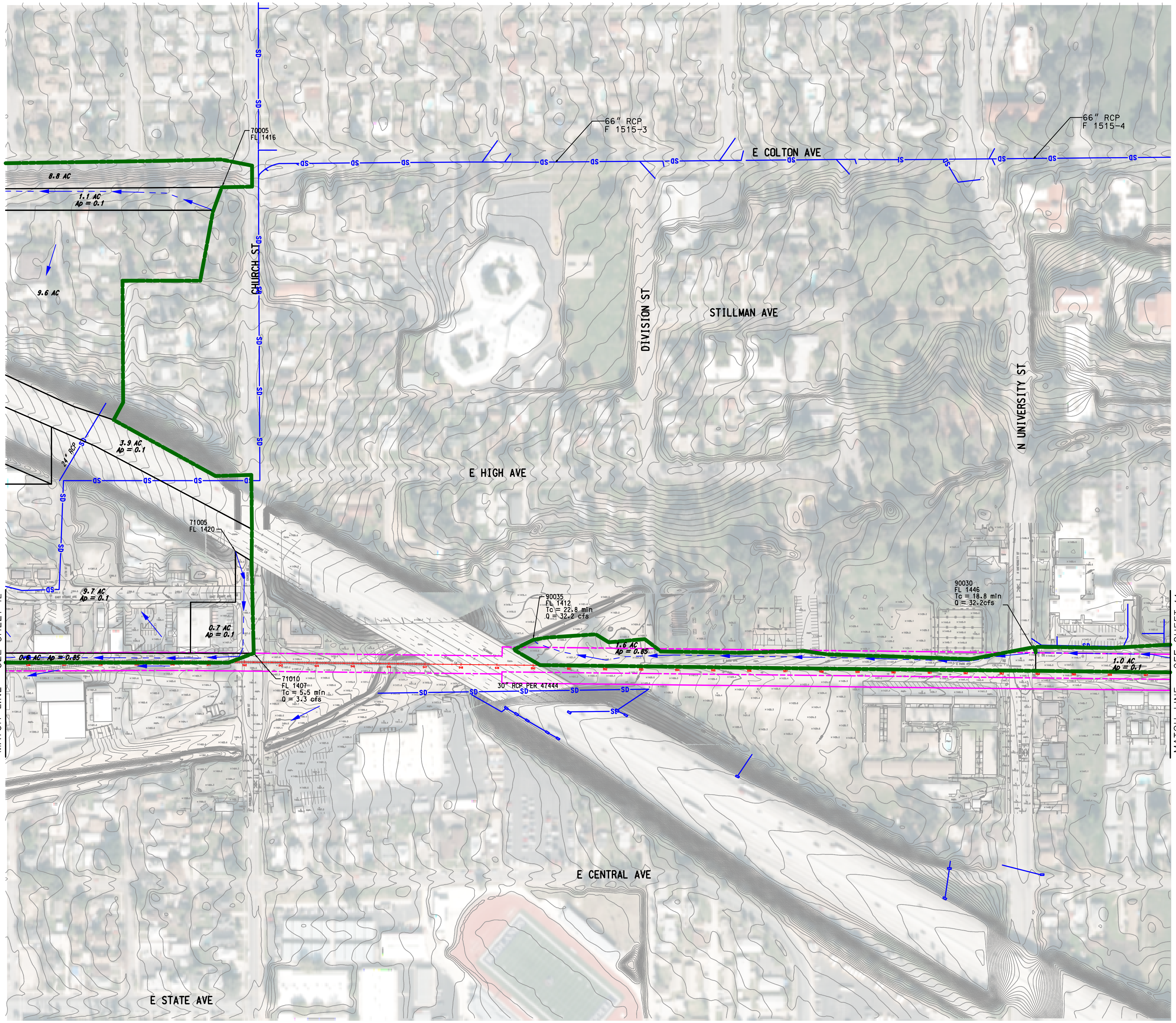


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SCALE: 1"=300'

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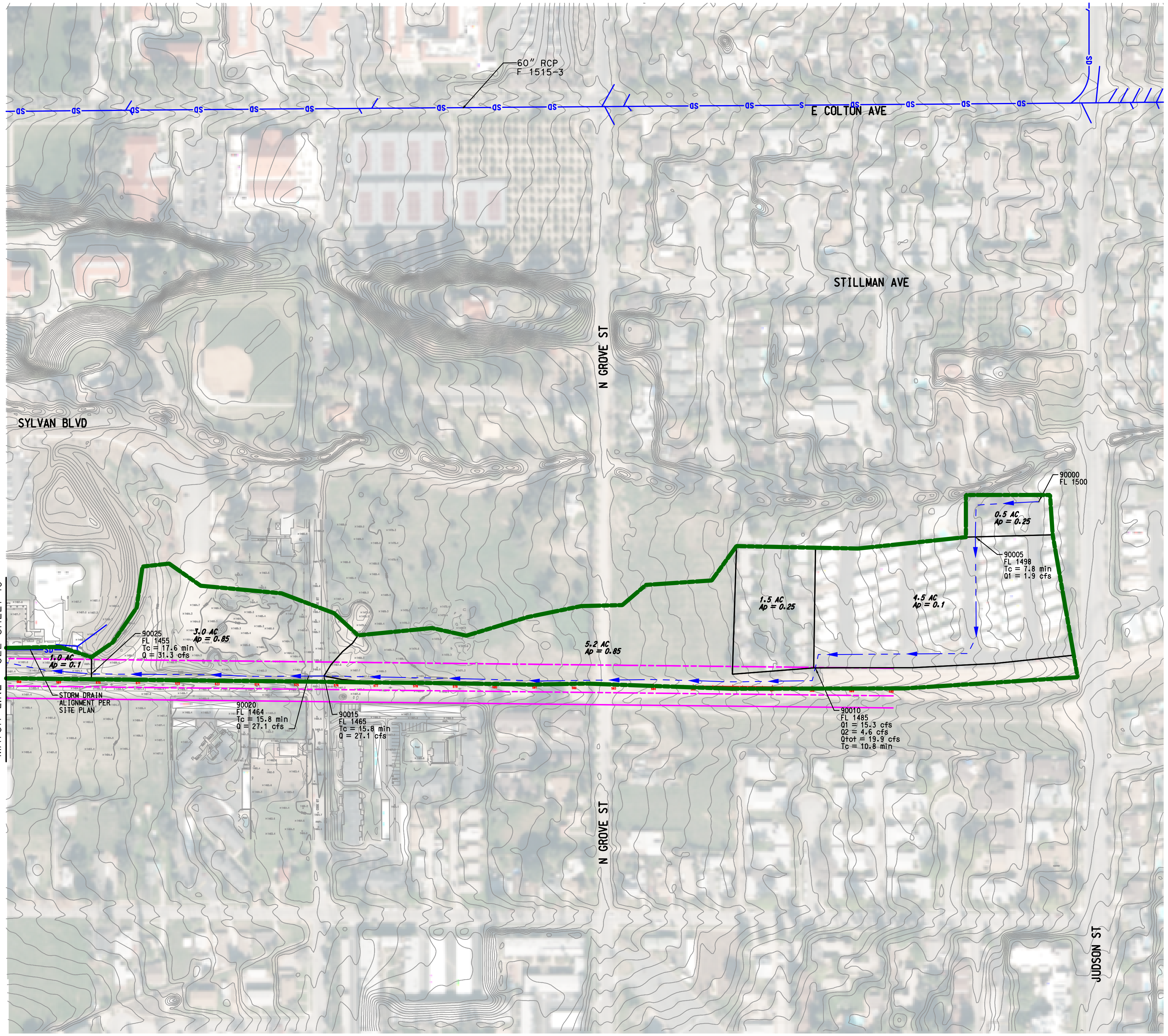


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SHEET 14 OF 14

SCALE: 1"=300'
DATE: 07-09-2012

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# Appendix C

# Historical Flood Photos


Aug 11, 1965 Intersection, Orange & State

Aug 11, 1965 State St. btwn 6th and 7th
View: east

Aug 11, 1965 Orange & State

Aug 11, 1965 State & Orange

State St. between 6th & 7th
View: east
Aug. 11, 1965

c
57.7
14471

Aug. 11, 1965
Intersection - orange & state

c
57.7
14275

Aug. 11, 1965
State & orange

c
57.7
14276

Aug. 11, 1965
orange & state

c
57.7
14274

FRIDAY SEPT. 24 1976

LOOKING N.E. INTO GLORY HOLE ON N.Y. ST. AT BRIDGE

FRIDAY SEPT 24 1976


LOOKING NORTH ON TEXAS & REDLANDS

FRIDAY SEPT 24 1976

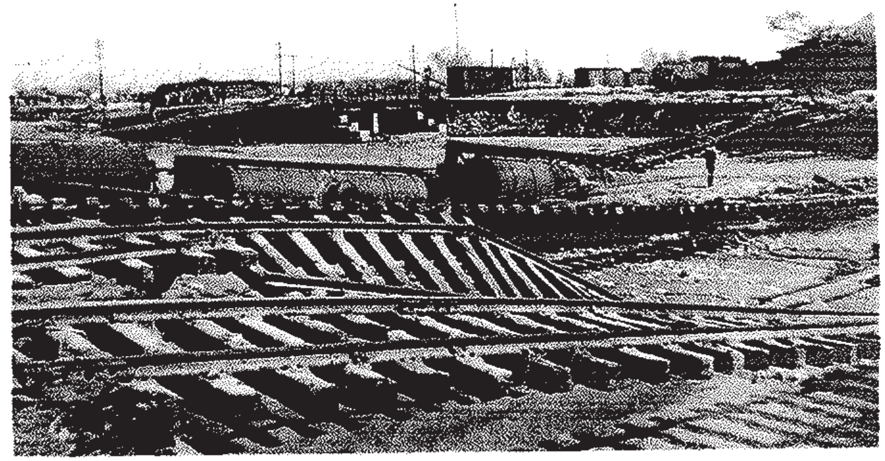
LOOKING EAST ON REDLANDS BLVD AT TEXAS

FRIDAY SEPT 24 1976

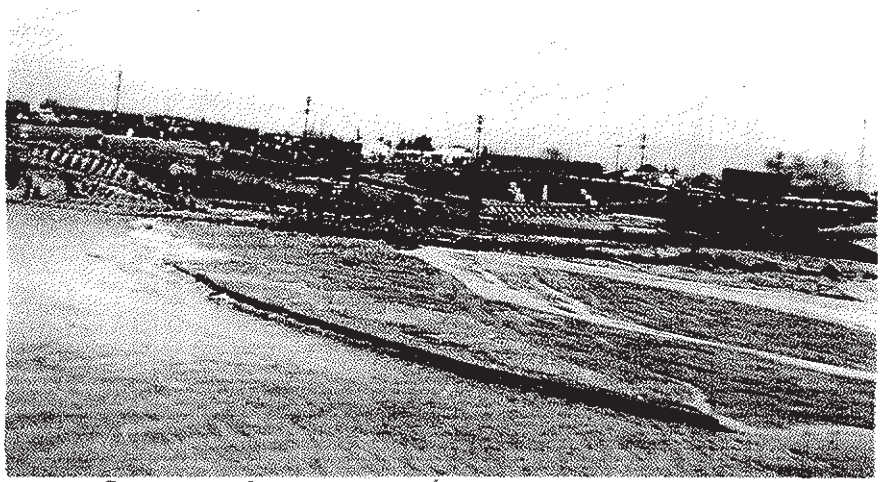
LOOKING IN TO ENTRANCE OF GLORY HOLE FROM NEW YORK ST.

FRIDAY SEPT 24 1976

LOOKING WEST CITRUS & EUREKA



1938 Flood Santa Ana River



1938 Flood Santa Ana River

Santa Ana River
1938 Flood

C
57.4
12604

Friday, September 24
1976

C
57.4
12207b

Santa Ana River
1938 Flood

C
57.4
12605

Page 2



WATER TALK—A number of residents of Sylvan Mobile Estates cluster together and talk—as everyone did yesterday afternoon—about the deluge. The grounds took some flooding from the railroad right-of-way at Judson but due to good drainage there was no major tr Wall is on property line by the railroad.

(Art Miller

JENNIE DAVIS LAKE—A trash barrel (center left) floats atop a swift river of water as it swirls through Jennie Davis park. Water and debris swept through the park during yesterday's flash flood, flattening grass, ripping off pieces of shrubs, and leaving an oozing layer of muck on picnic tables and park benches. Much of the park was submerged beneath several inches of water yesterday.

(Photo by Dick Wiley)

over

**BOULEVARD COLLAPSED**—Severe flooding undermined and collapsed this portion of Redlands boulevard in the eastbound lanes between New York and Tennessee streets. Motorists who were able to travel the road after nearly two feet of water drained off found they had to dodge rocks and other debris, as well as thick, slick deposits of mud. (Photo by Dick Wiley)

*River on State street*

# Flash flood damages business district

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By FRANK MOORE

A flash flood turned Redlands boulevard and State street into rivers yesterday afternoon.

Occupants of buildings along the way blocked the spaces under front doors as best they could, but some had the most trouble at their alley entrances.

Here is a partial inventory of places and damage:

Water against front doors of Harris' was effectively blocked. Water in alley invaded the warehouse stockroom, soaking bottom boxes of merchandise. This water also got into shoe basement, damaging bottom rows of stock. Alley damage was heightened when a 3 by 4 steel grating clogged and drainage was blocked.

Harris Bookstore had water on Fifth 18 inches deep against the front. Water on the floor was about eight to 10 inches, damaging lowest stock which could not be removed quickly enough.

Manager Steve Mathews said that when Harris' closed about 5 o'clock (instead of 9 p.m.) many employes could not get across the Redlands boulevard river to where their cars were parked.

At Bank of America, water rose about six inches against closed, east doors, but penetrated into about one third of the lobby.

Charlene Cooke and Pat Johnston said that three girls grabbed money bags—"empty bags", they emphasized with a laugh—and used them as a barrier. Doug Dixon, formerly of this branch, happened by and joined the sweep and mopping brigade. Fortunately there is a janitor's room, which has a floor drain, into which water could be coaxed. Manager Dean Cullop's office was partially wetted by water coming under the State street window.

Adding insult to injury, the roof leaked.

United California Bank, like the Bank of America, is new. Water came at it in flood on Redlands boulevard leaving mud marks about 30 inches high along the font glass on Orange street. Water passed over the carpet in a wide swath, going about 30 feet to the stand-up patrons counter in the center of the lobby space.

Adjoining the bank on the Redlands boulevard side is a large, new, unoccupied store or office space and it was well wetted inside.

Bob Hatfield said water flowing down Redlands boulevard was not invading the Buick agency at Eighth street. However, the Zanja comes down to the edge of his used car lot in a stone ditch, about 15 feet wide and six feet deep and goes underground, the cover being about four feet high.

Hatfield said that logs and debris floating on the tide partially jammed the entrance to the tunnel. The water then came over the used car lot, flooded the new-car show room and deposited about three inches of mud over two-thirds of the garage floor.

Hatfield said it was almost an exact replay of the flood of August 11, 1965 which was largely caused by the then-new drainage ditch along Redlands boulevard from Ford street to Fern simply pouring out onto the boulevard.

As a result of the 1965 flood a 30-inch pipe was installed in the bottom of the ditch about 100 yards above Fern avenue, carrying the water over to a ditch that runs between MacDonald's and the YMCA.

While the pipe took much of the water, the overflow again went down Redlands boulevard. But it also broke over onto Church street at the point where it makes an S turn to Redlands boulevard at the high school. This caused flooding on Clark between Redlands and Church.

The Reservoir Canyon Storm drain was a major contributor to flooding on Redlands boulevard, State and Citrus according to Horace P. Hinckley, chairman of the local county flood control district.

Directors have not been unmindful of the problem but have not been able to finance the necessary improvement for lack of sufficient funds, he said today. The major allocation in recent years has been for acquisition of rights-of-way to deepen and widen the Zanja, east of town.

As a result of the August 1965 flood, he explained, a 30 inch pipe was installed in the ditch by Redlands boulevard just above Fern. But this was inadequate Friday and a culvert with direct flow to the Zanja is needed. The current budget includes $20,000 for engineering this connection.

In the 1965 storm the Gold Banner Packing House on Redlands boulevard at Eighth—just west of Hatfield Buick—was badly flooded, with deep water in the basement. The common wisdom around town late yesterday was that the building would surely have suffered the same fate—but it didn't.

Now called The Packing House, it is the home of various small shops, selling specialties and old things. John Cortinger, one of the owners, said that the basement windows—two panes above ground level—held. If they had popped, water would have poured in. Many people worked like the little Dutch Boy putting his finger in the dike to keep the water out, he said.

The Robert Conreras family lives at 409 Central and faces the open Zanja, just at the portal to the tunnel. They thought they would be flooded indoors but they protected their home. Their water pipe across the ditch, however, was washed out.

Many places of business were inundated but the damage was quite variable. Many establishments have composition tile floors with no valuable merchandise resting on it. Hence the water was merely a nuisance, to be kept out as much as possible, and if not, then there was much sweeping and mopping.

But where there were vulnerable stocks to be water-damaged, the trouble was grievous. For example, Arthur Commercial Press on Fifth street between State and Redlands boulevard. Here the water came from three directions—State, the alley and Redlands boulevard.

Harvey Sawyer, the proprietor, said that much of his paper, at the back of his shop, was wetted. Where cartons of stock were standing on the floor, the bottom one in each pile was wetted. He said he was particularly hurt by the ruination of printing work that had been finished and was ready for delivery.

Places that could be swept out and mopped were soon back in business, such as Taco Blanco at Redlands and Seventh.

The Tartan Restaurant at Fifth and Redlands was very flood vunerable and took some water at the front door on Fifth

**RAINFALL TABLE**

| | Storm | Season | Last Year |
|---|---|---|---|
| Redlands | .66 | 3.83 | tr |
| Yucaipa | .90 | 4.98 | .32 |
| Calimesa | .92 | 5.72 | .11 |
| Mill Creek | .56 | 5.58 | tr |
| Camp Angelus | .15 | 12.26 | 2.09 |

bar was flooded it was back in operation by early evening. Dinners, however, were not served.

Because Bank of America and United California were inundated there was confused, but erroneous talk of damage at other banks. The brand new Bank of Redlands at Citrus and Sixth was not harmed nor was the long established Security Bank on State at Seventh.

State, the main shopping street of the town, carried a flood which threatened every place of business along it. However, the results were variable. At Pacific Finance the water only reached the first desk whereas at Postal Finance, just a few doors up, the water went through on the composition tile floor.

Nearly everyone struggled to keep the water from coming under and around closed store or office doors. At Lois Lauer's new real estate office the water covered the front portion of the rug. At [illegible] was only a small wetting. But the store did catch some water from the alley, Ed Grace said.

Nelson-Hales Furniture, like many State street neighbors, was not inundated at the front door. But the flow against the show windows at the Sixth street corner leaked around the glass, wetting the carpet and causing the owners to remove the show furniture.

At Gairs a beautiful, block wooden floor has been recently installed. Fortunately, it was not damaged. However, some water did come in the back door. Also on this alley the water went into the back of Wattenbarger's Office Supply.

McEwens Furniture Galleries on West Redlands boulevard is one of the finest stores in town and fortunately stands high enough above the surrounding ground to have escaped flooding.

There was much flooding at Citrus and Redlands boulevard and the nearby YMCA, facing Citrus had troubles. Bret Cox said that there was a little water in the lobby, which did not damage the furniture, and some came in the back door. About five volunteers pushed the water with brooms and mops into the basement to a depth of about nine inches. The roof leaked. The gym floor was not harmed.

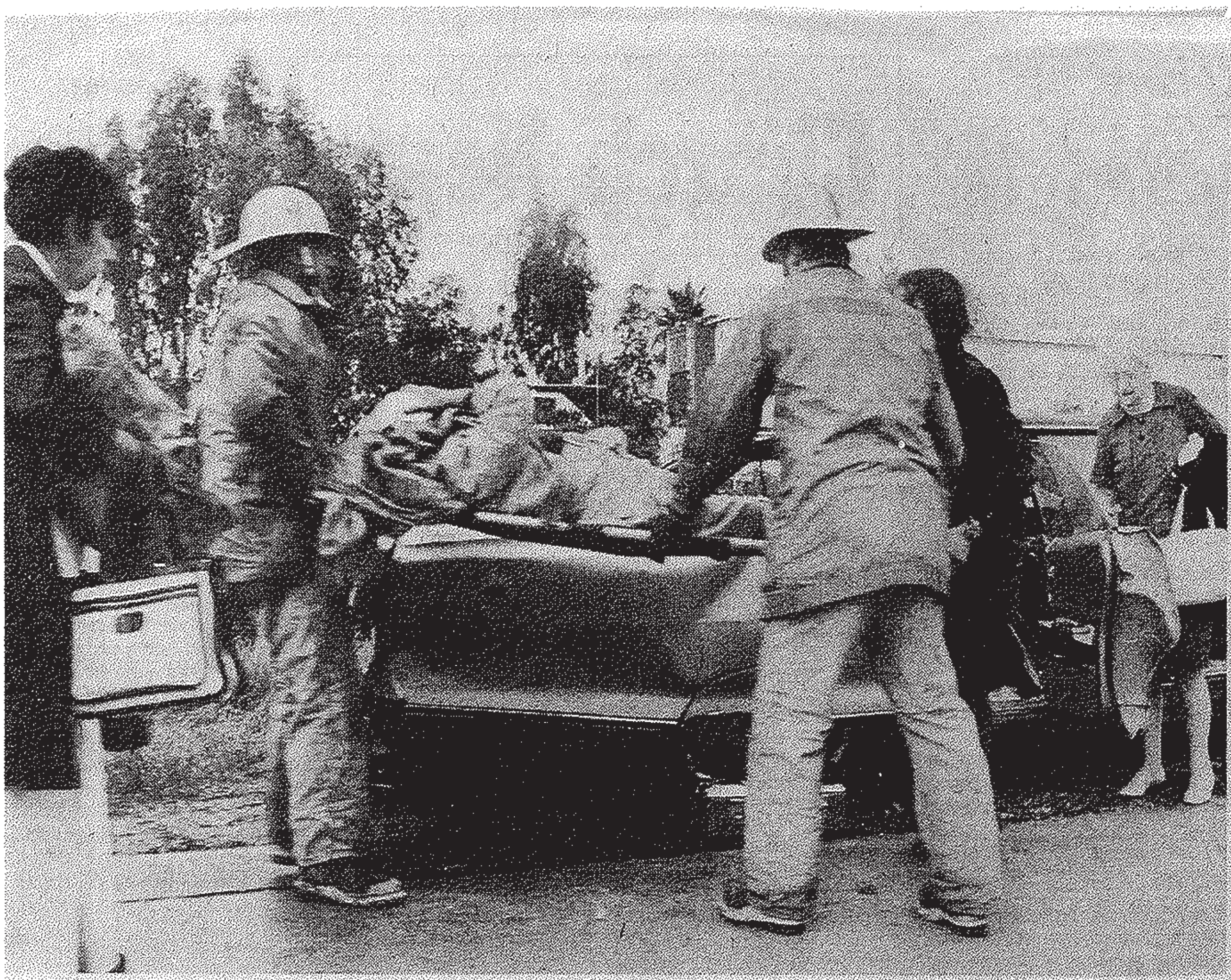
Water pouring down State street, upon reaching Orange, poured across the ground where the Mall now stands as exterior walls, roof, but hollow interior. Some water went into the broad east opening, but left about three-fourths of the floor area dry.

However the La Posada hotel has just been razed, exposing the basement. This filled with water creating a muddy lake about 40 feet wide and 90 feet long.

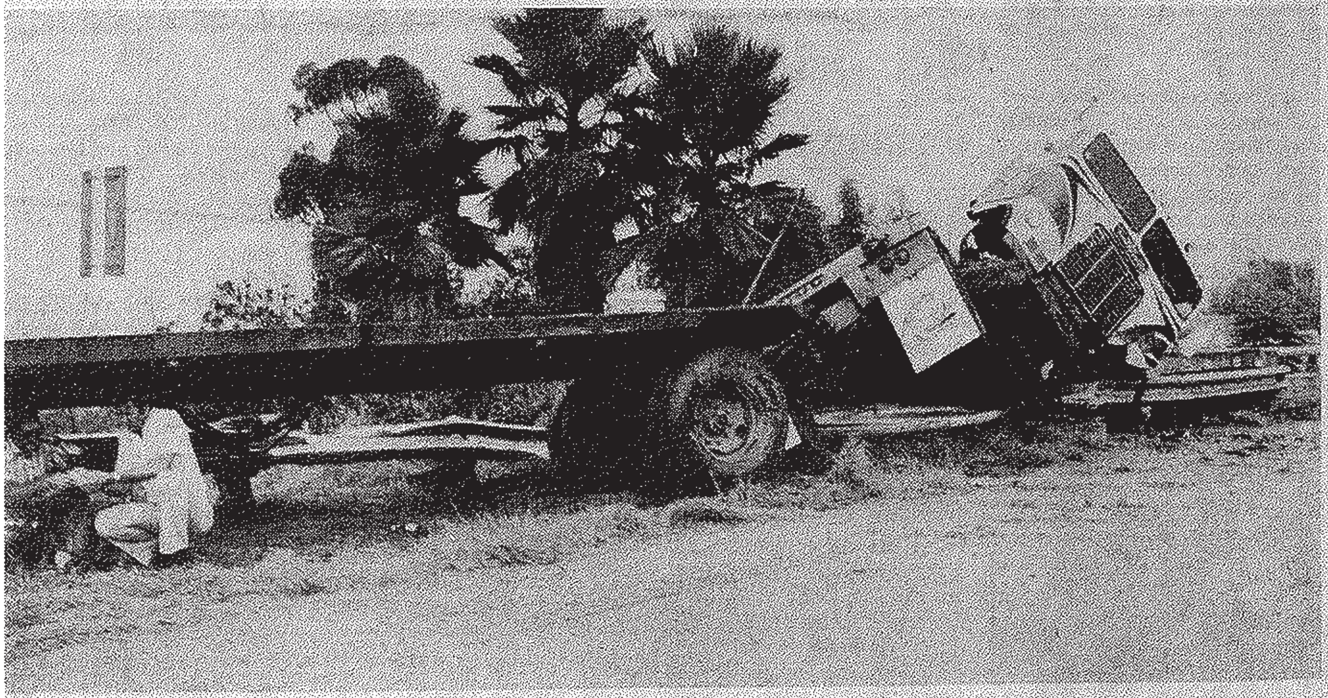
A large pond also formed in the vacant lot at State and Fifth, formerly the site of the Chandler building, and used during the summer of 1976 as an outdoor Crafton College Theater.

While various specific reports are included in this article, they are but samples of numerous cases that could be

Page 4



**WET RESCUE**—Redlands firemen pull an unidentified woman from the wreckage of her car after it was struck by a truck on the westbound lanes of Interstate 10 near University avenue yesterday afternoon. The woman was reportedly in a parked car on the side of the freeway when she was hit by a van that went out of control just moments after a truck-trailer rig flipped over in the center divider. No details of the accident were available this morning, but California Highway Patrol officers said traffic was tied up nearly three hours. (Facts photos by Kenison)



**RAINY MISHAP**—The driver of this tractor-trailer rig receives first aid for cuts and bruises (left), sheltered from yesterday's torrential downpour by the bed of the trailer. The driver, whose name was not available this morning, apparently lost control of the rig when he tried to slow down and flipped the rig on its side in the center divider on Interstate 10 near the University avenue off-ramp about 4:30 p.m. yesterday.

### *River on*

# Fla
# bus

By FRANK

A flash flood turned R
and State street into
afternoon.

Occupants of building
blocked the spaces und
best they could, but so
trouble at their alley e

Here is a partial inven
damage:

Water against front do
effectively blocked. W
vaded the warehouse st
bottom boxes of mercha
also got into shoe bas
bottom rows of stock. A
heightened when a 3 b
clogged and drainage w

Harris Bookstore had
inches deep against the f
floor was about eigh
damaging lowest stock
removed quickly enoug

Manager Steve Mathe
Harris' closed about 5 o'
p.m.) many employes c
the Redlands boulevar
their cars were parked.

At Bank of America,
six inches against close
penetrated into about
lobby.

Charlene Cooke and F
that three girls grabbe
"empty bags", they en
laugh—and used them a
Dixon, formerly of this
by and joined the swe
brigade. Fortunately th
room, which has a floor
water could be coaxed
Cullop's office was pa
water coming under
window.

Adding insult to injury

United California Bank
America, is new. Water
on Redlands boulevar
marks about 30 inches h
glass on Orange street. V
the carpet in a wide swa
feet to the stand-up patr
center of the lobby spac

Adjoining the bank
boulevard side is a large
store or office space and
inside.

Bob Hatfield said wa
Redlands boulevard was
Buick agency at Eighth
the Zanja comes down
used car lot in a stone d
wide and six feet de
derground, the cover be
high.

Hatfield said that
floating on the tide part
entrance to the tunnel.
came over the used ca
new-car show room and
three inches of mud over
garage floor.

Hatfield said it was
replay of the flood of Au
was largely caused
drainage ditch along R
from Ford street to Fe
out onto the boulevard.

As a result of the 19
pipe was installed in t
ditch about 100 yards a
carrying the water ove

[Sept, 1976]

**ZANJA OVERFLOWS**—The ancient Zanja was filled to overflowing during the flash flood during the sudden storm last Friday. At University street and Sylvan boulevard the water floods across the street into Sylvan park where it caused heavy damage, filled the municipal swimming pool with mud and debris. Water ran over the stone footbridges in Sylvan park.

(Photo by U.R. student Gary Trippeer)

Monday, Sept. 27,

1976

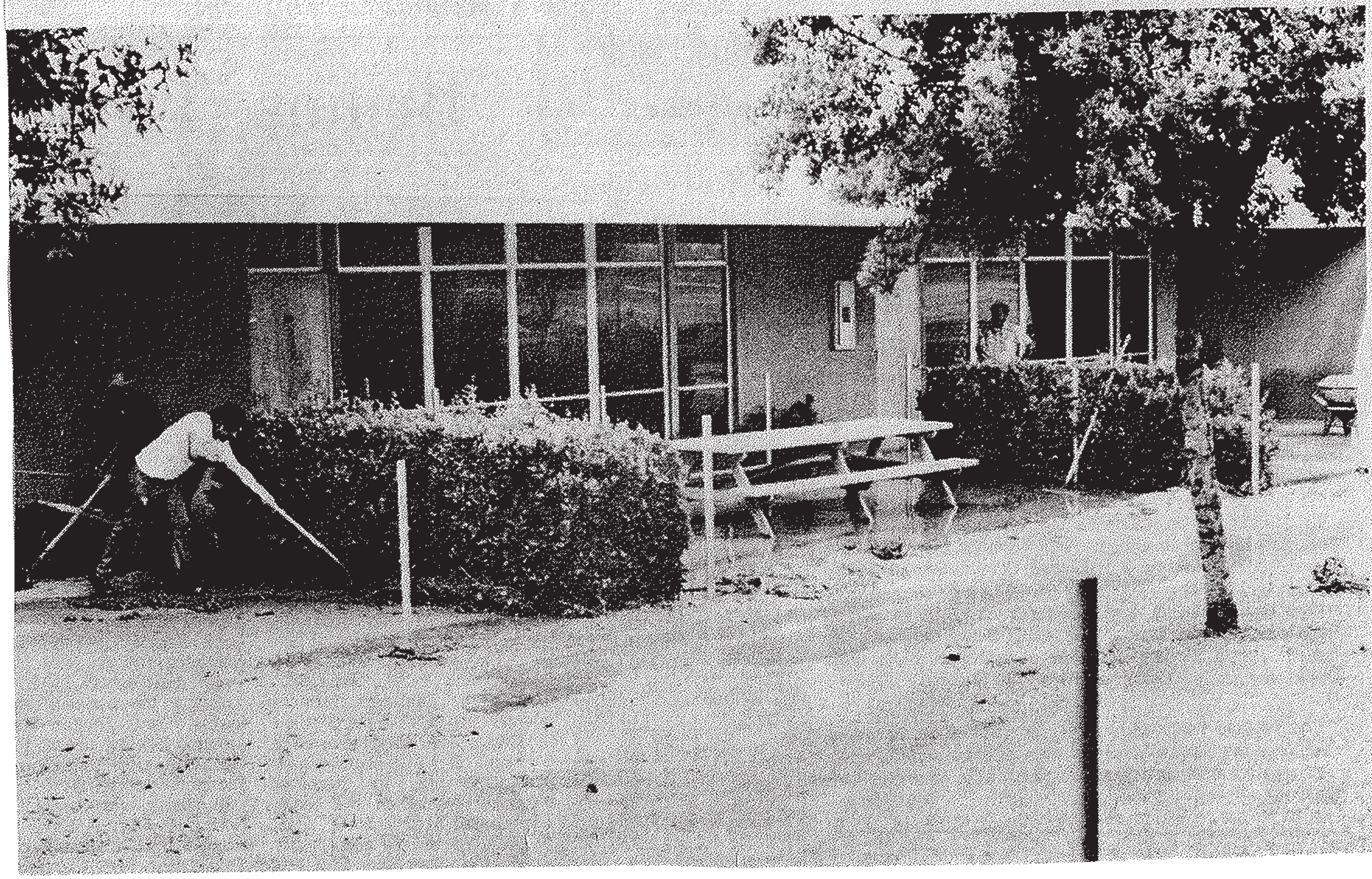
Daily Facts, Redlands, [illegible] Sept 29, 1976.

IN THE PARK—As a brook, Zanja flows under the stone-ornamented bridge (foreground) in Sylvan park. Approaching the park, however, much of the water (see other photo) could not find the Zanja and as shown here is flowing over the lawn between the bridge and the bowling greens and continuing to the right to fill Sylvan Plunge with water and mud.

(Photo by Gary Trippeer.)

Sept 29, 1976

ZANJA OVERFLOW—Taken by Gary Trippeer, UR student, during flash flood Friday this photo looks up Sylvan boulevard, above University street, bordering the campus. Zanja ditch is concealed by trees at left. This shows the large volume of water that the ditch would not accommodate. Reaching University street it spread out flowing into Sylvan park as a broad sheet.



**CRAFTON SCHOOL DAMAGED**—Costly cleanup and repairs were started at Crafton elementary school, which was exposed Friday to the full fury of the Mill Creek Zanja's flood waters. Bringing oil and overturned orchard heaters and other debris from upstream groves that the torrent invaded, the water swept through these classrooms, which school employes were trying to dry out Saturday. The school is on Wabash avenue, the eastern city limit line, and the Zanja is a close neighbor to the south, extending from east to west.

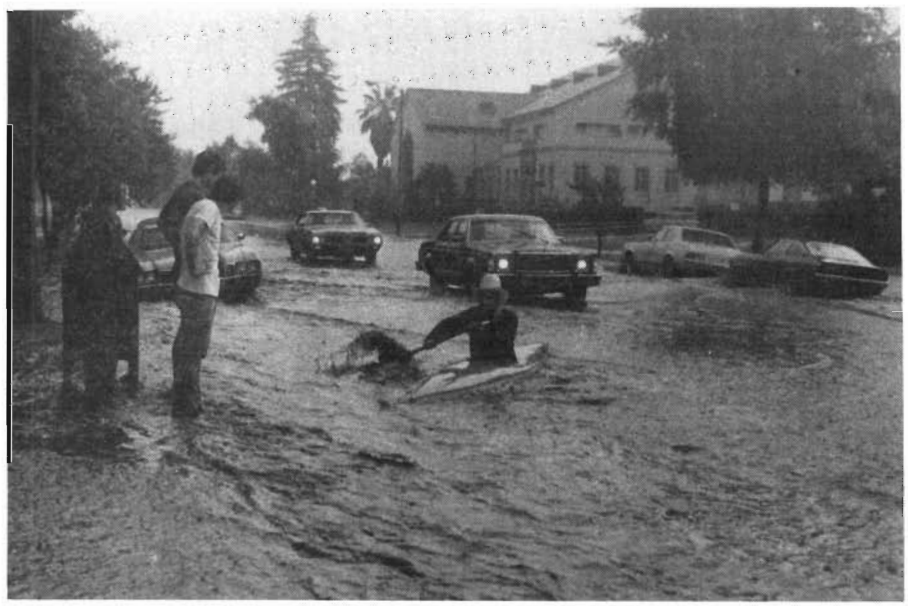
(Facts photo by Bettye Wells)

August 1965
Flash Flood
Downtown Redlands
Photo # 1


August 1965
Flash Flood
Downtown Redlands
Photo # 2

September 1976
Mission Zanja Creek
Flooding
Photo # 3

September 1976
Brookside St. & Eureka St
Photo # 4



September 1976
Flooding near
University St.
Photo # 5

September 1976
Redlands Furniture Store
Photo # 6

/CONTRIBUTED IMAGE

Redlands has been recommended to recieve a $5 million grant for a flood control project city officials hope will prevent a repeat of downtown flooding like this, which occurred at Citrus Avenue and Eureka Street in 1976.

# Appendix D

# Drainage-Related Project Photos

**Redlands Passenger Rail Project**
**Photos of Existing Drainage Facilities**

MP 2.25, 36-inch CMP (no. 1)

MP 2.25, 36-inch CMP (no. 2)

MP 2.4, 22-inch x 13-inch CMP

MP 2.6, 4-foot x 3-foot wood box buried (no. 1)

MP 2.6, 4-foot x 3-foot wood box buried (no. 2)

**Redlands Passenger Rail Project**
**Photos of Existing Drainage Facilities**

MP 2.6, 4-foot x 3-foot wood box buried (no. 3)

MP 3.9, culvert (no. 1)

MP 3.9, culvert (no. 2)

MP 3.9, culvert (no. 3)

MP 3.9, culvert (no. 4)

MP 4.2, 36-inch culvert (no. 1)

MP 4.2, 36-inch culvert (no. 2)

MP 4.2, culvert (no. 3)

MP 4.2, culvert (no. 4)

MP 4.2, culvert (no. 5)

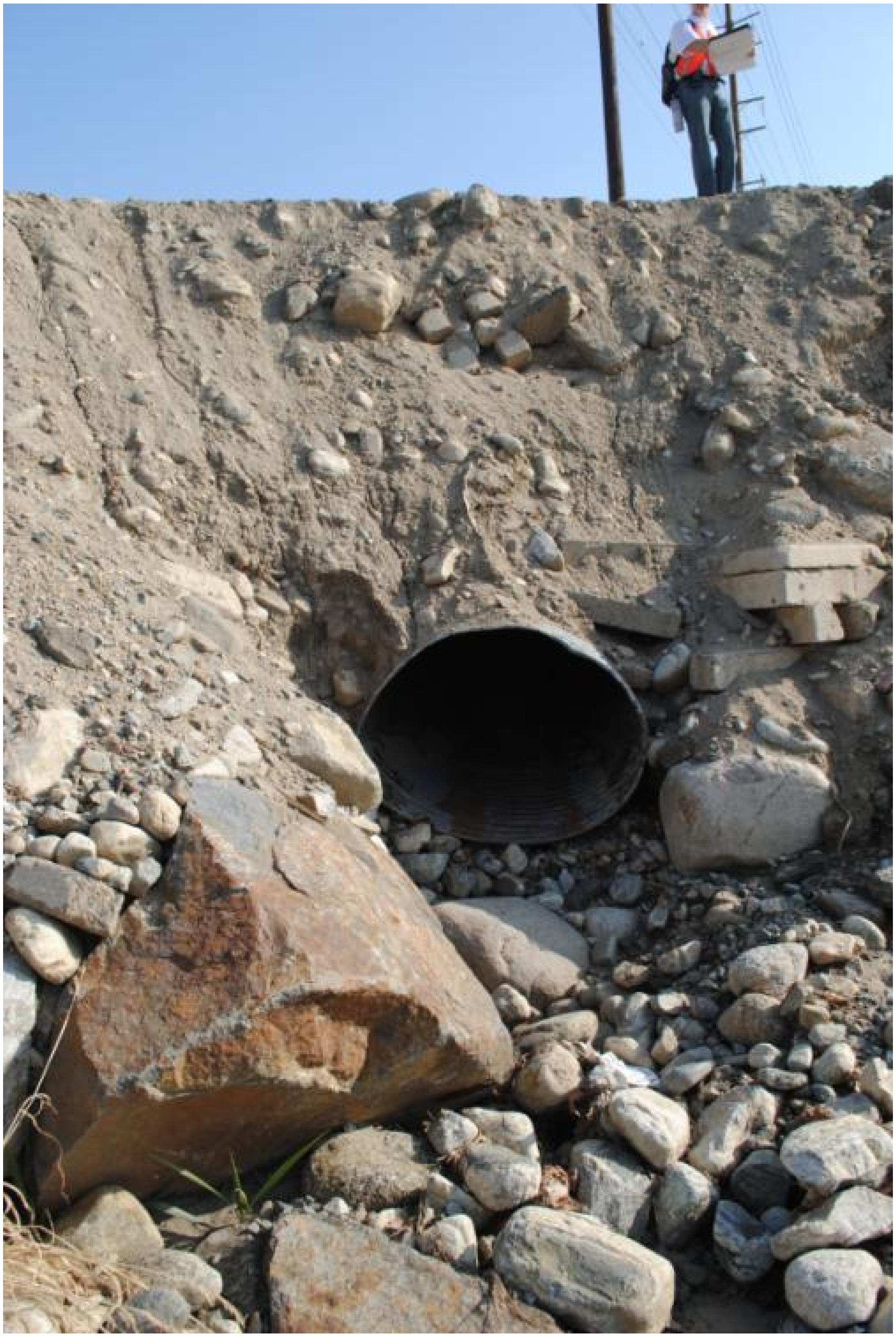
MP 5.1, buried culvert (no. 1)

MP 5.1, buried culvert (no. 2)

MP 5.1, buried culvert (no. 3)

MP 5.2, 24-inch RCP (no. 1)

MP 5.2, 24-inch RCP (no. 2)



MP 5.2, 24-inch RCP (no. 3)

MP 5.2, 24-inch RCP (no. 4)

MP 5.2, 24-inch RCP (no. 5)

MP 5.7, culvert

MP 6.05, 14-inch CMP

MP 7.4, 24-inch x 18-inch box culverts (no. 1)

MP 7.4, 24-inch x 18-inch box culverts (no. 2)

MP 7.4, 24-inch x 18-inch box culverts (no. 3)

MP 7.4, 24-inch x 18-inch box culverts (no. 4)

MP 7.4, culvert (no. 5)

MP 7.4, culvert (no. 6)

MP 7.8, 24-inch, 18-inch culverts (no. 1)

MP 7.8, 24-inch culvert (no. 2)

MP 7.8, 24-inch culvert (no. 3)

MP 7.8, 6-inch culvert (no. 4)

MP 8.2, 12-inch CMP (no. 1)

MP 8.2, 12-inch CMP (no. 2)

# Appendix E

# Miscellaneous Exhibits from Referenced Document

## REVIEW OF KEY DOCUMENTS

Many documents were reviewed for the tributary drainage systems, and policies and programs that may be impacted by the project. Of these documents, only the following key documents are summarized below. Applicable exhibits and figures from these documents are included in this Appendix.

**City of Redlands Local Hazards Mitigation Plan**

The Disaster Mitigation Act of 2000 requires that local governments, as a condition of receiving federal disaster mitigation funds, have a mitigation plan that describes the process for identifying hazards, risks and vulnerabilities, identify and prioritize mitigation actions, encourage the development of local mitigation and provide technical support for those efforts. This mitigation plan serves to meet those requirements, including as it relates to flood hazards and drainage risks.

The 2005 Plan identifies the SAR/Mill Creek and Zanja Creek as part of the City's flood history. Historic flood waters from these systems are responsible for extensive damage to the City. Since the watershed for the Mill Creek Zanja includes portions of City and County, a regional solution to flooding along the Creek has been a top priority for the City. Several attempts have been made to set assessments or development impact fees to fund improvements along the Mill Creek Zanja. Due to the extremely high cost of improvements, such efforts have failed. The USACE is currently involved in coordinating a full federal project to provide channel improvements and storm protection for the City of Redlands.

A number of local storm drain systems run through the City of Redlands. Several of these have experienced local flooding during recent storm events. Several drains are proposed in areas with the greatest potential for local flooding. Of these, the one that has the closest nexus to the project is "Lugonia Avenue from Alabama Street to the Mission Channel."

The Plan goes on to mention that approximately 25 percent of the community's critical facilities are vulnerable to flooding hazard; none of those facilities are located next to the Project. However, 75 percent of the City's non-critical facilities are vulnerable to this hazard and include the entire downtown commercial district, downtown industrial businesses, and the University of Redlands

Some of the related flood hazard mitigation projects are:

1. Flood Mitigation No. 3: Mission Storm Drain Bypass – approximately 7,500 feet in length in the reserved storm drain easement area parallel to and north of Redlands Boulevard through downtown Redlands to handle a minimum of a 100-year storm. Said storm drain system shall include all appurtenant structures to mitigate street and local flooding;
2. Flood Mitigation No. 9: Lugonia Avenue Storm Drain - 11,000 feet from Alabama Street to Mission Zanja Creek to handle a minimum of a 50-year storm. Said storm drain system shall include all appurtenant structures to mitigate street and local flooding.

Based on research, HDR is not aware that Flood Mitigation No. 9 has been constructed or implemented.

**City of Redlands Redevelopment Plan**

The City Council of the City of Redlands approved and adopted a Redevelopment Plan in September 1972 (City Ordinance 1575). The Redevelopment Plan cannot be fully implemented without provision for flood control which impacts local drainage. Current ordinance and commitments to the National Flood Insurance Program prescribe that the flood problem be resolved before redevelopment can be realized.

**Hydrology Study, Mill Creek Zanja Storm Drain**

Performed by BSI, the purpose this Study is to propose storm drain upgrades to address deficiencies to the existing Mission Storm Drain (along Redlands Boulevard) and the major tributary storm drain line -

Reservoir Canyon Drain. The existing Mission Storm Drain (Reinforced Concrete Box (RCB) under Redlands Boulevard) is of inadequate capacity to carry runoff during a major storm event (it only has current capacity for 25 year storm). In order to mitigate the flooding problem in the downtown area, this study proposes storm drain improvements consistent with those recommended in the Mission Zanja Creek Channel Improvement Study (Metcalf & Eddy (M&E), 1987). The M&E study was based on a preliminary hydrology study of the Mission Zanja watershed prepared by SBCFCD. It incorporated a proposed approximate 870 acre-foot detention basin located south and next to Mill Creek Zanja, east of Opal Avenue, west of Walnut Street, and north of Citrus Avenue, as recommended in the City of Redlands Mill Creek Zanja Detention Basin Study. From this point forward, this basin will be referred to as Opal Detention Basin.

The storm drain improvements projects proposed in the study to mitigate flooding in the downtown area of the City will consist of the Mission Storm Drain Bypass, a parallel relief system north of Redlands Boulevard (in a drainage easement) from the Mill Creek Zanja east of 9th Street to just west of Texas Street (back to Mission Zanja Creek). The other proposed storm drains will be Redlands High School Bypass Storm Drain and Reservoir Canyon Diversion Drain.

Flows in Mill Creek Zanja will be controlled by the proposed Opal Detention Basin which is designed with an outlet discharge of 600 cfs (storm event discharge associated with a 100 year frequency recurrence interval (Q100)). The existing Reservoir Canyon Drain has a peak Q100 runoff flow of 3,975 cfs while the capacity of the existing Mission Storm Drain is 2,400 cfs. The flow in the Reservoir Canyon Drain is thus split, with 2,400 cfs flowing to the existing Mission Storm Drain and 1,575 cfs flowing to the Mill Creek Zanja, upstream from the proposed Mission Storm Drain Bypass. The proposed Mission Storm Drain Bypass will divert all of the design storm flow in Mill Creek Zanja upstream from the entrance to the Mission Storm Drain.

HDR is not aware that any of these alternatives have been constructed or implemented.

**EIR, Long-Term Maintenance of Flood Control and Transportation Facilities Located Throughout San Bernardino County**

The County of San Bernardino Department of Public Works (DPW) is currently preparing environmental documents in accordance with the CEQA and NEPA.

The project involves maintenance of up to 1,100 flood control channels, basins, earthen streams and dams, approximately 140 bridges, and thousands of road culvert and Arizona crossings throughout San Bernardino County for the purposes of flood protection and road safety. Maintenance occurs year-round, with some facilities requiring maintenance several times a year and others on an as-needed basis in preparation or following large storm events. Maintenance is described as activities performed to allow a facility or structure to function at its current/designed capacity, including minor alterations to update a facility or structure to meet current standards or to maintain structural integrity. Maintenance does not include alterations for the purpose of expanding its original design capacity. Maintenance activities include, but are not limited to, the removal of excess sediment, debris and vegetation, stockpiling excess material and debris following removal, maintaining sufficient flowpaths, grooming/repairing of earthen and improved channel slopes and bottoms and maintaining culverts and bridges to ensure proper drainage and structural integrity. Many of the DPW-maintained facilities either traverse or contain a protected natural resource. As a result, some maintenance activities require the DPW to obtain complex permits, agreements and/or certifications from several regulatory agencies. Having to obtain multiple approvals for routine work to existing facilities and structures year after year, and sometimes multiple times a year, is a time-consuming approach and an inefficient method of performing maintenance and meeting DPW's mission of protecting life and property. Therefore, the intent of this environmental review process is to obtain long-term regulatory approvals to more effectively and efficiently maintain DPW-owned facilities and structures throughout the County.

The primary objective of the EIR is to provide the basis for acquisition of long-term maintenance permits from USACE for Section 404 permits, California Department of Fish and Game (CDFG) for Section 1602 Streambed Alteration Agreements, RWQCB for Section 401 Water Quality Certifications, and U.S. Fish and Wildlife Service (USFWS) consultations. The project proponents are SBCFCD and San Bernardino County Department of Public Works – Transportation.

**Mission Zanja Creek, Channel Improvement Study**

The purpose of the study was to conduct a study and cost effectiveness analysis for channel improvement alternatives for Mission Zanja Creek from Garnet Street to SAR for protection against flooding during the 100-year storm events. The results of the study are to serve as the basis for developing a financing program for implementation of the recommended improvements.

The Mission Zanja Creek is inadequate to carry the future 100-year storm flows in the majority of the reach evaluated. Various feasible open channel and closed conduit alternatives were evaluated for Mission Zanja Creek and Morey Arroyo for flood protection during the 100-year storm. The trapezoidal reinforced concrete lined channel section was found to be the most cost effective alternative although it has its disadvantages.

To date, HDR is not aware that any of that any of these alternatives have been constructed or implemented.

**Mission Zanja Creek, Detailed Project Report and Environmental Assessment**

This report was conducted by the Los Angeles District of the USACE to evaluate alternative improvements along the Mission Zanja Creek to mitigate the flooding problem in downtown Redlands, under the Small Flood Control Project Authority. (Note: this report refers to the Mission Storm Drain and Mill Creek Zanja inclusively as Mission Zanja Creek).

As shown in Appendix J, the recommended plan provides for a 13.5-foot high by 14-foot wide RCB from inlet structure no. 1, located along Mission Zanja Creek downstream from Division Street, to an outlet channel and an energy dissipating structure located upstream of New York Street, a distance of 1.4 miles. The RCB conduit, designed for a capacity of 5,500 cfs, would follow an abandoned railroad (SPRR) alignment running parallel to and north of Redlands Boulevard (between Redlands Boulevard and Oriental Avenue). Another set of inlet structures (no. 2), located in the vicinity of University Avenue north of I-10, would intercept the Oriental Drain and University Avenue flows and convey them to inlet structure no. 1, via a 9-foot diameter reinforced concrete pipe (RCP) designed for a capacity of 1,000 cfs. The total project cost was estimated at $10,195,000, based on May 1986 prices.

This report was conducted under the authority of Section 205 of the federal Flood Control Act of 1948, as amended. Also, the project received authorization for construction by the Water Resources Development Act of 1986, Title IV – Flood Control, Section 401(d) which states:

"Subject to section 903(a) of this Act, a project for flood control works along Mission Zanja Creek within the City of Redlands, California, in accordance with the plan developed by the District Engineer based on studies pursuant to section 205 of the Flood Control Act of 1948, at a total cost of $10,400,000, with an estimated first Federal cost of $4,500,000 and an estimated first non-Federal cost of $5,900,000."

Due to the federal limitation under the Small Project Authority, the federal share towards study and construction costs cannot exceed $5,000,000. This amount includes construction, study costs, preparing Plans, Specifications, and Estimates (PS&Es), administering contract for construction, conduct cultural resource investigations, and conduct periodic inspections to determine adherence to maintenance requirements. Additionally, the City of Redlands, as the local sponsor, will be required to pay the amount above the federal share and will responsible for providing all necessary lands, easements, and rights-of-way; bear the expense of all relocations excluding railroad bridges and local drainage; and maintain and operate the project.

The draft report was prepared and presented to the Redlands City Council on July 15, 1986. The City Council fully supported the project and subsequently prepared a letter of support indicating their commitment to their cost sharing responsibilities.

Based on research by HDR, none of these alternatives have been constructed or implemented.

**Reconnaissance Report for Mission Zanja Creek**

This report was prepared under Section 205 of the Flood Control Act of 1948 and was completed in February 1984. The Reconnaissance Report identified alternatives for flood control through the downtown area of the City of Redlands that appeared to be economically justified. The Reconnaissance Report was approved by the USACE and led to the initiation of the Mission Zanja Creek, Detailed Project Report and Environmental Assessment (refer to pertinent summary in this Section).

**Reconnaissance Study for Mission Zanja Creek**

The study, initiated at the request of SBCFCD, identifies the flooding problems throughout the entire Zanja watershed, to formulate and evaluate potential solutions to the identified problems, and to determine whether federal planning efforts should continue into a more detailed feasibility phase. The results of the study, presented in 1994, indicate that in the reach of Mission Zanja Creek from Opal Avenue to Iowa Street, estimated future flood damages will amount to over $1.3 million on an average annual basis. Approximately $830,000 or about 62 percent of the total estimated damages will accrue in the downtown Redlands area from the East I-10 Overpass to Texas Street to the west.

Several flood control measures were considered the most likely to be feasible including upstream detention, channelization and expanding an inlet. The results of the study also indicate that providing a higher level of flood control would not be economically justified and would not warrant further federal efforts to reduce or eliminate as of the date of the study (1994).

Most of the future flood damage that is expected to occur is the result of flooding from two separate sub-watersheds that meet in the eastern or upstream portion of the downtown area: the mainstem of the Zanja and Reservoir Canyon tributary. Elimination of all or most of the flooding in the downtown Redlands area would require complete channelization of the Zanja through Redlands, detention of flood flows on the Zanja through Redlands, detention of flood flows on the Zanja east of the downtown area combined with channelization through Redlands, or detention of flood flows on the Zanja and in Reservoir Canyon plus channelization through Redlands.

Complete channelization through Redlands would not be economically justified under 1994 conditions. Although channelization was found to be economically justified in prior studies in Redlands, conditions in the area with respect to redevelopment have changed and the benefits of flood control in this area are now limited to reduction of flood damages to existing development. The study also demonstrated that detention alone would do little in reducing flooding in Redlands due to the residual flooding that would be caused by the other source (Reservoir Canyon). Detention in Reservoir Canyon and on the upper reach of Mission Zanja Creek, as well as combining detention with expanding the inlet near 9$^{th}$ Street, was not justified as the benefit-cost ratio was unfavorable.

The only feasible flood control plan is expanding the existing inlet to the covered section of Mission Zanja Creek near 9$^{th}$ Street in Redlands which will reduce the frequency of flooding in the downtown Redlands area. A project that would raise the flow-carrying capacity of the inlet from the current 300 cfs to 2,400 cfs, the capacity of the covered channel under Redlands Boulevard, appears to be economically feasible and may be implemented under the USACE Continuing Authorities Program (CAP). (The CAP establishes a process by which the USACE can respond to a variety of water resource problems without the need to obtain specific congressional authorization for each project. This decreases the amount of time required to budget, develop, and approve a potential project for construction. Under the CAP, the USACE is authorized to construct small projects within specific federal funding limits and includes sharing of the total cost the federal government and a non-federal sponsor[s]). The Study recommended that based on a preliminary appraisal of the federal interest, costs, benefits, and environmental impacts of the identified potential solutions, planning should proceed further, into a feasibility phase under the CAP, for a plan to expand the capacity of the existing inlet to the covered channel of the creek near 9$^{th}$ Street in Redlands.

Based on research, HDR has determined that the expanded inlet project was constructed in 2005. See related project under Section 2.7 below (Mill Creek Zanja Expanded Inlet).

**Mill Creek Zanja Detention Basin Study**

This study, prepared for City of Redlands, investigated the feasibility of regional detention basins along Mission Zanja Creek upstream of downtown Redlands. The most cost-effective detention basin alternative evaluated provides for a 870 acre-foot basin to be constructed east of Opal Avenue. The study also recommended an investigation of a parallel system of the Mill Creek Zanja to relieve flooding in the vicinity of the University of Redlands.

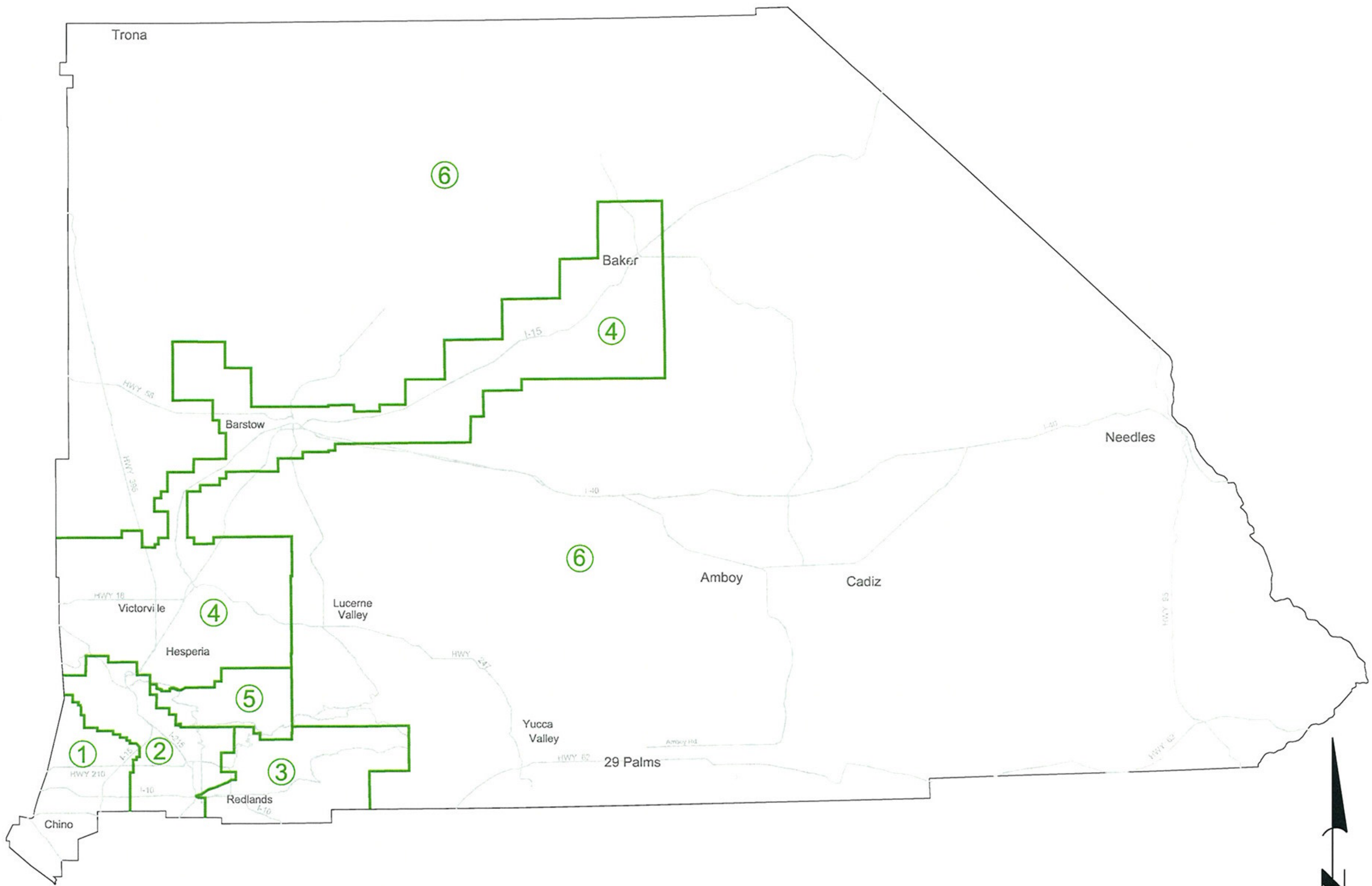
To date, none of these alternatives have been constructed and implemented.

# SAN BERNARDINO COUNTY

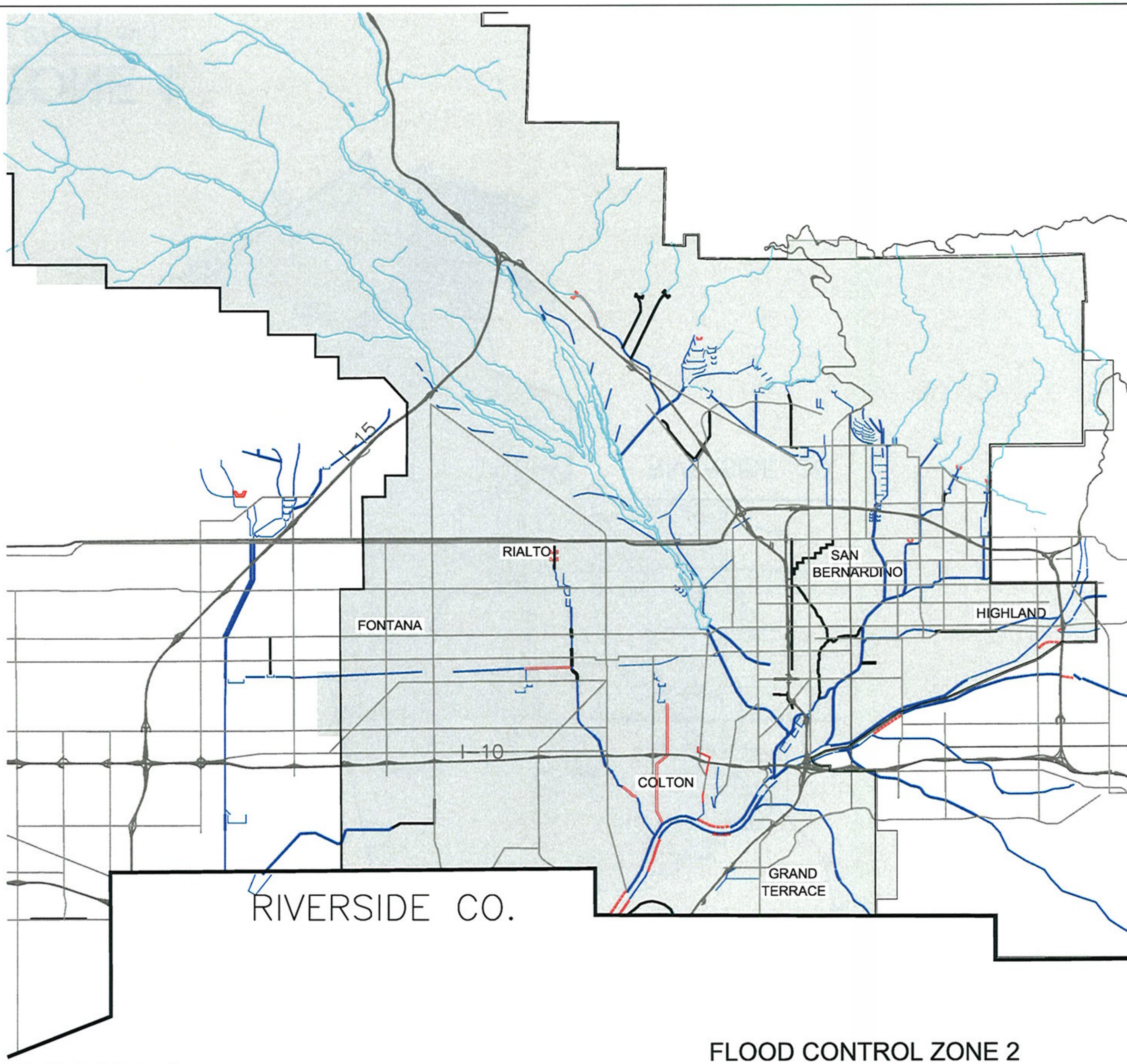
# FLOOD CONTROL DISTRICT

## GENERAL INFORMATION

JANUARY 2010



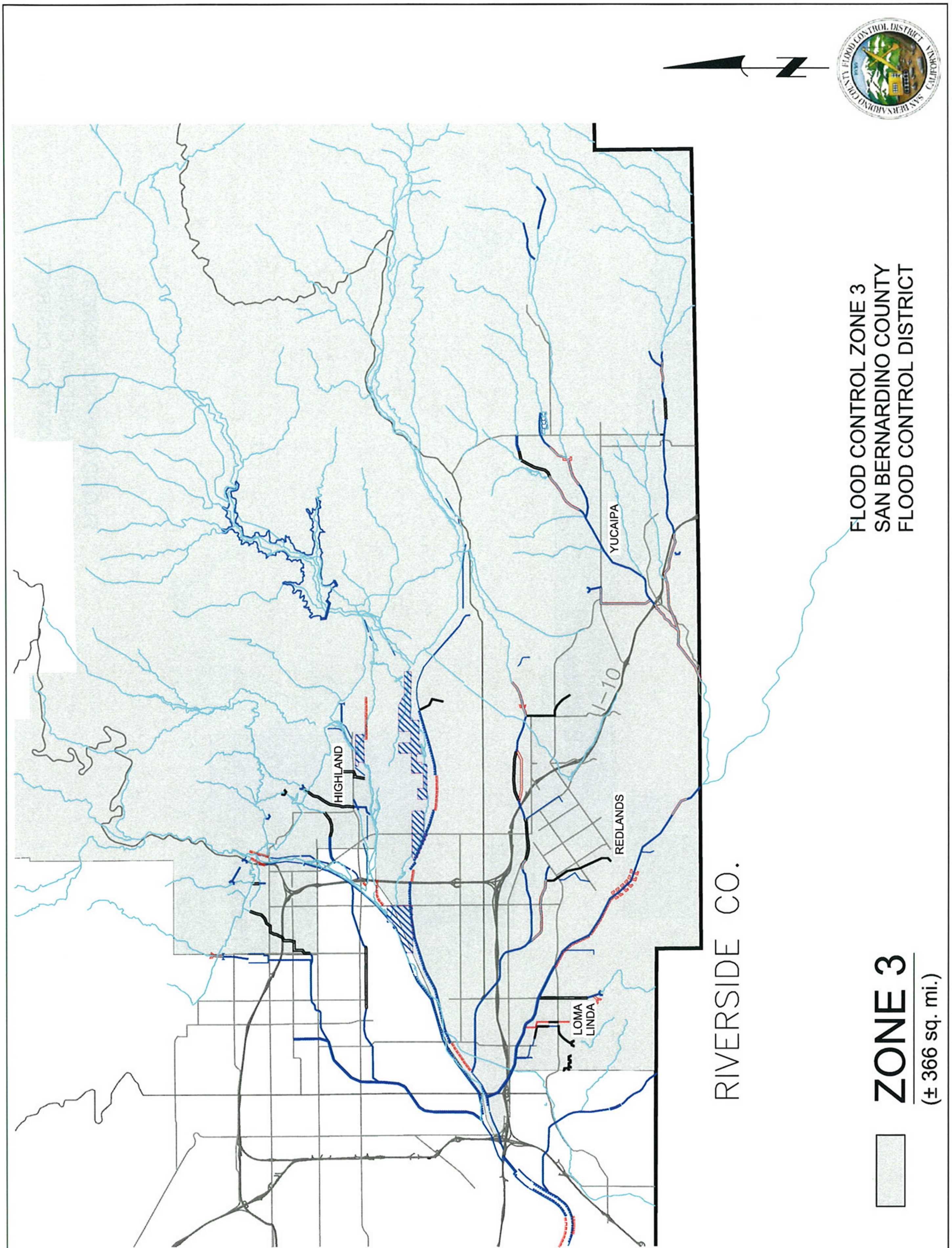

# SAN BERNARDINO COUNTY FLOOD CONTROL DISTRICT OVERALL ZONE MAP




**ZONE 2**

(± 318 sq. mi.)

FLOOD CONTROL ZONE 2
SAN BERNARDINO COUNTY
FLOOD CONTROL DISTRICT


FLOOD CONTROL ZONE 3
SAN BERNARDINO COUNTY
FLOOD CONTROL DISTRICT
ZONE 3
(± 366 sq. mi.)
RIVERSIDE CO.
YUCAIPA
HIGHLAND
REDLANDS
LOMA LINDA
I-10

## FEDERAL FLOOD CONTROL PROJECTS

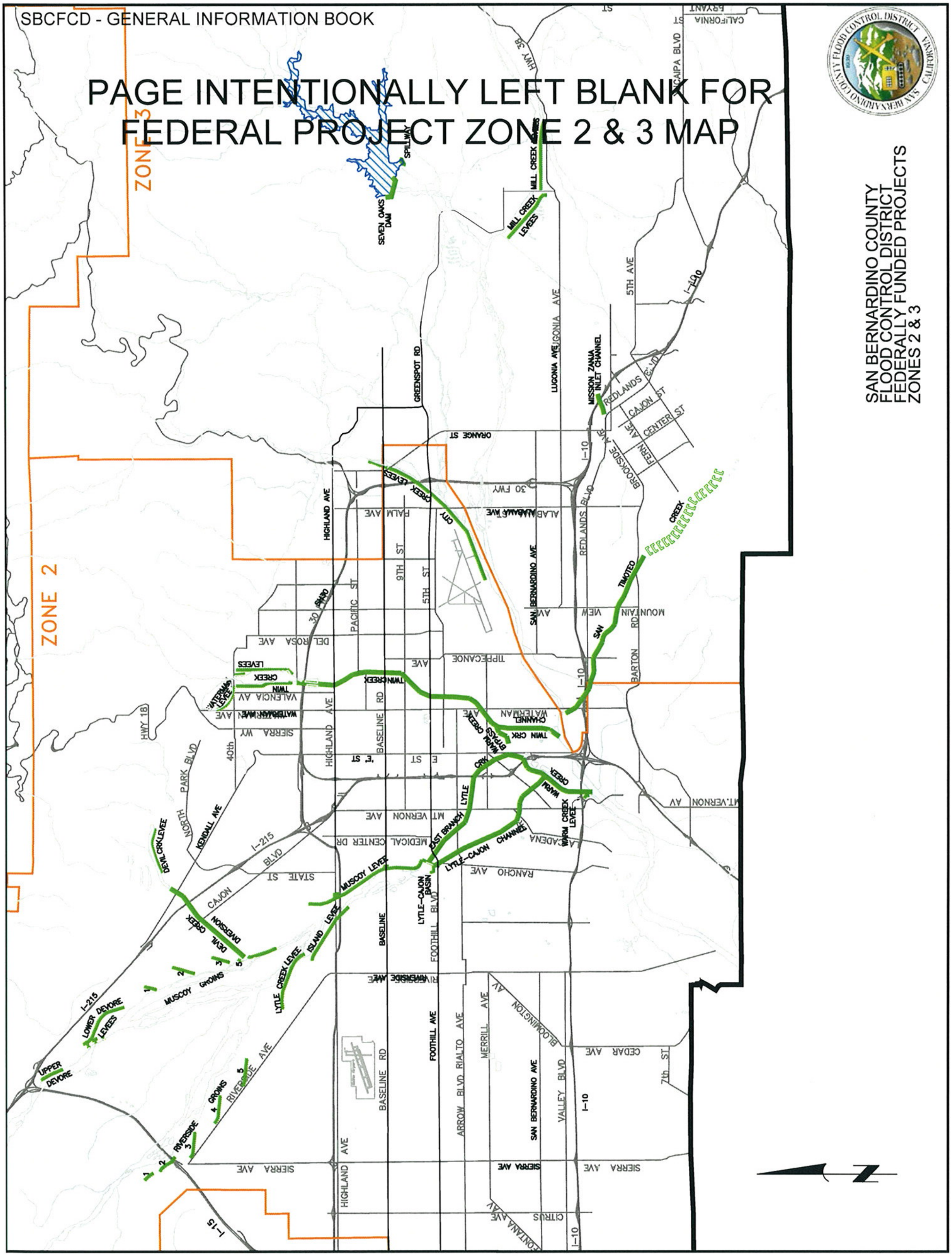
The following projects are US Army Corps of Engineers:

| Projects | Project Status | Total Cost $ |
|---|---|---|
| City Creek Levee | Completed 1942 | 470,000 |
| Lytle Cajon Creeks | Completed 1948 | 8,400,000 |
| San Antonio Dam & Reservoir | Completed 1956 | 7,600,000 |
| Lytle Creek Levee | Completed 1956 | 300,000 |
| Devil Creek Diversion | Completed Nov. 1957 | 1,600,000 |
| City Creek Levee | Completed Nov. 1959 | 900,000 |
| San Antonio & Chino Creeks | Completed Oct. 1960 | 11,500,000 |
| Mill Creek Levees | Completed Nov. 1960 | 700,000 |
| Quail Wash Levee | Completed Oct. 1961 | 200,000 |
| Twin & Warm Creek | Completed Nov. 1961 | 8,000,000 |
| Oro Grande Wash | Completed Feb. 1969 | 18,300,000 |
| Mojave River Forks Dam | Completed June 1973 | 2,000,000 |
| Needles "S" Street Channel | Completed June 1973 | 2,000,000 |
| Lytle - Warm Creek | Completed June 1977 | 39,000,000 |
| Cucamonga Creek | Completed Oct. 1983 | 121,000,000 |
| Mission Zanja Inlet Channel | Completed June 2005 | 1,100,000 |
| S.A.R. Mainstem Projects: | | |
| Seven Oaks Dam | Completed Oct. 2001 | 450,000,000 |
| Mill Creek Levee (Rebuilt) | Completed Jan. 1993 | 4,500,000 |
| San Timoteo Creek: | | |
| Phase 1 | Completed Sept. 1996 | Approximately 92,000,000 (Phase 1 through Phase 3B Landscaping) |
| Waterman Ave Bridge | Completed Sept. 1996 | |
| Phase 2 | Completed Dec. 1997 | |
| Redlands Blvd. Bridge | Completed Mar. 1998 | |
| Phase 3A | Completed Apr. 1998 | |
| Phase 3B (Const) | Completed Apr. 2006 | |
| Phase 3B (Landscaping- 5 Yr. Maintenance) | In Progress - Complete in Mar. 2013 | |
| Beaumont Ave. Bridge | Completed Mar. 2007 | 2,000,000 |

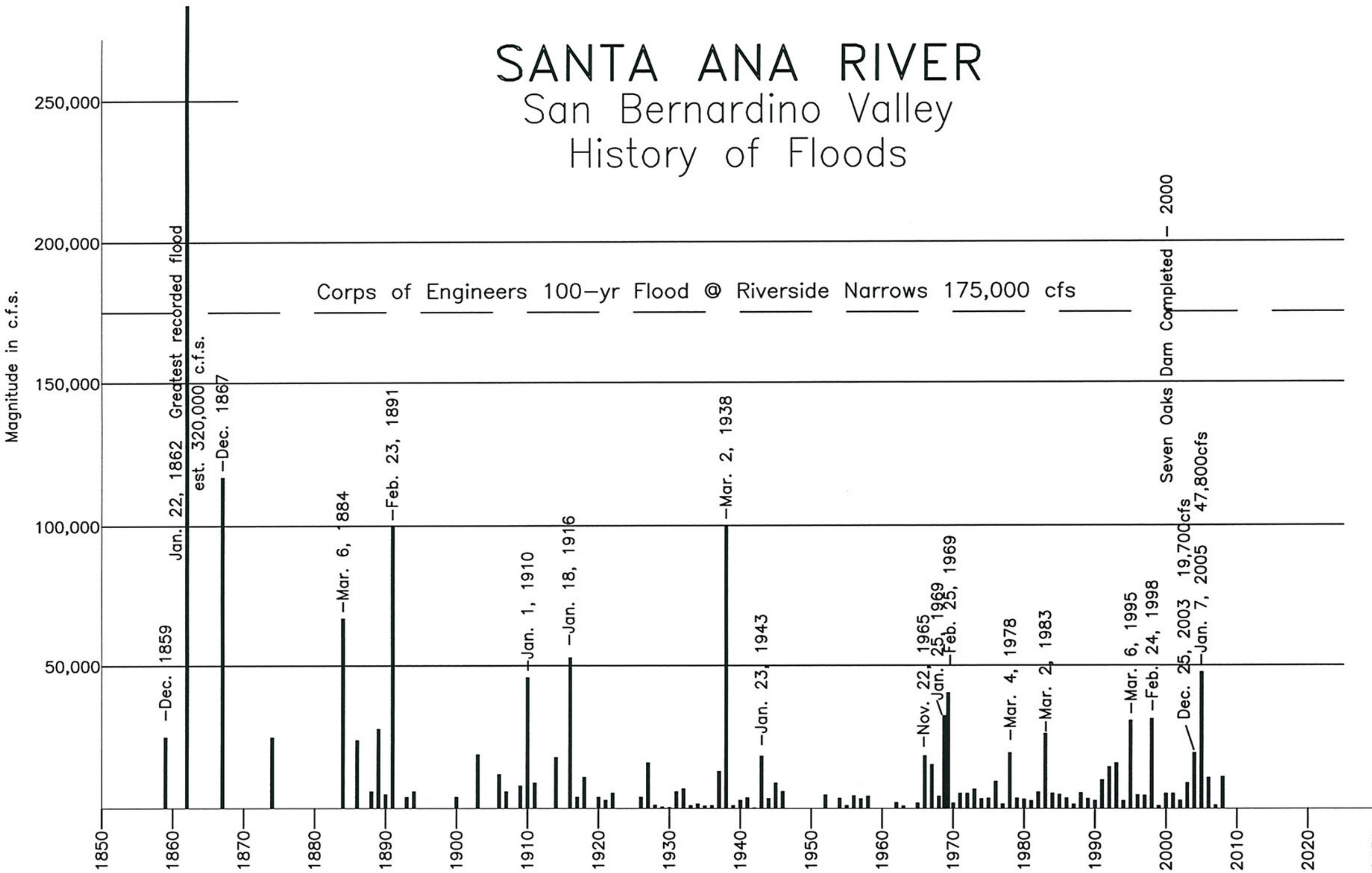
The following Projects are US Bureau of Reclamation:

| Projects | Project Status | Total Cost $ |
|---|---|---|
| Day Creek(Loan) | Completed 1993 | App. 50,000,000 |
| Etiwanda/San Sevaine | Completed Mar. 2009 | App. 130,000,000 |

# PAGE INTENTIONALLY LEFT BLANK FOR FEDERAL PROJECT ZONE 2 & 3 MAP



# SANTA ANA RIVER
## San Bernardino Valley
## History of Floods




U.S.G.S. Gauge #11066460
Santa Ana River at MWD Crossing
near Arlington, California

SAN BERNARDINO COUNTY
FLOOD CONTROL DISTRICT

**SANTA ANA RIVER FLOODS**

Discharge near Riverside Narrows

| DATE: | SYS. NO: | ACAD FILE: | S.B.C.F.C.D. FILE: |
|---|---|---|---|
| DEC. 2009 | 3-103 | SARFLOOD | BM-D1-11/a |

# STORM HISTORY

## 1769 to 1859

Flood history in the Santa Ana River Basin is traceable since the entry of the Spanish Mission Fathers into the Los Angeles and San Bernardino areas between 1769 and 1776. Based upon a wide variety of diaries, special reports, court records and writings of residents, the period from 1769 to 1859 experienced what would be referred to as eight small floods, seven large ones, and one great flood.

The great flood occurred in the 1824-25 season, which was described as "probably the greatest of earlier recorded floods". The event has been compared as having been almost as large as the greatest flood of record in 1862, and is generally recognized as equal to or greater than the 1938 flood. The flood of 1825 is known to have altered the course of the Santa Ana River, causing it to enter the Pacific Ocean several miles from its prior entry point.

The history of floods since 1859 is portrayed in the attached charts giving a comparative magnitude for events occurring in both the Santa Ana and Mojave River Basins.

Additional flood charts for various streams are also included at the end of this section.

## 1860 to 1929

Of particular interest are the large floods during this period, occurring in 1862, 1867 and 1891, which may generally be compared as approximately equal to or greater than the disastrous event of the year 1938. In the San Bernardino Valley, the flood of 1884 approaches this category as does the flood of 1910 in the Mojave River Valley.

The 1862 flood is by far the greatest of record and has been referred to as the Noachian deluge of California floods, during which the Santa Ana River is said to have rivaled the "Father of Waters". Rainfall started on Christmas Day 1862, and continued until the 18th day of January 1862, when a 24-hour downpour commenced. At that time, flood peaks rolled through the valley conservatively estimated as over twice the amounts of the 1938 flood. It has been stated that the area from Loma Linda to the hill at Third Street and Arrowhead Avenue in San Bernardino was under water and extended for miles up and down the Santa Ana River. At Agua Mansa below Colton, it is recorded: "There were billows 50 feet high. The waters from the vast drainage area found themselves forced abruptly into a narrow channel, and just above Agua Mansa the river filled the valley from bluff to bluff, reaching the little church. Father Borgatta, then the pastor, heard the roar in the distance, rang the bell frantically and the people fled to high ground. Some of the last ones had to swim."

In quick succession, six years later, came the 1867 flood which is reported to have approached the 1862 event in magnitude but it was written that: "Since the first flood had cleaned the channels, the damage done by the second storm appeared to be less." The flood of 1867 is accepted as substantially greater than that of 1938.

The season of 1883-84 is known as the wettest year of record with San Bernardino reporting 36.5 inches of rainfall. The flood produced on March 6, 1884, though somewhat less than the 1938 event, ranks with the major floods and is referred to as "the Great Flood of Later Times". Great damage was inflicted to newly-installed railroads, and once again, the course of the Santa Ana River was altered.

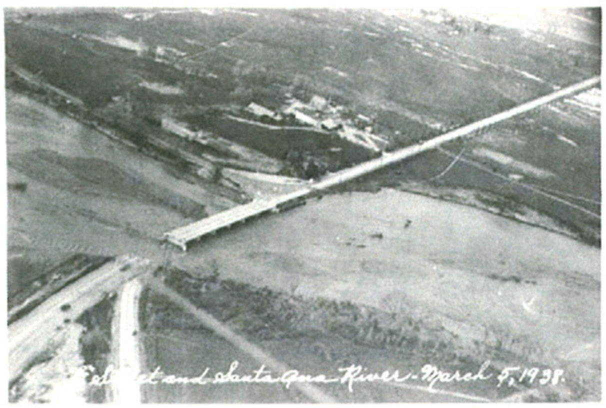
**1891 STORM**

In rapid succession came the flood of February 23, 1891, of magnitude equal to the flood of 1938, and large, though lesser, floods in 1910 and in 1916. Typical reports on these read: "East section of city (San Bernardino) under water and in west end houses float." "Millions of storm damage in southland – The entire Mexican section of East Highlands was swept away by Plunge Creek, 20 families – The Santa Ana River is now two miles wide and twenty feet deep – Disastrous flood sweeps across west end."

**1916 STORM**

**1930 to 1968**

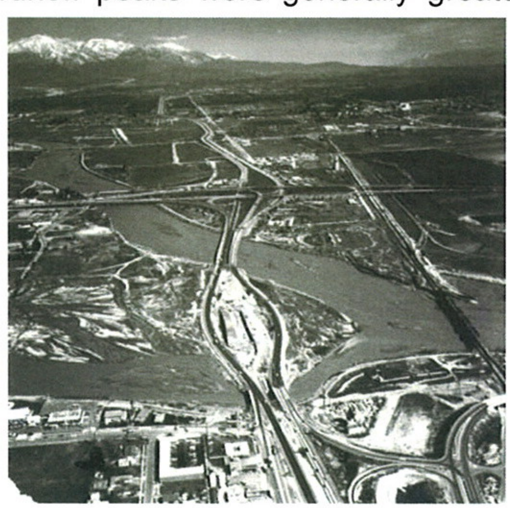
On March 2-3, 1938, the County was again swept by a large flood and the most damaging to that date due to the state of physical property improvements. There were 14 known deaths in the County with damages estimated at $12 million. Practically no part of the San Bernardino Valley or Mojave River Valley escaped the wrath of this storm. Almost every community was isolated with roads and bridges destroyed. Hundreds were homeless. During the 31 years between 1938 and 1969 there were no floods of note in the Santa Ana River Basin except for a moderate one occurring in 1943 with damage primarily to Lytle Creek and the Mojave River Valley. Moderate floods also occurred in 1952, 1956, 1965 and 1966.



**1938 STORM**

**1969**

Eclipsing, in many respects, the flood of 1938 were the floods of January and February 1969, occurring a month apart. Rainfall intensities and amounts were greater and, except for the Mojave River and its tributaries, runoff peaks were generally greater during the two 1969 floods. Although Flood Control facilities functioned well during the January flood period, there was insufficient time to perform necessary repairs and maintenance before the late February storm struck which caused nearly twice as much damage. Pecuniary losses in San Bernardino County alone from the January storm amounted to over $23 million and from the February storm over $31 million. This is, however, only a portion of the losses which would have been sustained had no flood control protection been provided. During the severe flooding throughout Southern California, 115 lives were lost; and there were



**1969 STORM**

costly damages exceeding $213 million in tangible property losses. San Bernardino and six neighboring counties were declared national disaster areas.

An overflow map of the 1969 floods is included at the end of this section.

## 1970 to 1979

The flood history of San Bernardino County remained relatively stable from 1969 until the 1978 flood which approached the magnitude of the 1943 and 1965 storms. The existing flood control facilities functioned well in 1978, but did sustain substantial damage from erosion and debris deposition. Total property damage from the 1978 storm is listed at $11.4 million dollars.

**1978 STORM**

There were no breakouts of flood flows; however, the earth levees of Cucamonga Channel downstream of Foothill Boulevard were critically eroded and evacuation of a portion of the City of Rancho Cucamonga was initiated. Construction of the Cucamonga Creek Corps of Engineers Channel was completed to Foothill Boulevard the following year. The entire project, including tributaries Deer Creek, Demens Creek and San Antonio Heights Intercept, currently provides flood protection for west end cities. In addition to the 1978 storm, the County was hit with numerous localized high-intensity storms, particularly the 1976 storms in the East Desert (Morongo, Yucca and Twentynine Palms) and the City of Redlands. In September 1976, a thunderstorm above the Crafton Hills dropped rainfall approaching four inches, with 75 to 100% occurring within a 30-minute time span. In Redlands, water flows of up to three feet deep caused flooding of the downtown business area and more than 200 homes. There was an estimated $1,750,000 worth of damage; $1 million to public and private property and $750,000 to Flood Control District Facilities.

## 1980 to 1989

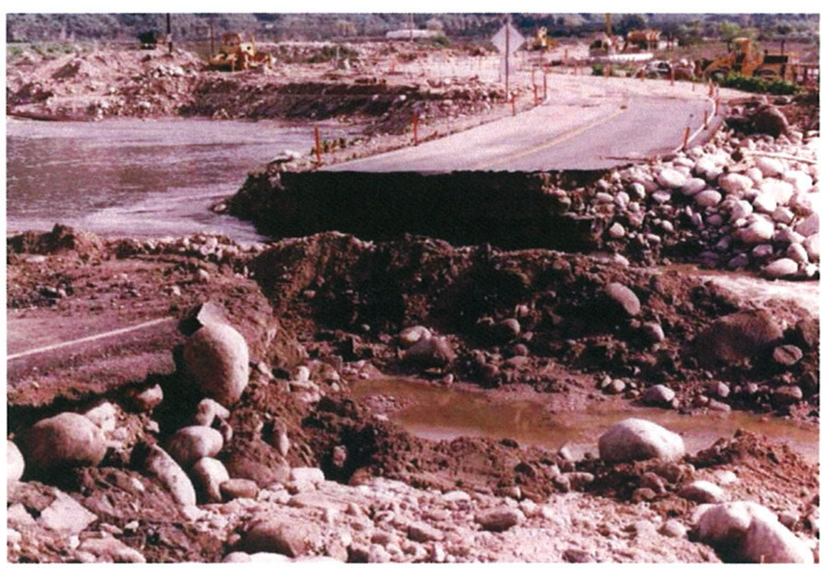
The San Bernardino Mountains were subjected to concentrated high-intensity rainfall in January and February of 1980. District gauges recorded short duration rainfall in excess of one-inch per hour, which fell on the denuded watershed, burned by the Daley and Shadow fires of September 1979. Many debris basins above the City of San Bernardino were filled with mud and debris, particularly Harrison Basin which overflowed into the neighborhood below on four occasions totally destroying 25 to 30 homes and severely damaging 25 more. The February storm caused Small Canyon Basin to overflow pouring mud, water and debris into houses along Small Canyon Outlet Channel and the residential areas south of Highland Avenue and west of SH 330. Between January and March, more than 30 inches of rain fell causing $18 million in damages in San Bernardino County, $8 million of this occurring to Flood Control District Facilities.

The fall of 1980 brought with it heavy Santa Ana winds and devastating watershed burns. The Panorama Fire destroyed or damaged 333 homes and 23,800 acres; combined with the Baldy and other fires, more than 41,000 acres of mountain watershed was burned. Fortunately, 1981 and 1982 were mild weather years. That, combined with an extensive $5 million federally financed District basin over-excavation program, allowed the San Bernardino Valley to survive nature's wrath with minimal damage.

**1980 STORM**

**1990 to 1999**

An unexpected and unusual storm event struck in the early morning hours of October 7, 1997, over the Sand Creek and Little Sand Creek watersheds causing flash flooding through portions of the cities of San Bernardino, Highland and San Bernardino County Service Area 38. The major cause of the flooding was the vast amounts of floatable (organic) debris and mud produced from the burned watersheds of the Hemlock Fire, which had occurred earlier in July. This debris plugged the box culverts at Lynwood Drive and Foothill Drive causing the flows to break over the channel walls



**1997 STORM**

and down the adjacent roadways affecting homes as far as two miles away. Both Lynwood Drive and Foothill Drive were closed to traffic because of the storm. February of 1998 was the most productive rainfall month during the 1997/98 winter. 14.59 inches of rain were recorded for the month at the Gilbert Street gauge in San Bernardino. The major storm event occurred in the Valley on February 23rd. The rain gauge at Gilbert Street recorded 3-10 inches for the day. Prior to February 23rd, a series of storms starting on February 14th occurred almost back-to-back. The storms brought light to moderate rainfall, except for February 22, which recorded 2.18 inches of rain. The already saturated soil contributed greatly to the impact of the February 23rd storm.

**2000 to PRESENT**

In October of 2003, the San Bernardino Valley experienced two large fires (the Grand Prix Fire and the Old Fire) which charred most of the foothill watershed. Shortly after the fires, a Pacific storm system moved through Southern California on December 25th and 26th, 2003. Heavy rain fell over much of the mountains and foothills causing flash flooding and debris to wash across several highways and roads. In a few locations, including Lytle Creek, rainfall rates of up to an inch per hour were recorded. Just south of Crestline, rainfall rates increased from 0.20 to 0.70 inches within a five-and-a-half hour span, causing debris slides. The debris flowed down into Waterman Canyon moving through Saint Sofia Camp where 14 people were killed. Farther down Waterman Canyon, the flow demolished two bridges and finally fanned out filling the basins just north of San Bernardino. A flash flood/mud slide moved through Cable Canyon and the KOA Campground, killing 2 people, a bear, and a horse and destroying 32 travel trailers, multiple vehicles, and roads. In all, 33 of the 34 debris basins along the foothills in the San Bernardino Mountains were filled with rocks, trees, and mud.

**2003 STORM**

The first major storm of 2004 occurred October 19-20. The storm was expected to have significant rainfall intensities and large runoff due to recent watershed burns. Fortunately, the flows from the burn areas were relatively "clean", thus allowing the Regional Flood Control System to handle the storm runoff. Any flooding experienced within cities or developed areas was a result of debris blocking inlets and overtaxed local drainage systems. The only noteworthy damage was the washout of the small wood railroad bridge crossing the undeveloped portion of the San Sevaine Channel, southerly of Whittram Avenue. There was also a derailment of a chlorine car and boxcar and two utility lines (16" jet fuel line and 20" gas line) were exposed, caused by storm flows collapsing the north set of tracks. The 2004/05 rainy season was significant, with three prior storms (two in October and one at the end of December). The ground was already saturated prior to the January 7th – 11th event which was only the first of a series of additional storms to hit San Bernardino County. The January 7th storm was more dominant than the storms of February 22nd thru 24th or the March 23rd storm. On January 5, 2005, light flows were reported in most of the channels. Basins were holding water and draining. Some basins experienced debris flows and had to be excavated. Some minor erosion was experienced on levees and in water courses. There were varying levels of damage to the Mojave River.

**2004 STORM**

**2005 STORM**

# FLOOD CONTROL
# SYTEM NUMBER INDEX
and
# GENERAL FILE CODES

SAN BERNARDINO COUNTY
FLOOD CONTROL DISTRICT
(Updated: January, 2010)

This San Bernardino County Flood Control District System Numbers Index Book is now revised to reflect all numbers currently being used within the Flood Control District. These numbers are used for facility identification, operation charge codes, correspondence, and map file numbers. Because of this multipurpose usage, there are listings not only for existing Flood Control District facilities but proposed facilities, overall systems and facilities constructed, operated or maintained by others. Wherever possible, we have noted these differences. Additionally, whenever reasonably possible, facilities that only exist through correspondence and not on the ground have been included. However, certain facilities that do not exist on the ground have not been shown on maps to increase clarity. As needed, these facilities will be added into the maps for more accurate locations.

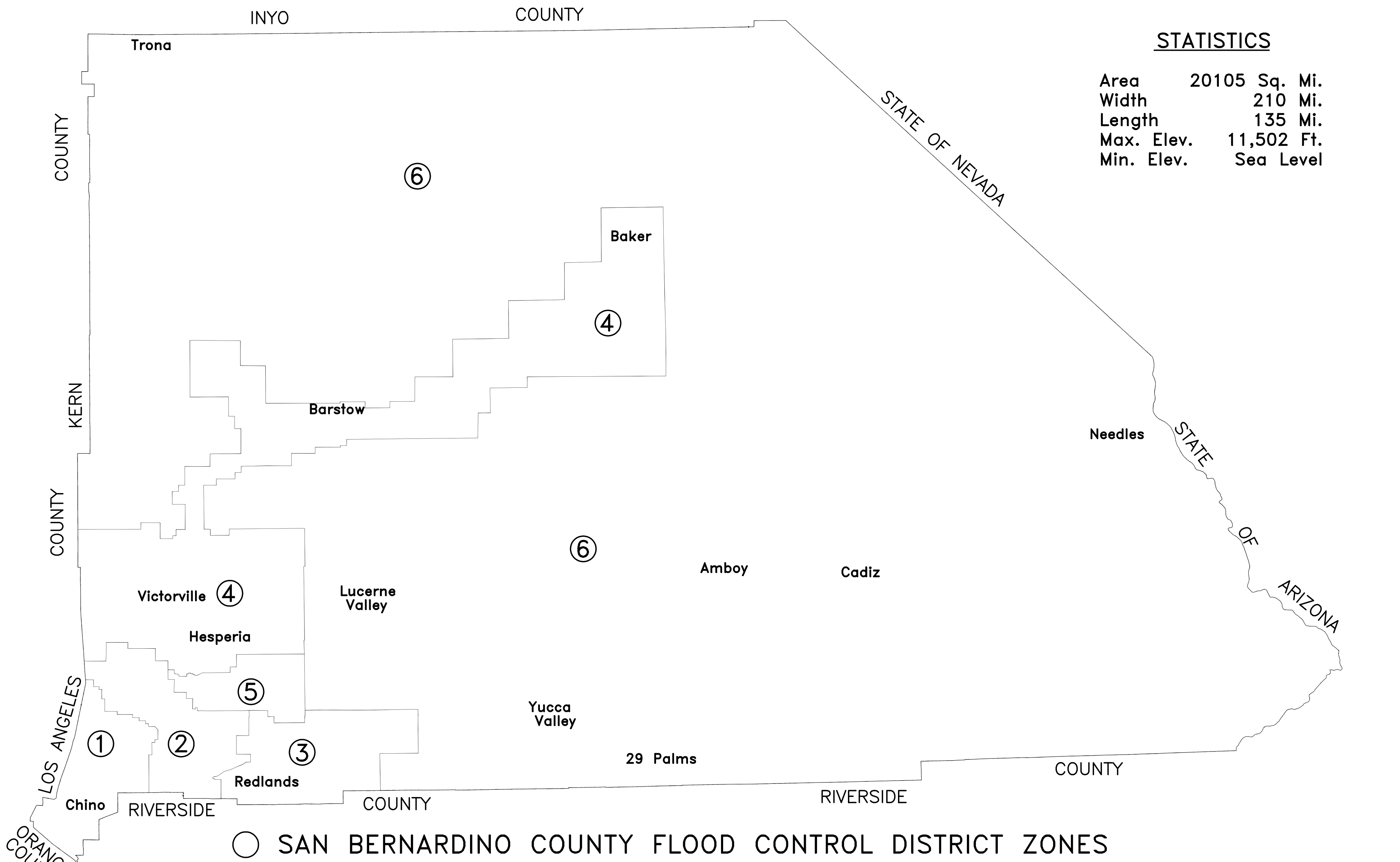
This listing is maintained by the Planning Division of the Food Control District, which has been designated to coordinate future revisions and updates. **Anyone requiring verification, explanation, or revision of an existing number should contact the Planning Division** at (909) 387-8120.

ALL CHANGES AND ADDITIONS WILL BE MADE BY THE PLANNING DIVISION.

Please note that requests for new numbers should meet the following criteria:

a) A facility is being taken over by the District for maintenance.
b) A property is purchased in fee or easement for future construction of a facility.
c) The design of a facility has commenced and is proposed to be constructed in the near future.

As the Red Book gets updated periodically, revised pages will be dated accordingly and made public on a regular basis. Please note that the Planning Division will no longer issue any new Red Book 3-ring binders.




# San Bernardino County
# FLOOD CONTROL DISTRICT

## TYPICAL PROJECT NUMBERS

DESCRIPTION OF COMPONENT PARTS

# 2 – 206 – 5A C.E

ZONE……………………………….**2**

STREAM SYSTEM #....................**(2)**00

INDIVIDUAL PROJECT #.............**06**

TYPE OF FACILITY……………….**5**

FACILITY REACH…………………**A**

CORPS OF ENGINEERS PROJECT……**C.E.**

## NUMBER DESIGNATING TYPE OF FACILITY

1 **Channel, Stream, Watercourse** (main channels)

2 **Spreading Grounds** (not including basins, dams, crosswalls)

3 **Dams** (under State Division of Safety of Dams, incl. reservoirs)

4 **Basins** (excluding dams)

5 **Levee** (reception levees, groins etc. but excluding channels)

6 **Storm Drain** (excluding channels)

**7 Fire Trails and Breaks**

8 **Check Dams** (major crosswalls only)

9 **Projects** (examples) i.e.

Studies

Aerial Topo

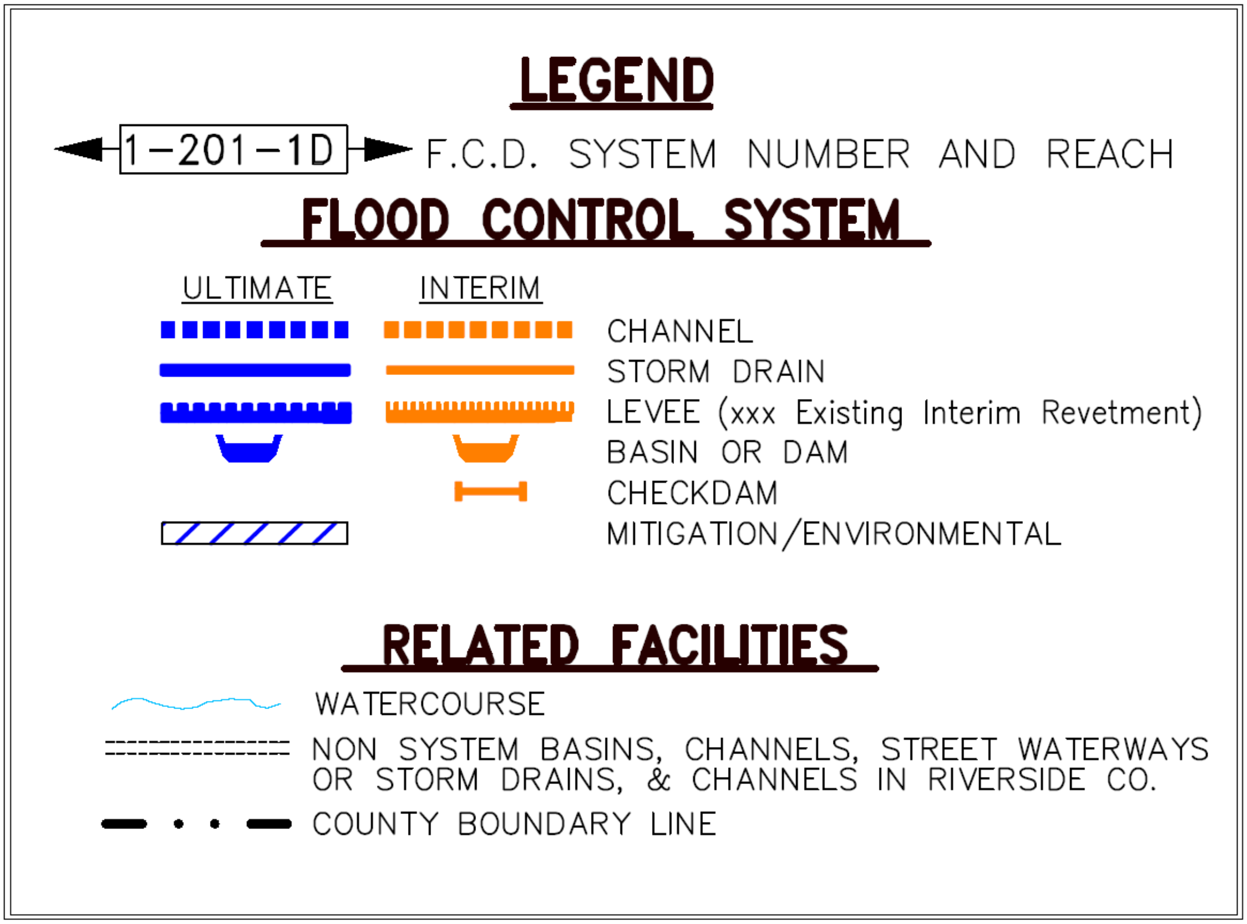
R/W Monumentation

Taxes

Obligations

Future Projects

Etc.

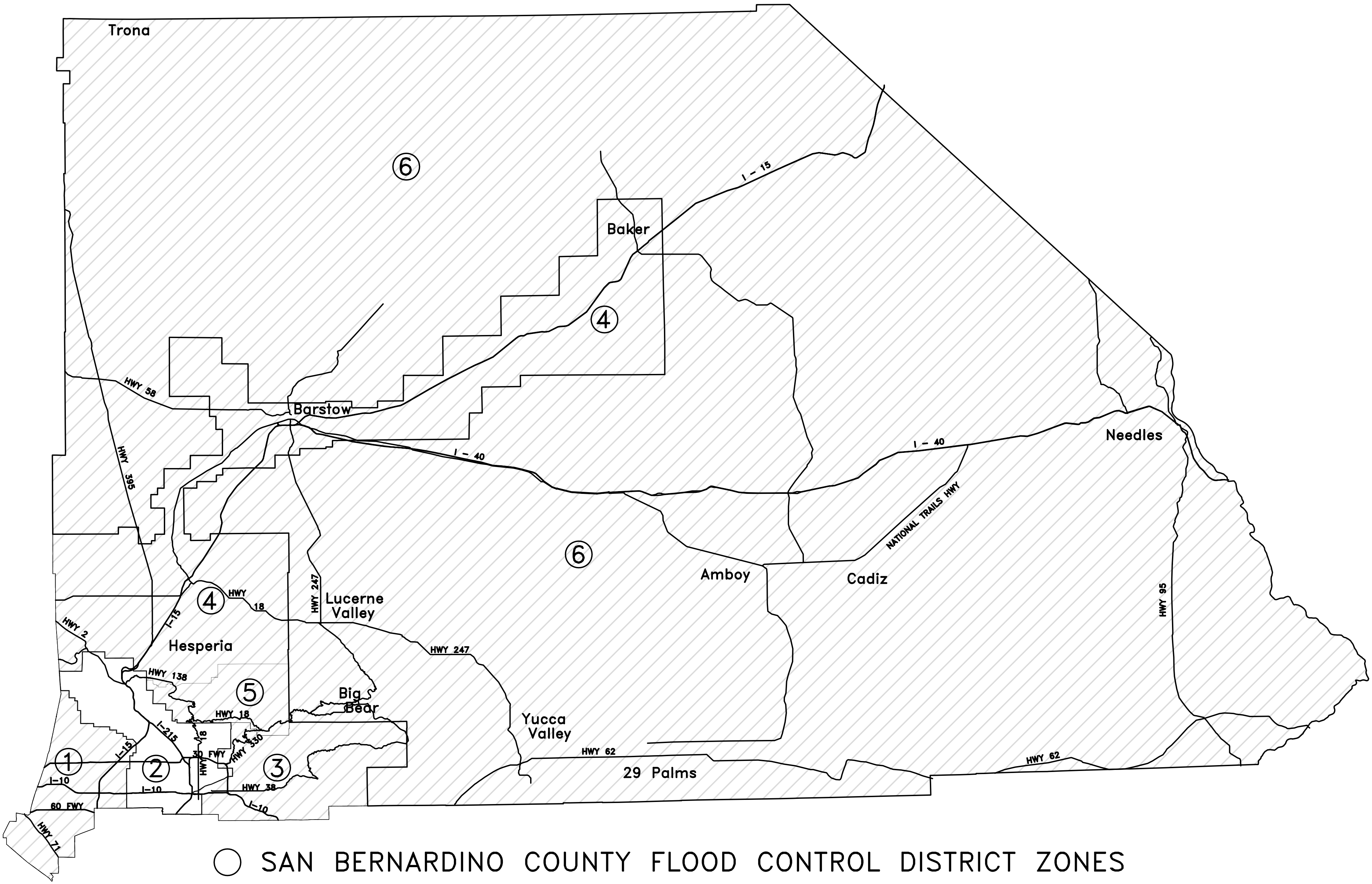



The legend above indicates the symbology used on all facility maps in this book.

**POSTSCRIPT NOTATION**

The following is a guide to using the postscript notations:

| | |
|---|---|
| " | Facility that is owned by SBCFCD in fee title or by easement but the District does not maintain the facility. |
| * | Operational or semi-operational facility owned and typically maintained by agency other than SBCFCD. |
| ^ | Facility that is either general in scope, in the planning stages (i.e. not developed) or is an inter-agency correspondence number. |

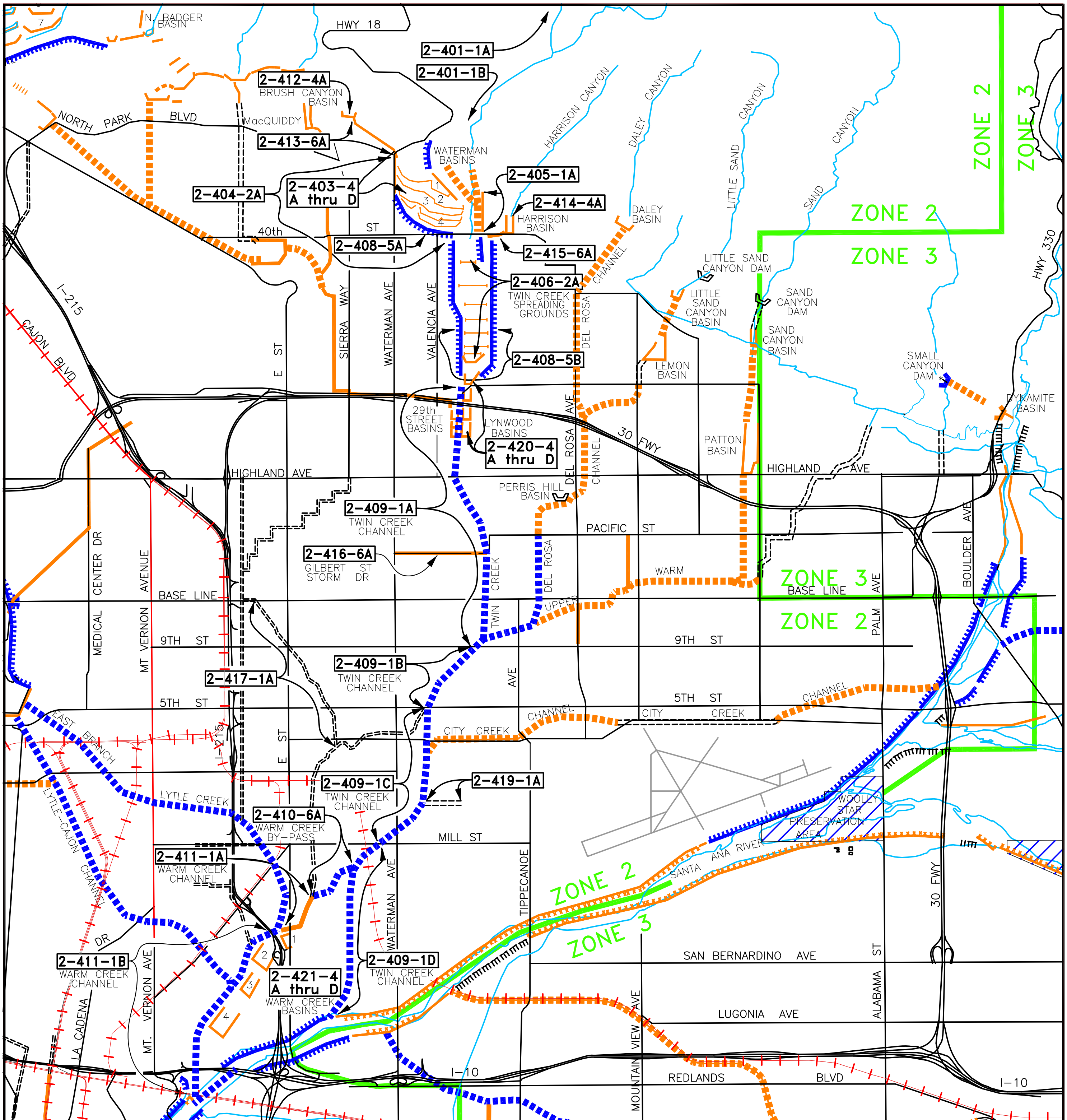



San Bernardino County

FLOOD CONTROL DISTRICT

Zone 2

ZONE 2




## LEGEND

1-201-1D F.C.D. SYSTEM NUMBER AND REACH

## FLOOD CONTROL SYSTEM

| ULTIMATE | INTERIM | |
|---|---|---|
| | | CHANNEL |
| | | STORM DRAIN |
| | | LEVEE (xxx Existing Interim Revetment) |
| | | BASIN OR DAM |
| | | CHECKDAM |
| | | MITIGATION/ENVIRONMENTAL |

## RELATED FACILITIES

WATERCOURSE
NON SYSTEM BASINS, CHANNELS, STREET WATERWAYS OR STORM DRAINS, & CHANNELS IN RIVERSIDE CO.
COUNTY BOUNDARY LINE

S.B.C.F.C.D. SYSTEM INDEX

TWIN & WARM CREEK SYSTEMS

2-400-00

| REV. DATE: | ACAD NO: | S.B.C.F.C.D. FILE NO.: |
|---|---|---|
| 01-2010 | SI2400 | RM-D4-8 |

# FLOOD CONTROL DISTRICT FACILITIES

## ZONE - 2

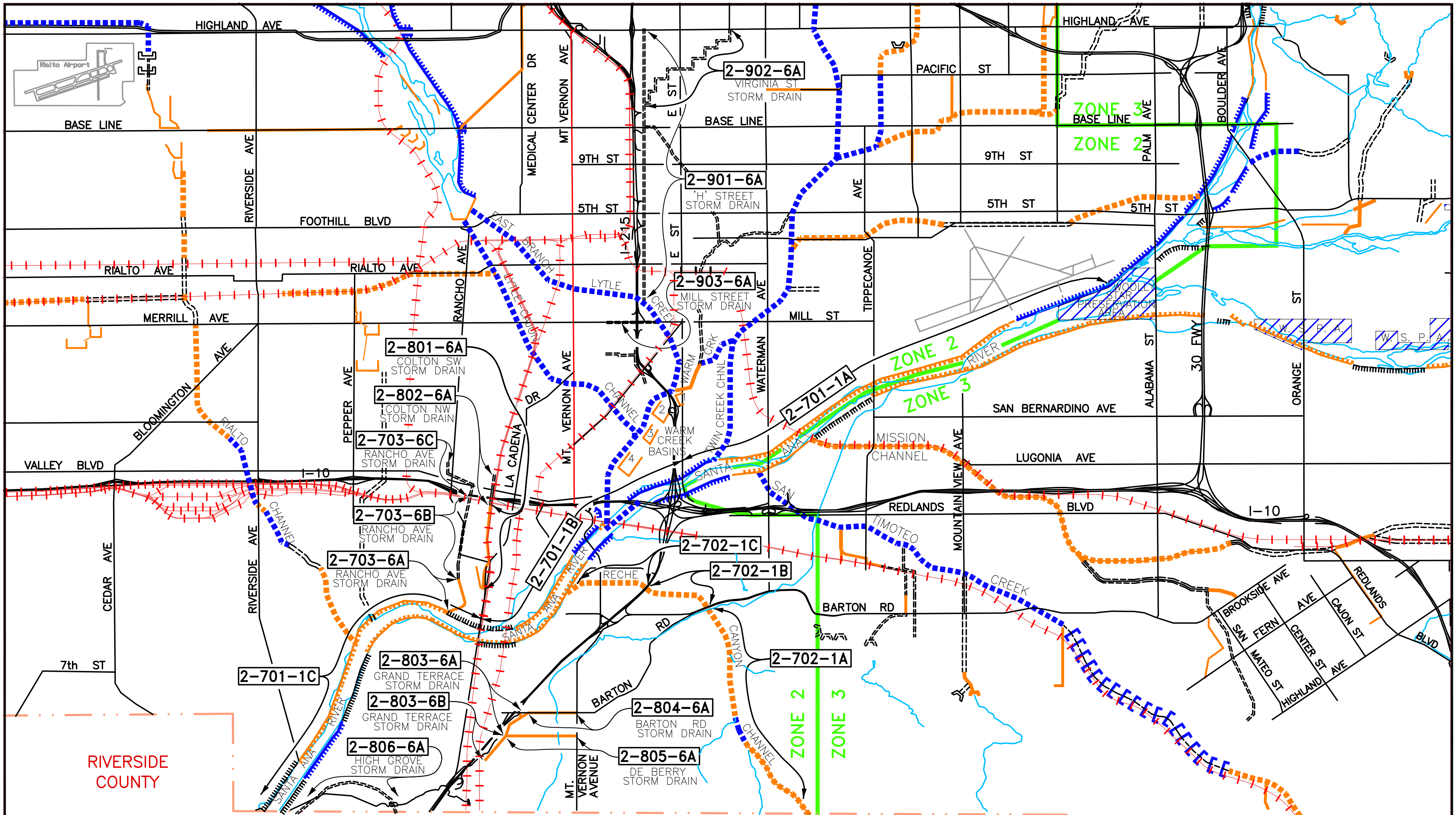
| SYSTEM # | FACILITY NAME | REACH LIMITS |
|---|---|---|
| **2-400-00** | **TWIN & WARM CREEKS SYSTEM^** | **General** |
| 2-401-1A | Waterman Creek^ | Above Canyon mouth (NDC) |
| 2-401-1B | Waterman Creek | Diversion Structure to Spreading Grounds |
| 2-403-4A | Waterman Basin #1 | In Waterman Spreading Grounds |
| 2-403-4B | Waterman Basin #2 | In Waterman Spreading Grounds |
| 2-403-4C | Waterman Basin #3 | In Waterman Spreading Grounds |
| 2-403-4D | Waterman Basin #4 | In Waterman Spreading Grounds |
| 2-404-2A | Waterman Sprdg Grnds | 40th St to Canyon mouth |
| 2-405-1A | Twin Creek | Twin Creek North of 40th St |
| 2-406-2A | Twin Creek Sprdg Grnds | Marshall Blvd to 40th St |
| 2-408-5A | Waterman Levee, COE | N/O of 40th St (Twin Creek Sprd Grds to Waterman Ave) |
| 2-408-5B | Twin Creek Levees, COE | North of Marshall Blvd to 40th St |
| 2-409-1A | Twin Creek Channel Improved, COE | Marshall Blvd to 9th St |
| 2-409-1B | Twin Creek Channel Improved, COE | 9th St to 5th St |
| 2-409-1C | Twin Creek Channel Improved, COE | 5th St to Mill St |
| 2-409-1D | Twin Creek Channel Improved, COE | Mill St to Santa Ana River |
| 2-410-6A | Warm Creek By-Pass, COE | Twin Creek Channel Improvement to Warm Creek Chnl |
| 2-411-1A | Warm Creek Channel | Warm Creek Bypass to "E" St |
| 2-411-1B | Warm Creek, COE | "E" St to Santa Ana River |
| 2-412-4A | Brush Canyon Basin | North of Sierra Ave & 54th St |
| 2-413-6A | Brush Canyon Storm Drain | Brush Basin to Waterman Spreading Grounds |
| 2-414-4A | Harrison Basin | North of Hampshire Ave & 40th St |
| 2-415-6A | Harrison Storm Drain | Harrison Basin to Twin Creek Spreading Grounds |
| 2-416-6A | Gilbert Street Storm Drain" | Waterman Ave to Twin Creek Channel |
| 2-417-1A | Town Creek* | Baseline & "H" St to Historic Warm Creek (City of San Bernardino) |
| 2-419-1A | Timber Creek* | Norton Drainage to Twin Creek Channel Imp. (City of San Bernardino) |
| 2-420-4A | Lynwood Basin #1 | South of Twin Creek Sprdg Grnds, East of Twin Creek |
| 2-420-4B | Lynwood Basin #2 | North of I-210 Fwy, East of Twin Creek |
| 2-420-4C | Lynwood Basin #3 | South of I-210 Fwy, East of Twin Creek |
| 2-420-4D | Lynwood Basin #4 | South of Lynwood Basin #3, East of Twin Creek |
| 2-421-4A | Warm Creek Conservation Basin #1^ | North-east of I-215 Fwy (No Longer Exists) |
| 2-421-4B | Warm Creek Conservation Basin #2 | South-west of I-215 Fwy |
| 2-421-4C | Warm Creek Conservation Basin #3 | South-west of Basin #2 |
| 2-421-4D | Warm Creek Conservation Basin #4 | South-west of Basin #3 |

**All facilities, unless denoted otherwise, are operated and maintained by the Flood Control District.**

" owned (via r/w or easement) by FCD but not maintained * owned by others ^ not owned, use as correspondence file number only

** used only during Federal Project coordination

Revised 1/2010




## LEGEND

1-201-1D F.C.D. SYSTEM NUMBER AND REACH

### FLOOD CONTROL SYSTEM

ULTIMATE | INTERIM
CHANNEL
STORM DRAIN
LEVEE (xxx Existing Interim Revetment)
BASIN OR DAM
CHECKDAM
MITIGATION/ENVIRONMENTAL

### RELATED FACILITIES

WATERCOURSE
NON SYSTEM CHANNELS, STREET WATERWAYS OR STORM DRAINS, & CHANNELS IN RIVERSIDE CO.
COUNTY BOUNDARY LINE

S.B.C.F.C.D. SYSTEM INDEX

SANTA ANA RIVER SYSTEM
COLTON DRAINAGE
SAN BERNARDINO DRAINAGE

2-700-00 thru 2-995-00

| REV. DATE: | ACAD NO: | S.B.C.F.C.D. FILE NO.: |
|---|---|---|
| 01-2010 | SI2700 | RM-D4-8 |

# FLOOD CONTROL DISTRICT FACILITIES

## ZONE - 2

| SYSTEM # | FACILITY NAME | REACH LIMITS |
|---|---|---|
| **2-700-00** | **SANTA ANA RIVER SYSTEM^** | **General / Santa Ana River Basin Survey** |
| 2-701-1A | Santa Ana River (Incl. COE) | Plunge Creek to South "E" St |
| 2-701-1B | Santa Ana River (Incl. COE) | South "E" St to La Cadena Ave |
| 2-701-1C | Santa Ana River | La Cadena Ave to Riverside County Line |
| 2-701-9D | Santa Ana River | Mitigation Lands |
| 2-702-1A | Reche Canyon Creek | County Line to Barton Rd |
| 2-702-1B | Reche Canyon Creek | Barton Rd to I-215 Fwy |
| 2-702-1C | Reche Canyon Creek | I-215 Fwy to Santa Ana River |
| 2-703-6A | Rancho Avenue Storm Drain | Santa Ana River to North of Agua Mansa Rd |
| 2-703-6B | Rancho Avenue Storm Drain* | North of Agua Mansa Rd to BNSF RR (City of Colton) |
| 2-703-6C | Rancho Avenue Storm Drain* | BNSF RR to upstream (City of Colton) |
| **2-800-00** | **COLTON DRAINAGE^** | **General** |
| 2-801-6A | Colton Southwest Storm Drain" | Intersection of J and Fifth St to east of La Cadena. Includes westerly segment from 750' s/o Rancho Ave. to La Cadena |
| 2-802-6A | Colton Northwest Storm Drain* | North of BNSF RR (City of Colton) |
| 2-803-6A | Grand Terrace Storm Drain | South of Barton Rd to BNSF RR |
| 2-803-6B | Grand Terrace Storm Drain | BNSF RR to I-215 Fwy |
| 2-804-6A | Barton Storm Drain | Mt. Vernon to Grand Terrace SD |
| 2-805-6A | De Berry Storm Drain | Mt. Vernon to Grand Terrace SD |
| 2-806-6A | Highgrove Storm Drain* | (City of Riverside) |
| **2-900-00** | **SAN BERNARDINO DRAINAGE^** | **General** |
| 2-901-6A | "H" Street Storm Drain* | (City of San Bernardino) |
| 2-902-6A | Virginia Street Storm Drain* | (City of San Bernardino) |
| 2-903-6A | Mill Street Storm Drain* | (City of San Bernardino) |
| **2-995-00** | **COMPREHENSIVE STORM DRAIN PLAN^** | **General** |
| **2-995-6A** | **COMPREHENSIVE STORM DRAIN PLAN^** | **CSDP #2** |
| **2-995-6B** | **COMPREHENSIVE STORM DRAIN PLAN^** | **CSDP #3** |
| **2-995-6C** | **COMPREHENSIVE STORM DRAIN PLAN^** | **CSDP #6** |
| **2-995-6D** | **COMPREHENSIVE STORM DRAIN PLAN^** | **CSDP #7** |

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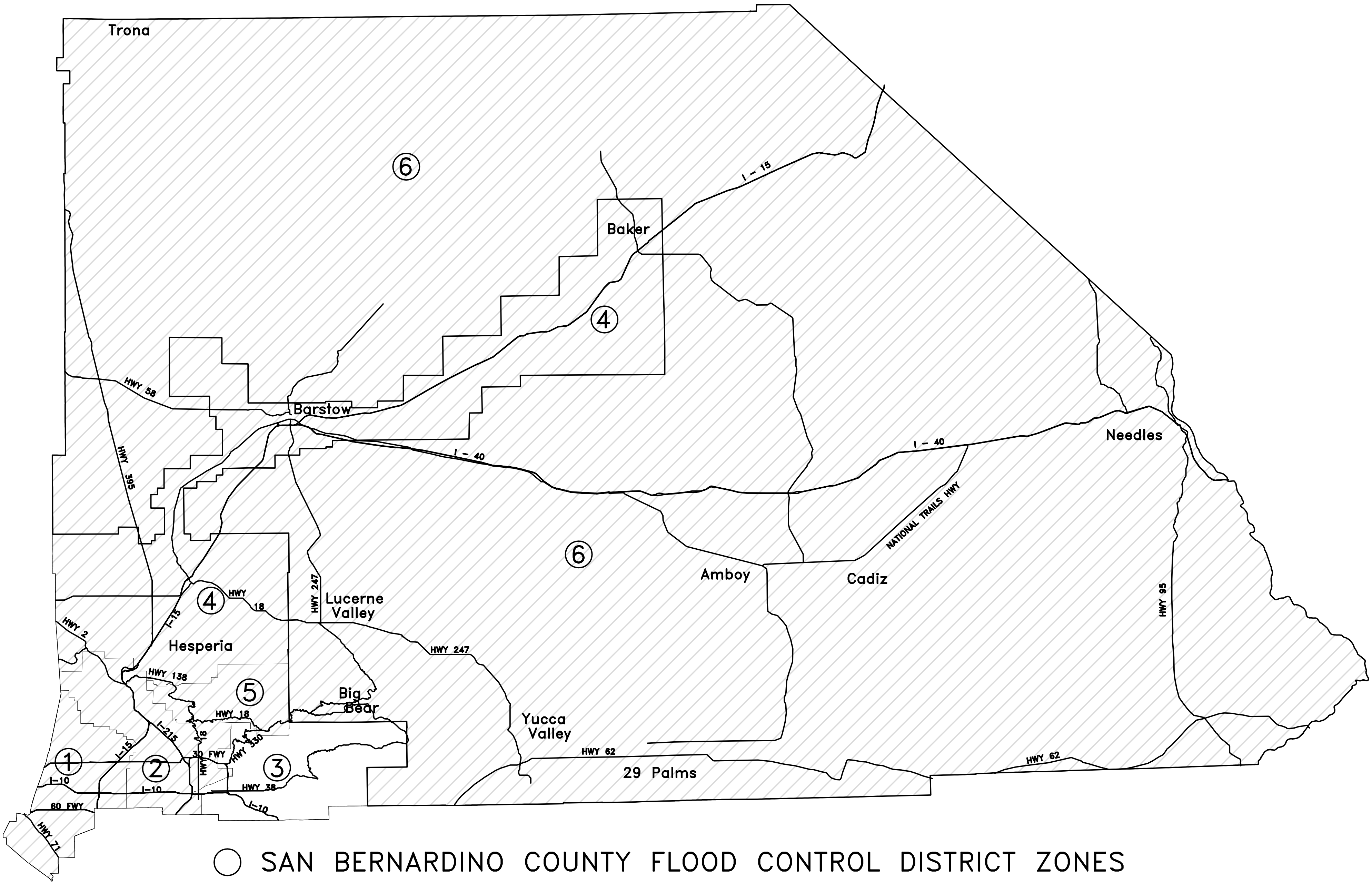
" owned (via r/w or easement) by FCD but not maintained * owned by others ^ not owned, use as correspondence file number only

** used only during Federal Project coordination

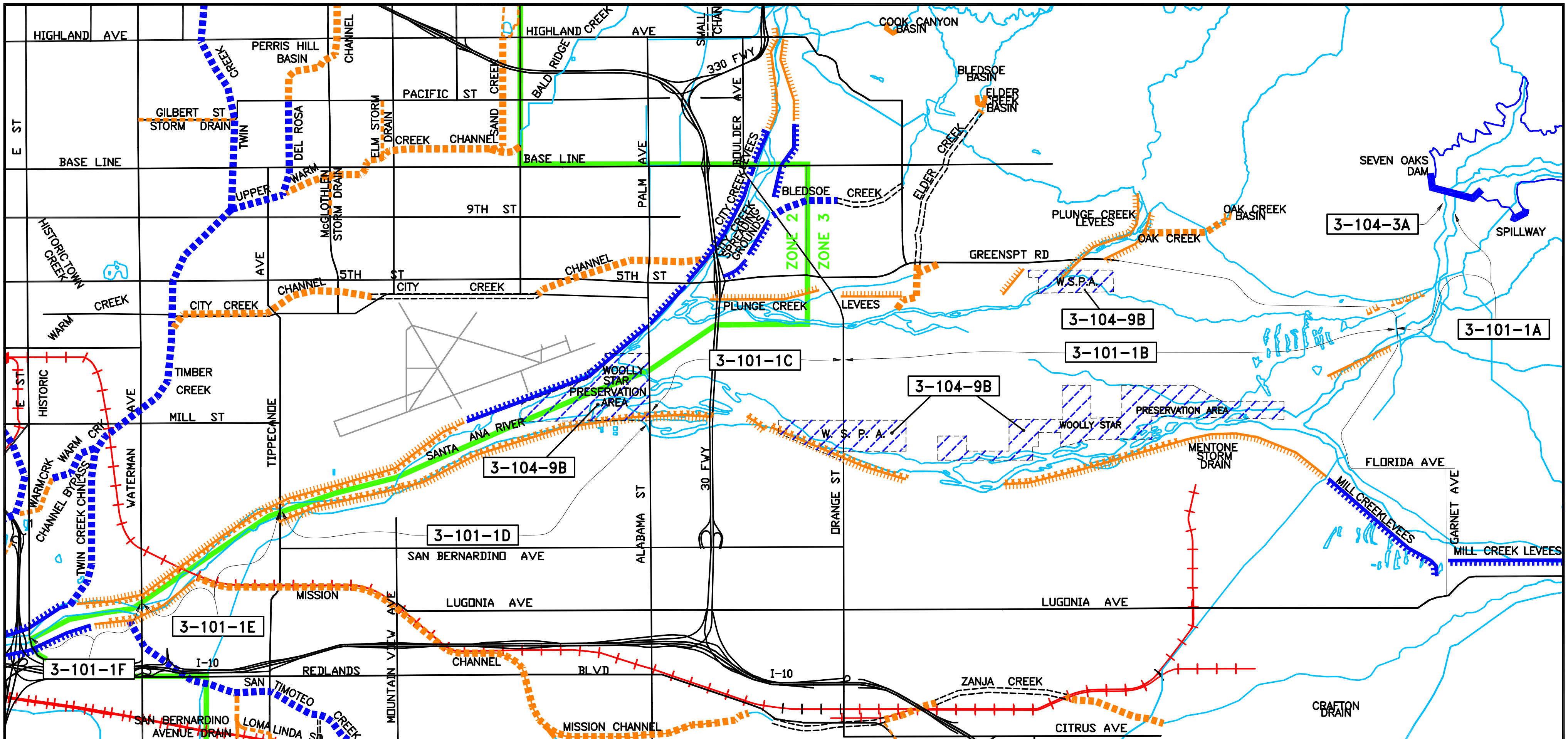



San Bernardino County

FLOOD CONTROL DISTRICT

Zone 3

# ZONE 3




## LEGEND

1-201-1D — F.C.D. SYSTEM NUMBER AND REACH

## FLOOD CONTROL SYSTEM

| ULTIMATE | INTERIM | |
|---|---|---|
| | | CHANNEL |
| | | STORM DRAIN |
| | | LEVEE (xxx Existing Interim Revetment) |
| | | BASIN OR DAM |
| | | CHECKDAM |
| | | MITIGATION/ENVIRONMENTAL |

## RELATED FACILITIES

- WATERCOURSE
- NON SYSTEM CHANNELS, STREET WATERWAYS OR STORM DRAINS, & CHANNELS IN RIVERSIDE CO.
- COUNTY BOUNDARY LINE

S.B.C.F.C.D. SYSTEM INDEX

SANTA ANA RIVER SYSTEM

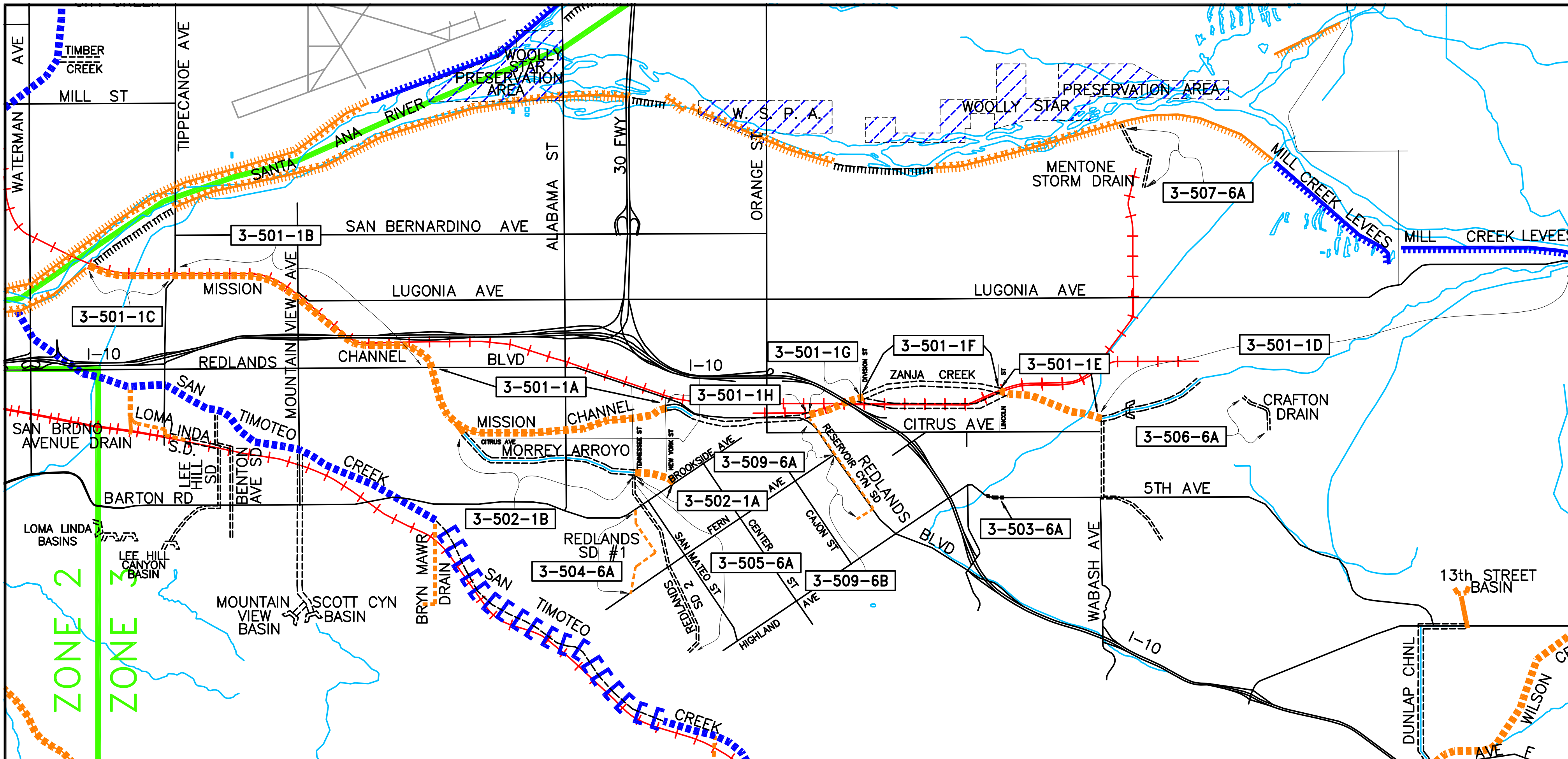
3-100-00

| REV. DATE: | ACAD NO: | S.B.C.F.C.D. FILE NO.: |
|---|---|---|
| 01-2010 | SI3100 | RM-D4-8 |

# FLOOD CONTROL DISTRICT FACILITIES

## ZONE - 3

| SYSTEM # | FACILITY NAME | REACH LIMITS |
|---|---|---|
| **3-000-00** | **ZONE 3^** | **General** |
| **3-100-00** | **SANTA ANA RIVER SYSTEM^** | **General / Santa Ana River Basin Survey** |
| 3-101-1A | Santa Ana River | Above Greenspot Rd. |
| 3-101-1B | Santa Ana River" | Greenspot Rd. to Orange St. |
| 3-101-1C | Santa Ana River | Orange St. to Alabama St. |
| 3-101-1D | Santa Ana River | Alabama St. to Tippecanoe Ave. |
| 3-101-1E | Santa Ana River | Tippecanoe to Waterman Ave. |
| 3-101-1F | Santa Ana River (Incl. COE) | Waterman Ave. to South "E" St. |
| 3-102-4A | Mentone Dam, COE^ | Santa Ana River south of E. Highlands; (no longer exists; see 3-104-3A) |
| **3-103-00** | **Santa Ana River, COE^** | **SAR - All Zones Including Orange & Riverside Co.;** |
| | | **See 1-000, 2-700 & 3-100 Prior to September 1984** |
| 3-104-3A | Seven Oaks Dam, COE [DSOD] | Seven Oaks Dam |
| 3-104-9A | Seven Oaks Dam, COE^ | Water Conservation Feasibility Study |
| 3-104-9B | Seven Oaks Dam, COE | Mitigation Lands |




## LEGEND

1-201-1D — F.C.D. SYSTEM NUMBER AND REACH

## FLOOD CONTROL SYSTEM

| ULTIMATE | INTERIM | |
|---|---|---|
| | | CHANNEL |
| | | STORM DRAIN |
| | | LEVEE (xxx Existing Interim Revetment) |
| | | BASIN OR DAM |
| | | CHECKDAM |
| | | MITIGATION/ENVIRONMENTAL |

## RELATED FACILITIES

- WATERCOURSE
- NON SYSTEM CHANNELS, STREET WATERWAYS OR STORM DRAINS, & CHANNELS IN RIVERSIDE CO.
- COUNTY BOUNDARY LINE

S.B.C.F.C.D. SYSTEM INDEX

# MISSION-ZANJA CREEK SYSTEM

3-500-00

| REV. DATE: | ACAD NO: | S.B.C.F.C.D. FILE NO.: |
|---|---|---|
| 01-2010 | SI3500 | RM-D4-8 |

# FLOOD CONTROL DISTRICT FACILITIES
## ZONE - 3

| SYSTEM # | FACILITY NAME | REACH LIMITS |
|---|---|---|
| **3-500-00** | **MISSION-ZANJA CREEK SYSTEM^** | **General** |
| 3-501-1A | Mission Channel | New York Ave. to Redlands Blvd. |
| 3-501-1B | Mission Channel | Redlands Blvd. to Tippecanoe Ave. |
| 3-501-1C | Mission Channel | Tippecanoe Ave. to Santa Ana River |
| 3-501-1D | Zanja Creek* | Mill Creek to Opal St. (Historical; Partial R/W only) |
| 3-501-1E | Zanja Creek | Opal St. to Lincoln |
| 3-501-1F | Zanja Creek* | Lincoln St. to Division St. |
| 3-501-1G | Zanja Creek | Division to 275' west of 9th St. |
| 3-501-1H | Zanja Creek* | 275' west of 9th to New York Ave. (Redlands) |
| 3-502-1A | Morrey Arroyo | Brookside Ave. to Tennessee |
| 3-502-1B | Morrey Arroyo* | Tennessee to Citrus (Redlands) |
| 3-503-6A | 5th Avenue SD* | Marion Rd. to Fairview Rd. (Redlands) |
| 3-504-6A | Redlands SD #1" | Laurel Ave. to Brookside Ave. (Redlands) (R/W only) |
| 3-505-6A | Redlands SD #2A* | Cedar to Crescent (Redlands) |
| **3-506-00** | **CRAFTON DRAINAGE^** | **General** |
| 3-506-6A | Crafton Drain^ | Citrus to Third Ave. (NDC) |
| 3-507-6A | Mentone SD" | Carlsbad to Santa Ana River (NDC) (R/W only) |
| 3-508-1A | Zanja By-Pass^ | Dearborn to Santa Ana River (NDC) |
| 3-509-6A | Reservoir Canyon SD^ | Zanja to Fern |
| 3-509-6B | Reservoir Canyon SD* | Fern to upstream (Redlands) |
| **3-550-00** | **REDLANDS DRAINAGE SYSTEM^** | **General** |
| 3-551-6A | Reservoir Canyon SD^ | (Does not exist - pertained to Participation Project) |

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" owned (via r/w or easement) by FCD but not maintained    * owned by others    ^ not owned, use as correspondence file number only

** used only during Federal Project coordination

Revised 1/2010

CITY OF REDLANDS

PUBLIC WORKS DEPARTMENT

# HYDROLOGY STUDY

# MILL CREEK ZANJA STORM DRAIN

**Prepared by:**

BSI Consultants, Inc.

# CITY OF REDLANDS
## 30 CAJON STREET - CITY HALL
## REDLANDS, CALIFORNIA 92373

# HYDROLOGY STUDY

# MILL CREEK ZANJA STORM DRAIN

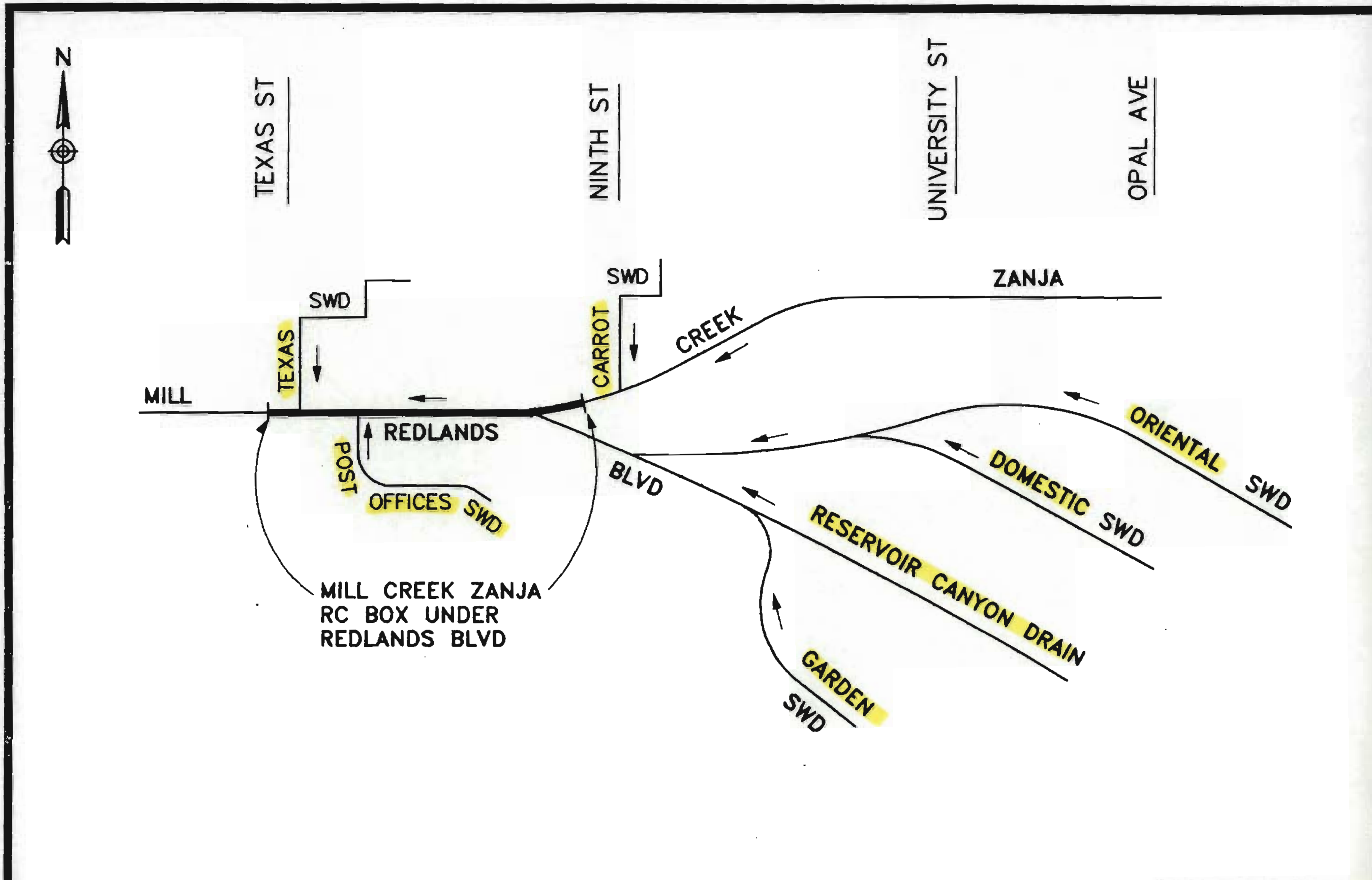

*PREPARED BY:*

*BSI CONSULTANTS, INC.*
*2001 EAST FIRST STREET*
*SANTA ANA, CALIFORNIA 92701*
*(714) 568-7300*

*Under the Supervision of:*

REGISTERED PROFESSIONAL ENGINEER
MOHAMMED NAJIEB KHAN ROWTHER
37127
CIVIL
STATE OF CALIFORNIA

SIGNATURE Mohammed Rowther DATE 6/17/89
*Mohammed N.K. Rowther, P.E.*

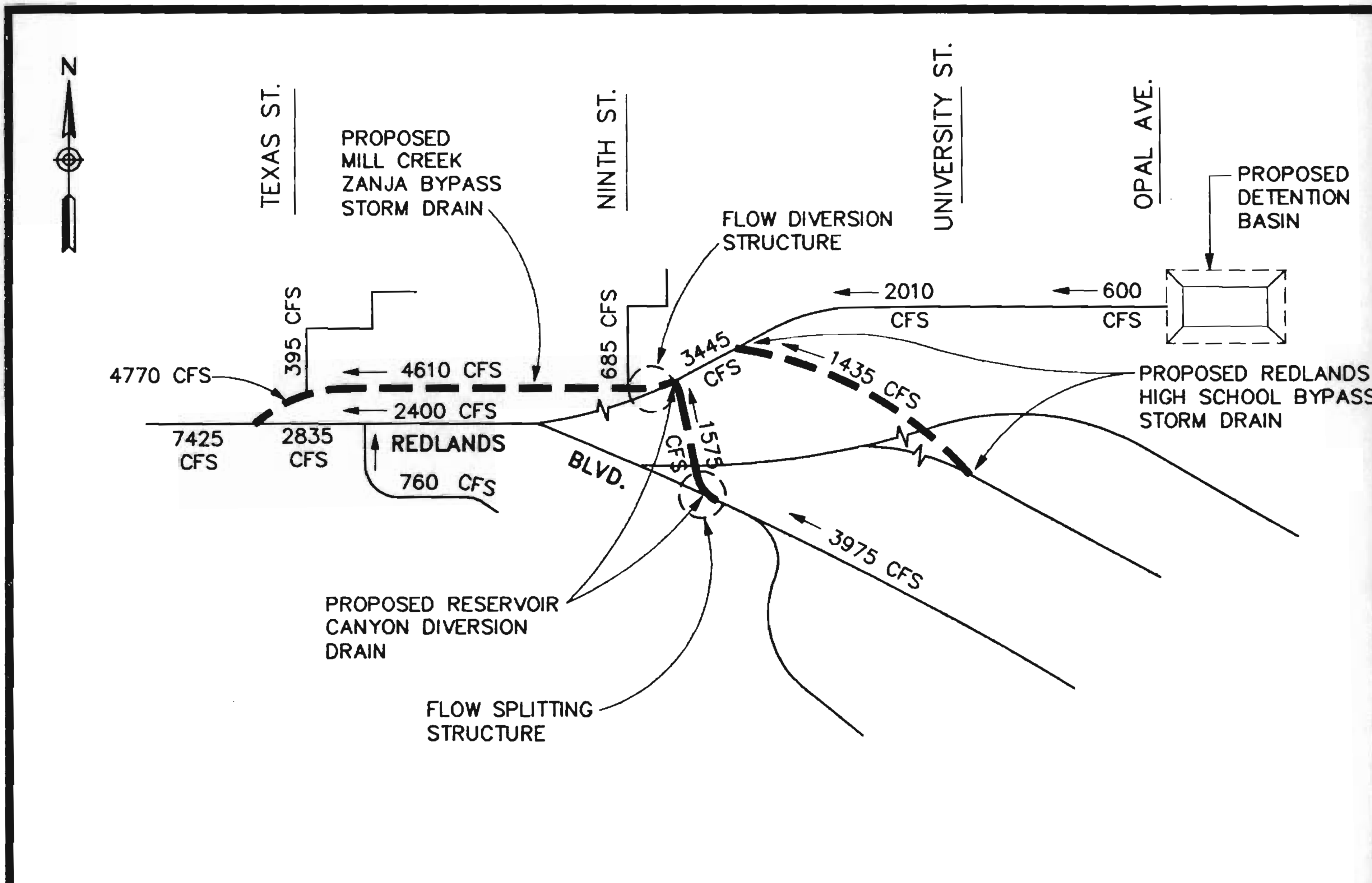




BSI CONSULTANTS, INC.
2001 E. First Street
Santa Ana CA 91406
(714)568-7300
(714)836-5906 Fax


MILL CREEK & REDLANDS
HIGH SCHOOL BYPASS S.D.

EXISTING STORM DRAINS
Figure 1




BSI CONSULTANTS, INC.
2001 E. First Street
Santa Ana CA 91406
(714)568-7300
(714)836-5906 Fax

MILL CREEK & REDLANDS HIGH SCHOOL BYPASS S.D.

100-YEAR PEAK FLOWS

Figure 2

F01060.17

# MISSION ZANJA CREEK

## CHANNEL IMPROVEMENT STUDY

## FINAL

**OCTOBER 1987**

**Prepared for:**
**SAN BERNARDINO COUNTY FLOOD CONTROL DISTRICT**

M&E
Metcalf & Eddy

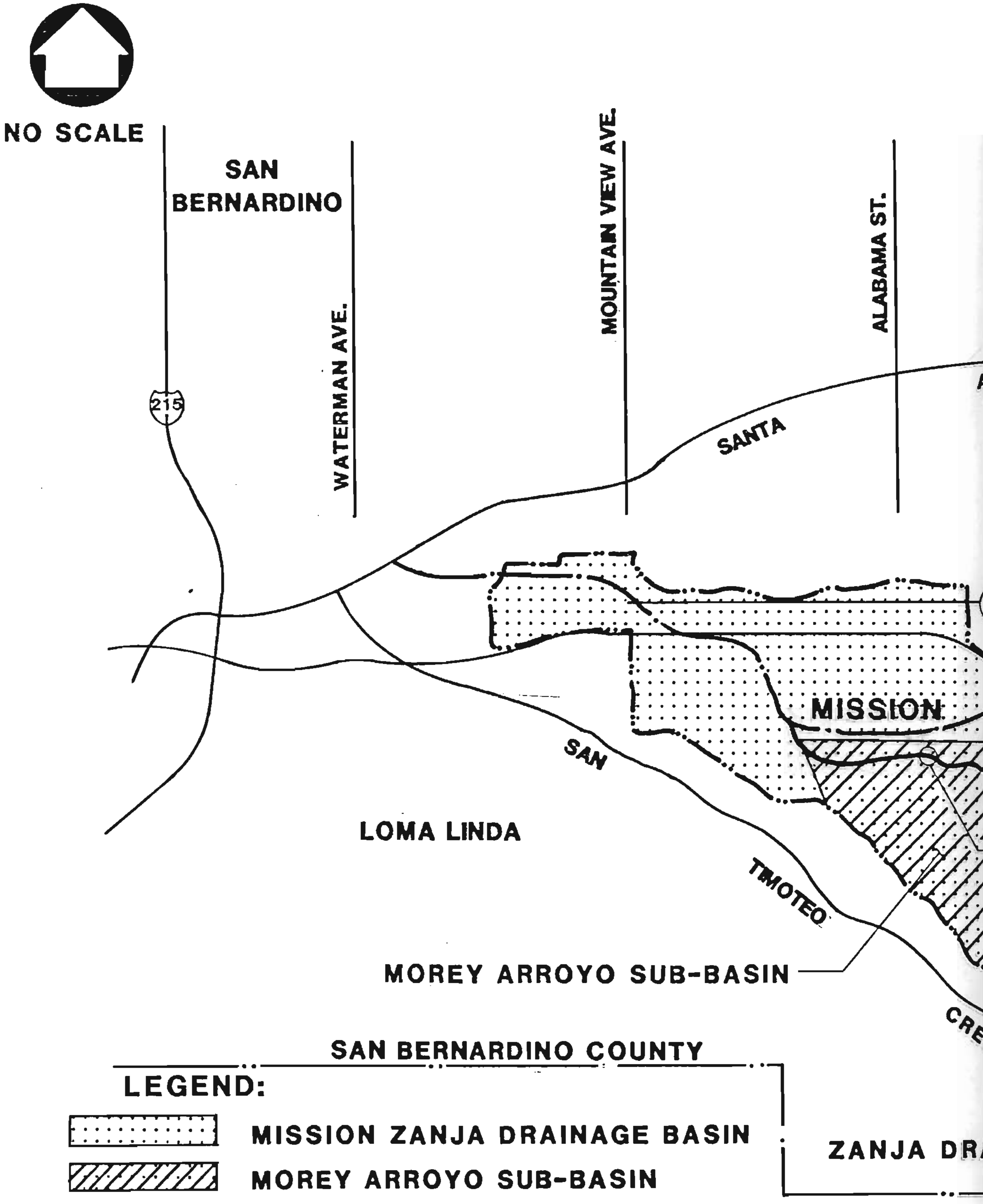
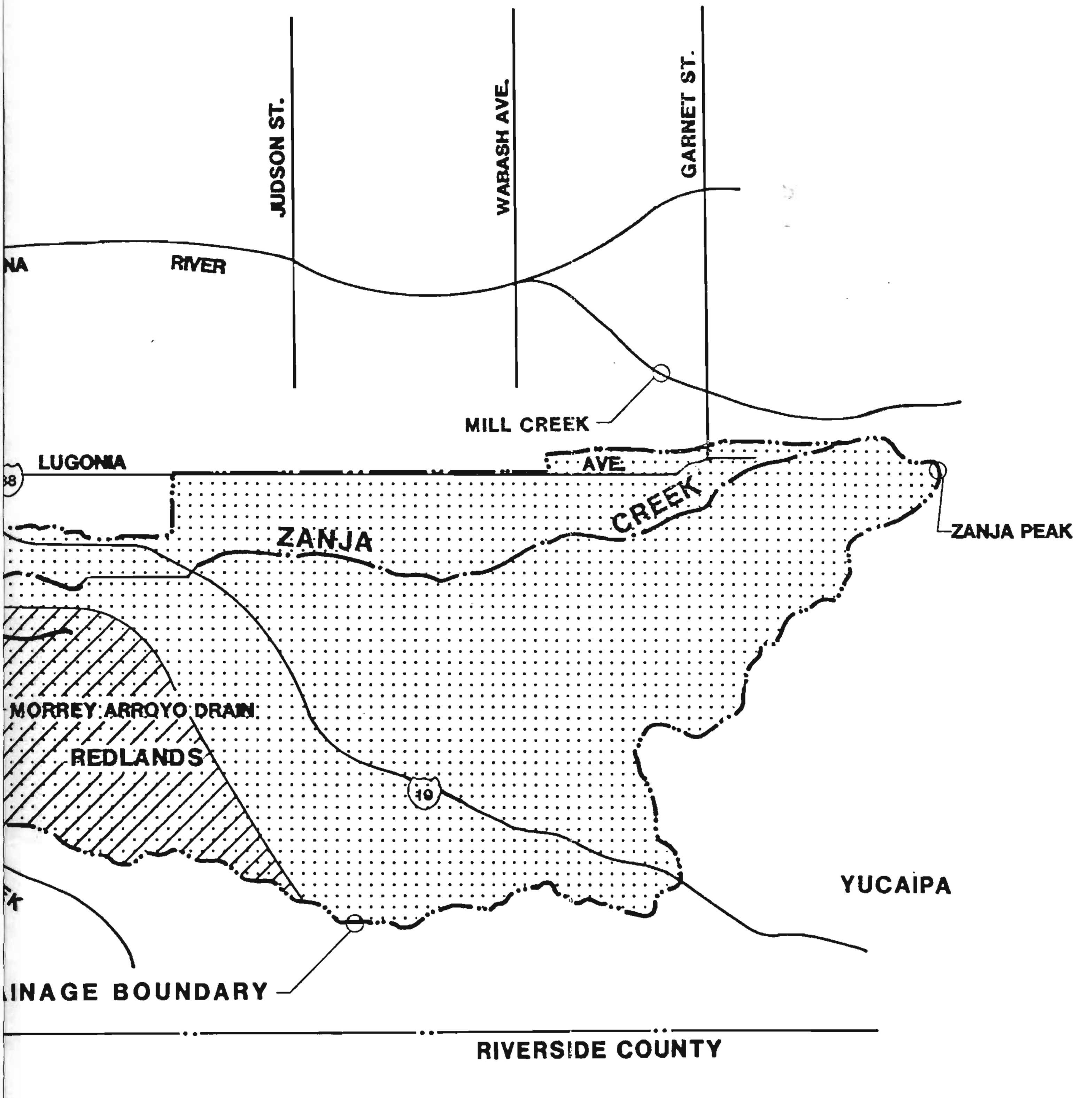
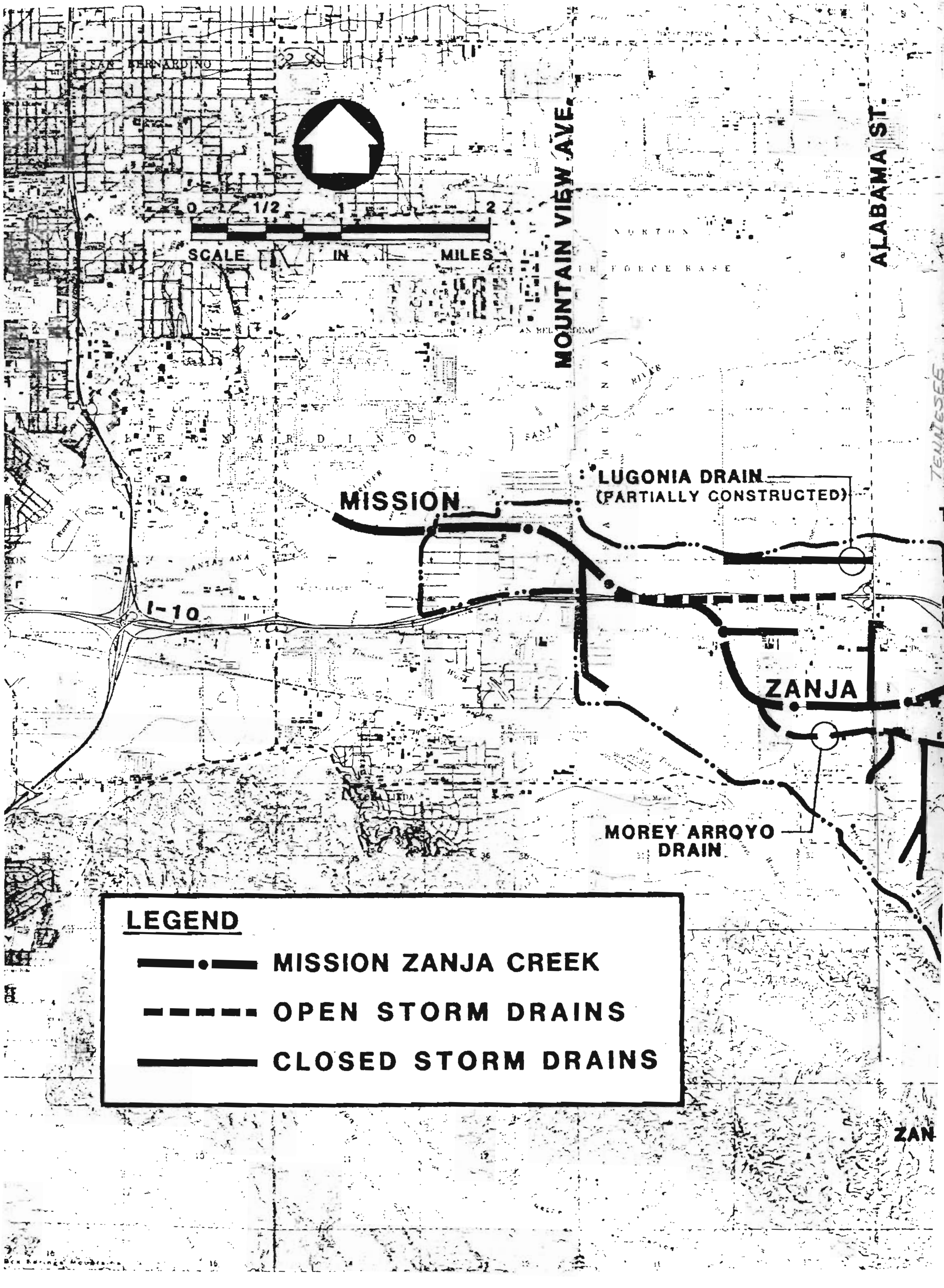

NO SCALE
SAN BERNARDINO
WATERMAN AVE.
MOUNTAIN VIEW AVE.
ALABAMA ST.
215
SANTA
MISSION
SAN
TIMOTEO
LOMA LINDA
MOREY ARROYO SUB-BASIN
SAN BERNARDINO COUNTY
LEGEND:
MISSION ZANJA DRAINAGE BASIN
MOREY ARROYO SUB-BASIN

FIGURE 3-1
MISSION ZANJA-STUDY AREA
LOCATION MAP




Metcalf & Eddy



SAN BERNARDINO
0 1/2 1 2
SCALE IN MILES
MOUNTAIN VIEW AVE.
ALABAMA ST.
NORTON
AIR FORCE BASE
TENNESSEE
MISSION
LUGONIA DRAIN
(PARTIALLY CONSTRUCTED)
I-10
ZANJA
MOREY ARROYO
DRAIN
LEGEND
MISSION ZANJA CREEK
OPEN STORM DRAINS
CLOSED STORM DRAINS
ZAN

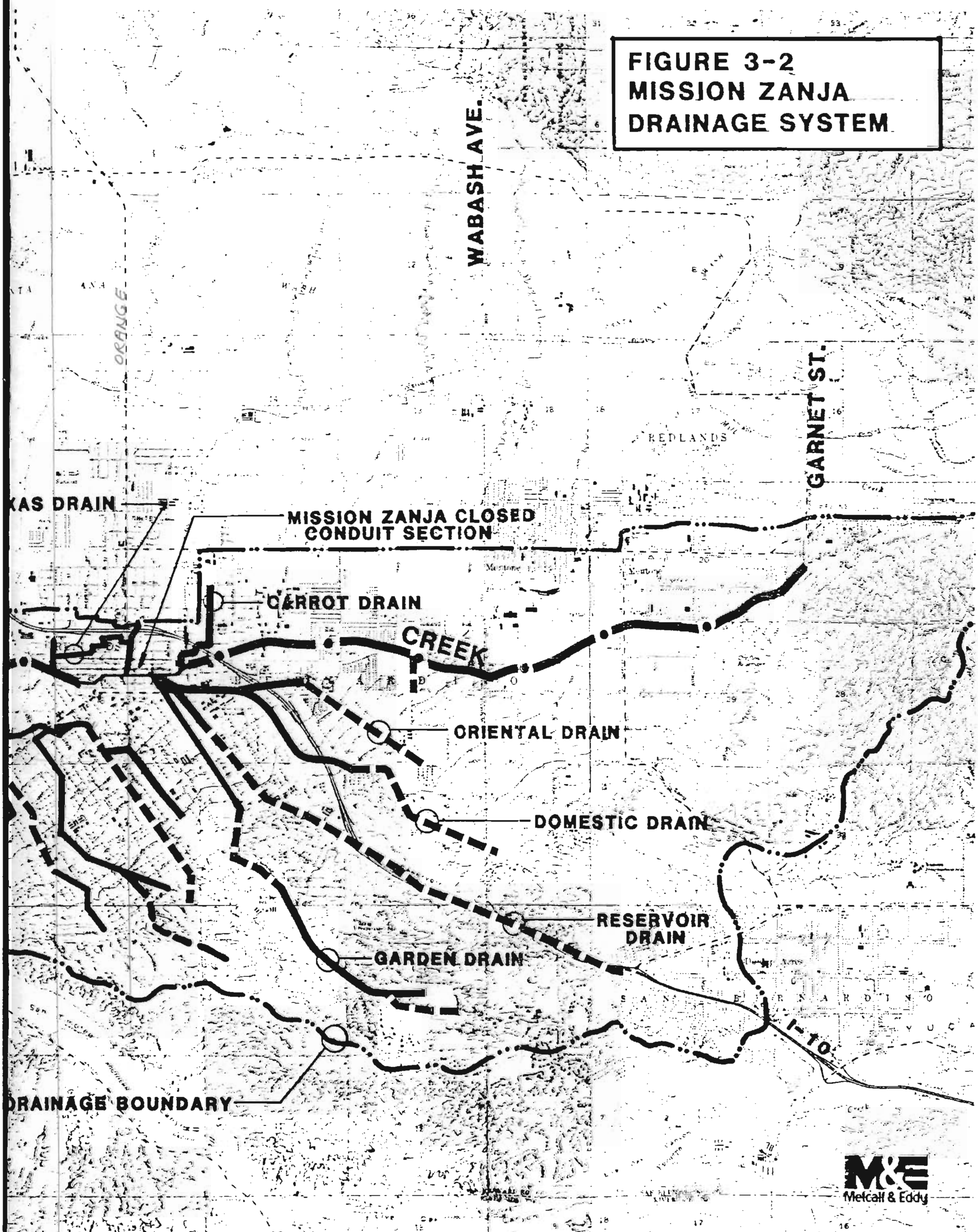


FIGURE 3-2
MISSION ZANJA
DRAINAGE SYSTEM
WABASH AVE.
GARNET ST.
ORANGE
REDLANDS
TEXAS DRAIN
MISSION ZANJA CLOSED
CONDUIT SECTION
CARROT DRAIN
CREEK
ORIENTAL DRAIN
DOMESTIC DRAIN
RESERVOIR
DRAIN
GARDEN DRAIN
DRAINAGE BOUNDARY
SAN BERNARDINO
I-10
M&E
Metcalf & Eddy

# MILL CREEK ZANJA DETENTION BASIN STUDY

ESPECIALLY PREPARED FOR

CITY OF REDLANDS

AND

SAN BERNARDINO COUNTY FLOOD CONTROL DISTRICT

OUR JOB NO. 85219.10

R21

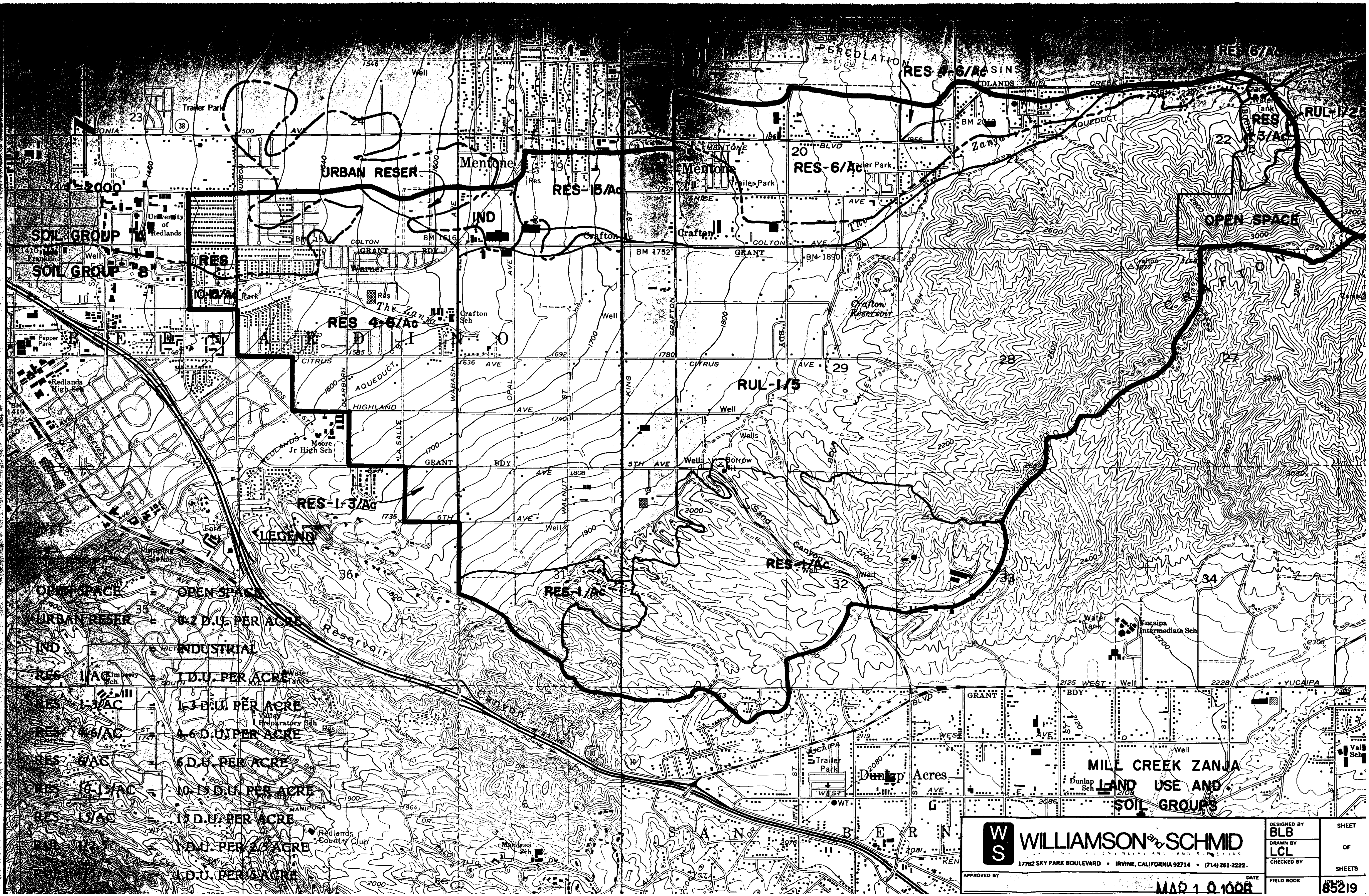
MARCH 18, 1986

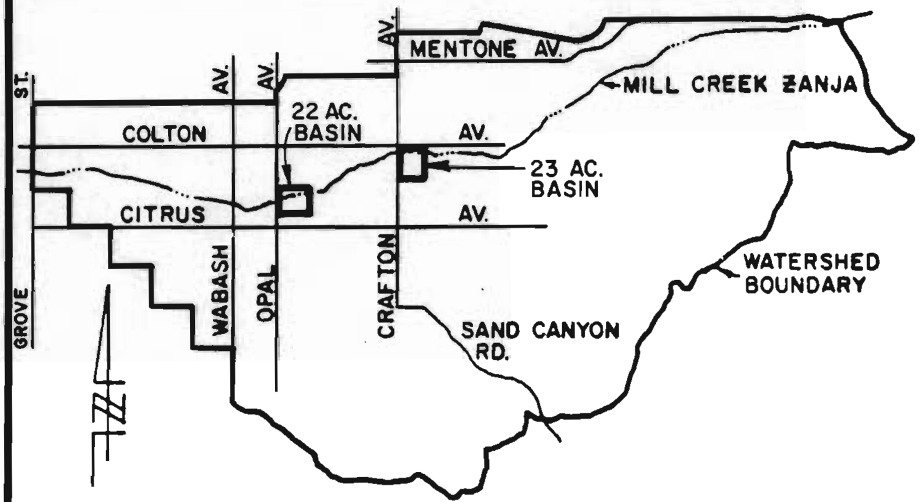
WS

WILLIAMSON and SCHMID

CONSULTING CIVIL ENGINEERS AND LAND SURVEYORS

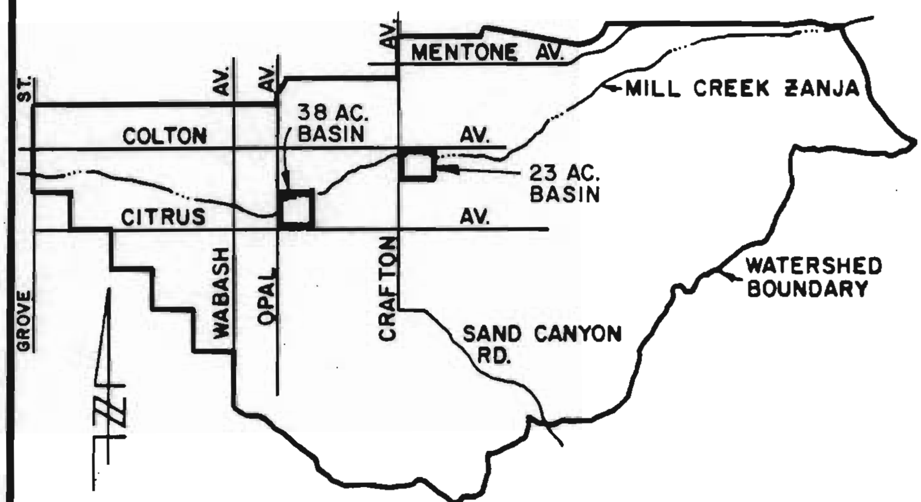
Corporate Office • 17782 Sky Park Blvd. • Irvine, California 92714 • 714/261-2222


MILL CREEK ZANJA
LAND USE AND
SOIL GROUPS
LEGEND
OPEN SPACE = OPEN SPACE
URBAN RESER = 0-2 D.U. PER ACRE
IND = INDUSTRIAL
RES 1/AC = 1 D.U. PER ACRE
RES 1-3/AC = 1-3 D.U. PER ACRE
RES 4-6/AC = 4-6 D.U. PER ACRE
RES 6/AC = 6 D.U. PER ACRE
RES 10-15/AC = 10-15 D.U. PER ACRE
RES 15/AC = 15 D.U. PER ACRE
1 D.U. PER 2.5 ACRE
1 D.U. PER 5 ACRE
SOIL GROUP "A"
SOIL GROUP "B"
URBAN RESER
RES 4-6/Ac
RES-15/Ac
RES-6/Ac
IND
RES 10-15/Ac
RUL-1/5
RES-1-3/Ac
RES-1/Ac
OPEN SPACE
Mentone
Crafton
Redlands High Sch
University of Redlands
Moore Jr High Sch
Crafton Reservoir
Dunlap Acres
Yucaipa Intermediate Sch
Redlands Country Club
WILLIAMSON and SCHMID
17782 SKY PARK BOULEVARD • IRVINE, CALIFORNIA 92714 • (714) 261-2222
APPROVED BY
DATE
DESIGNED BY BLB
DRAWN BY LCL
CHECKED BY
FIELD BOOK
SHEET OF SHEETS
JOB NO. 85219



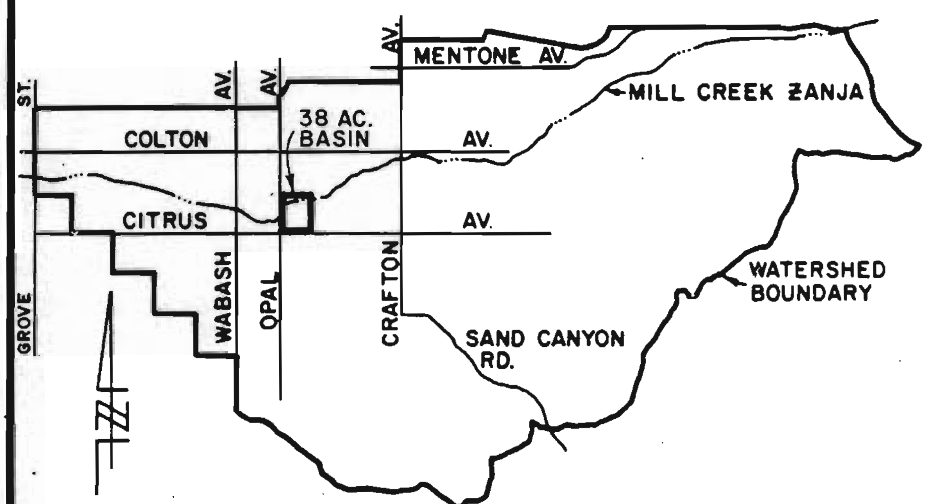

## SCHEME A

2000 CFS AT GROVE STREET
CONSTRUCTION COSTS
= $ 4,400,000




## SCHEME B

1670 CFS AT GROVE STREET
CONSTRUCTION COSTS
= $ 7,300,000




## SCHEME C

1940 CFS AT GROVE STREET
CONSTRUCTION COSTS
= $ 4,200,000

WS WILLIAMSON and SCHMID
CONSULTING CIVIL ENGINEERS AND LAND SURVEYORS
17782 SKY PARK BOULEVARD
IRVINE, CALIFORNIA 92714

APPROVED BY

FIGURE 2

WATERSHED SCHEMATICS

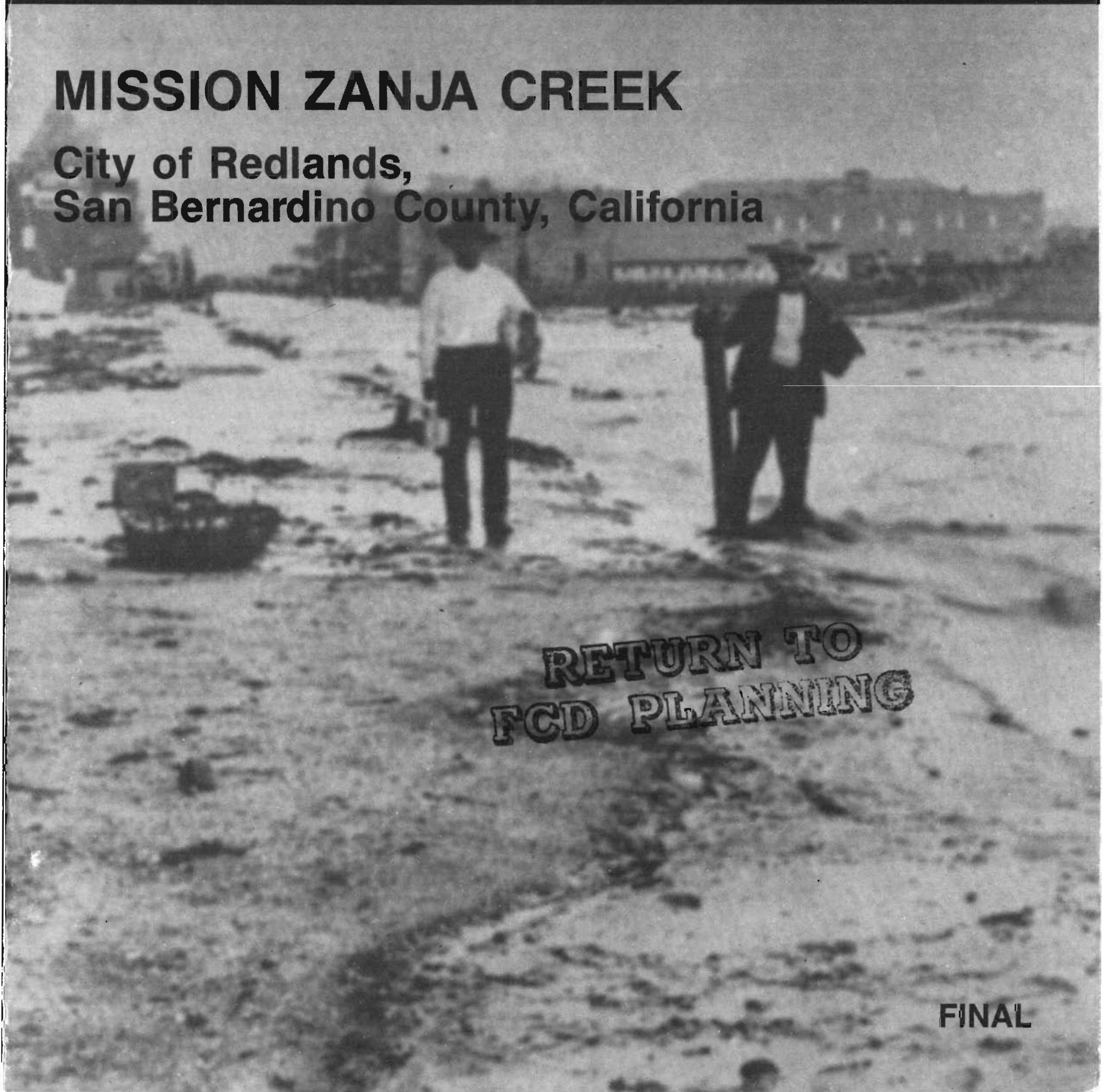
| | |
|---|---|
| SCALE | NO SCALE |
| DRAWN BY | WVB |
| SURVEYED BY | |
| CHECKED BY | |
| FIELD BOOK | |
| DATE | 11-20-85 |
| JOB NO. | 85219.1 |

US Army Corps
of Engineers
Los Angeles District

Small Flood Control Project Authority
Detailed Project Report and
Environmental Assessment

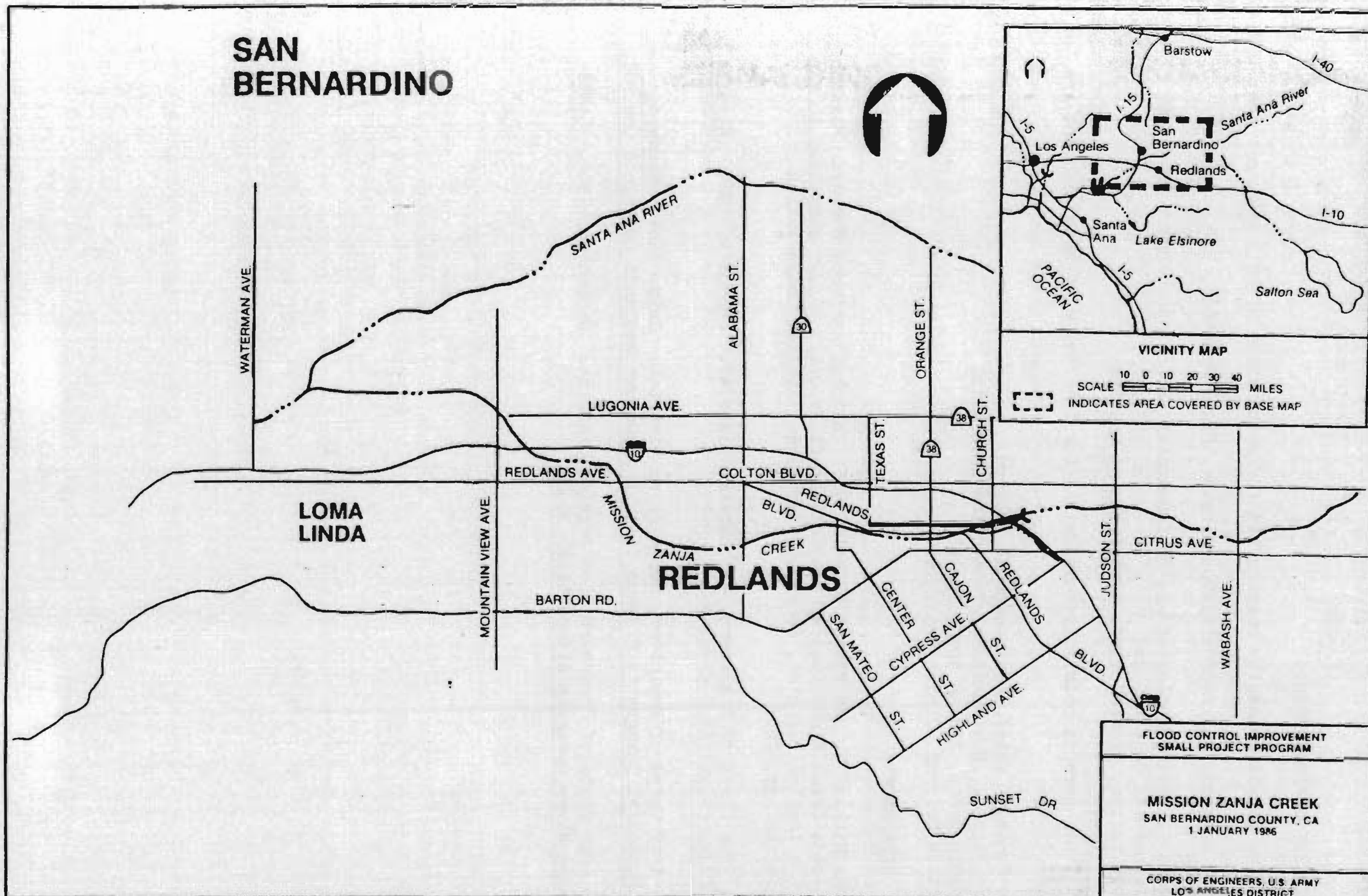
# MISSION ZANJA CREEK

## City of Redlands, San Bernardino County, California





FINAL




MISSION ZANJA CREEK VICINITY MAP

FIGURE 1

# MISSION ZANJA CREEK PROJECT LOCATION


| |
|---|
| MISSION ZANJA CREEK<br>REDLANDS, CALIFORNIA |
| **RECOMMENDED PLAN** |
| US ARMY CORPS OF ENGINEERS<br>LOS ANGELES DISTRICT |

**FIGURE 2**

# BASIC FEATURES OF MAIN INLET

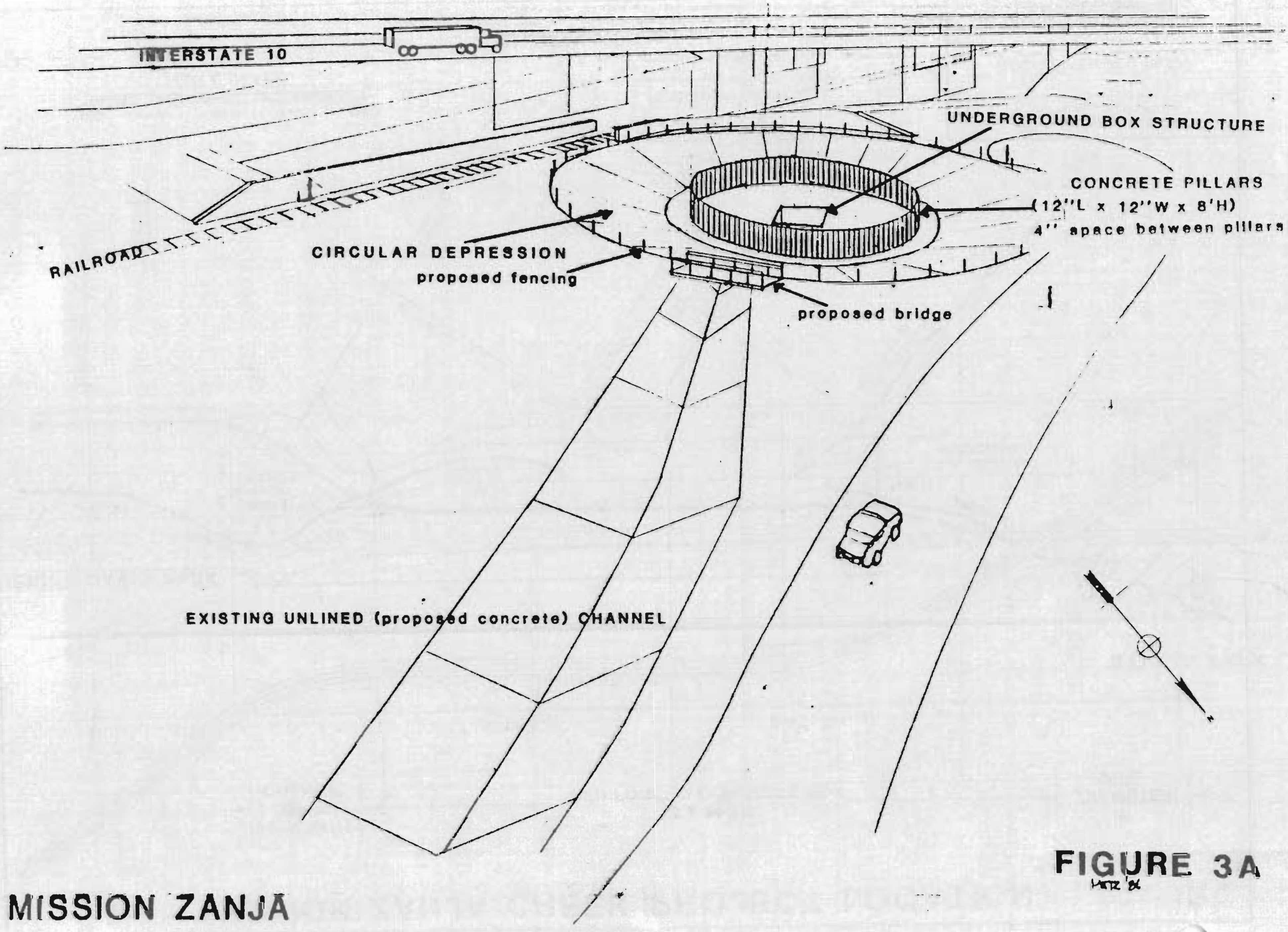



FIGURE 3A

MISSION ZANJA

# POSSIBLE ESTHETIC ENHANCEMENT OF MAIN INLET STRUCTURE

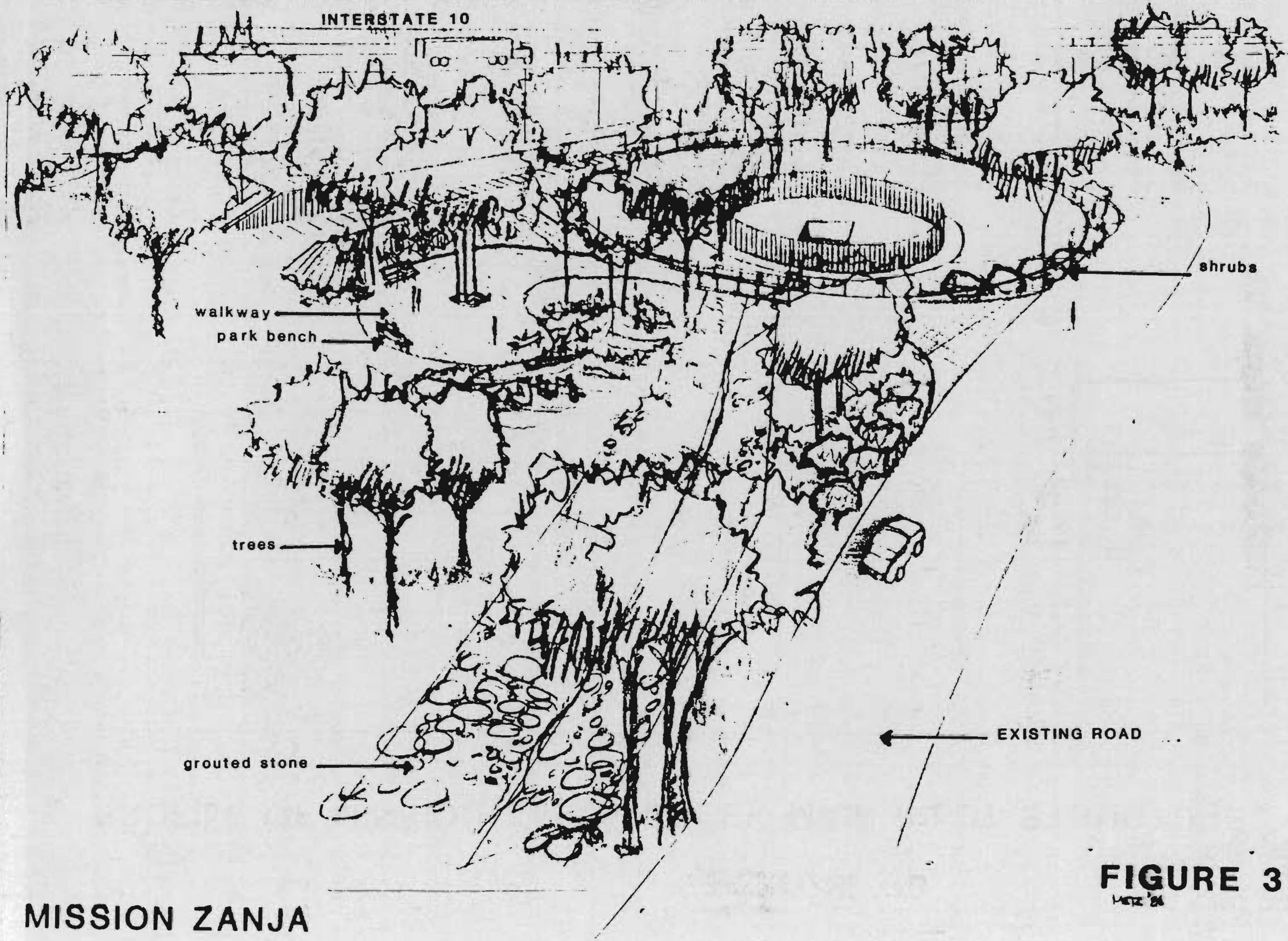
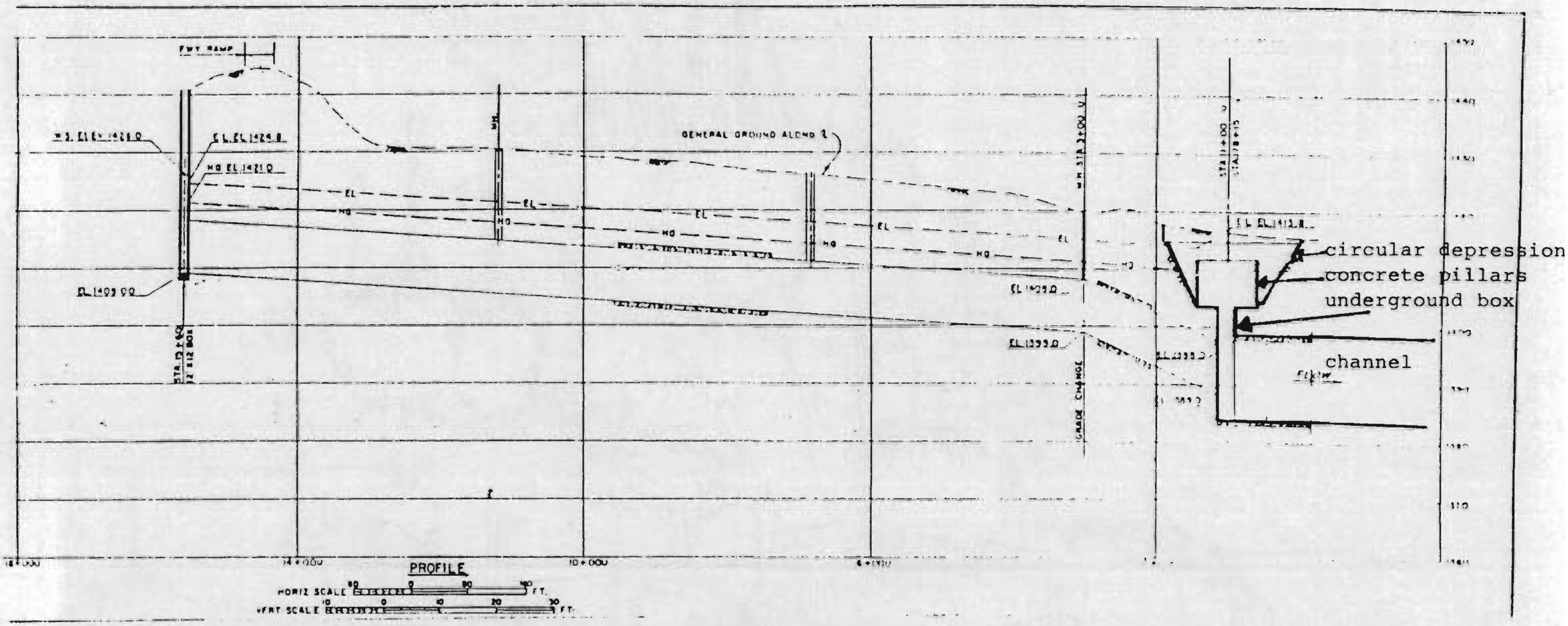



**FIGURE 3B**

**MISSION ZANJA**

# PROFILE OF MISSION ZANJA CREEK MAIN INLET STRUCTURE




NOTE: The main inlet structure will be located in and adjacent to the existing channel (see Figure 3A) and will collect flows from the secondary inlet structure, overland flow in the area emanating from Mission Zanja Creek and flows from the Mission Zanja Creek existing channel. The main inlet will be a circular depression, 180 feet in diameter. Vertical concrete pillars within the depression will control the entrance of the water into the structure and prevent large debris from entering the structure.

**FIGURE 3C**

MISSION ZANJA CREEK SECONDARY INLET STRUCTURE

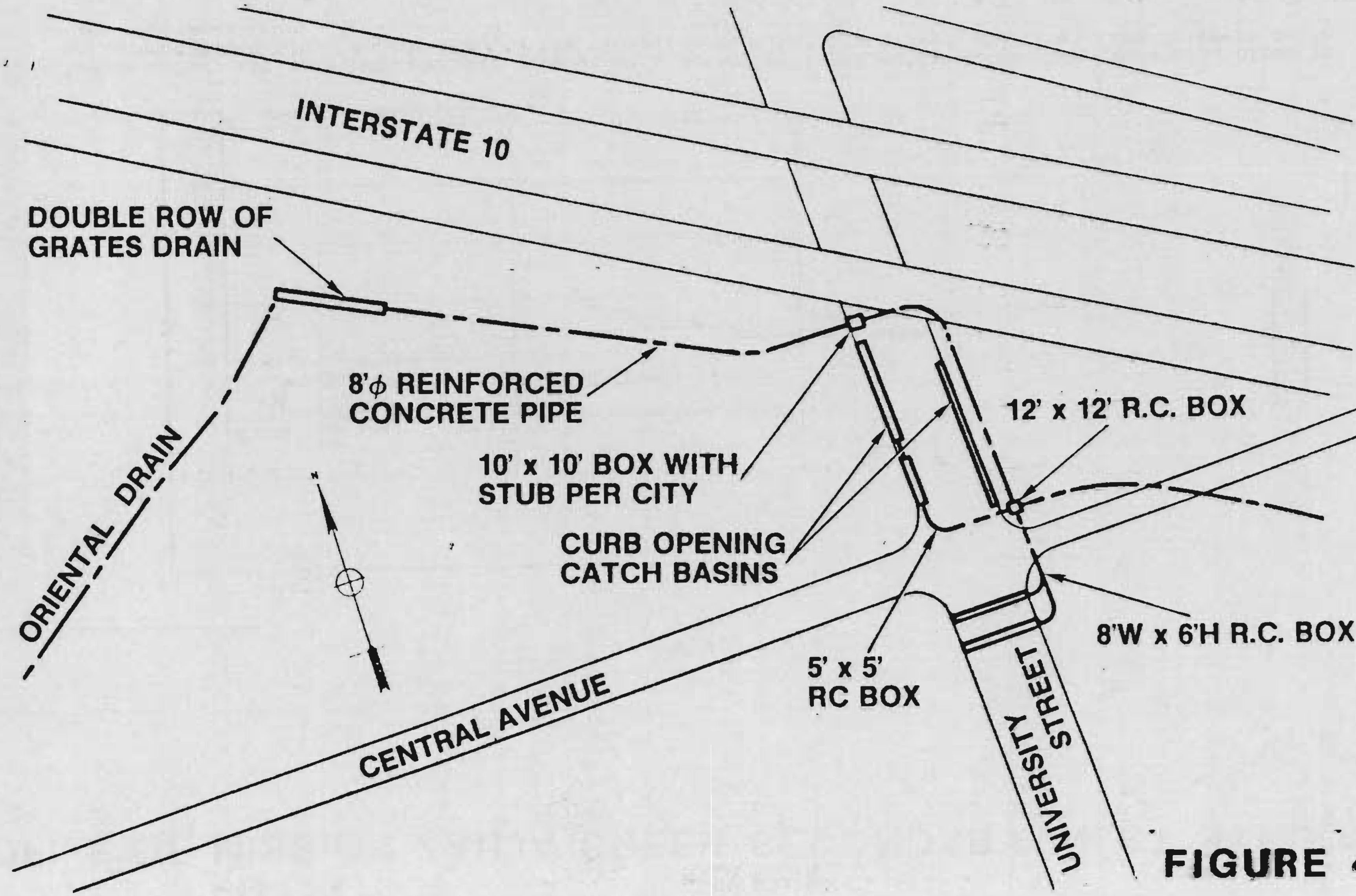
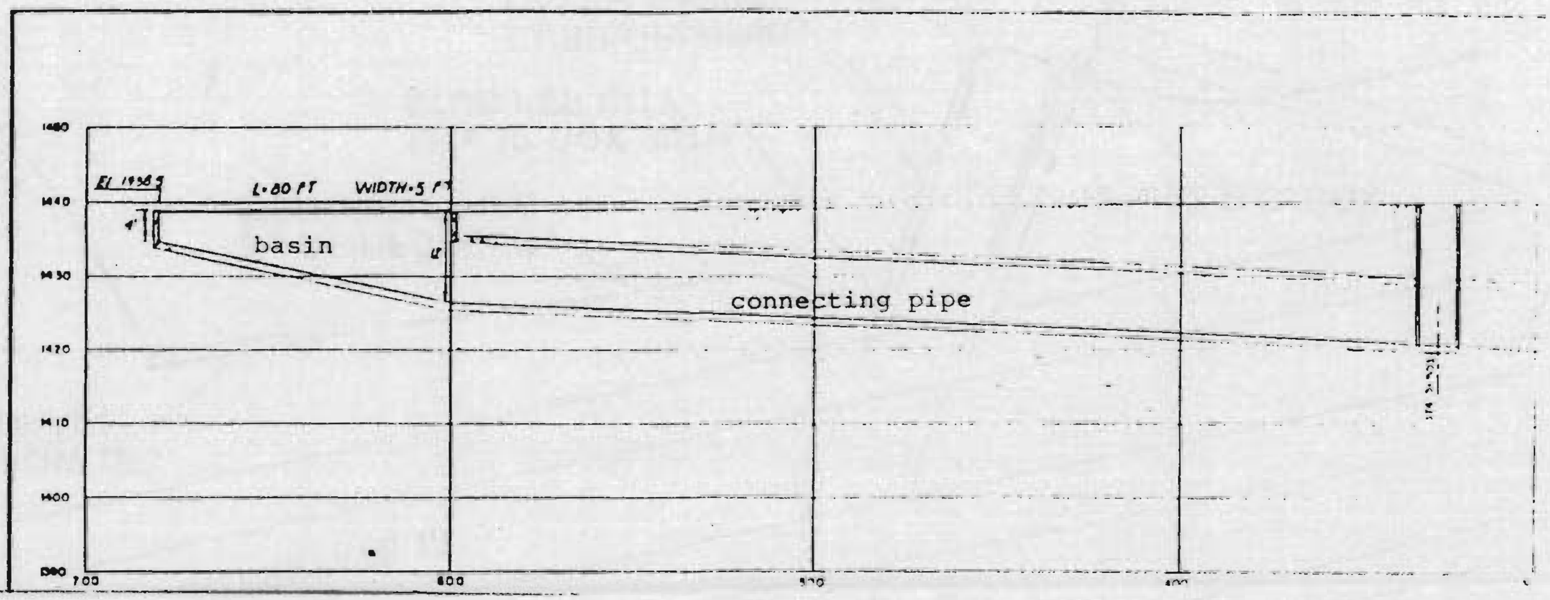



FIGURE 4A

# PROFILE OF MISSION ZANJA CREEK SECONDARY INLET STRUCTURE

(typical)




NOTE: The secondary outlet structure will consist of a series of small catch basins and connecting pipes to collect overland flow, street flow in the vicinity of University Street and flows from Oriental Drain (see Figure 4A).

**FIGURE 4B**

# MISSION ZANJA CREEK OUTLET (dissipator) STRUCTURE

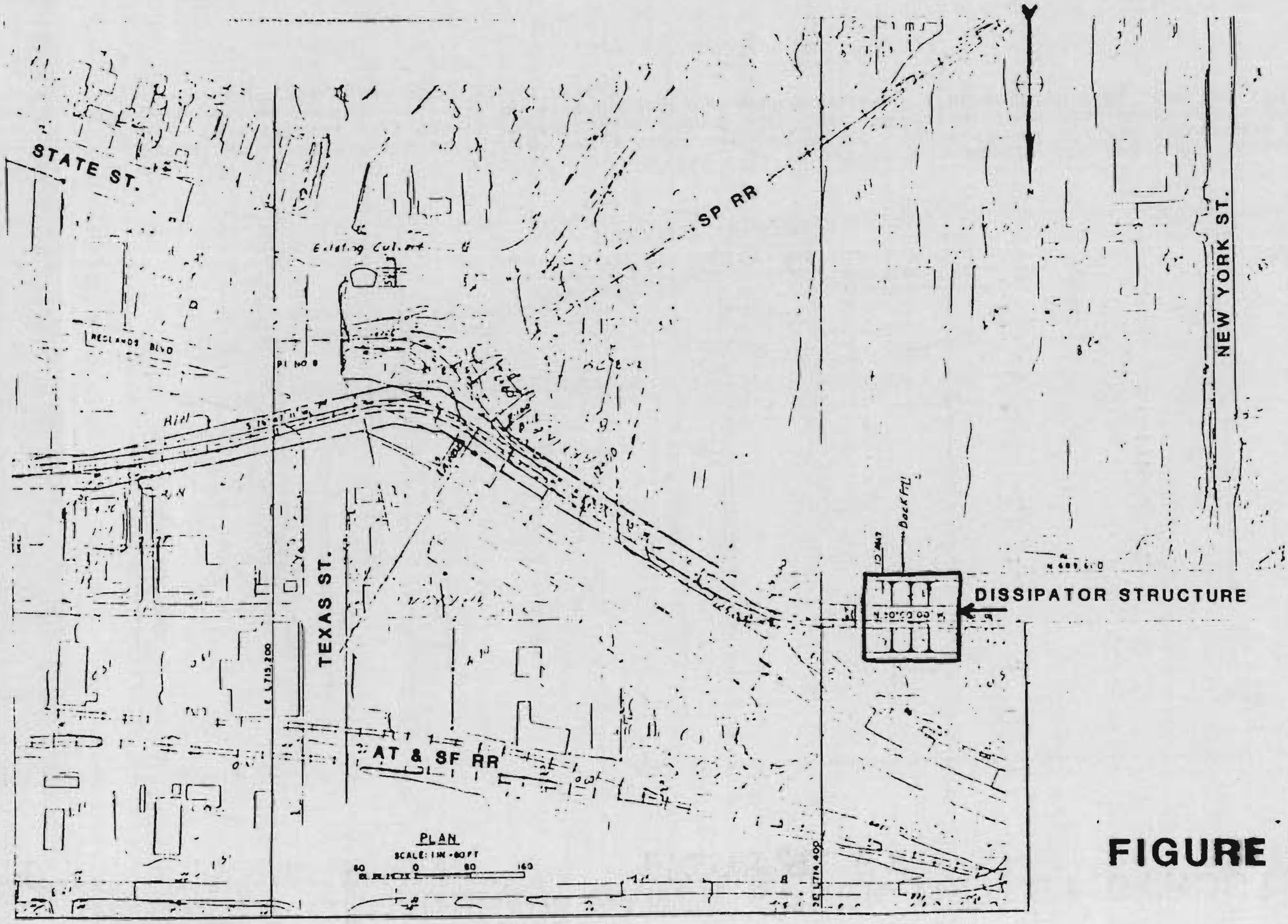
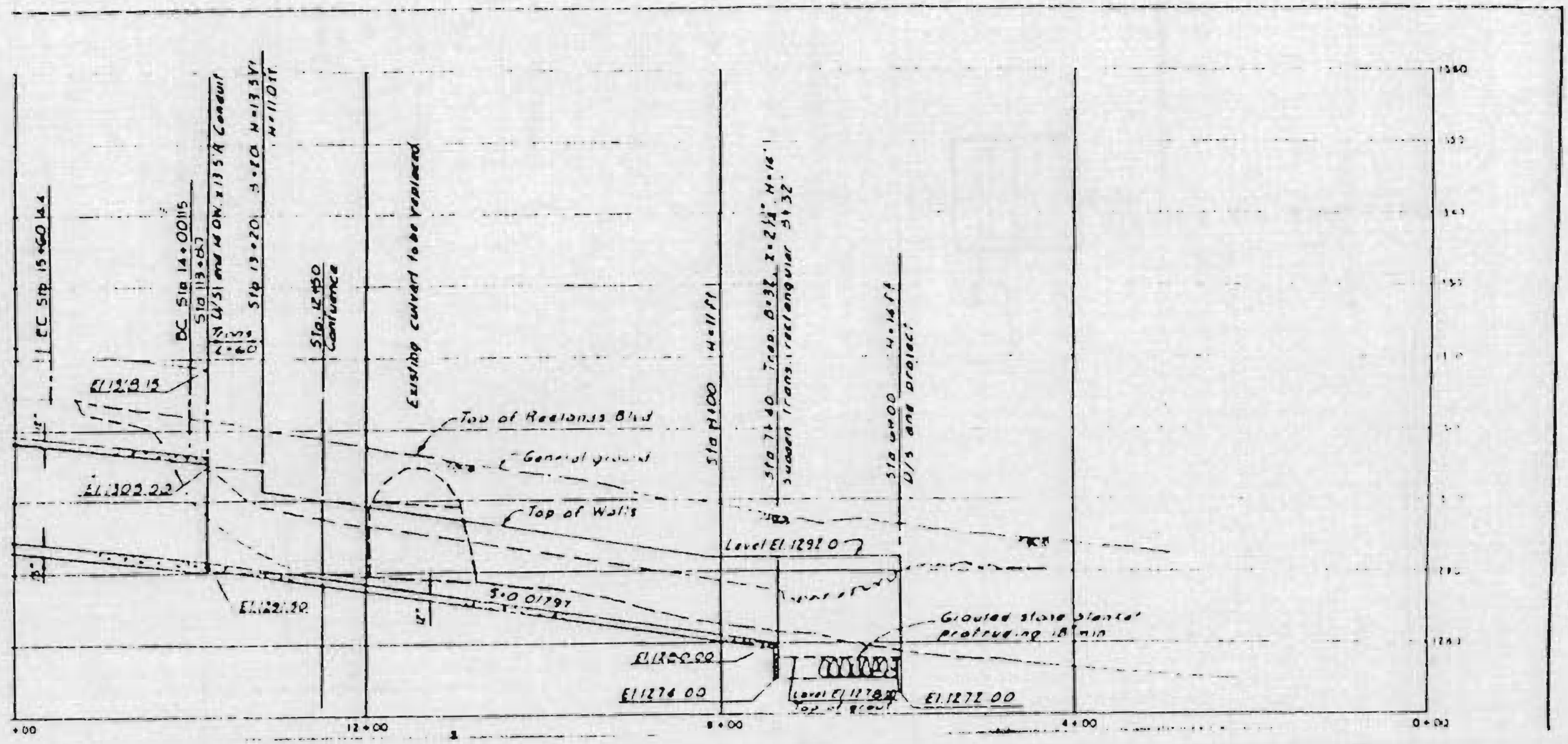



FIGURE 5A

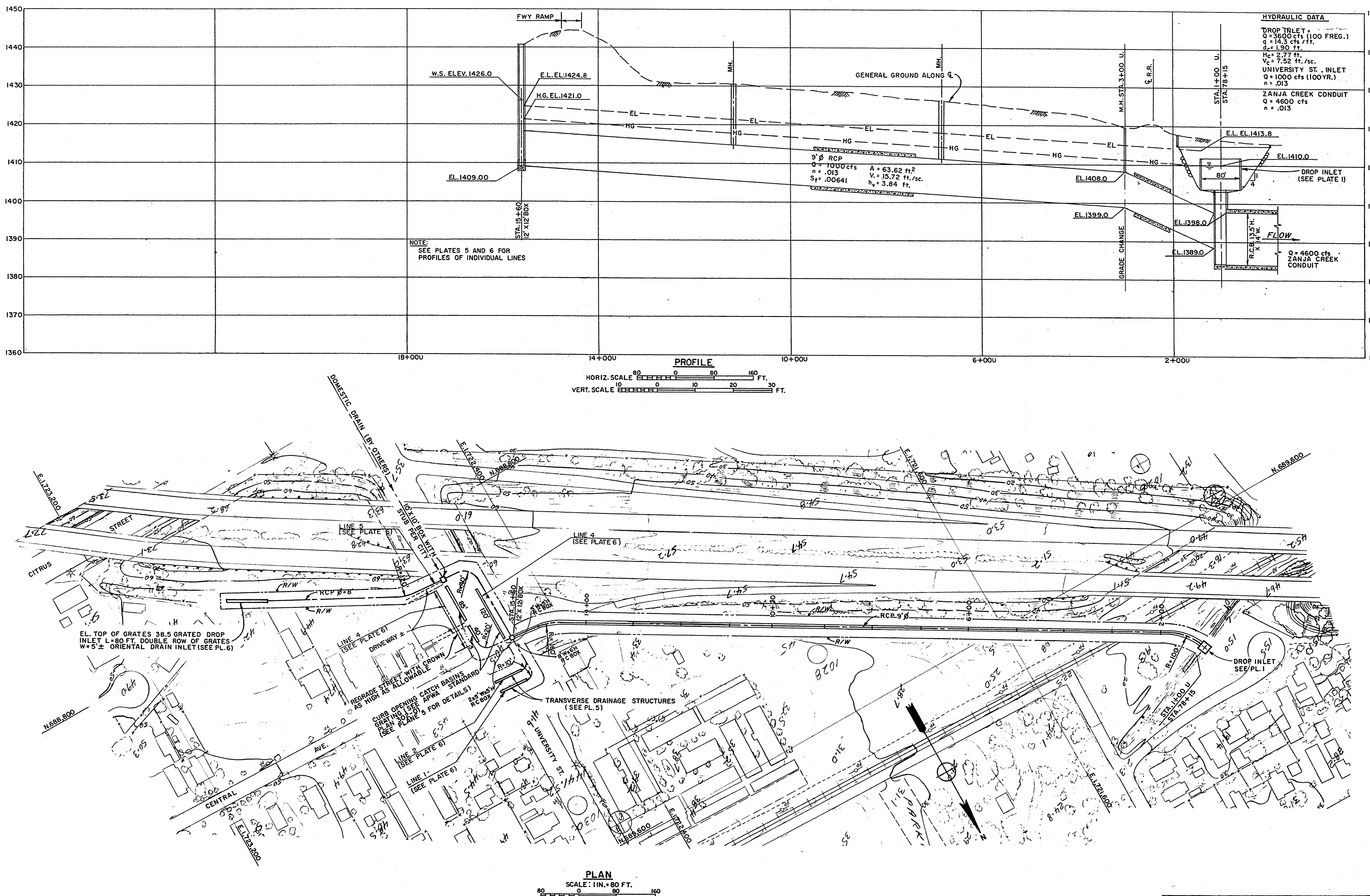
# PROFILE OF MISSION ZANJA CREEK OUTLET STRUCTURE

(dissipator)




NOTE: The existing open channel downstream of Texas Street will be expanded to accept the required discharge. This new channel would have a concrete lined rectangular section with a base width of 12 feet and a wall height of 10 feet. This channel will convey flows a distance of 1200 feet downstream to a dissipator structure. The dissipator structure (outlet) will be a trapezoidal-shaped section of channel, 140 feet long and 120 feet wide at the top, with a grouted stone rough finish.

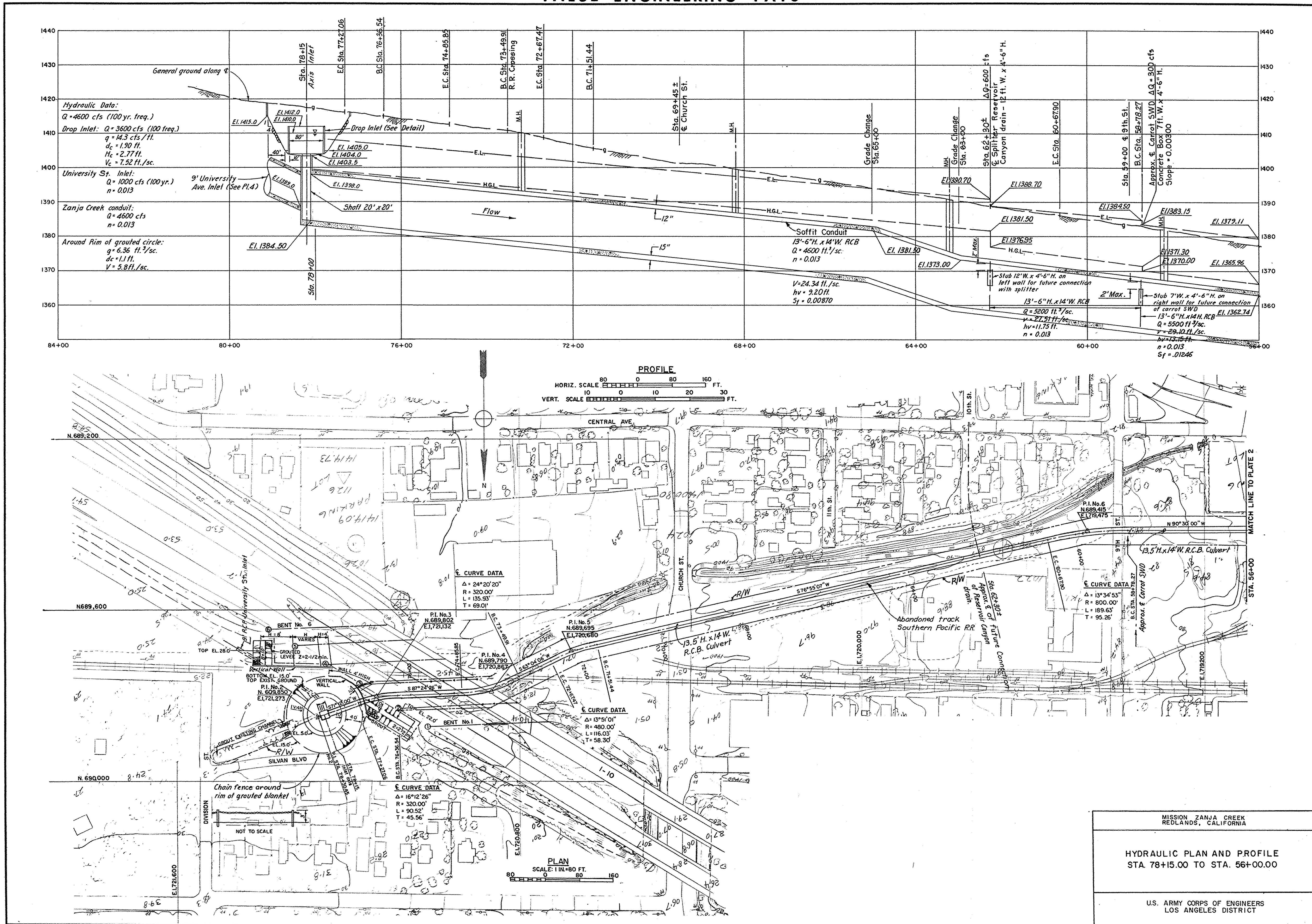
FIGURE 5B




MISSION ZANJA CREEK
REDLANDS, CA

UNIVERSITY STREET
SECONDARY CHANNELS
HYDRAULIC PLAN AND PROFILE
STA. 15+60U TO STA. 1+00U

U.S. ARMY CORPS OF ENGINEERS
LOS ANGELES DISTRICT




MISSION ZANJA CREEK
REDLANDS, CALIFORNIA

HYDRAULIC PLAN AND PROFILE
STA. 78+15.00 TO STA. 56+00.00

U.S. ARMY CORPS OF ENGINEERS
LOS ANGELES DISTRICT



PLATE

US Army Corps
of Engineers
Los Angeles District

General Investigations

FEDERAL PROJECTS

# Reconnaissance Study

## Flood Control and Related Purposes

## MISSION ZANJA CREEK
## San Bernardino County, California

February 1994

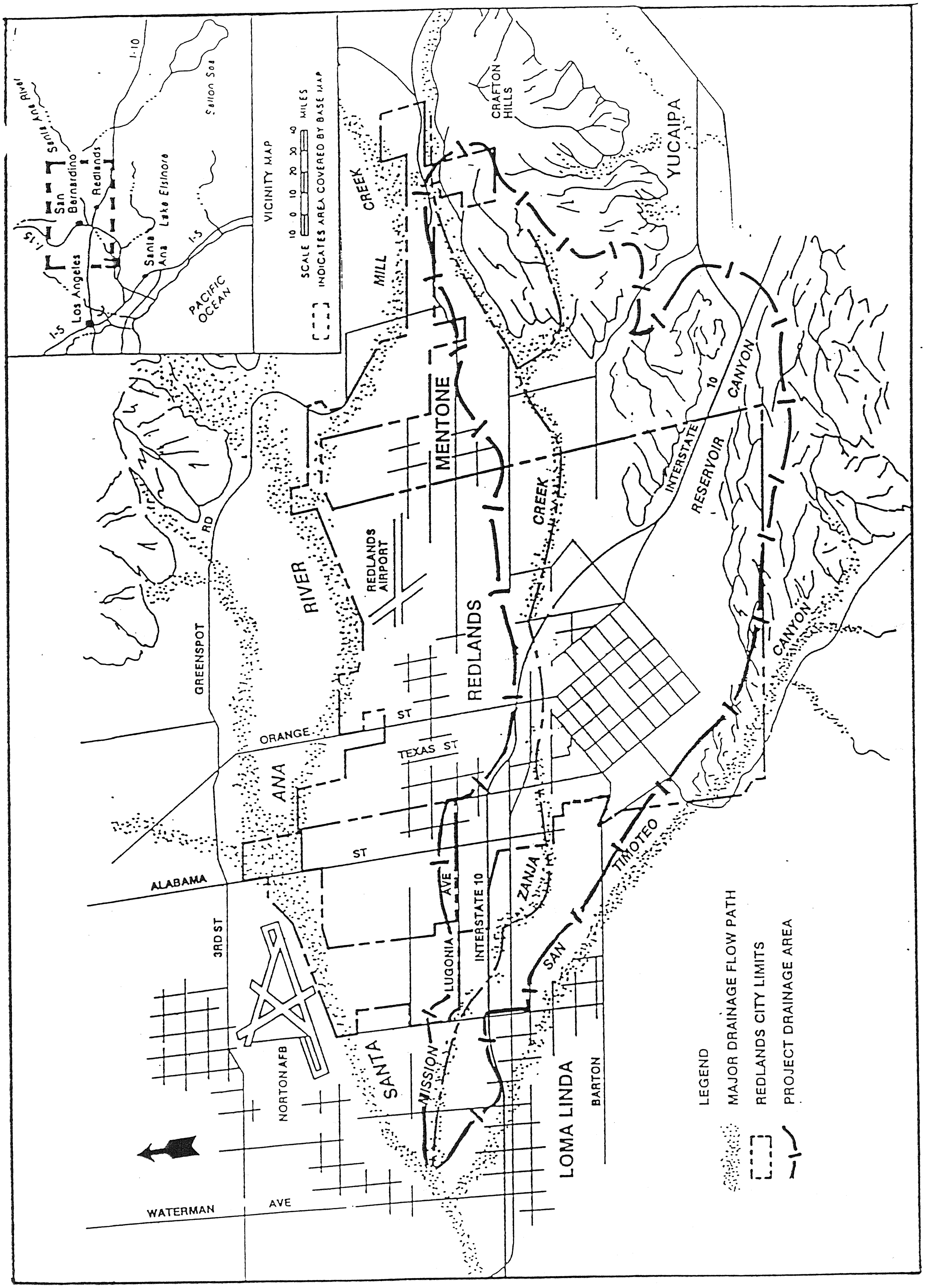



Figure 2. Study Area

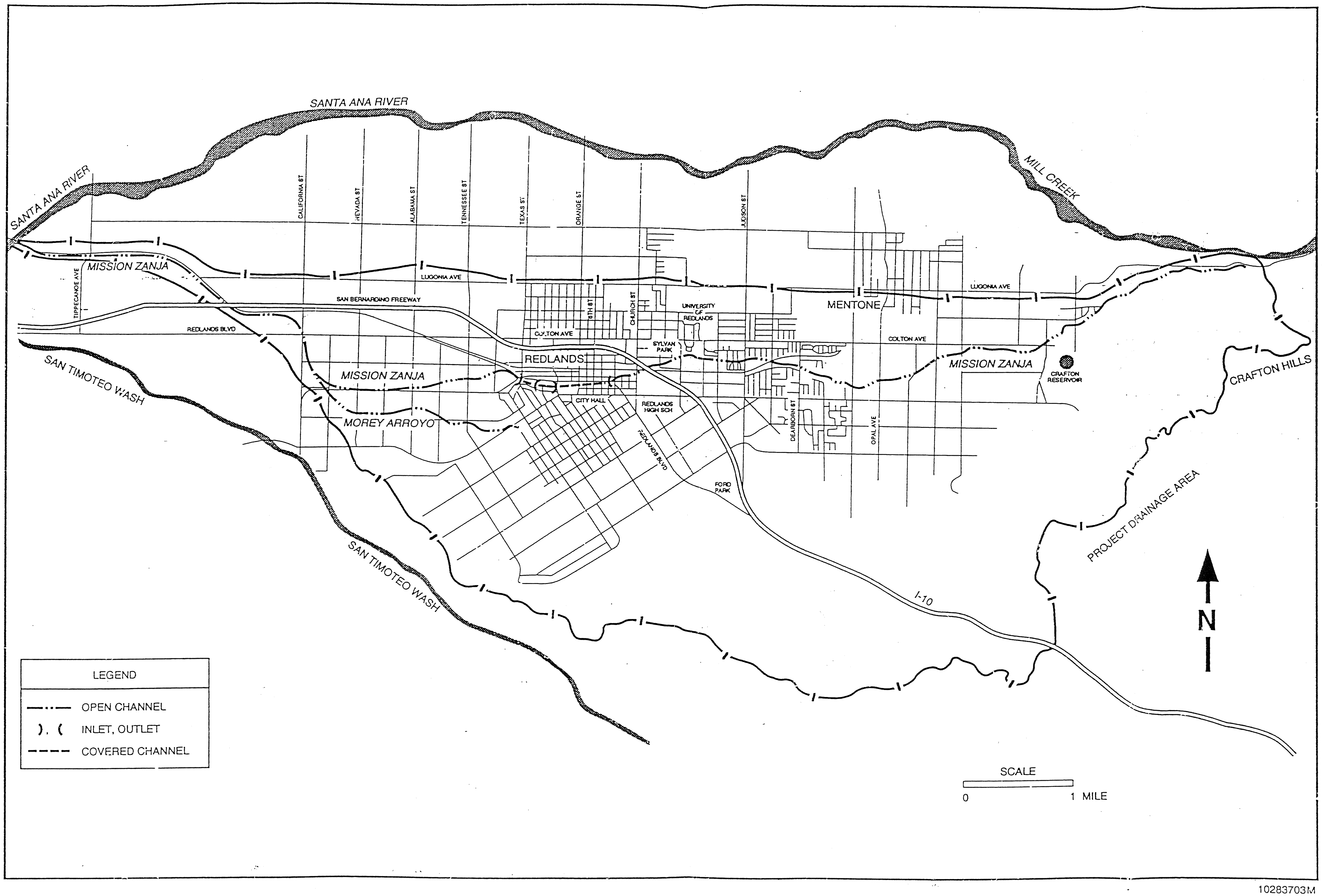



Figure 3. Mission Zanja Creek Drainage

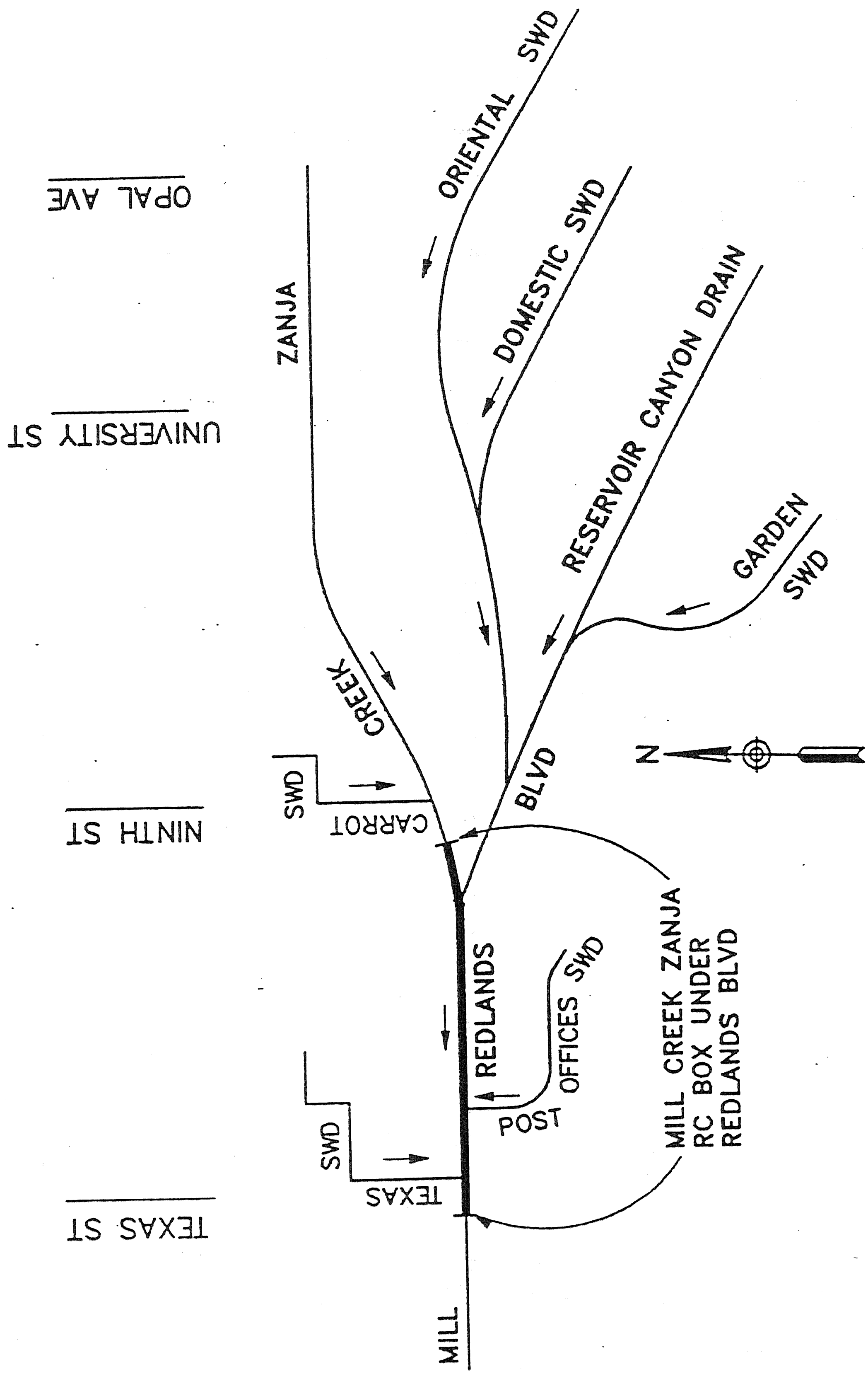
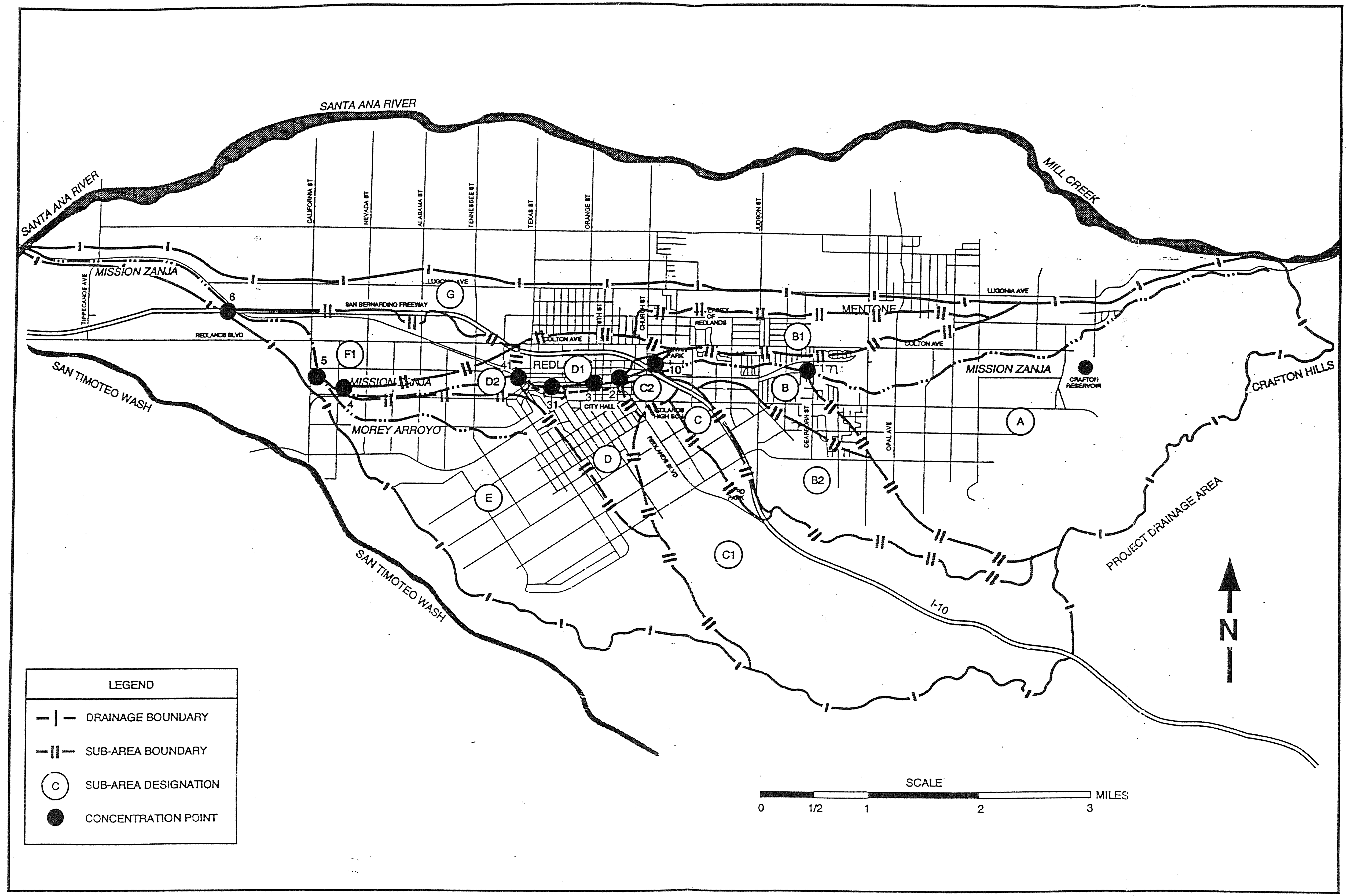



Figure 4. Mission Zanja Creek Stormwater Drains




10283705M

Figure 11. Drainage Boundaries and Concentration Points

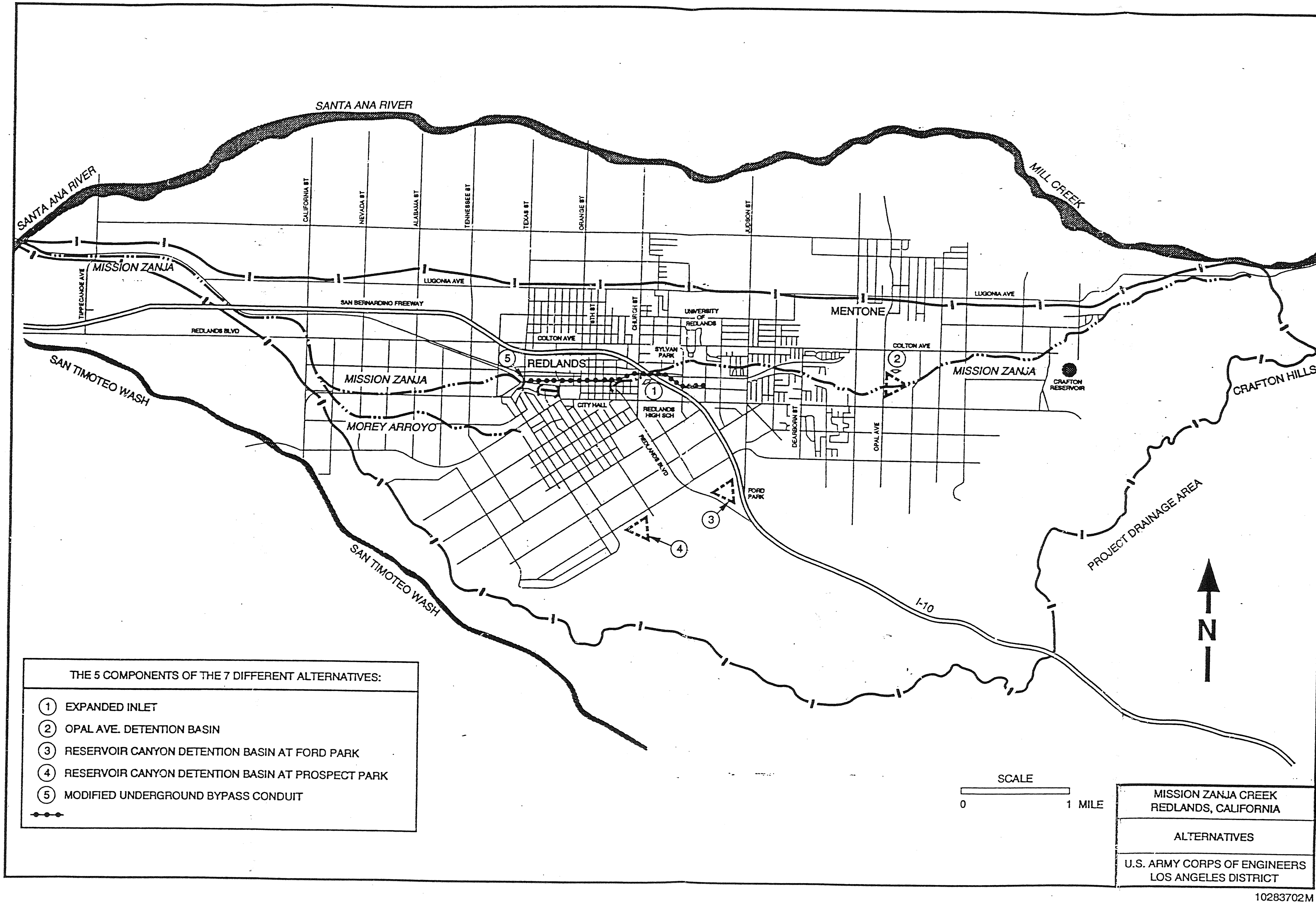



Figure 13. Flood Control Measures Considered

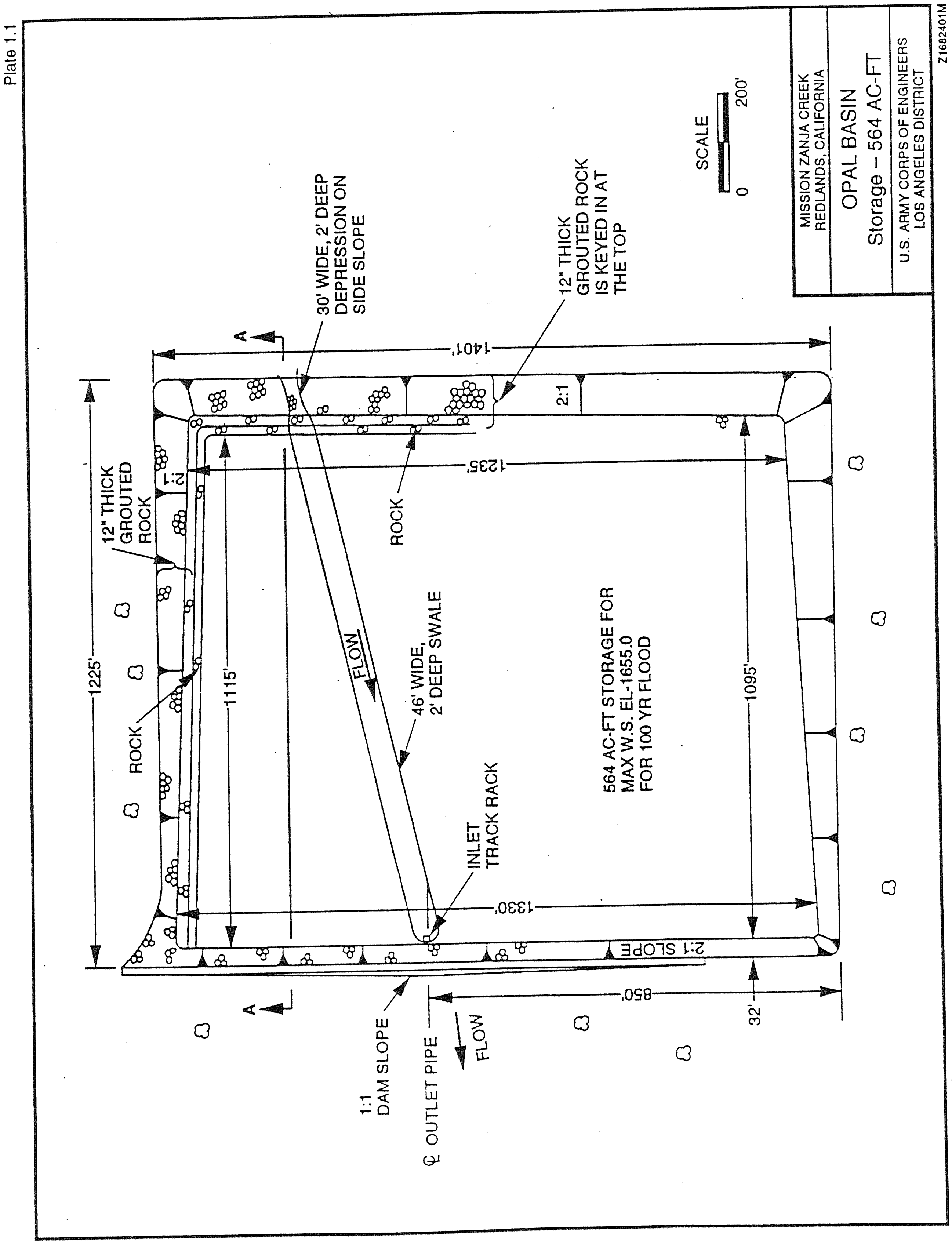



Figure 14. Mission Zanja Creek Detention Basin at Opal Ave.

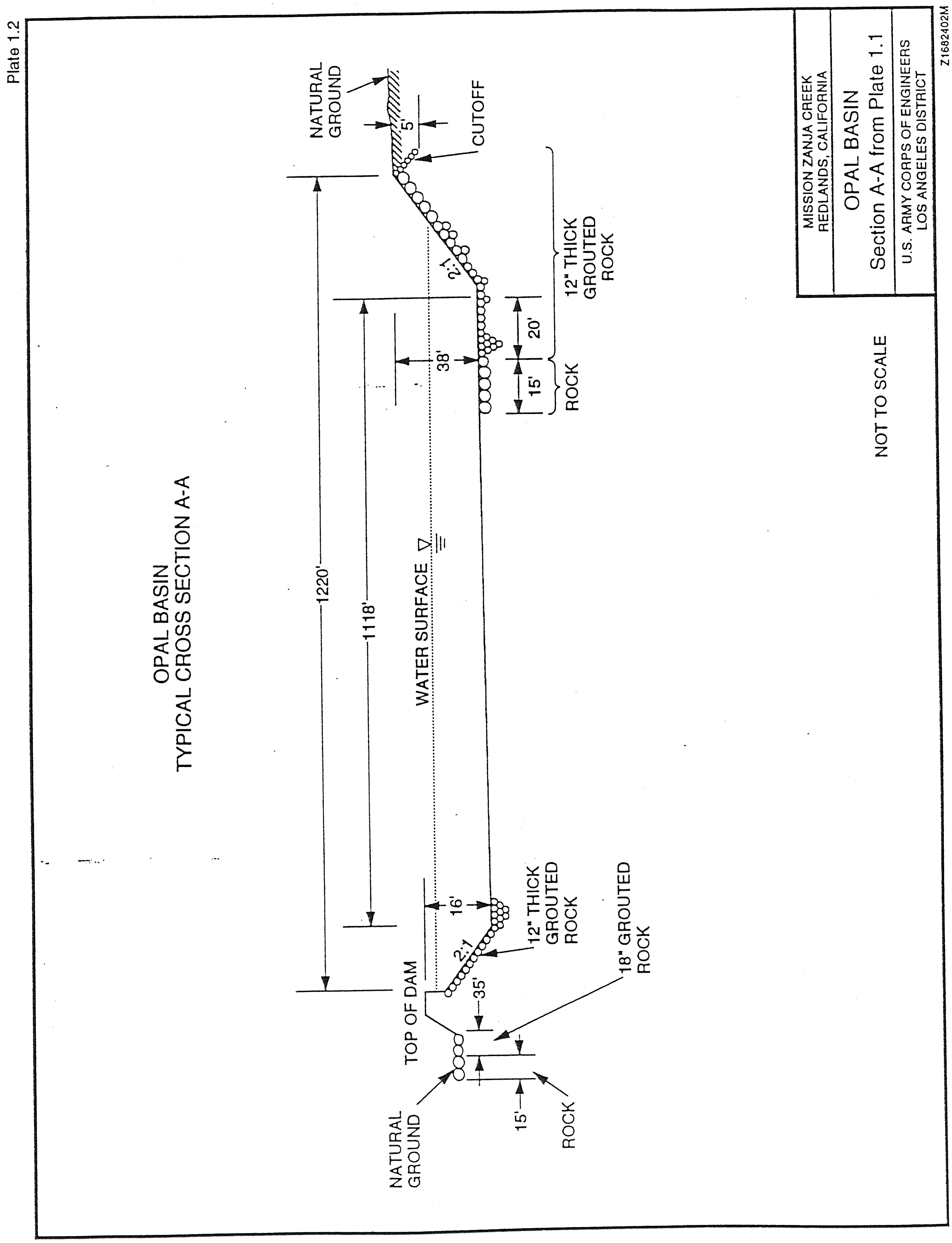



Figure 15. Mission Zanja Creek Detention Basin at Opal Ave.

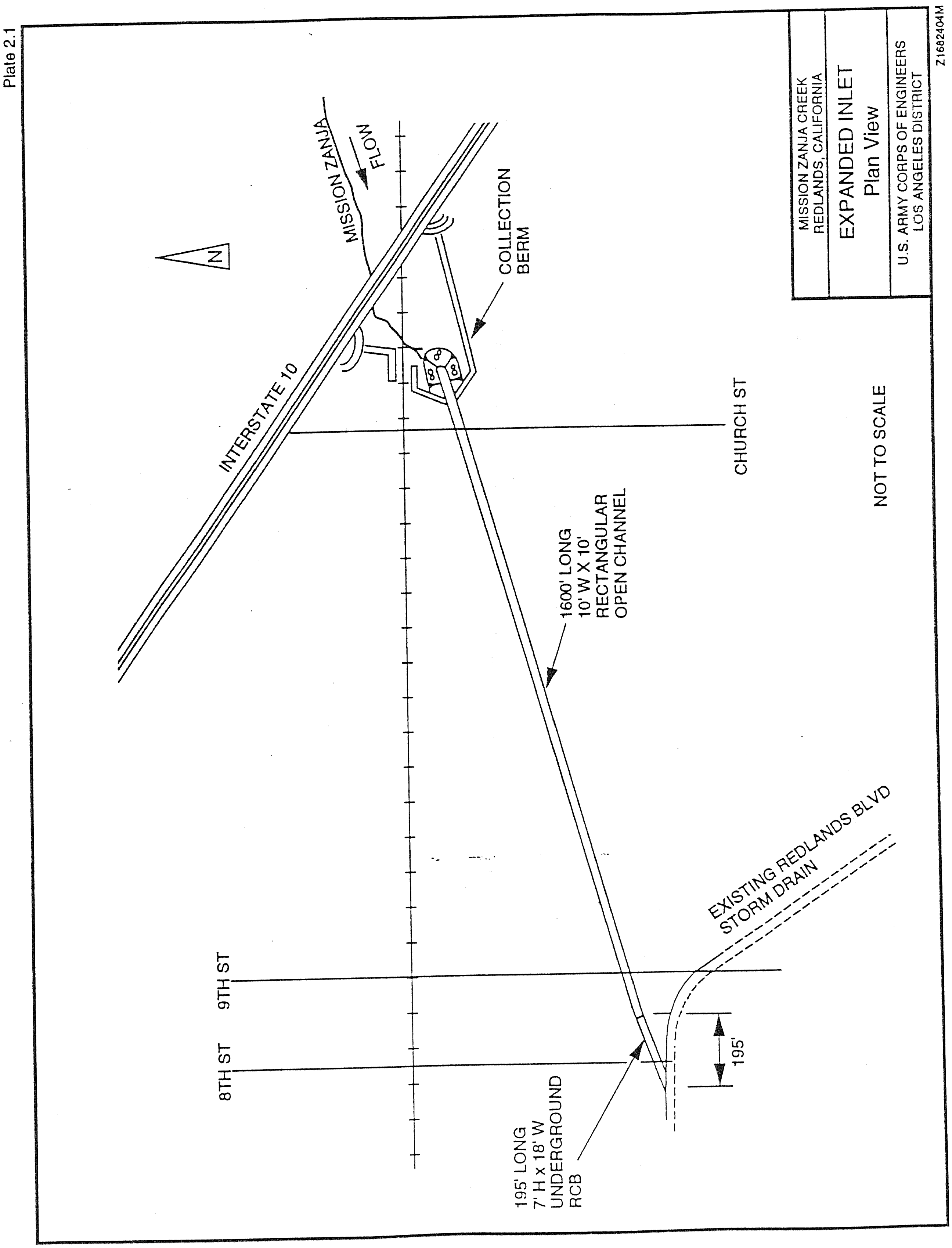



Figure 16. Mission Zanja Creek Inlet Expansion

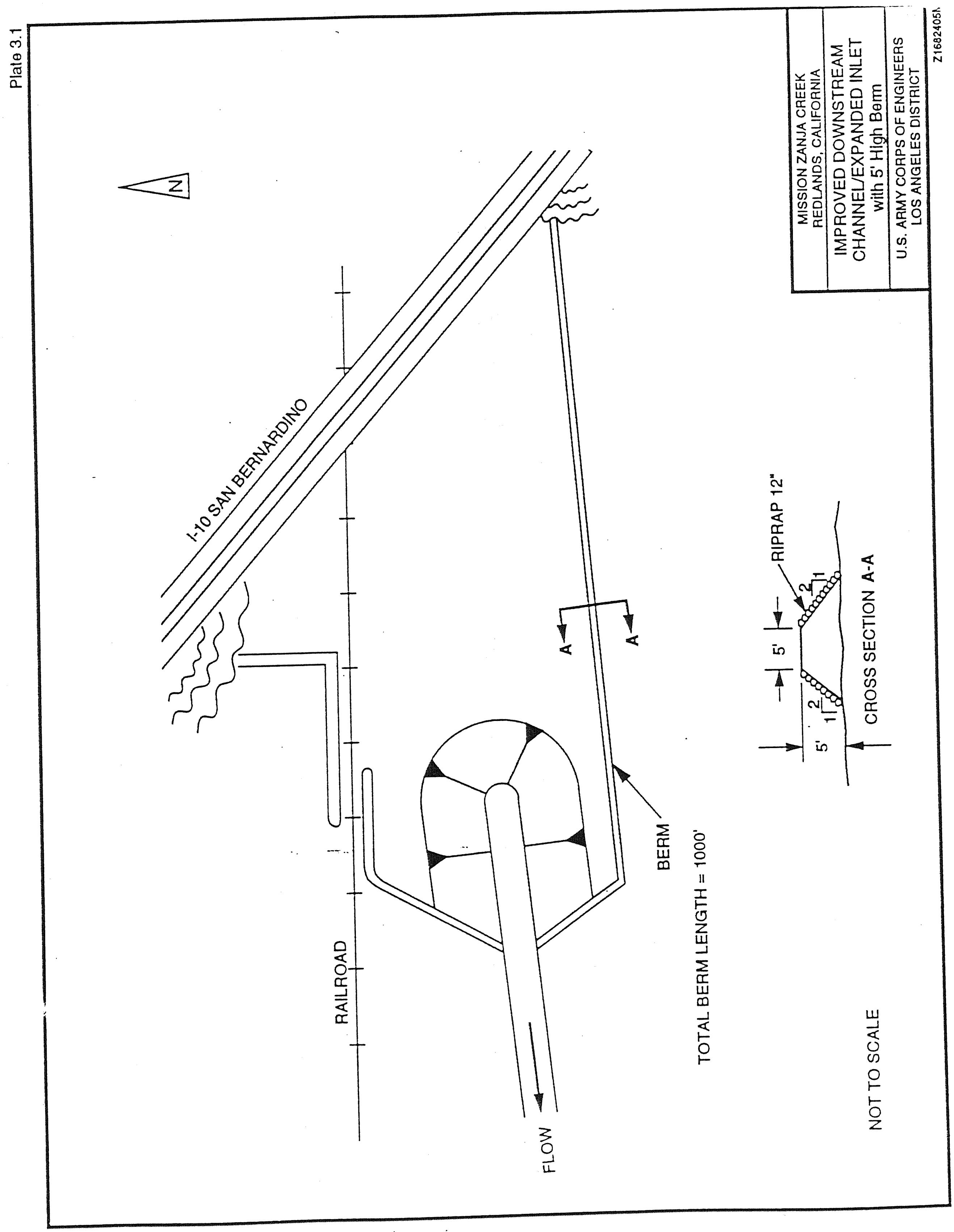



Figure 17. Mission Zanja Creek Inlet Expansion

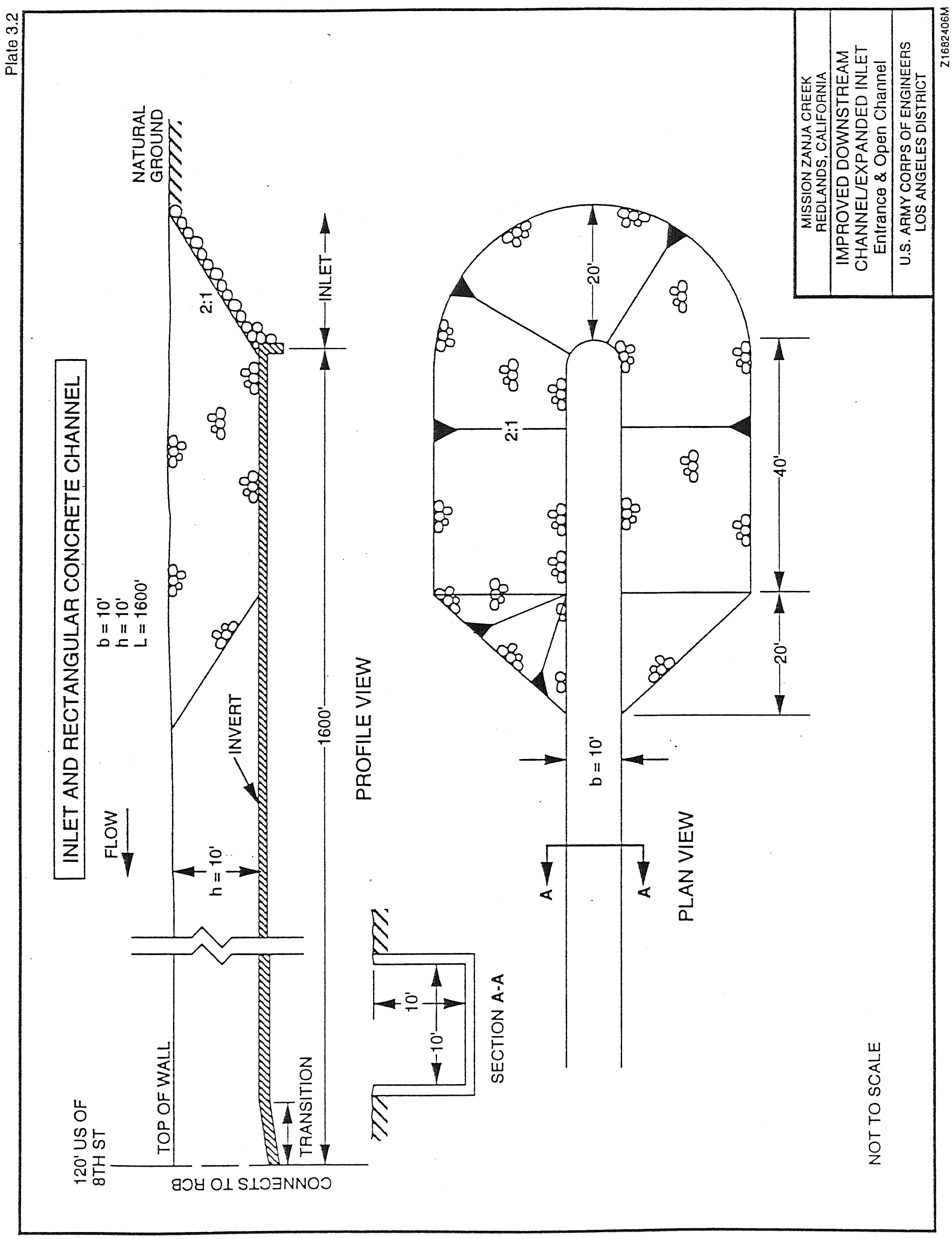
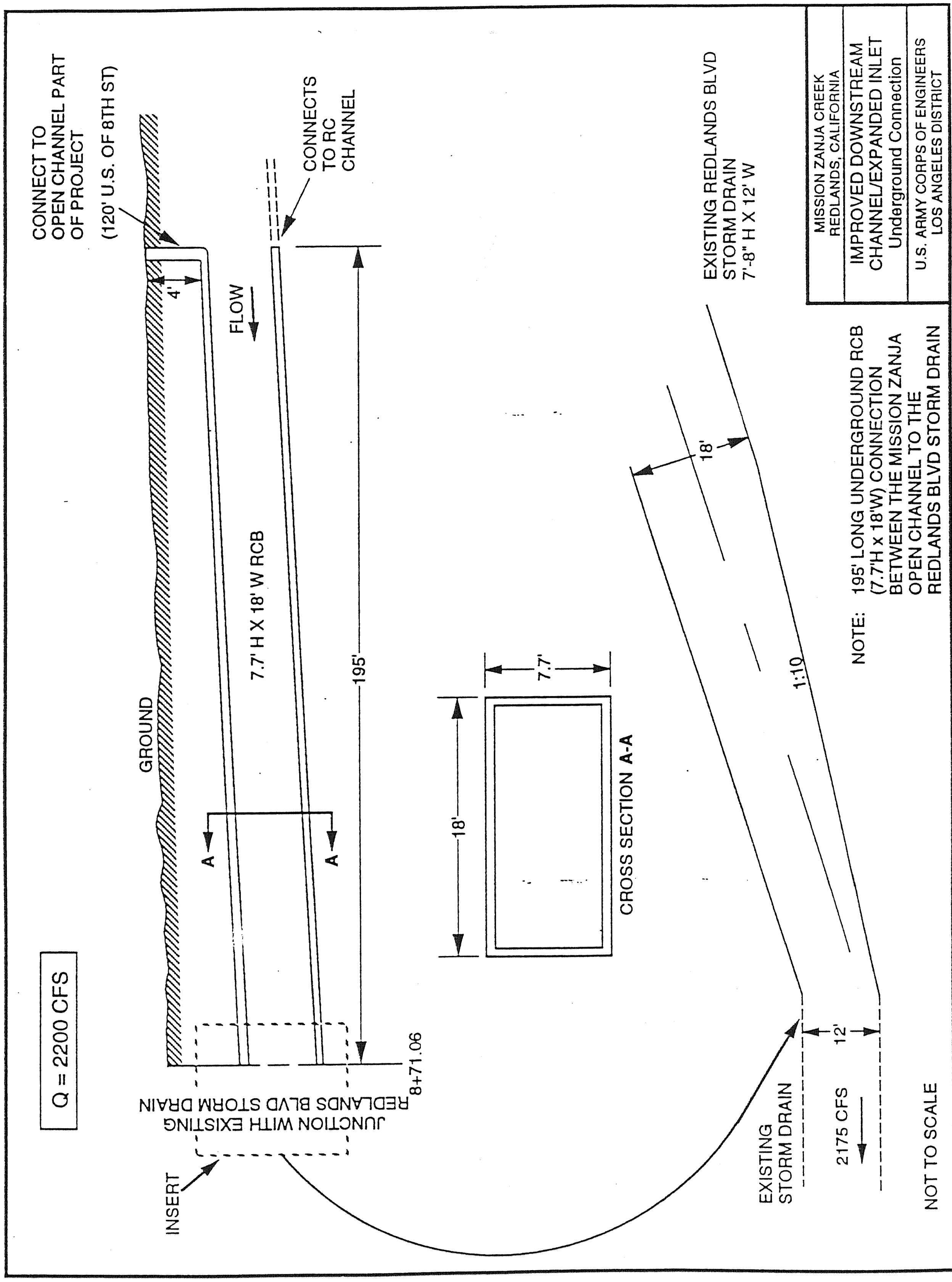



Figure 18. Mission Zanja Creek Inlet Expansion

Plate 3.3




Z1682407M

Figure 19. Mission Zanja Creek Inlet Expansion

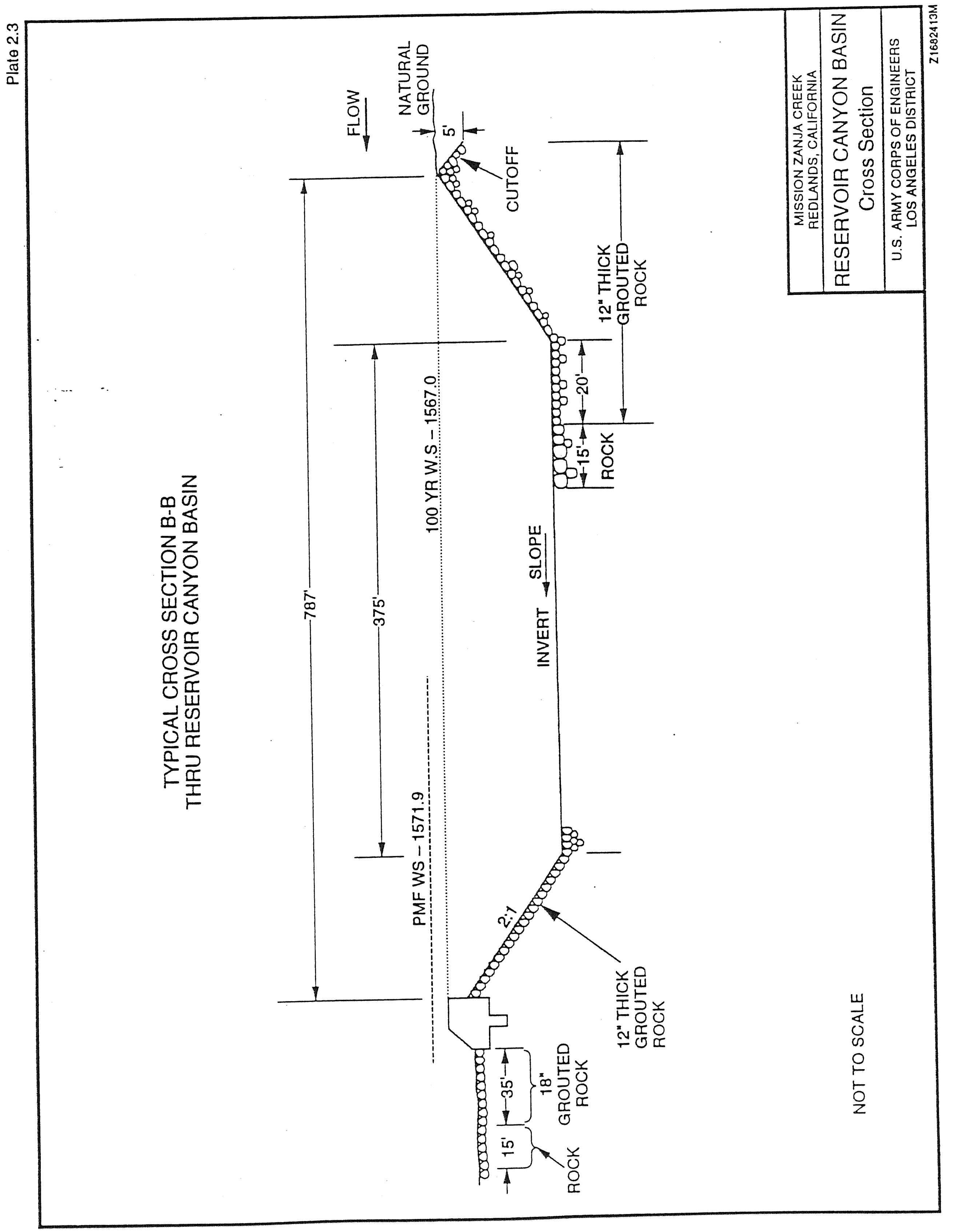



Figure 20. Reservoir Canyon Detention Basin Plan

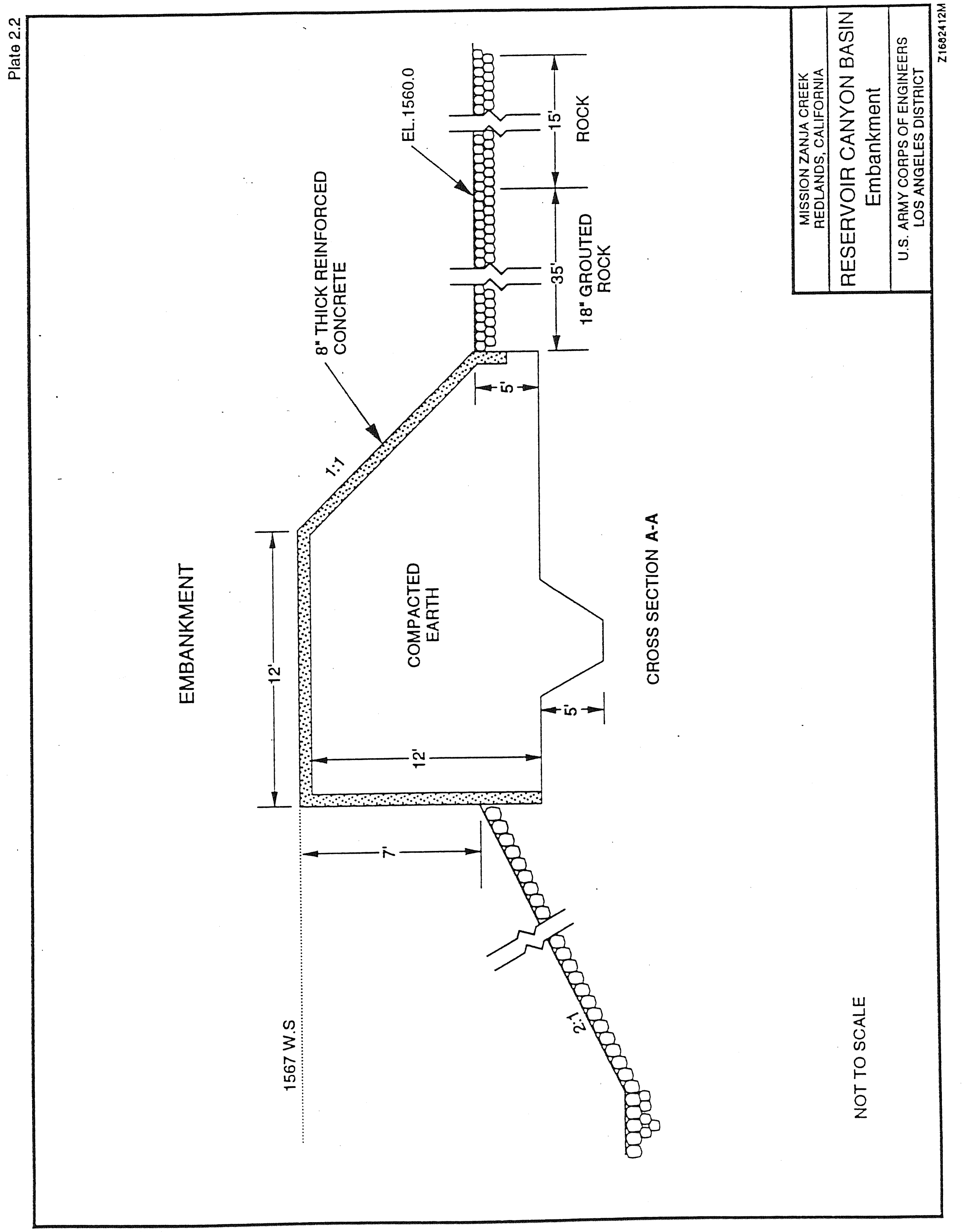



Figure 21. Reservoir Canyon Detention Basin Plan

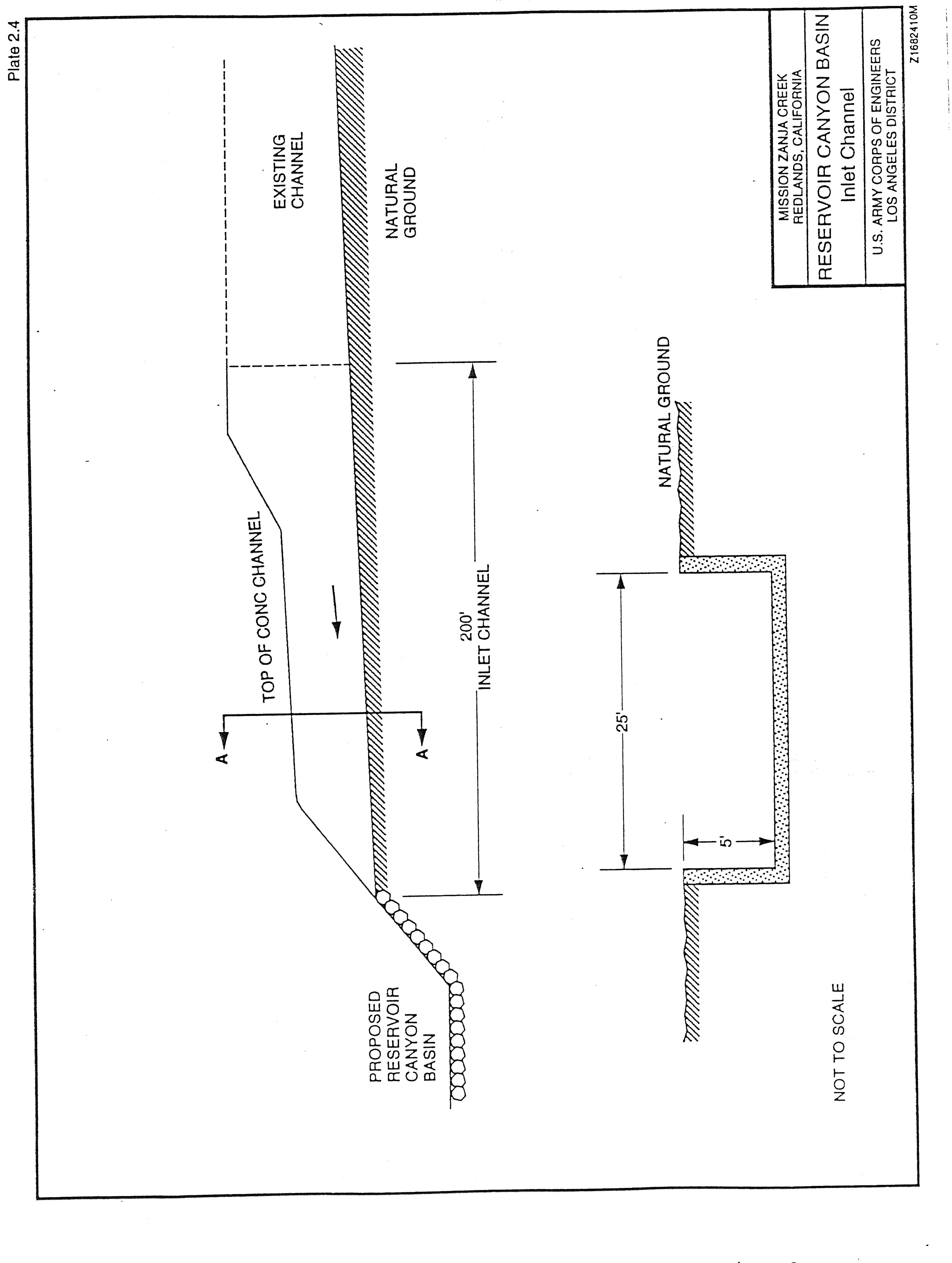



Figure 22. Reservoir Canyon Detention Basin Plan

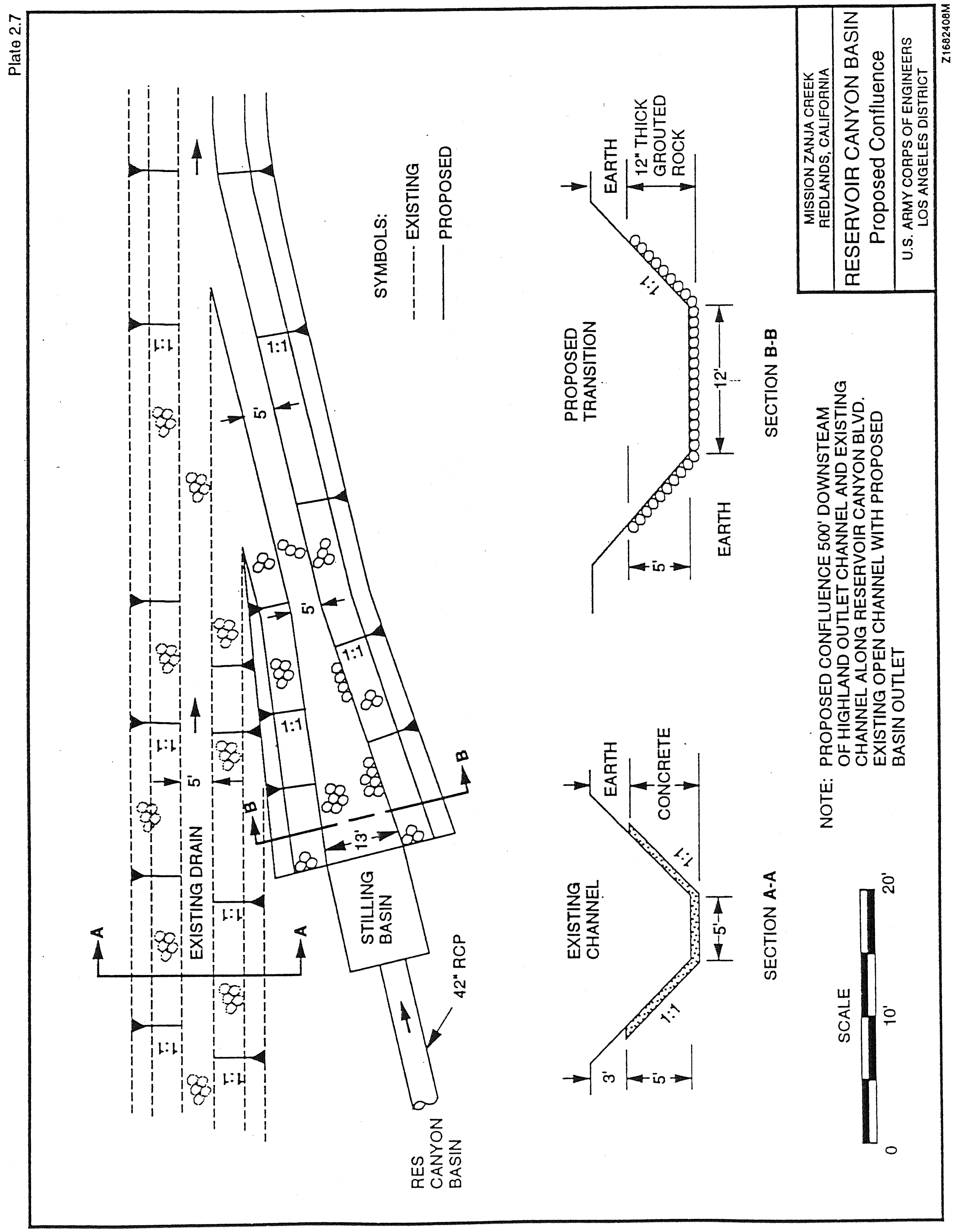



Figure 23. Reservoir Canyon Detention Basin Plan

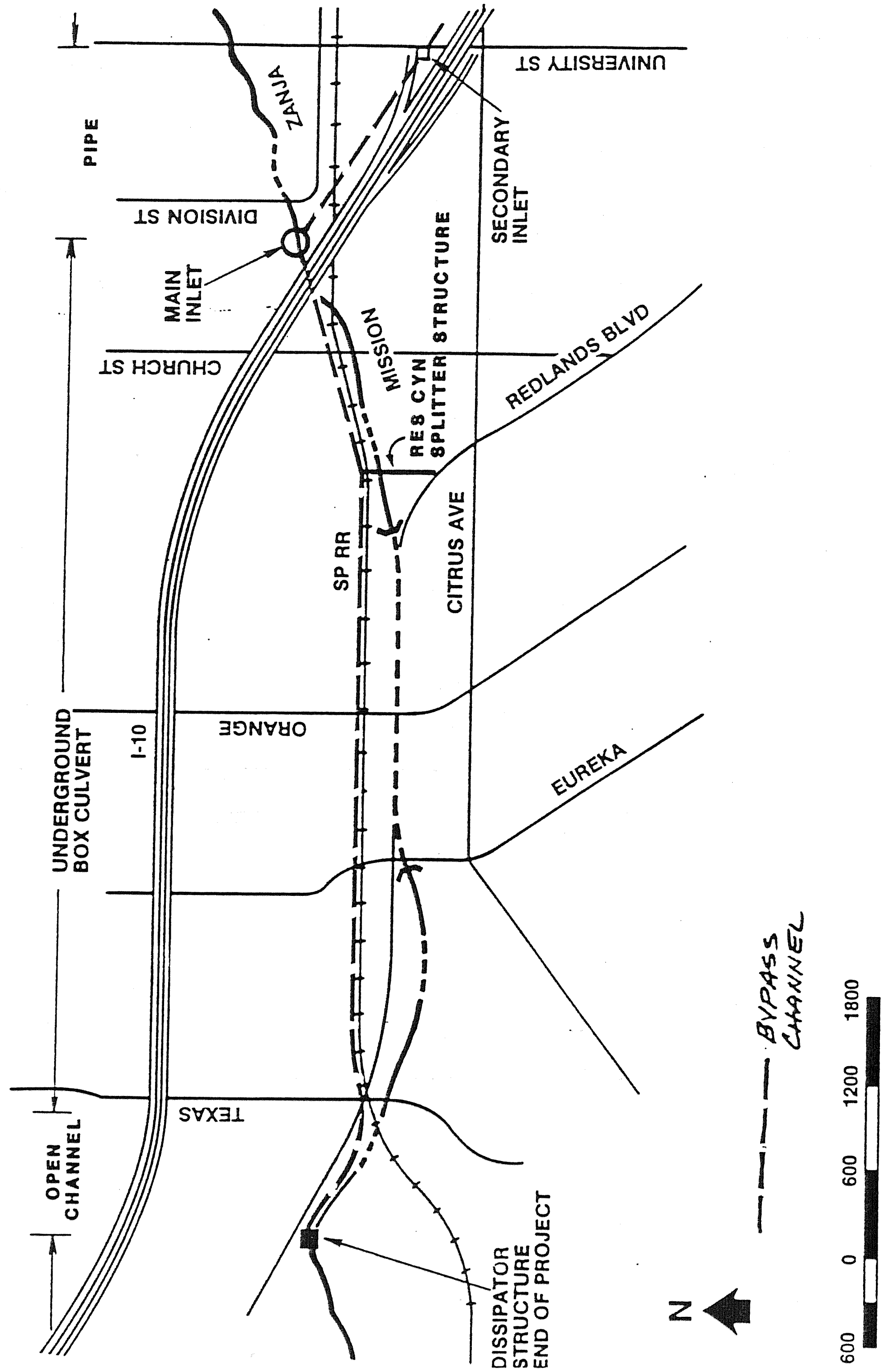



Figure 24. Redlands Bypass Channel Plan

# SANBAG Redlands Passenger Rail Project

Job Name: Hydraulic Impact Analysis – Warm Creek
Job Number: 170063
Client: SANBAG
Consultant: HDR Engineering, Inc.

This report and the analysis and design calculations contained herein have been prepared under the supervision of the following Registered Civil Engineer:

__________________________________ February 2014
Mark Seits, P.E. Date
CA 41103

# Table of Contents



# List of Attachments



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# List of Figures



# List of Exhibits

## 1. Purpose

The rail from historic Warm Creek (that portion of Warm Creek that was not combined with East Twin Creek and Warm Creek Improvements) to Mill Creek Zanja is proposed to be improved as part of the Redlands Passenger Rail Project (RPRP) (see Exhibit 1). This report covers the hydraulic impact analysis for AT&SF Bridge 1.1 (Bridge 1.1) which crosses over Warm Creek. The improvements are proposed to reconstruct the bridge from its existing freight-only operation to current standards required for regular passenger rail operations. As part of this project, recommendations, including hydraulic analysis, are provided to assist in this process. The purpose of the hydraulic modeling is to evaluate the hydraulic impact of the proposed improvements to Bridge 1.1.

## 2. Background

The RPRP will design a double track alignment for passenger and freight service from the proposed San Bernardino Transit Center east to the University of Redlands. The Redlands Corridor Strategic Plan (RCSP) was developed by San Bernardino Associated Governments (SANBAG) to address the transportation needs of the Redlands Corridor, assess the capability of transit service and multimodal improvements to meet mobility needs, and describe a course of action to implement transit service in the Redlands Corridor in a cost-effective manner. The first phase of the RCSP calls for the development of a passenger rail service operating between the San Bernardino Transit Center and the University of Redlands, an approximate distance of nine miles.

Bridge 1.1 is a railroad crossing over historic Warm Creek (called simply Warm Creek in the remainder of this report). Exhibit 2 shows the drainage area. Bridge 1.1 is in Federal Emergency Management Agency (FEMA) Zone X (unshaded), which is an area of minimal flood hazard, usually depicted on Flood Insurance Rate Map (FIRM) as above the 500-year flood level (FEMA 2008) as shown on Exhibit 4, FEMA FIRM Panel 06071C8681H. No FEMA hydraulic model or data is available to examine flooding conditions. Therefore, the analysis approach was to calculate the hydrology based on local drainage and perform the hydraulic analysis based on the calculated hydrologic data. A hydraulic model was developed of the project area based on the additional information obtained to model existing and proposed conditions through the bridge and to evaluate the relative changes in water surface for a 100-year flood. The proposed bridge will be designed per structure, constructability, and geotechnical and hydraulic issues.

Bridge 1.1 is located 400 feet south of West Rialto Avenue in the City of San Bernardino, California (Exhibit 2). Warm Creek at this location consists of a rectangular concrete channel constructed in the late 1960s. As discussed in the 1964 USACE Lytle and Warm Creeks report, Warm Creek flows formerly entered the Santa Ana River just downstream from the San Bernardino Freeway bridge. However, construction of the East Twin and Warm Creek improvements by the U.S. Army Corps of Engineers (USACE) in 1960 delivered most of the Warm Creek flows (the flow interception occurs upstream of Bridge 1.1 location) to the Santa Ana River at a point 1.4 miles upstream. Flows in the historic Warm Creek channel upstream from the East Branch of Lytle Creek were then limited to the local drainage from an 18-square-mile area in the City of San Bernardino (USACE 1964). Bridge 1.1 is located within this 18-square mile drainage area. However, because of surface drainage improvements that have occurred since the 1960's, the contributing drainage area has been further reduced at Bridge 1.1.

Figure 1 shows Warm Creek, looking downstream from Bridge 1.1. Figure 2 shows Warm Creek looking upstream from Bridge 1.1. Figure 3 shows the Bridge 1.1 deck.

**Figure 1: Existing AT&SF Bridge 1.1- Looking Downstream**

**Figure 2: Existing AT&SF Bridge 1.1- Looking Upstream**

**Figure 3: Existing AT&SF Bridge 1.1**

The standard freeboard criteria selected for the bridge (in the following priority) are shown below. For this project, the 50-year flow rate is not available and only the 100-year flow rate was evaluated.

1. 100-year water surface elevation below low chord;
2. 100-year energy grade line (EGL) elevation below top of subgrade and 50-year water surface[hydraulic grade line (HGL)] elevation below low chord;
3. 50-year water surface (HGL) elevation below low chord; and
4. No increase of water surface elevations within project area.

Bridge 1.1 is not in a designated FEMA 100-year floodplain; therefore, the changes to flood levels due to modifications to the bridge are not required to be submitted to FEMA. This report presents analysis results for the drainage; however, it does contain some assumptions and approximations. Prior to 100% design, the assumptions and approximations made within this report should be verified. Primarily, these include the proposed bridge geometry.

## 3. Hydrology

The contributing watershed to Bridge 1.1 was historically larger than currently exists today. Due to the construction of East Twin Creek, the contributing drainage area of Warm Creek at Bridge 1.1 was reduced. The contributing drainage area to Bridge 1.1 has been further reduced since the 1960's as a result of surface drainage improvements in the area.

The hydrology study was prepared in accordance with the San Bernardino County Flood Control criteria and the San Bernardino County Hydrology Manual (Manual) (1986). The 100-year return period was considered in the analysis. The Unit Hydrograph Method was applicable as the drainage area is greater than 640 acres. Based on 4-foot contour mapping, aerial photographs, and San Bernardino County Redbook and Comprehensive Storm Drain Project (CSDP) 7, the tributary watershed of Warm Creek at Bridge 1.1 was delineated. Exhibit 2 shows the drainage area boundary. The isohyetal maps in the Manual are based on NOAA Atlas 2 and were used in preparation of precipitation data used in Unit Hydrograph analyses. The available isohyetal maps cover 1-hour, 6-hour, and 24-hour durations for 100-year rainfall. The 5-minute, 30-minute, and 3-hour rainfall data were calculated by the program based on the hydrology manual procedures. For the 100-year storm analysis, Antecedent Moisture Condition (AMC) III was used. Soil Group B was defined per the hydrologic soil group map in the Manual. The land use for the study is based on the San Bernardino County GIS data. Engineering software CivilDesign was used to facilitate the hydrology modeling (Bonadiman 2004). CivilDesign calculations are shown in Attachment 1.

The calculated drainage area at Bridge 1.1 is 1,222 acres (1.9 square miles) with a computed 100-year peak flow rate of 2,525 cubic feet per second (cfs). The delineated drainage area is less extensive for Warm Creek compared to what was shown in the USACE 1964 report. The conclusion from the hydrology review is that storm drains and other surface drainage improvements have limited the contributing area to 1.9 square miles at Bridge 1.1. The 1967 Warm Creek channel design plans

(Sheet 1, Drawing No. 3669) show the design storm frequency was 20 years with peak flow rate of 2,900 cfs. The drainage area described on the plan is consistent with the 1964 USACE delineation which, as stated, is larger than the drainage area determined for this report .

# 4. Hydraulic Modeling

## 4.1 Modeling Overview

Modeling of the AT&SF railroad bridge was conducted using USACE Hydrologic Engineering Center River Analysis System (HEC-RAS, v4.1) program (USACE 2010). Channel geometry was generated based on the topographic map by using HEC-GeoRAS program (v.4.1.1), an extension for support of HEC-RAS using ArcGIS. The topographic map was based on the 1-foot contour surveyed for RPRP. All reference topography is based on the North American Vertical Datum of 1988 (NAVD 88) datum(National Geodetic Survey 1991).

## 4.2 Model Inputs

### 4.2.1 Existing Condition

The existing condition model is based on as-built plan and topographic data. A centerline was laid at the center of the creek utilizing HEC-GeoRAS. Cross-sections were cut perpendicular to the centerline. Due to the limit of the topographic data, a total of five cross-sections were cut in the reach. The total reach length is approximately 560 feet. Cross section locations are shown in Exhibit 3.

Model input data includes:

- Manning’s n values, concrete channel: n=0.014.
- Normal depth is used for upstream and downstream boundary conditions.
- The model was run under supercritical flow condition because the channel is concrete.
- Water surface elevations from the channel design plans were added on the profile as “Observed Water Surface” for comparison.

### 4.2.2 Proposed Condition Bridge Model

Proposed conditions channel geometry and modeling approach are identical to the Existing Condition Bridge Model for all hydraulic cross sections outside of the bridge area. A total of two bridge alternatives were analyzed. The alternatives were taken from the design plans. Bridge alternative plans can be found at Exhibit 5.

The model was modified as follows:

- ***Offline Alternative*** – 30-inch pre-stressed concrete box girder design with supporting piles outside existing channel walls and a total span of 28 feet. Bridge profile was assumed to be the concrete box girder with ties, subgrade, rails and fence.
- ***In-line Alternative*** – 36-inch pre-stressed concrete box girder design with supporting piles outside existing channel walls and a total span of 43 feet. Bridge profile was assumed to be the concrete box girder with ties, subgrade, rails and fence.

## 4.3 Model Results

A hydraulic analysis was conducted to generate water surface profiles for the channel and bridge for the 100-year flow rate. The results obtained from 100-year flow rate analysis of Bridge 1.1 are shown in Table 1. Since the flow is contained in the channel and both alternatives only vary outside of the existing channel (different deck size, pile location, etc.), the results are the same for both alternatives. Velocity and Froude Number results vary slightly between existing conditions and the alternatives because the proposed bridge is wider than the existing bridge with the change from one track to two and the variables are being reported at a location further upstream. The differences are small and of no significance. Hydraulic profiles and cross-sections are shown in Attachment 2. Full hydraulic model results are shown in Attachment 3 (Hydraulic Analysis Results). Figure 4 shows the profile for existing conditions for the flow rate of 2,525 cfs (1,222 ac drainage), 2,900 cfs (as-built plan flow rate, Q20) and water surface measured from plans as Observed Water Surface (OWS). Figure 5 shows the existing cross-section of the upstream of the bridge. Figure 6 shows the Offline Alternative bridge upstream cross-section. Cross-sections of In-line Alternative is similar to Offline Alternative.

**Table 1: Hydraulic Results**

| | | **Existing Bridge** | **Offline Alternative** | **In-line Alternative** |
|---|---|---|---|---|
| 100-Yr storm event | WSE | 1003.41 | 1003.41 | 1003.41 |
| | EGL | 1011.13 | 1011.13 | 1011.13 |
| | VCH | 21.99 | 22.14 | 22.15 |
| | Froude # | 1.53 | 1.55 | 1.55 |
| WSE = water surface elevation (ft); EGL = energy grade line elevation (ft); VCH = main channel average velocity (ft/s); All elevations are NAVD 1988 | | | | |

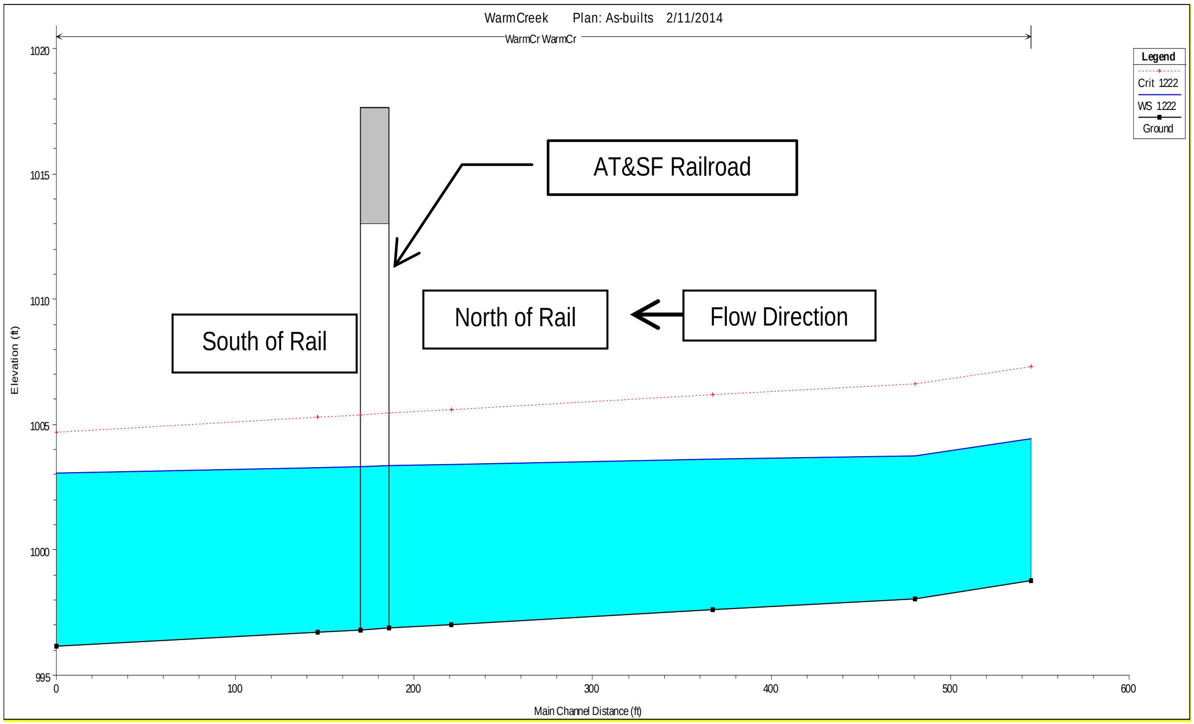



**Figure 4: Profile of Existing Conditions**

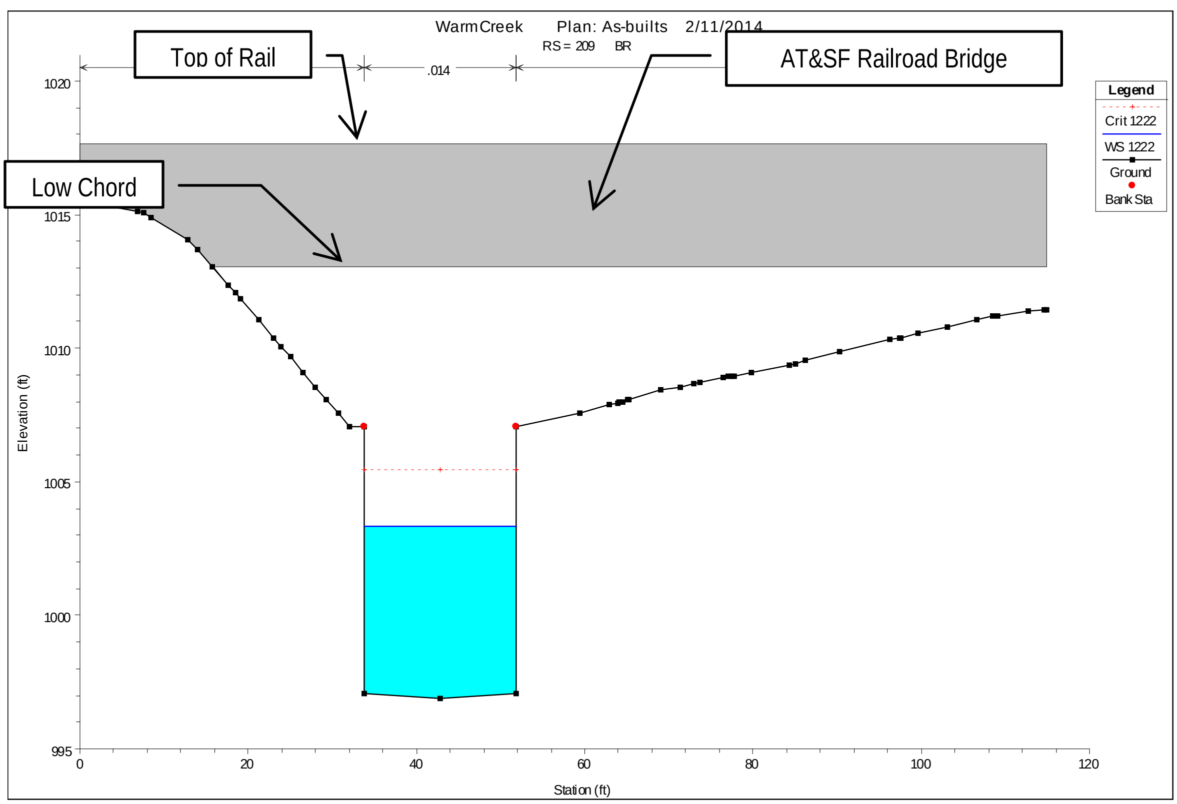



**Figure 5: Cross-Section of Existing Conditions Upstream of AT&SF Railroad Bridge**

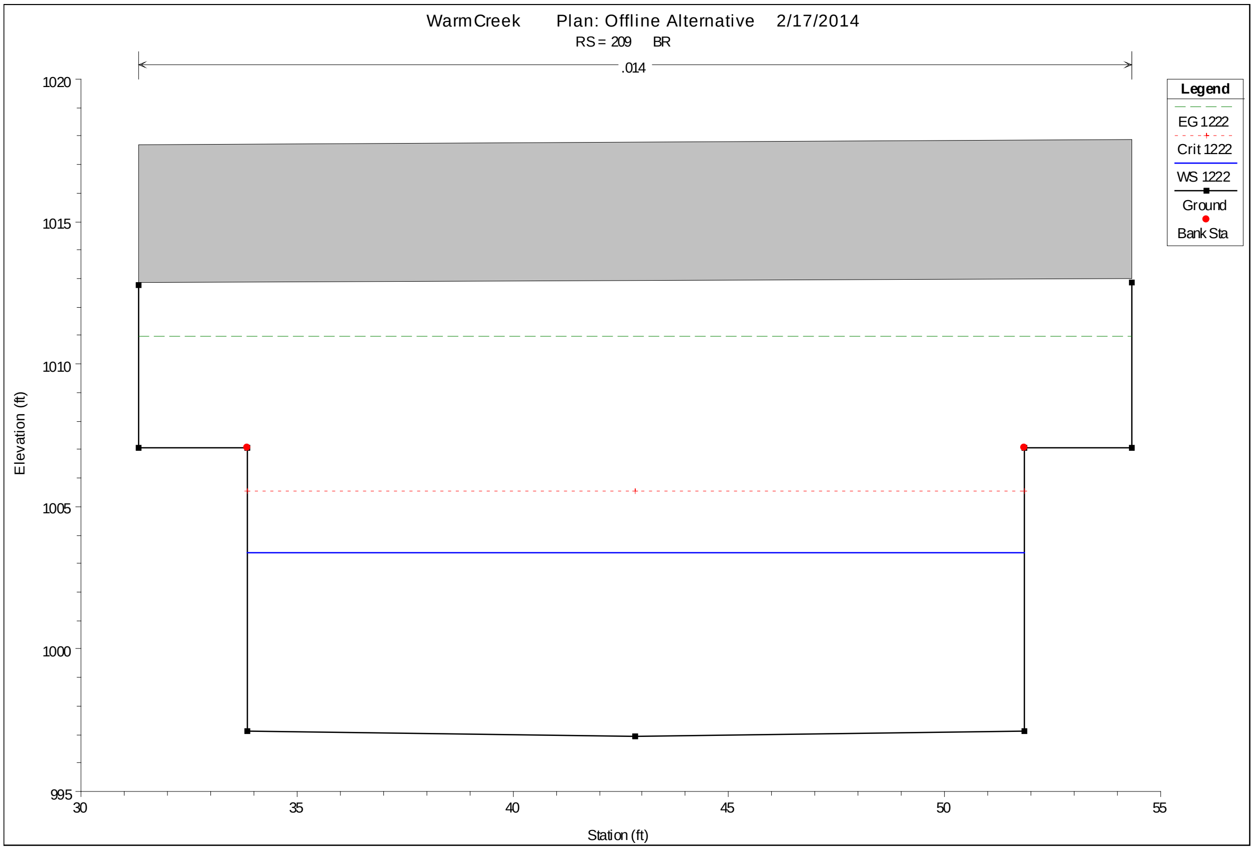



**Figure 6: Cross-Section of Proposed Conditions Upstream of AT&SF Railroad Bridge**

The 100-year freeboard criteria selected for the bridge (in the following priority) for alternatives are presented below in Tables 2, 3, and 4. The proposed bridges meet all 100-year criteria and therefore, meets 50-year criteria by default.

**Table 2: Hydraulic Freeboard Criteria- Offline Alternative**

| Criterion | Standard | Proposed Model Results | Criterion Met? |
|---|---|---|---|
| 1. 100-yr WSE < Low Chord | Low Chord = 1012.87 | 100-yr WSE = 1003.41 | Yes |
| 2. 100-yr EGL < Top of SBGD | Top of SBGD = 1014.78 | 100-yr EGL = 1011.13 | Yes |
| 3. Proposed WSE ≤ Existing WSE | Existing 100-yr WSE = 1003.41 | Proposed 100-yr WSE = Existing 100-yr WSE | Yes |
| WSE = water surface elevation (ft); EGL = energy grade line elevation (ft); SBGD = subgrade. All elevations are NAVD 1988. | | | |

**Table 3: Hydraulic Freeboard Criteria-In-line Alternative**

| Criterion | Standard | Proposed Model Results | Criterion Met? |
|---|---|---|---|
| 1. 100-yr WSE < Low Chord | Low Chord = 1012.32 | 100-yr WSE = 1003.41 | Yes |
| 2. 100-yr EGL < Top of SBGD | Top of SBGD = 1014.74 | 100-yr EGL = 1011.13 | Yes |
| 3. Proposed WSE ≤ Existing WSE | Existing 100-yr WSE = 1003.41 | Proposed 100-yr WSE = Existing 100-yr WSE | Yes |
| WSE = water surface elevation (ft); EGL = energy grade line elevation (ft); SBGD = subgrade. All elevations are NGVD 1988. | | | |

## 5. Conclusions

Using the data and resources available, the hydraulic conditions were modeled for Bridge 1.1 for both existing and proposed conditions. The 100-year flow is contained within the channel for both existing and proposed alternatives. The results of the modeling indicate that the proposed bridge improvements result in the same 100-year water surface and energy grade elevations as the existing condition; therefore, the proposed bridge alternatives will meet the freeboard criteria.

## 6. References

City of San Bernardino. 1968. Warm Creek Channel Plans.

County of San Bernardino. 1986. San Bernardino County Hydrology Manual.

Federal Emergency Management Agency (FEMA). 2008. Flood Insurance Study, San Bernardino County, California.

Joseph E. Bonadiman and Associates, Inc. 2004. CivilDesign Manual.

National Geodetic Survey. 1991. North American Vertical Datum (NAVD) 88.

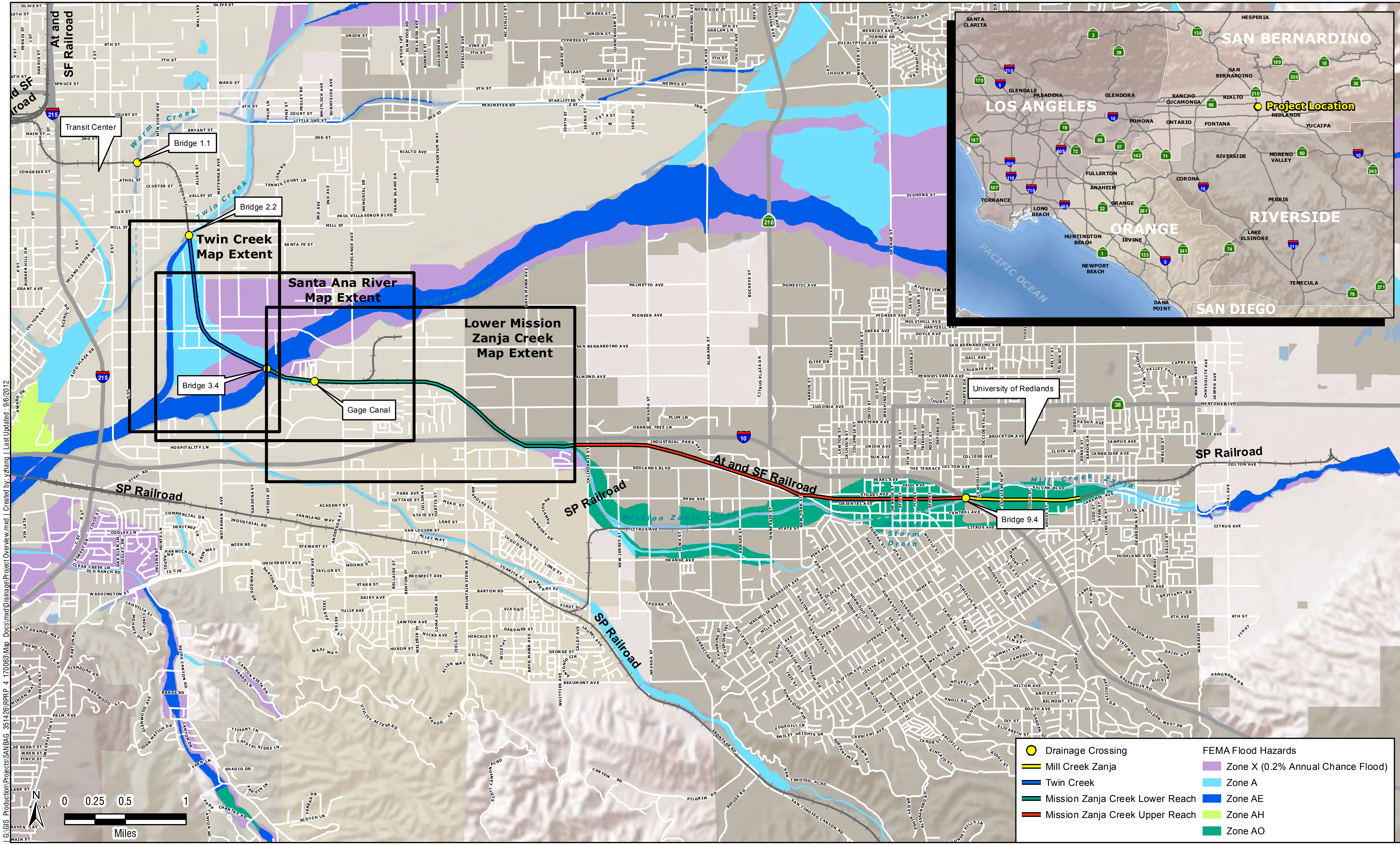
San Bernardino County Flood Control District. 1982. Comprehensive Storm Drain Project No.7 (CSDP 7).

U.S. Army Corps of Engineers (USACE). 2010. HEC-RAS v.4.1 User's Manual and Technical Reference Manual.

U.S. Army Corps of Engineers. 2004. Corpscon 6.0.1.

U.S. Army Corps of Engineers. 1964. Lytle and Warm Creeks.

**Exhibit 1: RPRP Project Overview**

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HDR ONE COMPANY | *Many Solutions*

# Project Overview

**EXHIBIT 1**

SANBAG | Redlands Passenger Rail Project | Hydraulic Impact Report

**Exhibit 2: Warm Creek Drainage Area**

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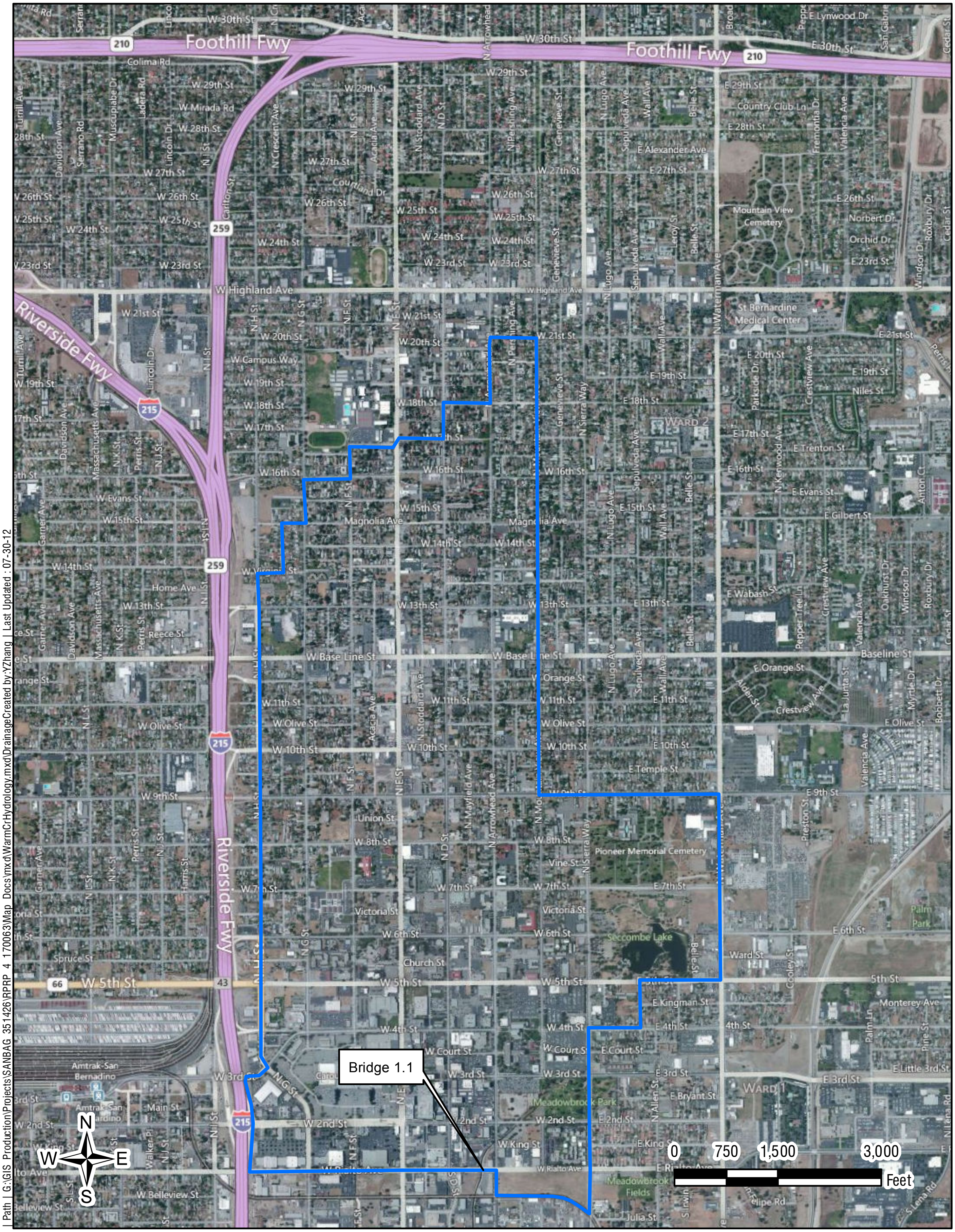


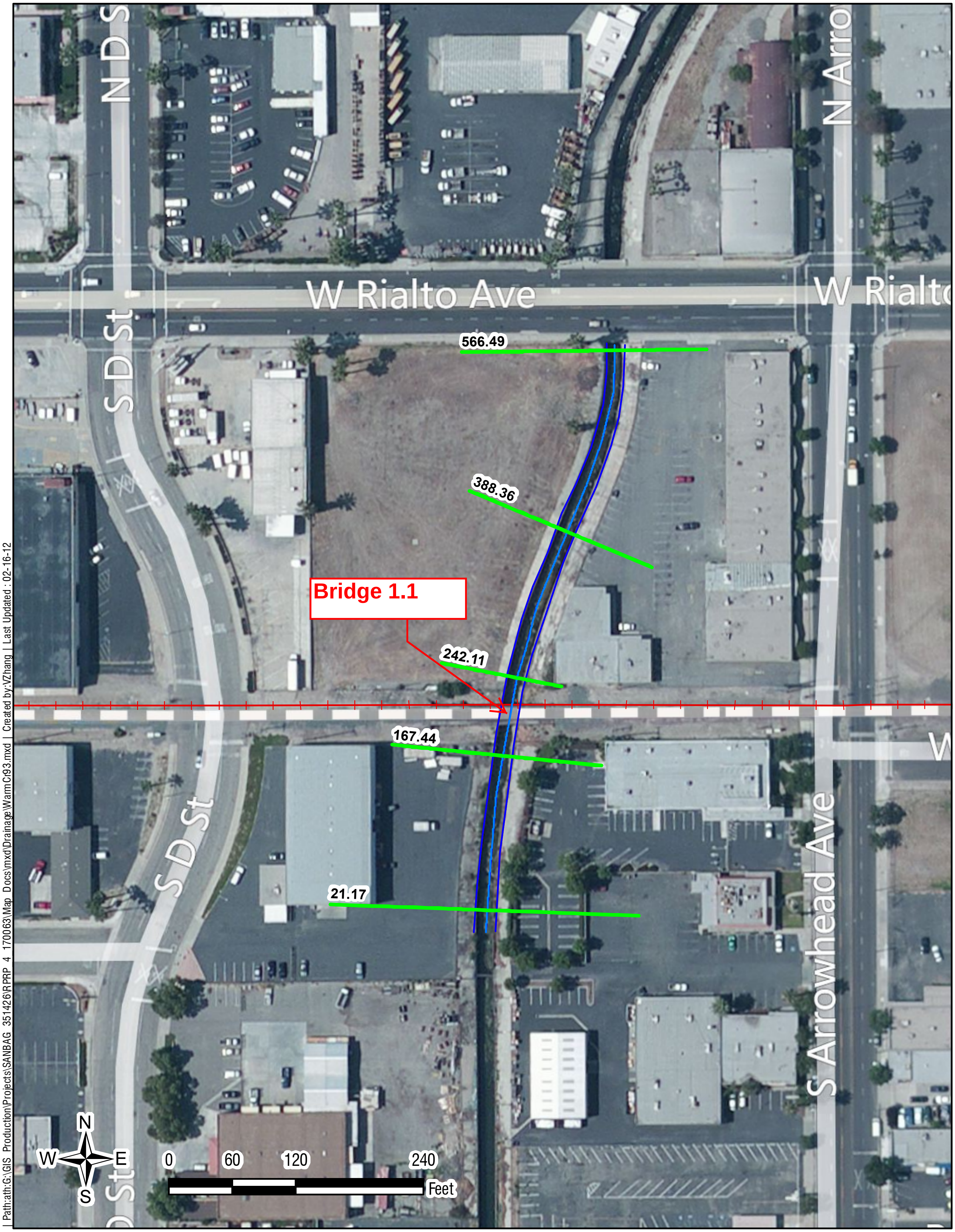

# Warm Creek Drainage Area

**EXHIBIT 2**

SANBAG | Redlands Passenger Rail Project | Warm Creek Report

HDR ONE COMPANY | *Many Solutions*℠

# Exhibit 3: HEC-RAS Model – Cross-Sections

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# HEC-RAS Model - Cross Sections

**EXHIBIT 3**

SANBAG | Redlands Passenger Rail Project | Warm Creek Report

HDR ONE COMPANY | *Many Solutions*℠

## Exhibit 4: FEMA FIRM 06071C Panel 8681H

ional Flood Insurance Program at 1-800-638-6620.


MAP SCALE 1" = 500'

250 0 500 1000 FEET

METERS

NFIP

PANEL 8681H

# FIRM

## FLOOD INSURANCE RATE MAP

**SAN BERNARDINO COUNTY, CALIFORNIA**
**AND INCORPORATED AREAS**

**PANEL 8681 OF 9400**

(SEE MAP INDEX FOR FIRM PANEL LAYOUT)

CONTAINS:

| COMMUNITY | NUMBER | PANEL | SUFFIX |
|---|---|---|---|
| SAN BERNARDINO, CITY OF | 060281 | 8681 | H |

Notice to User: The **Map Number** shown below should be used when placing map orders; the **Community Number** shown above should be used on insurance applications for the subject community.

NATIONAL FLOOD INSURANCE PROGRAM

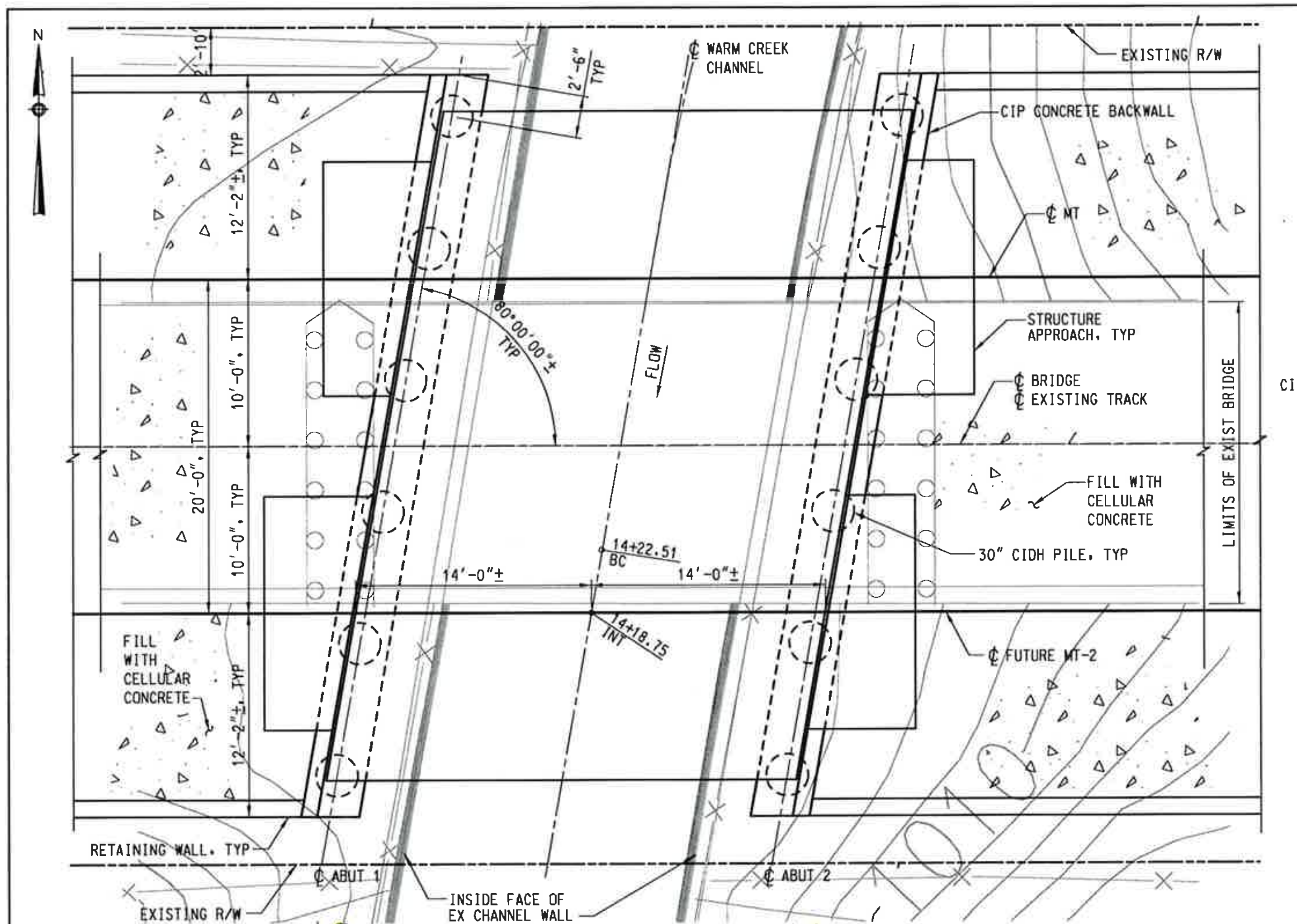
**MAP NUMBER**
**06071C8681H**

**MAP REVISED**
**AUGUST 28, 2008**

**Federal Emergency Management Agency**

This is an official copy of a portion of the above referenced flood map. It was extracted using F-MIT On-Line. This map does not reflect changes or amendments which may have been made subsequent to the date on the title block. For the latest product information about National Flood Insurance Program flood maps check the FEMA Flood Map Store at www.msc.fema.gov

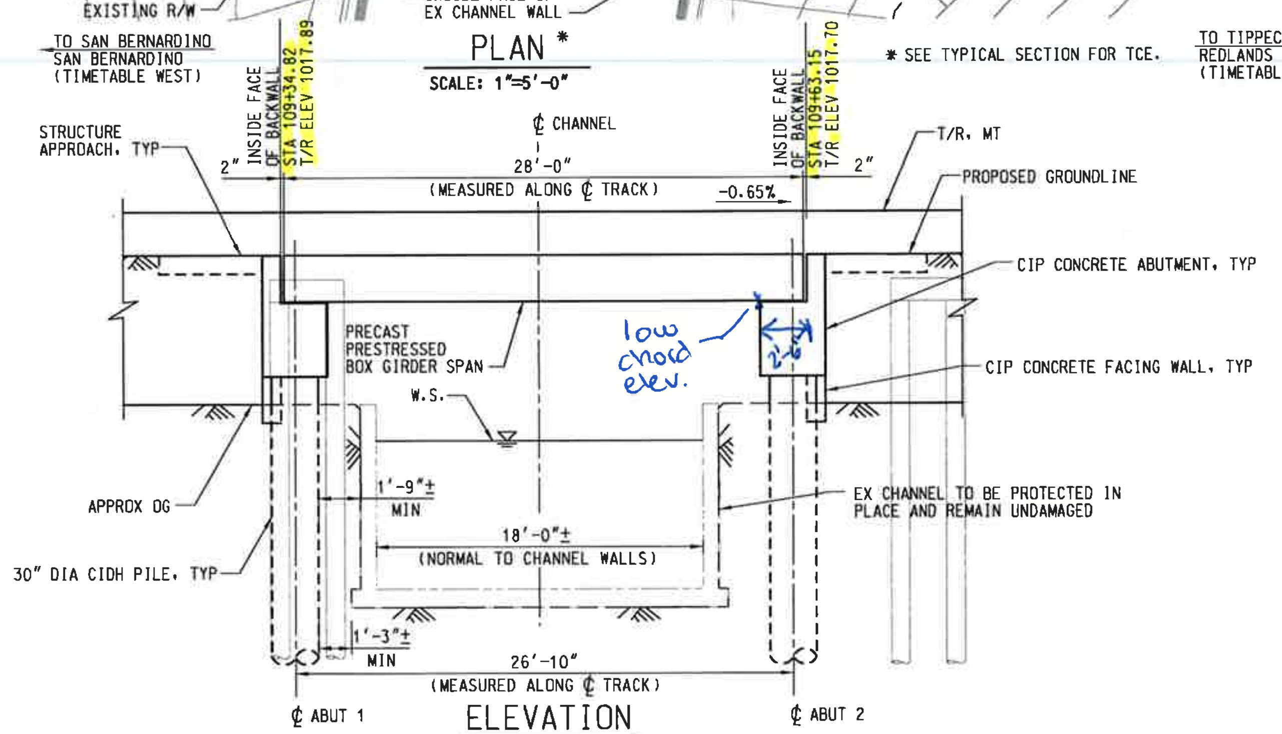
**Exhibit 5: Proposed Bridge Alternative Plans**




PLAN *

SCALE: 1"=5'-0"

* SEE TYPICAL SECTION FOR TCE.




ELEVATION

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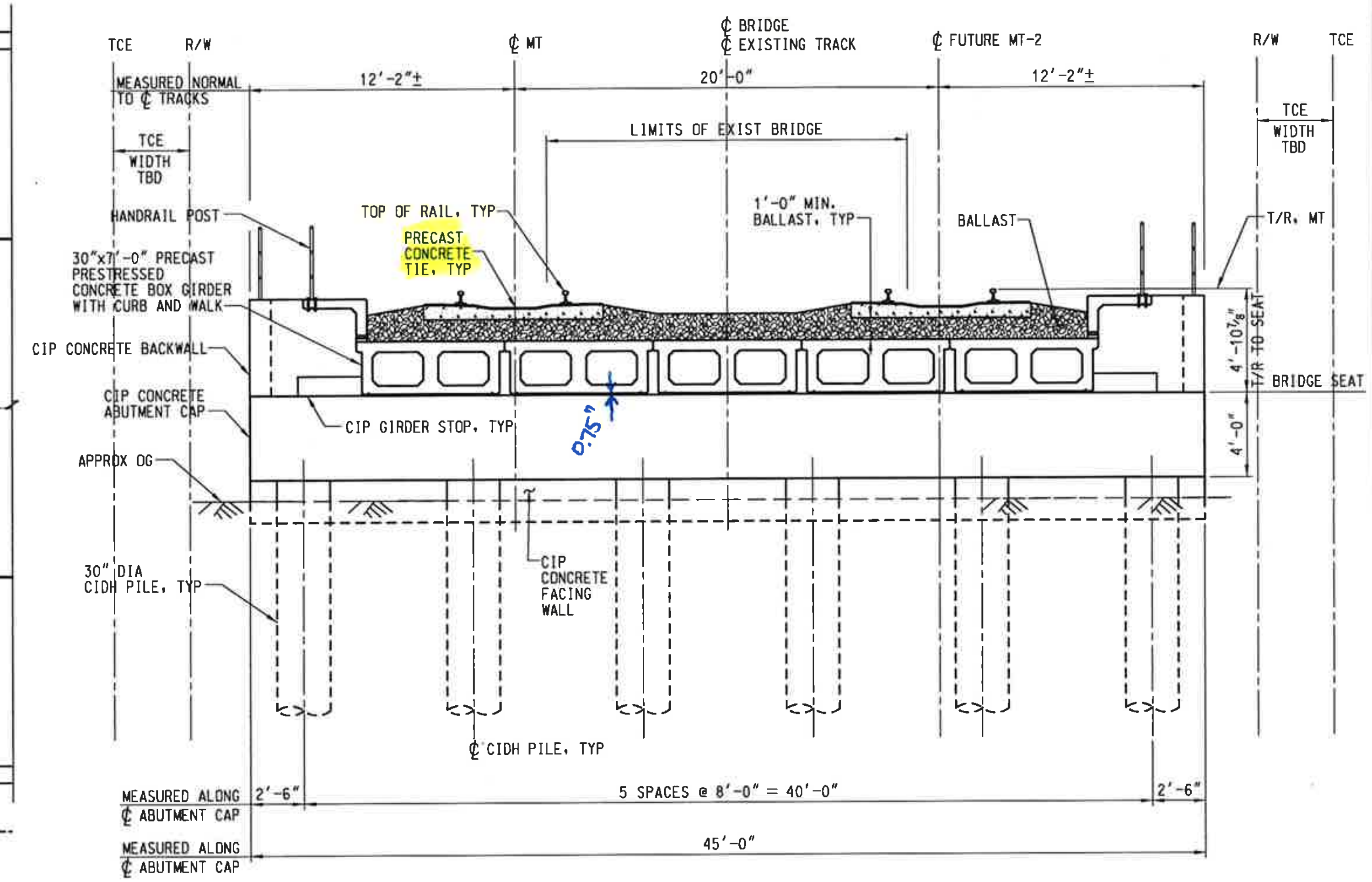


TYPICAL SECTION

(LOOKING TIMETABLE EAST)

SCALE: 1/4"=1'-0"

low chord elevation = (1017.70 + 0.65/100 × 2.5) − (4'-10⅞" − 0.75")

= 1017.716 − 4.844

= 1012.87'

LEGEND

- - - - - EXISTING STRUCTURE

———— NEW STRUCTURE

2/5/2014 5:37:30 PM mgranado
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c:\pwworking\sac\d0301512\SANBAG-11x17bw_pdf.pltcfg

| REV. | DATE | | BY | SUB. | APP. |
|---|---|---|---|---|---|

DESIGNED BY J. HEREDIA
DRAWN BY R. ZHAO
CHECKED BY B. REZNIKOV
APPROVED BY M. BORAKS
DATE FEB 2013

SANBAG Governments Working Together — SAN BERNARDINO ASSOCIATED GOVERNMENTS

HDR ONE COMPANY Many Solutions — HDR Engineering, Inc.

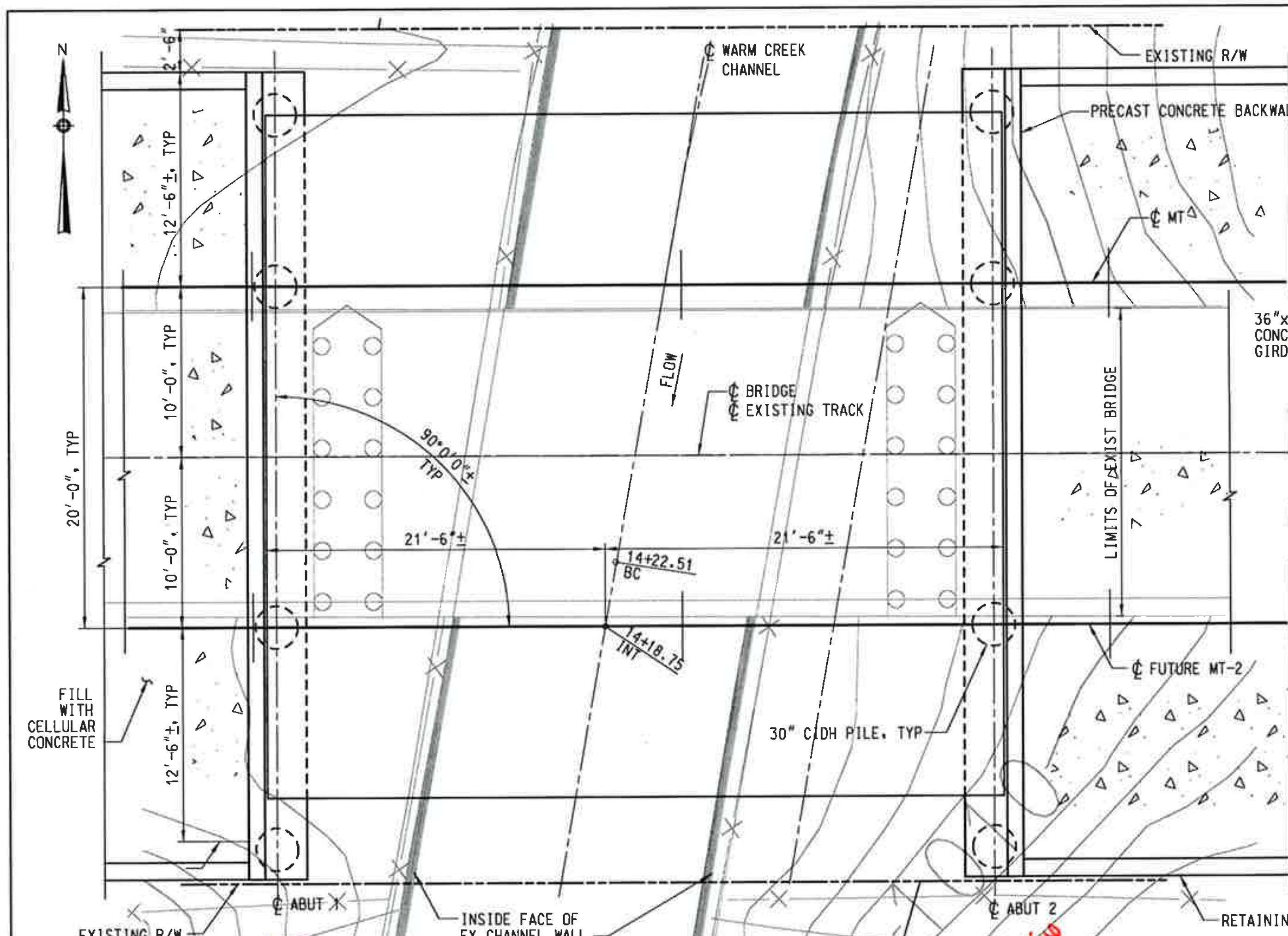
SUBMITTED: PROJECT MANAGER     APPROVED:

**30% SUBMITTAL**
NOT FOR CONSTRUCTION

**REDLANDS PASSENGER RAIL PROJECT**

OFFLINE ALTERNATIVE
BRIDGE 1.1
GENERAL PLAN

CONTRACT NO.
DRAWING NO. SB-06101
REVISION | SHEET NO.
SCALE AS NOTED




## PLAN

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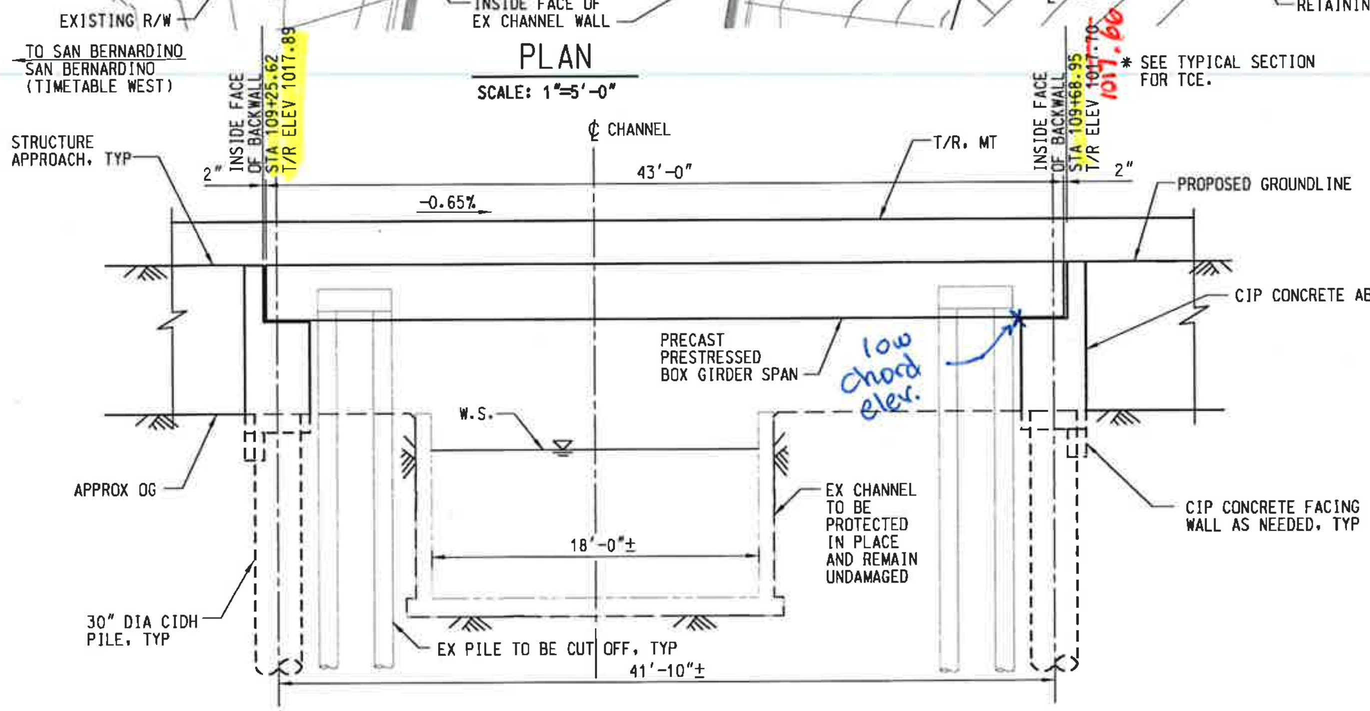
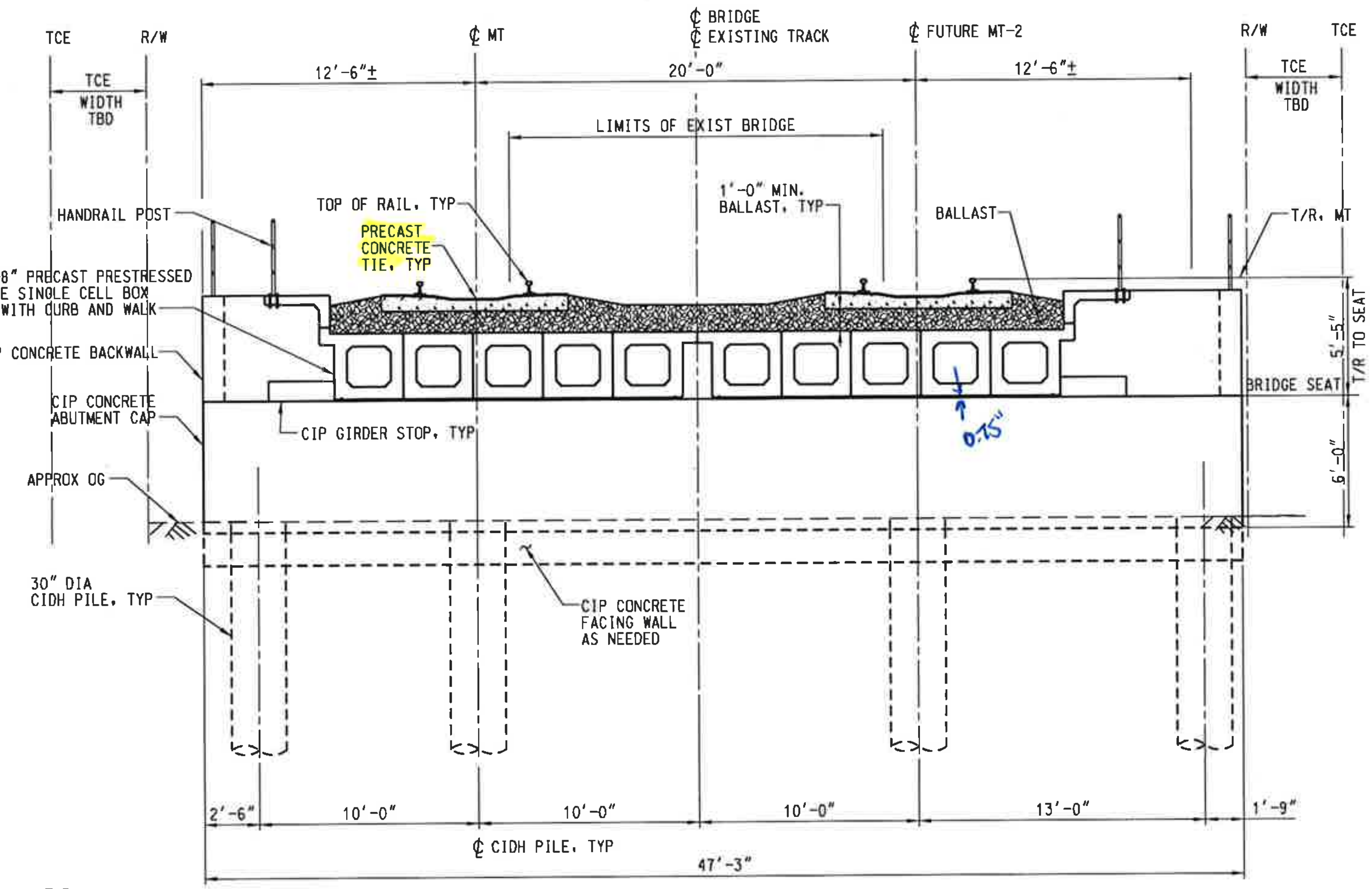



## ELEVATION

SCALE: 1"=5'-0"




## TYPICAL SECTION

(LOOKING TIMETABLE EAST)

SCALE: 1/4"=1'-0"

low chord elevation = (1017.66' + 0.65/100×2.5') − (5'-5" − 0.75")
= 1017.676 − 5.354
= 1012.32'

### LEGEND

- - - - - EXISTING STRUCTURE

——— NEW STRUCTURE

| REV. | DATE | | BY | SUB | APP. |
|---|---|---|---|---|---|

DESIGNED BY J. HEREDIA
DRAWN BY R. ZHAO
CHECKED BY B. REZNIKOV
APPROVED BY M. BORAKS
DATE FEB 2013

SANBAG Governments Working Together — SAN BERNARDINO ASSOCIATED GOVERNMENTS

HDR ONE COMPANY Many Solutions — HDR Engineering, Inc.

SUBMITTED: PROJECT MANAGER    APPROVED:

**30% SUBMITTAL**
NOT FOR CONSTRUCTION

**REDLANDS PASSENGER RAIL PROJECT**
IN-LINE ALTERNATIVE
BRIDGE 1.1
GENERAL PLAN

CONTRACT NO.
DRAWING NO. SB-06104
REVISION
SHEET NO.
SCALE AS NOTED

2/5/2014 5:38:26 PM mgranado

**Attachment 1 – CivilDesign Results**

U n i t   H y d r o g r a p h   A n a l y s i s



Study date 05/09/12

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------------------------------------------------------------------------

San Bernardino County Synthetic Unit Hydrology Method
Manual date - August 1986

Program License Serial Number 4055

------------------------------------------------------------------------
Warm Creek, 1222ac

------------------------------------------------------------------------

Storm Event Year = 100

Antecedent Moisture Condition = 3

English (in-lb) Input Units Used

English Rainfall Data (Inches) Input Values Used

English Units used in output format

Area averaged rainfall intensity isohyetal data:

| Sub-Area (Ac.) | Duration (hours) | Isohyetal (In) |
|---|---|---|
| Rainfall data for year 100 | | |
| 1222.00 | 1 | 1.47 |
| Rainfall data for year 100 | | |
| 1222.00 | 6 | 3.09 |
| Rainfall data for year 100 | | |
| 1222.00 | 24 | 5.79 |

++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++

******** Area-averaged max loss rate, Fm ********

| SCS curve No.(AMCII) | SCS curve NO.(AMC 3) | Area (Ac.) | Area Fraction | Fp(Fig C6) (In/Hr) | Ap (dec.) | Fm (In/Hr) |
|---|---|---|---|---|---|---|
| 56.0 | 75.8 | 1222.00 | 1.000 | 0.440 | 0.265 | 0.117 |

Area-averaged adjusted loss rate Fm (In/Hr) = 0.117

********* Area-Averaged low loss rate fraction, Yb **********

Area       Area           SCS CN    SCS CN      S     Pervious

| (Ac.) | Fract | (AMC2) | (AMC3) | | Yield Fr |
|---|---|---|---|---|---|
| 323.83 | 0.265 | 56.0 | 75.8 | 3.19 | 0.549 |
| 898.17 | 0.735 | 98.0 | 98.0 | 0.20 | 0.959 |

Area-averaged catchment yield fraction, Y = 0.850
Area-averaged low loss fraction, Yb = 0.150
+++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
Watercourse length = 12171.00(Ft.)
Length from concentration point to centroid = 4974.00(Ft.)
Elevation difference along watercourse = 144.00(Ft.)
Mannings friction factor along watercourse = 0.025
Watershed area = 1222.00(Ac.)
Catchment Lag time = 0.367 hours
Unit interval = 5.000 minutes
Unit interval percentage of lag time = 22.6921
Hydrograph baseflow = 0.00(CFS)
Average maximum watershed loss rate(Fm) = 0.117(In/Hr)
Average low loss rate fraction (Yb) = 0.150 (decimal)
VALLEY DEVELOPED S-Graph Selected
Computed peak 5-minute rainfall = 0.544(In)
Computed peak 30-minute rainfall = 1.114(In)
Specified peak 1-hour rainfall = 1.470(In)
Computed peak 3-hour rainfall = 2.316(In)
Specified peak 6-hour rainfall = 3.086(In)
Specified peak 24-hour rainfall = 5.785(In)

Rainfall depth area reduction factors:
Using a total area of 1222.00(Ac.) (Ref: fig. E-4)

5-minute factor = 0.943 Adjusted rainfall = 0.513(In)
30-minute factor = 0.943 Adjusted rainfall = 1.050(In)
1-hour factor = 0.943 Adjusted rainfall = 1.386(In)
3-hour factor = 0.993 Adjusted rainfall = 2.300(In)
6-hour factor = 0.996 Adjusted rainfall = 3.074(In)
24-hour factor = 0.998 Adjusted rainfall = 5.776(In)
---------------------------------------------------------------------

U n i t H y d r o g r a p h

(K = 14778.56 (CFS))

| Interval Number | 'S' Graph Mean values | Unit Hydrograph ((CFS)) |
|---|---|---|
| 1 | 1.377 | 203.561 |
| 2 | 6.244 | 719.193 |
| 3 | 17.339 | 1639.664 |
| 4 | 32.345 | 2217.723 |
| 5 | 51.349 | 2808.557 |
| 6 | 70.297 | 2800.198 |
| 7 | 81.330 | 1630.465 |
| 8 | 89.304 | 1178.548 |
| 9 | 93.622 | 638.053 |
| 10 | 96.428 | 414.658 |
| 11 | 97.947 | 224.476 |
| 12 | 98.497 | 81.386 |
| 13 | 98.906 | 60.370 |
| 14 | 99.314 | 60.349 |
| 15 | 99.722 | 60.299 |
| 16 | 100.000 | 41.061 |

| Peak Unit Number | Adjusted mass rainfall (In) | Unit rainfall (In) |
|---|---|---|
| 1 | 0.5129 | 0.5129 |
| 2 | 0.6768 | 0.1639 |

| | | |
|---|---|---|
| 3 | 0.7959 | 0.1192 |
| 4 | 0.8930 | 0.0971 |
| 5 | 0.9764 | 0.0834 |
| 6 | 1.0502 | 0.0739 |
| 7 | 1.1170 | 0.0668 |
| 8 | 1.1783 | 0.0613 |
| 9 | 1.2352 | 0.0568 |
| 10 | 1.2883 | 0.0532 |
| 11 | 1.3384 | 0.0501 |
| 12 | 1.3858 | 0.0474 |
| 13 | 1.4379 | 0.0521 |
| 14 | 1.4879 | 0.0500 |
| 15 | 1.5359 | 0.0481 |
| 16 | 1.5823 | 0.0464 |
| 17 | 1.6272 | 0.0448 |
| 18 | 1.6706 | 0.0434 |
| 19 | 1.7128 | 0.0422 |
| 20 | 1.7537 | 0.0410 |
| 21 | 1.7936 | 0.0399 |
| 22 | 1.8325 | 0.0389 |
| 23 | 1.8704 | 0.0379 |
| 24 | 1.9075 | 0.0371 |
| 25 | 1.9437 | 0.0362 |
| 26 | 1.9792 | 0.0355 |
| 27 | 2.0139 | 0.0347 |
| 28 | 2.0480 | 0.0340 |
| 29 | 2.0814 | 0.0334 |
| 30 | 2.1142 | 0.0328 |
| 31 | 2.1464 | 0.0322 |
| 32 | 2.1780 | 0.0316 |
| 33 | 2.2091 | 0.0311 |
| 34 | 2.2397 | 0.0306 |
| 35 | 2.2698 | 0.0301 |
| 36 | 2.2995 | 0.0297 |
| 37 | 2.3261 | 0.0265 |
| 38 | 2.3522 | 0.0261 |
| 39 | 2.3779 | 0.0257 |
| 40 | 2.4033 | 0.0254 |
| 41 | 2.4283 | 0.0250 |
| 42 | 2.4529 | 0.0246 |
| 43 | 2.4772 | 0.0243 |
| 44 | 2.5012 | 0.0240 |
| 45 | 2.5248 | 0.0237 |
| 46 | 2.5482 | 0.0234 |
| 47 | 2.5712 | 0.0231 |
| 48 | 2.5940 | 0.0228 |
| 49 | 2.6165 | 0.0225 |
| 50 | 2.6387 | 0.0222 |
| 51 | 2.6607 | 0.0220 |
| 52 | 2.6825 | 0.0217 |
| 53 | 2.7039 | 0.0215 |
| 54 | 2.7252 | 0.0213 |
| 55 | 2.7462 | 0.0210 |
| 56 | 2.7670 | 0.0208 |
| 57 | 2.7876 | 0.0206 |
| 58 | 2.8080 | 0.0204 |
| 59 | 2.8282 | 0.0202 |
| 60 | 2.8482 | 0.0200 |
| 61 | 2.8680 | 0.0198 |
| 62 | 2.8876 | 0.0196 |
| 63 | 2.9070 | 0.0194 |
| 64 | 2.9262 | 0.0192 |
| 65 | 2.9453 | 0.0191 |
| 66 | 2.9642 | 0.0189 |
| 67 | 2.9829 | 0.0187 |
| 68 | 3.0015 | 0.0186 |

| | | |
|---|---|---|
| 69 | 3.0199 | 0.0184 |
| 70 | 3.0382 | 0.0183 |
| 71 | 3.0563 | 0.0181 |
| 72 | 3.0742 | 0.0180 |
| 73 | 3.0936 | 0.0194 |
| 74 | 3.1128 | 0.0192 |
| 75 | 3.1318 | 0.0191 |
| 76 | 3.1508 | 0.0189 |
| 77 | 3.1696 | 0.0188 |
| 78 | 3.1882 | 0.0187 |
| 79 | 3.2068 | 0.0185 |
| 80 | 3.2252 | 0.0184 |
| 81 | 3.2434 | 0.0183 |
| 82 | 3.2616 | 0.0182 |
| 83 | 3.2796 | 0.0180 |
| 84 | 3.2976 | 0.0179 |
| 85 | 3.3154 | 0.0178 |
| 86 | 3.3330 | 0.0177 |
| 87 | 3.3506 | 0.0176 |
| 88 | 3.3681 | 0.0175 |
| 89 | 3.3854 | 0.0174 |
| 90 | 3.4027 | 0.0173 |
| 91 | 3.4198 | 0.0171 |
| 92 | 3.4369 | 0.0170 |
| 93 | 3.4538 | 0.0169 |
| 94 | 3.4707 | 0.0168 |
| 95 | 3.4874 | 0.0167 |
| 96 | 3.5041 | 0.0167 |
| 97 | 3.5206 | 0.0166 |
| 98 | 3.5371 | 0.0165 |
| 99 | 3.5535 | 0.0164 |
| 100 | 3.5698 | 0.0163 |
| 101 | 3.5860 | 0.0162 |
| 102 | 3.6021 | 0.0161 |
| 103 | 3.6181 | 0.0160 |
| 104 | 3.6340 | 0.0159 |
| 105 | 3.6499 | 0.0159 |
| 106 | 3.6657 | 0.0158 |
| 107 | 3.6814 | 0.0157 |
| 108 | 3.6970 | 0.0156 |
| 109 | 3.7125 | 0.0155 |
| 110 | 3.7280 | 0.0155 |
| 111 | 3.7433 | 0.0154 |
| 112 | 3.7587 | 0.0153 |
| 113 | 3.7739 | 0.0152 |
| 114 | 3.7890 | 0.0152 |
| 115 | 3.8041 | 0.0151 |
| 116 | 3.8191 | 0.0150 |
| 117 | 3.8341 | 0.0149 |
| 118 | 3.8490 | 0.0149 |
| 119 | 3.8638 | 0.0148 |
| 120 | 3.8785 | 0.0147 |
| 121 | 3.8932 | 0.0147 |
| 122 | 3.9078 | 0.0146 |
| 123 | 3.9223 | 0.0145 |
| 124 | 3.9368 | 0.0145 |
| 125 | 3.9512 | 0.0144 |
| 126 | 3.9656 | 0.0143 |
| 127 | 3.9798 | 0.0143 |
| 128 | 3.9941 | 0.0142 |
| 129 | 4.0082 | 0.0142 |
| 130 | 4.0223 | 0.0141 |
| 131 | 4.0364 | 0.0140 |
| 132 | 4.0504 | 0.0140 |
| 133 | 4.0643 | 0.0139 |
| 134 | 4.0782 | 0.0139 |

| | | |
|---|---|---|
| 135 | 4.0920 | 0.0138 |
| 136 | 4.1058 | 0.0138 |
| 137 | 4.1195 | 0.0137 |
| 138 | 4.1331 | 0.0137 |
| 139 | 4.1467 | 0.0136 |
| 140 | 4.1603 | 0.0135 |
| 141 | 4.1738 | 0.0135 |
| 142 | 4.1872 | 0.0134 |
| 143 | 4.2006 | 0.0134 |
| 144 | 4.2139 | 0.0133 |
| 145 | 4.2272 | 0.0133 |
| 146 | 4.2405 | 0.0132 |
| 147 | 4.2536 | 0.0132 |
| 148 | 4.2668 | 0.0131 |
| 149 | 4.2799 | 0.0131 |
| 150 | 4.2929 | 0.0130 |
| 151 | 4.3059 | 0.0130 |
| 152 | 4.3189 | 0.0129 |
| 153 | 4.3318 | 0.0129 |
| 154 | 4.3446 | 0.0129 |
| 155 | 4.3574 | 0.0128 |
| 156 | 4.3702 | 0.0128 |
| 157 | 4.3829 | 0.0127 |
| 158 | 4.3956 | 0.0127 |
| 159 | 4.4082 | 0.0126 |
| 160 | 4.4208 | 0.0126 |
| 161 | 4.4334 | 0.0125 |
| 162 | 4.4459 | 0.0125 |
| 163 | 4.4584 | 0.0125 |
| 164 | 4.4708 | 0.0124 |
| 165 | 4.4832 | 0.0124 |
| 166 | 4.4955 | 0.0123 |
| 167 | 4.5078 | 0.0123 |
| 168 | 4.5201 | 0.0123 |
| 169 | 4.5323 | 0.0122 |
| 170 | 4.5445 | 0.0122 |
| 171 | 4.5566 | 0.0121 |
| 172 | 4.5687 | 0.0121 |
| 173 | 4.5808 | 0.0121 |
| 174 | 4.5928 | 0.0120 |
| 175 | 4.6048 | 0.0120 |
| 176 | 4.6167 | 0.0120 |
| 177 | 4.6287 | 0.0119 |
| 178 | 4.6405 | 0.0119 |
| 179 | 4.6524 | 0.0118 |
| 180 | 4.6642 | 0.0118 |
| 181 | 4.6760 | 0.0118 |
| 182 | 4.6877 | 0.0117 |
| 183 | 4.6994 | 0.0117 |
| 184 | 4.7111 | 0.0117 |
| 185 | 4.7227 | 0.0116 |
| 186 | 4.7343 | 0.0116 |
| 187 | 4.7458 | 0.0116 |
| 188 | 4.7574 | 0.0115 |
| 189 | 4.7689 | 0.0115 |
| 190 | 4.7803 | 0.0115 |
| 191 | 4.7918 | 0.0114 |
| 192 | 4.8032 | 0.0114 |
| 193 | 4.8145 | 0.0114 |
| 194 | 4.8259 | 0.0113 |
| 195 | 4.8372 | 0.0113 |
| 196 | 4.8484 | 0.0113 |
| 197 | 4.8597 | 0.0112 |
| 198 | 4.8709 | 0.0112 |
| 199 | 4.8821 | 0.0112 |
| 200 | 4.8932 | 0.0111 |

| | | |
|---|---|---|
| 201 | 4.9043 | 0.0111 |
| 202 | 4.9154 | 0.0111 |
| 203 | 4.9265 | 0.0111 |
| 204 | 4.9375 | 0.0110 |
| 205 | 4.9485 | 0.0110 |
| 206 | 4.9594 | 0.0110 |
| 207 | 4.9704 | 0.0109 |
| 208 | 4.9813 | 0.0109 |
| 209 | 4.9922 | 0.0109 |
| 210 | 5.0030 | 0.0109 |
| 211 | 5.0139 | 0.0108 |
| 212 | 5.0246 | 0.0108 |
| 213 | 5.0354 | 0.0108 |
| 214 | 5.0462 | 0.0107 |
| 215 | 5.0569 | 0.0107 |
| 216 | 5.0676 | 0.0107 |
| 217 | 5.0782 | 0.0107 |
| 218 | 5.0889 | 0.0106 |
| 219 | 5.0995 | 0.0106 |
| 220 | 5.1100 | 0.0106 |
| 221 | 5.1206 | 0.0106 |
| 222 | 5.1311 | 0.0105 |
| 223 | 5.1416 | 0.0105 |
| 224 | 5.1521 | 0.0105 |
| 225 | 5.1626 | 0.0105 |
| 226 | 5.1730 | 0.0104 |
| 227 | 5.1834 | 0.0104 |
| 228 | 5.1938 | 0.0104 |
| 229 | 5.2041 | 0.0104 |
| 230 | 5.2144 | 0.0103 |
| 231 | 5.2247 | 0.0103 |
| 232 | 5.2350 | 0.0103 |
| 233 | 5.2453 | 0.0103 |
| 234 | 5.2555 | 0.0102 |
| 235 | 5.2657 | 0.0102 |
| 236 | 5.2759 | 0.0102 |
| 237 | 5.2860 | 0.0102 |
| 238 | 5.2962 | 0.0101 |
| 239 | 5.3063 | 0.0101 |
| 240 | 5.3164 | 0.0101 |
| 241 | 5.3264 | 0.0101 |
| 242 | 5.3365 | 0.0100 |
| 243 | 5.3465 | 0.0100 |
| 244 | 5.3565 | 0.0100 |
| 245 | 5.3665 | 0.0100 |
| 246 | 5.3764 | 0.0100 |
| 247 | 5.3864 | 0.0099 |
| 248 | 5.3963 | 0.0099 |
| 249 | 5.4062 | 0.0099 |
| 250 | 5.4160 | 0.0099 |
| 251 | 5.4259 | 0.0098 |
| 252 | 5.4357 | 0.0098 |
| 253 | 5.4455 | 0.0098 |
| 254 | 5.4553 | 0.0098 |
| 255 | 5.4651 | 0.0098 |
| 256 | 5.4748 | 0.0097 |
| 257 | 5.4845 | 0.0097 |
| 258 | 5.4942 | 0.0097 |
| 259 | 5.5039 | 0.0097 |
| 260 | 5.5135 | 0.0097 |
| 261 | 5.5232 | 0.0096 |
| 262 | 5.5328 | 0.0096 |
| 263 | 5.5424 | 0.0096 |
| 264 | 5.5520 | 0.0096 |
| 265 | 5.5615 | 0.0096 |
| 266 | 5.5711 | 0.0095 |

| | | |
|---|---|---|
| 267 | 5.5806 | 0.0095 |
| 268 | 5.5901 | 0.0095 |
| 269 | 5.5996 | 0.0095 |
| 270 | 5.6090 | 0.0095 |
| 271 | 5.6185 | 0.0094 |
| 272 | 5.6279 | 0.0094 |
| 273 | 5.6373 | 0.0094 |
| 274 | 5.6467 | 0.0094 |
| 275 | 5.6561 | 0.0094 |
| 276 | 5.6654 | 0.0093 |
| 277 | 5.6747 | 0.0093 |
| 278 | 5.6840 | 0.0093 |
| 279 | 5.6933 | 0.0093 |
| 280 | 5.7026 | 0.0093 |
| 281 | 5.7119 | 0.0093 |
| 282 | 5.7211 | 0.0092 |
| 283 | 5.7303 | 0.0092 |
| 284 | 5.7395 | 0.0092 |
| 285 | 5.7487 | 0.0092 |
| 286 | 5.7579 | 0.0092 |
| 287 | 5.7670 | 0.0092 |
| 288 | 5.7762 | 0.0091 |

| Unit Period (number) | Unit Rainfall (In) | Unit Soil-Loss (In) | Effective Rainfall (In) |
|---|---|---|---|
| 1 | 0.0091 | 0.0014 | 0.0078 |
| 2 | 0.0092 | 0.0014 | 0.0078 |
| 3 | 0.0092 | 0.0014 | 0.0078 |
| 4 | 0.0092 | 0.0014 | 0.0078 |
| 5 | 0.0092 | 0.0014 | 0.0079 |
| 6 | 0.0093 | 0.0014 | 0.0079 |
| 7 | 0.0093 | 0.0014 | 0.0079 |
| 8 | 0.0093 | 0.0014 | 0.0079 |
| 9 | 0.0093 | 0.0014 | 0.0079 |
| 10 | 0.0094 | 0.0014 | 0.0080 |
| 11 | 0.0094 | 0.0014 | 0.0080 |
| 12 | 0.0094 | 0.0014 | 0.0080 |
| 13 | 0.0095 | 0.0014 | 0.0080 |
| 14 | 0.0095 | 0.0014 | 0.0081 |
| 15 | 0.0095 | 0.0014 | 0.0081 |
| 16 | 0.0095 | 0.0014 | 0.0081 |
| 17 | 0.0096 | 0.0014 | 0.0081 |
| 18 | 0.0096 | 0.0014 | 0.0082 |
| 19 | 0.0096 | 0.0014 | 0.0082 |
| 20 | 0.0097 | 0.0014 | 0.0082 |
| 21 | 0.0097 | 0.0015 | 0.0082 |
| 22 | 0.0097 | 0.0015 | 0.0083 |
| 23 | 0.0098 | 0.0015 | 0.0083 |
| 24 | 0.0098 | 0.0015 | 0.0083 |
| 25 | 0.0098 | 0.0015 | 0.0084 |
| 26 | 0.0098 | 0.0015 | 0.0084 |
| 27 | 0.0099 | 0.0015 | 0.0084 |
| 28 | 0.0099 | 0.0015 | 0.0084 |
| 29 | 0.0100 | 0.0015 | 0.0085 |
| 30 | 0.0100 | 0.0015 | 0.0085 |
| 31 | 0.0100 | 0.0015 | 0.0085 |
| 32 | 0.0100 | 0.0015 | 0.0085 |
| 33 | 0.0101 | 0.0015 | 0.0086 |
| 34 | 0.0101 | 0.0015 | 0.0086 |
| 35 | 0.0102 | 0.0015 | 0.0086 |
| 36 | 0.0102 | 0.0015 | 0.0087 |
| 37 | 0.0102 | 0.0015 | 0.0087 |
| 38 | 0.0103 | 0.0015 | 0.0087 |
| 39 | 0.0103 | 0.0015 | 0.0088 |

| | | | |
|---|---|---|---|
| 40 | 0.0103 | 0.0015 | 0.0088 |
| 41 | 0.0104 | 0.0016 | 0.0088 |
| 42 | 0.0104 | 0.0016 | 0.0088 |
| 43 | 0.0105 | 0.0016 | 0.0089 |
| 44 | 0.0105 | 0.0016 | 0.0089 |
| 45 | 0.0105 | 0.0016 | 0.0090 |
| 46 | 0.0106 | 0.0016 | 0.0090 |
| 47 | 0.0106 | 0.0016 | 0.0090 |
| 48 | 0.0106 | 0.0016 | 0.0090 |
| 49 | 0.0107 | 0.0016 | 0.0091 |
| 50 | 0.0107 | 0.0016 | 0.0091 |
| 51 | 0.0108 | 0.0016 | 0.0092 |
| 52 | 0.0108 | 0.0016 | 0.0092 |
| 53 | 0.0109 | 0.0016 | 0.0092 |
| 54 | 0.0109 | 0.0016 | 0.0093 |
| 55 | 0.0109 | 0.0016 | 0.0093 |
| 56 | 0.0110 | 0.0016 | 0.0093 |
| 57 | 0.0110 | 0.0017 | 0.0094 |
| 58 | 0.0111 | 0.0017 | 0.0094 |
| 59 | 0.0111 | 0.0017 | 0.0095 |
| 60 | 0.0111 | 0.0017 | 0.0095 |
| 61 | 0.0112 | 0.0017 | 0.0095 |
| 62 | 0.0112 | 0.0017 | 0.0096 |
| 63 | 0.0113 | 0.0017 | 0.0096 |
| 64 | 0.0113 | 0.0017 | 0.0096 |
| 65 | 0.0114 | 0.0017 | 0.0097 |
| 66 | 0.0114 | 0.0017 | 0.0097 |
| 67 | 0.0115 | 0.0017 | 0.0098 |
| 68 | 0.0115 | 0.0017 | 0.0098 |
| 69 | 0.0116 | 0.0017 | 0.0099 |
| 70 | 0.0116 | 0.0017 | 0.0099 |
| 71 | 0.0117 | 0.0018 | 0.0099 |
| 72 | 0.0117 | 0.0018 | 0.0100 |
| 73 | 0.0118 | 0.0018 | 0.0100 |
| 74 | 0.0118 | 0.0018 | 0.0101 |
| 75 | 0.0119 | 0.0018 | 0.0101 |
| 76 | 0.0120 | 0.0018 | 0.0102 |
| 77 | 0.0120 | 0.0018 | 0.0102 |
| 78 | 0.0121 | 0.0018 | 0.0103 |
| 79 | 0.0121 | 0.0018 | 0.0103 |
| 80 | 0.0122 | 0.0018 | 0.0104 |
| 81 | 0.0123 | 0.0018 | 0.0104 |
| 82 | 0.0123 | 0.0018 | 0.0105 |
| 83 | 0.0124 | 0.0019 | 0.0105 |
| 84 | 0.0124 | 0.0019 | 0.0106 |
| 85 | 0.0125 | 0.0019 | 0.0106 |
| 86 | 0.0125 | 0.0019 | 0.0107 |
| 87 | 0.0126 | 0.0019 | 0.0107 |
| 88 | 0.0127 | 0.0019 | 0.0108 |
| 89 | 0.0128 | 0.0019 | 0.0109 |
| 90 | 0.0128 | 0.0019 | 0.0109 |
| 91 | 0.0129 | 0.0019 | 0.0110 |
| 92 | 0.0129 | 0.0019 | 0.0110 |
| 93 | 0.0130 | 0.0020 | 0.0111 |
| 94 | 0.0131 | 0.0020 | 0.0111 |
| 95 | 0.0132 | 0.0020 | 0.0112 |
| 96 | 0.0132 | 0.0020 | 0.0113 |
| 97 | 0.0133 | 0.0020 | 0.0113 |
| 98 | 0.0134 | 0.0020 | 0.0114 |
| 99 | 0.0135 | 0.0020 | 0.0115 |
| 100 | 0.0135 | 0.0020 | 0.0115 |
| 101 | 0.0137 | 0.0020 | 0.0116 |
| 102 | 0.0137 | 0.0021 | 0.0117 |
| 103 | 0.0138 | 0.0021 | 0.0117 |
| 104 | 0.0139 | 0.0021 | 0.0118 |
| 105 | 0.0140 | 0.0021 | 0.0119 |

| | | | |
|---|---|---|---|
| 106 | 0.0140 | 0.0021 | 0.0119 |
| 107 | 0.0142 | 0.0021 | 0.0120 |
| 108 | 0.0142 | 0.0021 | 0.0121 |
| 109 | 0.0143 | 0.0021 | 0.0122 |
| 110 | 0.0144 | 0.0022 | 0.0123 |
| 111 | 0.0145 | 0.0022 | 0.0124 |
| 112 | 0.0146 | 0.0022 | 0.0124 |
| 113 | 0.0147 | 0.0022 | 0.0125 |
| 114 | 0.0148 | 0.0022 | 0.0126 |
| 115 | 0.0149 | 0.0022 | 0.0127 |
| 116 | 0.0150 | 0.0022 | 0.0128 |
| 117 | 0.0152 | 0.0023 | 0.0129 |
| 118 | 0.0152 | 0.0023 | 0.0130 |
| 119 | 0.0154 | 0.0023 | 0.0131 |
| 120 | 0.0155 | 0.0023 | 0.0131 |
| 121 | 0.0156 | 0.0023 | 0.0133 |
| 122 | 0.0157 | 0.0023 | 0.0133 |
| 123 | 0.0159 | 0.0024 | 0.0135 |
| 124 | 0.0159 | 0.0024 | 0.0136 |
| 125 | 0.0161 | 0.0024 | 0.0137 |
| 126 | 0.0162 | 0.0024 | 0.0138 |
| 127 | 0.0164 | 0.0025 | 0.0139 |
| 128 | 0.0165 | 0.0025 | 0.0140 |
| 129 | 0.0167 | 0.0025 | 0.0142 |
| 130 | 0.0167 | 0.0025 | 0.0142 |
| 131 | 0.0169 | 0.0025 | 0.0144 |
| 132 | 0.0170 | 0.0026 | 0.0145 |
| 133 | 0.0173 | 0.0026 | 0.0147 |
| 134 | 0.0174 | 0.0026 | 0.0148 |
| 135 | 0.0176 | 0.0026 | 0.0149 |
| 136 | 0.0177 | 0.0026 | 0.0150 |
| 137 | 0.0179 | 0.0027 | 0.0152 |
| 138 | 0.0180 | 0.0027 | 0.0153 |
| 139 | 0.0183 | 0.0027 | 0.0155 |
| 140 | 0.0184 | 0.0028 | 0.0156 |
| 141 | 0.0187 | 0.0028 | 0.0159 |
| 142 | 0.0188 | 0.0028 | 0.0160 |
| 143 | 0.0191 | 0.0029 | 0.0162 |
| 144 | 0.0192 | 0.0029 | 0.0163 |
| 145 | 0.0180 | 0.0027 | 0.0153 |
| 146 | 0.0181 | 0.0027 | 0.0154 |
| 147 | 0.0184 | 0.0028 | 0.0157 |
| 148 | 0.0186 | 0.0028 | 0.0158 |
| 149 | 0.0189 | 0.0028 | 0.0161 |
| 150 | 0.0191 | 0.0029 | 0.0162 |
| 151 | 0.0194 | 0.0029 | 0.0165 |
| 152 | 0.0196 | 0.0029 | 0.0167 |
| 153 | 0.0200 | 0.0030 | 0.0170 |
| 154 | 0.0202 | 0.0030 | 0.0172 |
| 155 | 0.0206 | 0.0031 | 0.0175 |
| 156 | 0.0208 | 0.0031 | 0.0177 |
| 157 | 0.0213 | 0.0032 | 0.0181 |
| 158 | 0.0215 | 0.0032 | 0.0183 |
| 159 | 0.0220 | 0.0033 | 0.0187 |
| 160 | 0.0222 | 0.0033 | 0.0189 |
| 161 | 0.0228 | 0.0034 | 0.0194 |
| 162 | 0.0231 | 0.0035 | 0.0196 |
| 163 | 0.0237 | 0.0035 | 0.0201 |
| 164 | 0.0240 | 0.0036 | 0.0204 |
| 165 | 0.0246 | 0.0037 | 0.0209 |
| 166 | 0.0250 | 0.0037 | 0.0212 |
| 167 | 0.0257 | 0.0039 | 0.0219 |
| 168 | 0.0261 | 0.0039 | 0.0222 |
| 169 | 0.0297 | 0.0044 | 0.0252 |
| 170 | 0.0301 | 0.0045 | 0.0256 |
| 171 | 0.0311 | 0.0047 | 0.0265 |

| | | | |
|---|---|---|---|
| 172 | 0.0316 | 0.0047 | 0.0269 |
| 173 | 0.0328 | 0.0049 | 0.0279 |
| 174 | 0.0334 | 0.0050 | 0.0284 |
| 175 | 0.0347 | 0.0052 | 0.0295 |
| 176 | 0.0355 | 0.0053 | 0.0302 |
| 177 | 0.0371 | 0.0055 | 0.0315 |
| 178 | 0.0379 | 0.0057 | 0.0323 |
| 179 | 0.0399 | 0.0060 | 0.0339 |
| 180 | 0.0410 | 0.0061 | 0.0348 |
| 181 | 0.0434 | 0.0065 | 0.0369 |
| 182 | 0.0448 | 0.0067 | 0.0381 |
| 183 | 0.0481 | 0.0072 | 0.0409 |
| 184 | 0.0500 | 0.0075 | 0.0425 |
| 185 | 0.0474 | 0.0071 | 0.0403 |
| 186 | 0.0501 | 0.0075 | 0.0426 |
| 187 | 0.0568 | 0.0085 | 0.0483 |
| 188 | 0.0613 | 0.0092 | 0.0521 |
| 189 | 0.0739 | 0.0097 | 0.0642 |
| 190 | 0.0834 | 0.0097 | 0.0737 |
| 191 | 0.1192 | 0.0097 | 0.1094 |
| 192 | 0.1639 | 0.0097 | 0.1542 |
| 193 | 0.5129 | 0.0097 | 0.5032 |
| 194 | 0.0971 | 0.0097 | 0.0874 |
| 195 | 0.0668 | 0.0097 | 0.0571 |
| 196 | 0.0532 | 0.0080 | 0.0452 |
| 197 | 0.0521 | 0.0078 | 0.0443 |
| 198 | 0.0464 | 0.0069 | 0.0394 |
| 199 | 0.0422 | 0.0063 | 0.0358 |
| 200 | 0.0389 | 0.0058 | 0.0331 |
| 201 | 0.0362 | 0.0054 | 0.0308 |
| 202 | 0.0340 | 0.0051 | 0.0289 |
| 203 | 0.0322 | 0.0048 | 0.0274 |
| 204 | 0.0306 | 0.0046 | 0.0260 |
| 205 | 0.0265 | 0.0040 | 0.0226 |
| 206 | 0.0254 | 0.0038 | 0.0216 |
| 207 | 0.0243 | 0.0036 | 0.0207 |
| 208 | 0.0234 | 0.0035 | 0.0199 |
| 209 | 0.0225 | 0.0034 | 0.0191 |
| 210 | 0.0217 | 0.0033 | 0.0185 |
| 211 | 0.0210 | 0.0031 | 0.0179 |
| 212 | 0.0204 | 0.0031 | 0.0173 |
| 213 | 0.0198 | 0.0030 | 0.0168 |
| 214 | 0.0192 | 0.0029 | 0.0164 |
| 215 | 0.0187 | 0.0028 | 0.0159 |
| 216 | 0.0183 | 0.0027 | 0.0155 |
| 217 | 0.0194 | 0.0029 | 0.0165 |
| 218 | 0.0189 | 0.0028 | 0.0161 |
| 219 | 0.0185 | 0.0028 | 0.0158 |
| 220 | 0.0182 | 0.0027 | 0.0154 |
| 221 | 0.0178 | 0.0027 | 0.0151 |
| 222 | 0.0175 | 0.0026 | 0.0149 |
| 223 | 0.0171 | 0.0026 | 0.0146 |
| 224 | 0.0168 | 0.0025 | 0.0143 |
| 225 | 0.0166 | 0.0025 | 0.0141 |
| 226 | 0.0163 | 0.0024 | 0.0138 |
| 227 | 0.0160 | 0.0024 | 0.0136 |
| 228 | 0.0158 | 0.0024 | 0.0134 |
| 229 | 0.0155 | 0.0023 | 0.0132 |
| 230 | 0.0153 | 0.0023 | 0.0130 |
| 231 | 0.0151 | 0.0023 | 0.0128 |
| 232 | 0.0149 | 0.0022 | 0.0126 |
| 233 | 0.0147 | 0.0022 | 0.0125 |
| 234 | 0.0145 | 0.0022 | 0.0123 |
| 235 | 0.0143 | 0.0021 | 0.0121 |
| 236 | 0.0141 | 0.0021 | 0.0120 |
| 237 | 0.0139 | 0.0021 | 0.0118 |

| | | | |
|---|---|---|---|
| 238 | 0.0138 | 0.0021 | 0.0117 |
| 239 | 0.0136 | 0.0020 | 0.0116 |
| 240 | 0.0134 | 0.0020 | 0.0114 |
| 241 | 0.0133 | 0.0020 | 0.0113 |
| 242 | 0.0131 | 0.0020 | 0.0112 |
| 243 | 0.0130 | 0.0019 | 0.0111 |
| 244 | 0.0129 | 0.0019 | 0.0109 |
| 245 | 0.0127 | 0.0019 | 0.0108 |
| 246 | 0.0126 | 0.0019 | 0.0107 |
| 247 | 0.0125 | 0.0019 | 0.0106 |
| 248 | 0.0123 | 0.0018 | 0.0105 |
| 249 | 0.0122 | 0.0018 | 0.0104 |
| 250 | 0.0121 | 0.0018 | 0.0103 |
| 251 | 0.0120 | 0.0018 | 0.0102 |
| 252 | 0.0119 | 0.0018 | 0.0101 |
| 253 | 0.0118 | 0.0018 | 0.0100 |
| 254 | 0.0117 | 0.0017 | 0.0099 |
| 255 | 0.0116 | 0.0017 | 0.0098 |
| 256 | 0.0115 | 0.0017 | 0.0097 |
| 257 | 0.0114 | 0.0017 | 0.0097 |
| 258 | 0.0113 | 0.0017 | 0.0096 |
| 259 | 0.0112 | 0.0017 | 0.0095 |
| 260 | 0.0111 | 0.0017 | 0.0094 |
| 261 | 0.0110 | 0.0016 | 0.0094 |
| 262 | 0.0109 | 0.0016 | 0.0093 |
| 263 | 0.0108 | 0.0016 | 0.0092 |
| 264 | 0.0107 | 0.0016 | 0.0091 |
| 265 | 0.0107 | 0.0016 | 0.0091 |
| 266 | 0.0106 | 0.0016 | 0.0090 |
| 267 | 0.0105 | 0.0016 | 0.0089 |
| 268 | 0.0104 | 0.0016 | 0.0089 |
| 269 | 0.0104 | 0.0015 | 0.0088 |
| 270 | 0.0103 | 0.0015 | 0.0087 |
| 271 | 0.0102 | 0.0015 | 0.0087 |
| 272 | 0.0101 | 0.0015 | 0.0086 |
| 273 | 0.0101 | 0.0015 | 0.0086 |
| 274 | 0.0100 | 0.0015 | 0.0085 |
| 275 | 0.0099 | 0.0015 | 0.0084 |
| 276 | 0.0099 | 0.0015 | 0.0084 |
| 277 | 0.0098 | 0.0015 | 0.0083 |
| 278 | 0.0097 | 0.0015 | 0.0083 |
| 279 | 0.0097 | 0.0014 | 0.0082 |
| 280 | 0.0096 | 0.0014 | 0.0082 |
| 281 | 0.0096 | 0.0014 | 0.0081 |
| 282 | 0.0095 | 0.0014 | 0.0081 |
| 283 | 0.0094 | 0.0014 | 0.0080 |
| 284 | 0.0094 | 0.0014 | 0.0080 |
| 285 | 0.0093 | 0.0014 | 0.0079 |
| 286 | 0.0093 | 0.0014 | 0.0079 |
| 287 | 0.0092 | 0.0014 | 0.0078 |
| 288 | 0.0092 | 0.0014 | 0.0078 |

```
----------------------------------------------------------------------
----------------------------------------------------------------------
Total soil rain loss =      0.77(In)
Total effective rainfall =      5.01(In)
Peak flow rate in flood hydrograph =   2524.87(CFS)
-----------------------------------------------------------------------
++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
                24 - H O U R   S T O R M
           R u n o f f     H y d r o g r a p h
----------------------------------------------------------------------
        Hydrograph in   5   Minute intervals ((CFS))

----------------------------------------------------------------------
Time(h+m) Volume Ac.Ft   Q(CFS)  0      650.0    1300.0    1950.0    2600.0
-----------------------------------------------------------------------
```

```
 0+ 5        0.0109       1.58  Q          |          |          |          |
 0+10        0.0603       7.17  Q          |          |          |          |
 0+15        0.1974      19.92  Q          |          |          |          |
 0+20        0.4536      37.19  Q          |          |          |          |
 0+25        0.8606      59.10  Q          |          |          |          |
 0+30        1.4184      81.00  VQ         |          |          |          |
 0+35        2.0650      93.89  VQ         |          |          |          |
 0+40        2.7765     103.31  VQ         |          |          |          |
 0+45        3.5241     108.55  VQ         |          |          |          |
 0+50        4.2961     112.09  VQ         |          |          |          |
 0+55        5.0823     114.16  VQ         |          |          |          |
 1+ 0        5.8752     115.13  VQ         |          |          |          |
 1+ 5        6.6736     115.93  VQ         |          |          |          |
 1+10        7.4777     116.75  VQ         |          |          |          |
 1+15        8.2874     117.56  VQ         |          |          |          |
 1+20        9.1017     118.24  VQ         |          |          |          |
 1+25        9.9184     118.59  VQ         |          |          |          |
 1+30       10.7376     118.95  VQ         |          |          |          |
 1+35       11.5594     119.31  VQ         |          |          |          |
 1+40       12.3836     119.68  VQ         |          |          |          |
 1+45       13.2104     120.05  |Q         |          |          |          |
 1+50       14.0398     120.42  |Q         |          |          |          |
 1+55       14.8717     120.80  |Q         |          |          |          |
 2+ 0       15.7063     121.18  |Q         |          |          |          |
 2+ 5       16.5435     121.56  |Q         |          |          |          |
 2+10       17.3833     121.95  |Q         |          |          |          |
 2+15       18.2259     122.33  |Q         |          |          |          |
 2+20       19.0711     122.73  |Q         |          |          |          |
 2+25       19.9191     123.12  |Q         |          |          |          |
 2+30       20.7698     123.53  |Q         |          |          |          |
 2+35       21.6233     123.93  |Q         |          |          |          |
 2+40       22.4796     124.34  |Q         |          |          |          |
 2+45       23.3388     124.75  |Q         |          |          |          |
 2+50       24.2008     125.17  |Q         |          |          |          |
 2+55       25.0657     125.58  |Q         |          |          |          |
 3+ 0       25.9335     126.01  |QV        |          |          |          |
 3+ 5       26.8043     126.43  |QV        |          |          |          |
 3+10       27.6780     126.87  |QV        |          |          |          |
 3+15       28.5547     127.30  |QV        |          |          |          |
 3+20       29.4345     127.74  |QV        |          |          |          |
 3+25       30.3173     128.19  |QV        |          |          |          |
 3+30       31.2033     128.64  |QV        |          |          |          |
 3+35       32.0923     129.09  |QV        |          |          |          |
 3+40       32.9845     129.55  |QV        |          |          |          |
 3+45       33.8799     130.01  | Q        |          |          |          |
 3+50       34.7785     130.48  | Q        |          |          |          |
 3+55       35.6803     130.95  | Q        |          |          |          |
 4+ 0       36.5854     131.43  | Q        |          |          |          |
 4+ 5       37.4939     131.91  | Q        |          |          |          |
 4+10       38.4057     132.40  | QV       |          |          |          |
 4+15       39.3209     132.88  | QV       |          |          |          |
 4+20       40.2395     133.38  | QV       |          |          |          |
 4+25       41.1616     133.88  | QV       |          |          |          |
 4+30       42.0872     134.40  | QV       |          |          |          |
 4+35       43.0163     134.91  | QV       |          |          |          |
 4+40       43.9490     135.43  | QV       |          |          |          |
 4+45       44.8853     135.95  | QV       |          |          |          |
 4+50       45.8252     136.48  | QV       |          |          |          |
 4+55       46.7689     137.02  | QV       |          |          |          |
 5+ 0       47.7163     137.56  | QV       |          |          |          |
 5+ 5       48.6674     138.11  | QV       |          |          |          |
 5+10       49.6224     138.67  | QV       |          |          |          |
 5+15       50.5813     139.22  | QV       |          |          |          |
 5+20       51.5440     139.79  | Q V      |          |          |          |
 5+25       52.5108     140.37  | Q V      |          |          |          |
 5+30       53.4815     140.95  | Q V      |          |          |          |
```

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 5+35      54.4562    141.54  | Q V     |         |         |         |
 5+40      55.4351    142.13  | Q V     |         |         |         |
 5+45      56.4181    142.73  | Q V     |         |         |         |
 5+50      57.4054    143.35  | Q V     |         |         |         |
 5+55      58.3968    143.96  | Q V     |         |         |         |
 6+ 0      59.3926    144.59  | Q V     |         |         |         |
 6+ 5      60.3927    145.22  | Q V     |         |         |         |
 6+10      61.3972    145.86  | Q V     |         |         |         |
 6+15      62.4062    146.50  | Q V     |         |         |         |
 6+20      63.4197    147.16  | Q V     |         |         |         |
 6+25      64.4378    147.82  | Q  V    |         |         |         |
 6+30      65.4606    148.50  | Q  V    |         |         |         |
 6+35      66.4880    149.18  | Q  V    |         |         |         |
 6+40      67.5202    149.88  | Q  V    |         |         |         |
 6+45      68.5572    150.57  | Q  V    |         |         |         |
 6+50      69.5991    151.29  | Q  V    |         |         |         |
 6+55      70.6459    152.00  | Q  V    |         |         |         |
 7+ 0      71.6978    152.73  | Q  V    |         |         |         |
 7+ 5      72.7547    153.47  | Q  V    |         |         |         |
 7+10      73.8169    154.22  | Q  V    |         |         |         |
 7+15      74.8842    154.98  | Q  V    |         |         |         |
 7+20      75.9569    155.75  | Q  V    |         |         |         |
 7+25      77.0349    156.53  | Q   V   |         |         |         |
 7+30      78.1184    157.33  | Q   V   |         |         |         |
 7+35      79.2075    158.13  | Q   V   |         |         |         |
 7+40      80.3021    158.95  | Q   V   |         |         |         |
 7+45      81.4025    159.77  | Q   V   |         |         |         |
 7+50      82.5086    160.61  | Q   V   |         |         |         |
 7+55      83.6206    161.46  | Q   V   |         |         |         |
 8+ 0      84.7386    162.33  | Q   V   |         |         |         |
 8+ 5      85.8627    163.21  | Q   V   |         |         |         |
 8+10      86.9929    164.11  | Q   V   |         |         |         |
 8+15      88.1293    165.01  | Q   V   |         |         |         |
 8+20      89.2721    165.93  | Q    V  |         |         |         |
 8+25      90.4213    166.87  | Q    V  |         |         |         |
 8+30      91.5771    167.82  | Q    V  |         |         |         |
 8+35      92.7395    168.78  | Q    V  |         |         |         |
 8+40      93.9087    169.77  | Q    V  |         |         |         |
 8+45      95.0848    170.76  | Q    V  |         |         |         |
 8+50      96.2679    171.79  | Q    V  |         |         |         |
 8+55      97.4580    172.81  | Q    V  |         |         |         |
 9+ 0      98.6555    173.87  | Q    V  |         |         |         |
 9+ 5      99.8603    174.93  | Q    V  |         |         |         |
 9+10     101.0726    176.03  | Q    V  |         |         |         |
 9+15     102.2925    177.13  | Q     V |         |         |         |
 9+20     103.5202    178.26  | Q     V |         |         |         |
 9+25     104.7557    179.40  | Q     V |         |         |         |
 9+30     105.9994    180.58  | Q     V |         |         |         |
 9+35     107.2512    181.77  | Q     V |         |         |         |
 9+40     108.5115    182.99  | Q     V |         |         |         |
 9+45     109.7802    184.22  | Q     V |         |         |         |
 9+50     111.0576    185.48  | Q     V |         |         |         |
 9+55     112.3439    186.76  | Q     V |         |         |         |
10+ 0     113.6392    188.08  | Q     V |         |         |         |
10+ 5     114.9437    189.41  | Q      V|         |         |         |
10+10     116.2577    190.79  | Q      V|         |         |         |
10+15     117.5812    192.17  | Q      V|         |         |         |
10+20     118.9145    193.60  | Q      V|         |         |         |
10+25     120.2578    195.05  |  Q     V|         |         |         |
10+30     121.6114    196.54  |  Q     V|         |         |         |
10+35     122.9754    198.05  |  Q     V|         |         |         |
10+40     124.3501    199.61  |  Q     V|         |         |         |
10+45     125.7357    201.19  |  Q     V|         |         |         |
10+50     127.1325    202.82  |  Q     V|         |         |         |
10+55     128.5407    204.47  |  Q      V         |         |         |
11+ 0     129.9607    206.18  |  Q      V         |         |         |
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11+ 5     131.3926    207.91  |  Q      V         |         |         |
11+10     132.8368    209.70  |  Q      V         |         |         |
11+15     134.2935    211.52  |  Q      V         |         |         |
11+20     135.7632    213.40  |  Q      V         |         |         |
11+25     137.2461    215.31  |  Q      V         |         |         |
11+30     138.7426    217.29  |  Q      V         |         |         |
11+35     140.2529    219.30  |  Q      |V        |         |         |
11+40     141.7776    221.39  |  Q      |V        |         |         |
11+45     143.3169    223.51  |  Q      |V        |         |         |
11+50     144.8714    225.71  |  Q      |V        |         |         |
11+55     146.4414    227.96  |  Q      |V        |         |         |
12+ 0     148.0274    230.29  |  Q      |V        |         |         |
12+ 5     149.6279    232.40  |  Q      |V        |         |         |
12+10     151.2390    233.93  |  Q      |V        |         |         |
12+15     152.8526    234.30  |  Q      |V        |         |         |
12+20     154.4643    234.01  |  Q      | V       |         |         |
12+25     156.0690    233.00  |  Q      | V       |         |         |
12+30     157.6675    232.11  |  Q      | V       |         |         |
12+35     159.2709    232.80  |  Q      | V       |         |         |
12+40     160.8839    234.21  |  Q      | V       |         |         |
12+45     162.5120    236.40  |  Q      | V       |         |         |
12+50     164.1581    239.01  |  Q      | V       |         |         |
12+55     165.8245    241.97  |  Q      |  V      |         |         |
13+ 0     167.5136    245.26  |  Q      |  V      |         |         |
13+ 5     169.2263    248.68  |  Q      |  V      |         |         |
13+10     170.9637    252.27  |  Q      |  V      |         |         |
13+15     172.7267    255.99  |  Q      |  V      |         |         |
13+20     174.5168    259.92  |  Q      |  V      |         |         |
13+25     176.3352    264.04  |   Q     |  V      |         |         |
13+30     178.1836    268.39  |   Q     |  V      |         |         |
13+35     180.0631    272.90  |   Q     |   V     |         |         |
13+40     181.9753    277.66  |   Q     |   V     |         |         |
13+45     183.9217    282.61  |   Q     |   V     |         |         |
13+50     185.9042    287.86  |   Q     |   V     |         |         |
13+55     187.9243    293.33  |   Q     |   V     |         |         |
14+ 0     189.9846    299.15  |   Q     |   V     |         |         |
14+ 5     192.0900    305.71  |   Q     |    V    |         |         |
14+10     194.2516    313.86  |   Q     |    V    |         |         |
14+15     196.4862    324.46  |   Q     |    V    |         |         |
14+20     198.8063    336.88  |    Q    |    V    |         |         |
14+25     201.2244    351.11  |    Q    |    V    |         |         |
14+30     203.7445    365.92  |    Q    |    V    |         |         |
14+35     206.3521    378.63  |    Q    |     V   |         |         |
14+40     209.0453    391.04  |     Q   |     V   |         |         |
14+45     211.8201    402.91  |     Q   |     V   |         |         |
14+50     214.6795    415.19  |     Q   |     V   |         |         |
14+55     217.6267    427.93  |     Q   |      V  |         |         |
15+ 0     220.6675    441.53  |     Q   |      V  |         |         |
15+ 5     223.8100    456.29  |      Q  |      V  |         |         |
15+10     227.0651    472.65  |      Q  |      V  |         |         |
15+15     230.4447    490.71  |      Q  |       V |         |         |
15+20     233.9638    510.98  |      Q  |       V |         |         |
15+25     237.6310    532.48  |       Q |       V |         |         |
15+30     241.4479    554.20  |       Q |       V |         |         |
15+35     245.4042    574.46  |       Q |        V|         |         |
15+40     249.5131    596.61  |        Q|        V|         |         |
15+45     253.8028    622.87  |        Q|        V|         |         |
15+50     258.3533    660.73  |         Q         V         |         |
15+55     263.3594    726.89  |         |Q        V         |         |
16+ 0     269.1084    834.75  |         | Q       |V        |         |
16+ 5     276.5085   1074.48  |         |     Q   |V        |         |
16+10     286.6211   1468.35  |         |         | Q       |         |
16+15     300.3294   1990.45  |         |         |  V      Q         |
16+20     316.3040   2319.51  |         |         |   V     |    Q    |
16+25     333.6929   2524.87  |         |         |     V   |       Q |
16+30     350.0409   2373.74  |         |         |      V  |     Q   |
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16+35      362.0535   1744.23  |         |         |     Q V |         |
16+40      371.6501   1393.42  |         |         |Q       V|         |
16+45      378.8849   1050.49  |         |     Q   |        V|         |
16+50      384.7998    858.84  |         |  Q      |         V         |
16+55      389.6346    702.02  |         Q         |         V         |
17+ 0      393.6743    586.56  |        Q|         |         V         |
17+ 5      397.3427    532.65  |       Q |         |         |V        |
17+10      400.7551    495.48  |      Q  |         |         |V        |
17+15      403.9218    459.81  |      Q  |         |         |V        |
17+20      406.8012    418.08  |     Q   |         |         |V        |
17+25      409.3627    371.93  |    Q    |         |         | V       |
17+30      411.7459    346.04  |    Q    |         |         | V       |
17+35      413.9934    326.34  |    Q    |         |         | V       |
17+40      416.1270    309.80  |   Q     |         |         | V       |
17+45      418.1651    295.94  |   Q     |         |         | V       |
17+50      420.1207    283.94  |   Q     |         |         | V       |
17+55      422.0043    273.50  |   Q     |         |         |  V      |
18+ 0      423.8246    264.31  |   Q     |         |         |  V      |
18+ 5      425.5892    256.23  |  Q      |         |         |  V      |
18+10      427.3075    249.49  |  Q      |         |         |  V      |
18+15      428.9917    244.54  |  Q      |         |         |  V      |
18+20      430.6508    240.90  |  Q      |         |         |  V      |
18+25      432.2938    238.56  |  Q      |         |         |  V      |
18+30      433.9233    236.60  |  Q      |         |         |   V     |
18+35      435.5310    233.45  |  Q      |         |         |   V     |
18+40      437.1151    230.01  |  Q      |         |         |   V     |
18+45      438.6727    226.15  |  Q      |         |         |   V     |
18+50      440.2034    222.26  |  Q      |         |         |   V     |
18+55      441.7072    218.36  |  Q      |         |         |   V     |
19+ 0      443.1844    214.48  |  Q      |         |         |   V     |
19+ 5      444.6360    210.78  |  Q      |         |         |   V     |
19+10      446.0634    207.26  |  Q      |         |         |   V     |
19+15      447.4678    203.91  |  Q      |         |         |    V    |
19+20      448.8500    200.70  |  Q      |         |         |    V    |
19+25      450.2107    197.57  |  Q      |         |         |    V    |
19+30      451.5508    194.58  | Q       |         |         |    V    |
19+35      452.8712    191.72  | Q       |         |         |    V    |
19+40      454.1726    188.97  | Q       |         |         |    V    |
19+45      455.4559    186.33  | Q       |         |         |    V    |
19+50      456.7216    183.79  | Q       |         |         |    V    |
19+55      457.9706    181.35  | Q       |         |         |    V    |
20+ 0      459.2034    179.00  | Q       |         |         |     V   |
20+ 5      460.4206    176.73  | Q       |         |         |     V   |
20+10      461.6227    174.55  | Q       |         |         |     V   |
20+15      462.8103    172.44  | Q       |         |         |     V   |
20+20      463.9838    170.40  | Q       |         |         |     V   |
20+25      465.1438    168.42  | Q       |         |         |     V   |
20+30      466.2906    166.51  | Q       |         |         |     V   |
20+35      467.4246    164.67  | Q       |         |         |     V   |
20+40      468.5463    162.87  | Q       |         |         |     V   |
20+45      469.6561    161.14  | Q       |         |         |     V   |
20+50      470.7542    159.45  | Q       |         |         |     V   |
20+55      471.8411    157.81  | Q       |         |         |      V  |
21+ 0      472.9170    156.22  | Q       |         |         |      V  |
21+ 5      473.9823    154.68  | Q       |         |         |      V  |
21+10      475.0372    153.18  | Q       |         |         |      V  |
21+15      476.0821    151.71  | Q       |         |         |      V  |
21+20      477.1172    150.29  | Q       |         |         |      V  |
21+25      478.1427    148.91  | Q       |         |         |      V  |
21+30      479.1589    147.56  | Q       |         |         |      V  |
21+35      480.1661    146.24  | Q       |         |         |      V  |
21+40      481.1644    144.96  | Q       |         |         |      V  |
21+45      482.1541    143.71  | Q       |         |         |      V  |
21+50      483.1354    142.48  | Q       |         |         |      V  |
21+55      484.1085    141.29  | Q       |         |         |      V  |
22+ 0      485.0736    140.13  | Q       |         |         |       V |
```
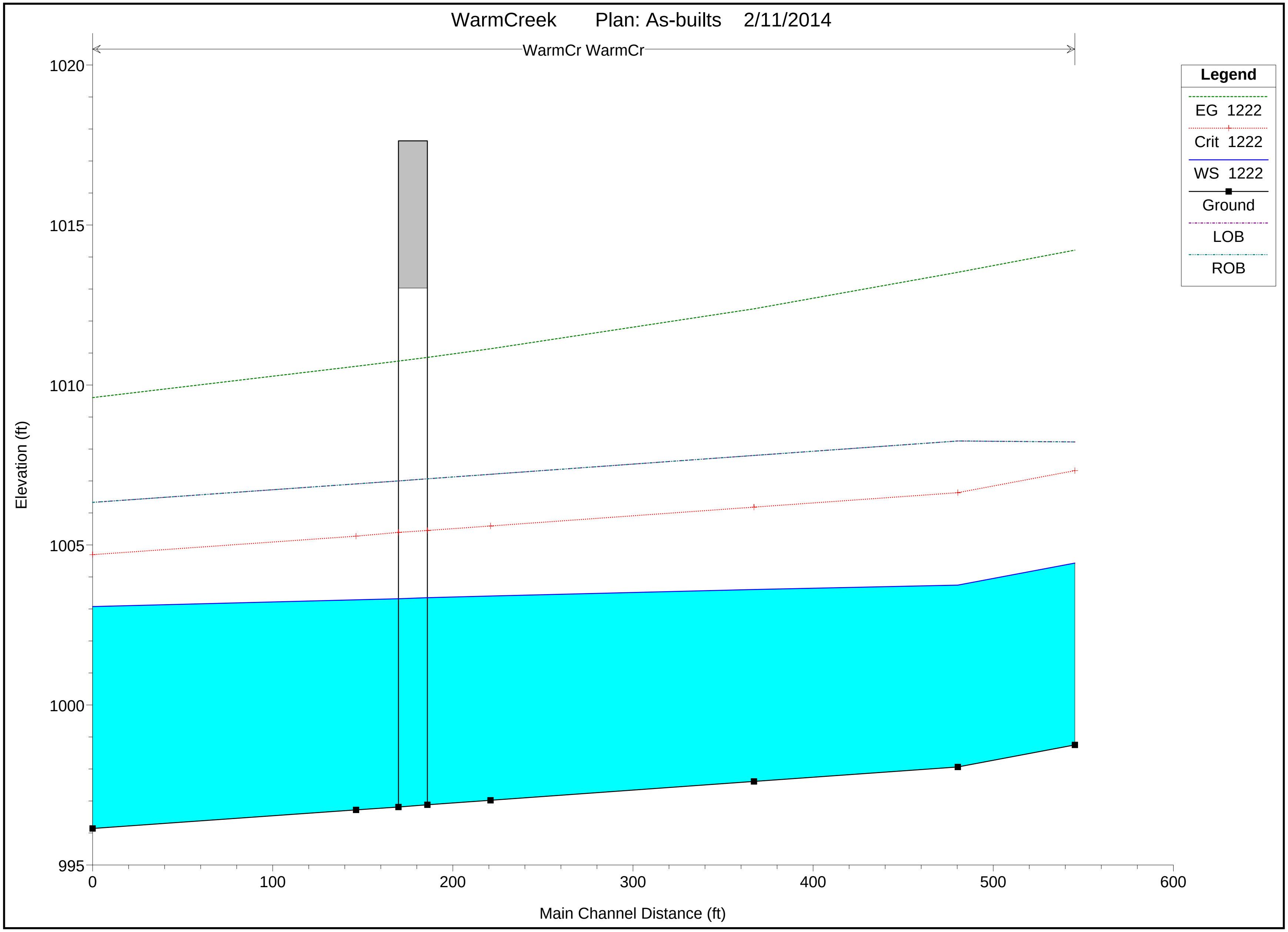
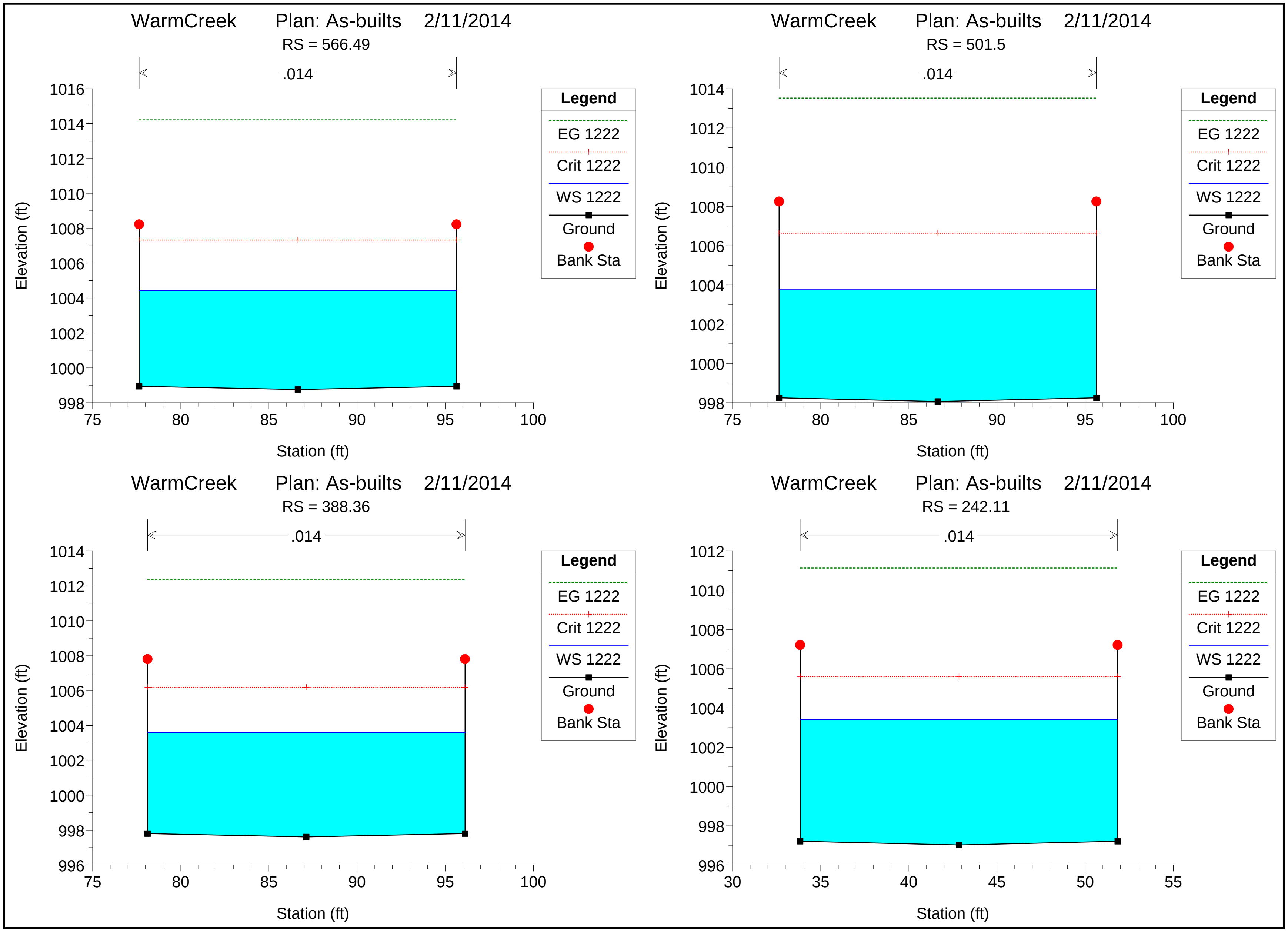
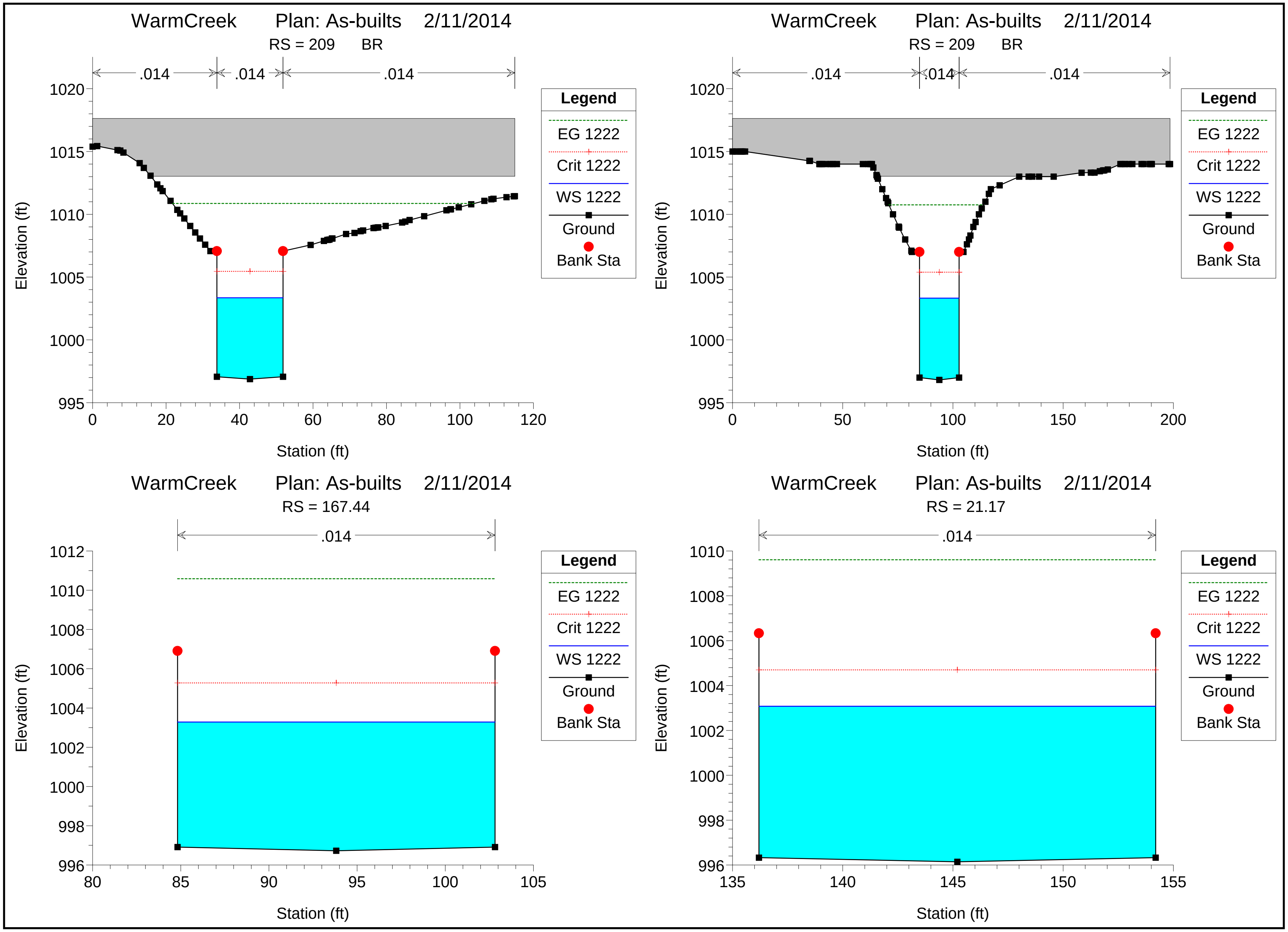

```
   22+ 5      486.0308    138.99  | Q         |         |         |        V |
   22+10      486.9804    137.88  | Q         |         |         |        V |
   22+15      487.9225    136.79  | Q         |         |         |        V |
   22+20      488.8572    135.73  | Q         |         |         |        V |
   22+25      489.7848    134.69  | Q         |         |         |        V |
   22+30      490.7054    133.67  | Q         |         |         |        V |
   22+35      491.6192    132.68  | Q         |         |         |        V |
   22+40      492.5262    131.70  | Q         |         |         |        V |
   22+45      493.4267    130.75  | Q         |         |         |        V |
   22+50      494.3207    129.81  |Q          |         |         |        V |
   22+55      495.2084    128.89  |Q          |         |         |        V |
   23+ 0      496.0898    127.99  |Q          |         |         |        V |
   23+ 5      496.9653    127.11  |Q          |         |         |        V |
   23+10      497.8348    126.25  |Q          |         |         |         V|
   23+15      498.6984    125.40  |Q          |         |         |         V|
   23+20      499.5563    124.57  |Q          |         |         |         V|
   23+25      500.4086    123.75  |Q          |         |         |         V|
   23+30      501.2554    122.95  |Q          |         |         |         V|
   23+35      502.0967    122.16  |Q          |         |         |         V|
   23+40      502.9327    121.39  |Q          |         |         |         V|
   23+45      503.7635    120.63  |Q          |         |         |         V|
   23+50      504.5892    119.89  |Q          |         |         |         V|
   23+55      505.4098    119.15  |Q          |         |         |         V|
   24+ 0      506.2255    118.43  |Q          |         |         |         V|
   24+ 5      507.0254    116.15  |Q          |         |         |         V|
   24+10      507.7822    109.89  |Q          |         |         |         V|
   24+15      508.4470     96.53  |Q          |         |         |         V|
   24+20      508.9896     78.78  |Q          |         |         |         V|
   24+25      509.3791     56.56  Q           |         |         |         V|
   24+30      509.6168     34.52  Q           |         |         |         V|
   24+35      509.7662     21.69  Q           |         |         |         V|
   24+40      509.8518     12.43  Q           |         |         |         V|
   24+45      509.9028      7.41  Q           |         |         |         V|
   24+50      509.9314      4.15  Q           |         |         |         V|
   24+55      509.9479      2.39  Q           |         |         |         V|
   25+ 0      509.9599      1.74  Q           |         |         |         V|
   25+ 5      509.9686      1.27  Q           |         |         |         V|
   25+10      509.9741      0.79  Q           |         |         |         V|
   25+15      509.9763      0.32  Q           |         |         |          V
-----------------------------------------------------------------------
```

# Attachment 2 – HEC-RAS Modeling Exhibits


WarmCreek Plan: As-builts 2/11/2014
WarmCr WarmCr
Legend
EG 1222
Crit 1222
WS 1222
Ground
LOB
ROB
Elevation (ft)
1020
1015
1010
1005
1000
995
0
100
200
300
400
500
600
Main Channel Distance (ft)



WarmCreek Plan: As-builts 2/11/2014
RS = 566.49
.014
Elevation (ft)
1016
1014
1012
1010
1008
1006
1004
1002
1000
998
75
80
85
90
95
100
Station (ft)
Legend
EG 1222
Crit 1222
WS 1222
Ground
Bank Sta
WarmCreek Plan: As-builts 2/11/2014
RS = 501.5
.014
Elevation (ft)
1014
1012
1010
1008
1006
1004
1002
1000
998
75
80
85
90
95
100
Station (ft)
Legend
EG 1222
Crit 1222
WS 1222
Ground
Bank Sta
WarmCreek Plan: As-builts 2/11/2014
RS = 388.36
.014
Elevation (ft)
1014
1012
1010
1008
1006
1004
1002
1000
998
996
75
80
85
90
95
100
Station (ft)
Legend
EG 1222
Crit 1222
WS 1222
Ground
Bank Sta
WarmCreek Plan: As-builts 2/11/2014
RS = 242.11
.014
Elevation (ft)
1012
1010
1008
1006
1004
1002
1000
998
996
30
35
40
45
50
55
Station (ft)
Legend
EG 1222
Crit 1222
WS 1222
Ground
Bank Sta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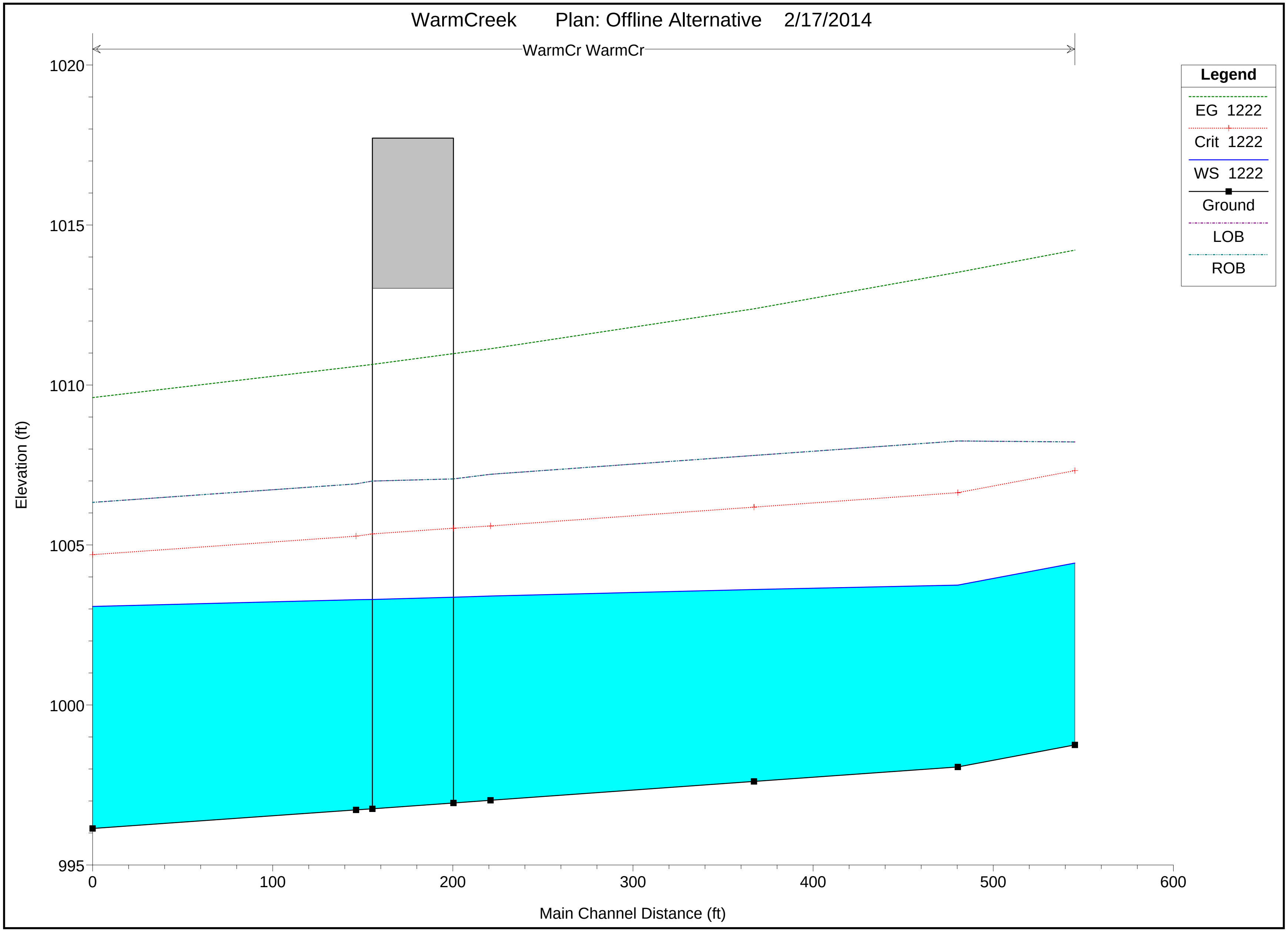
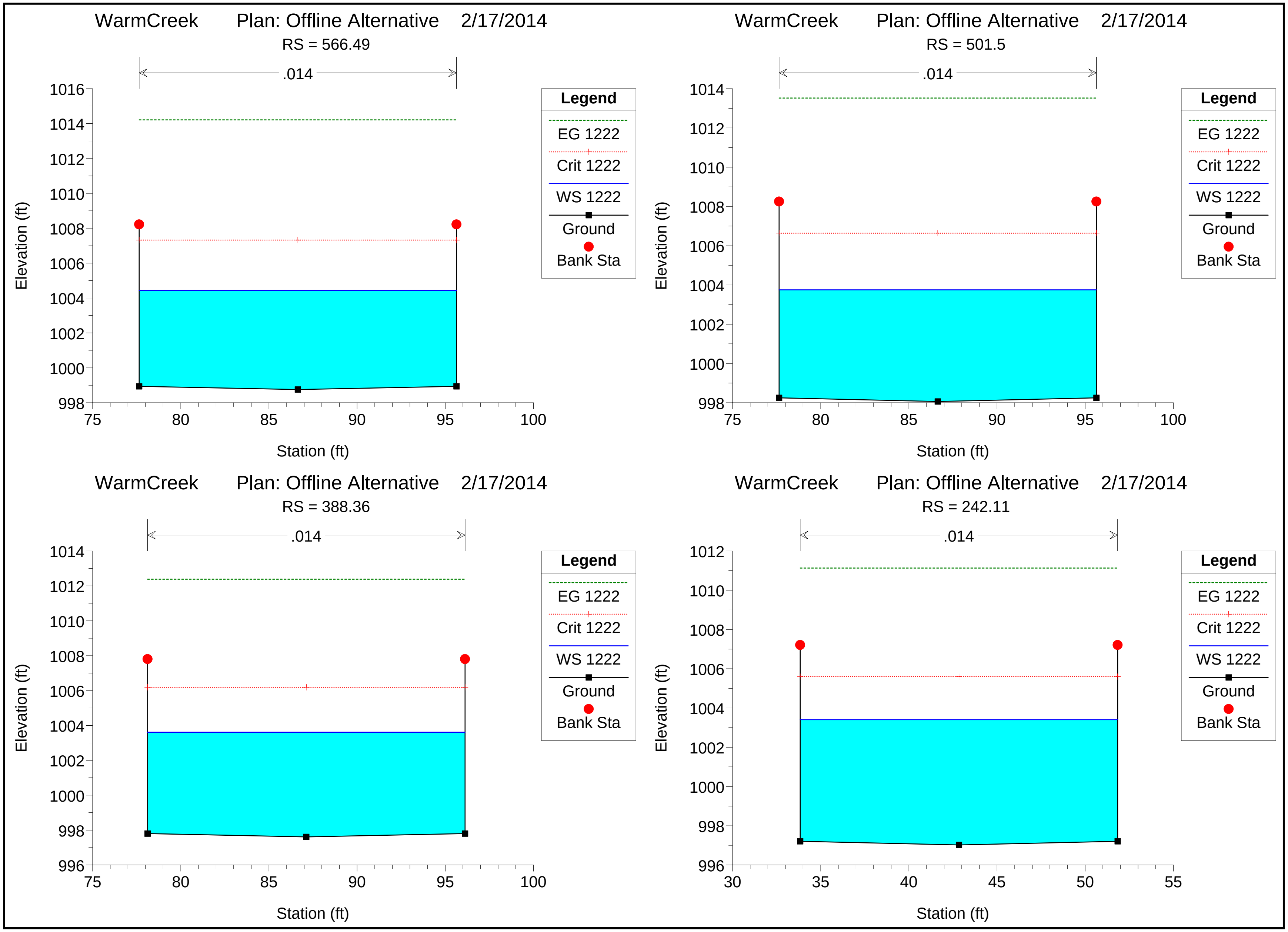
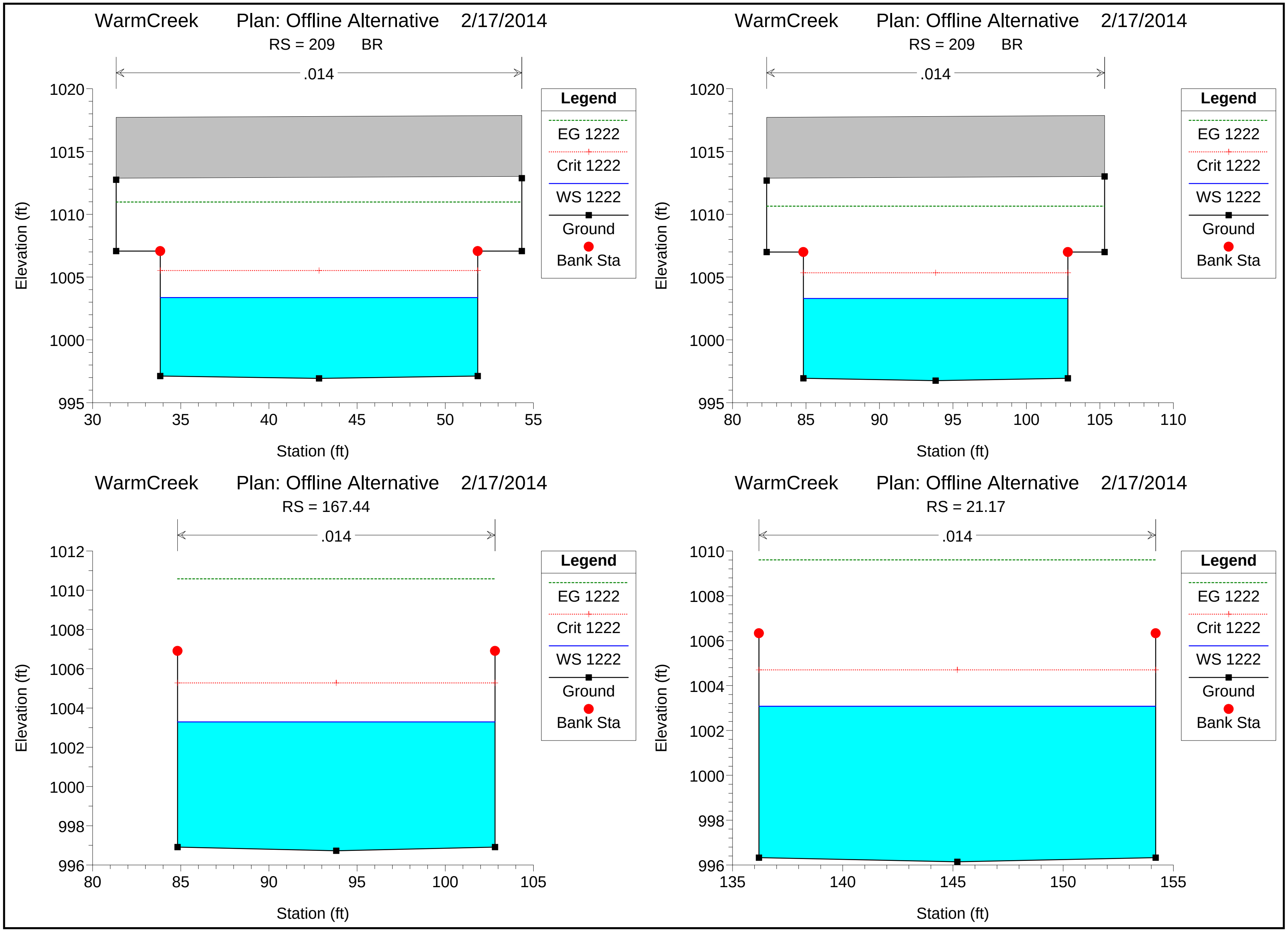
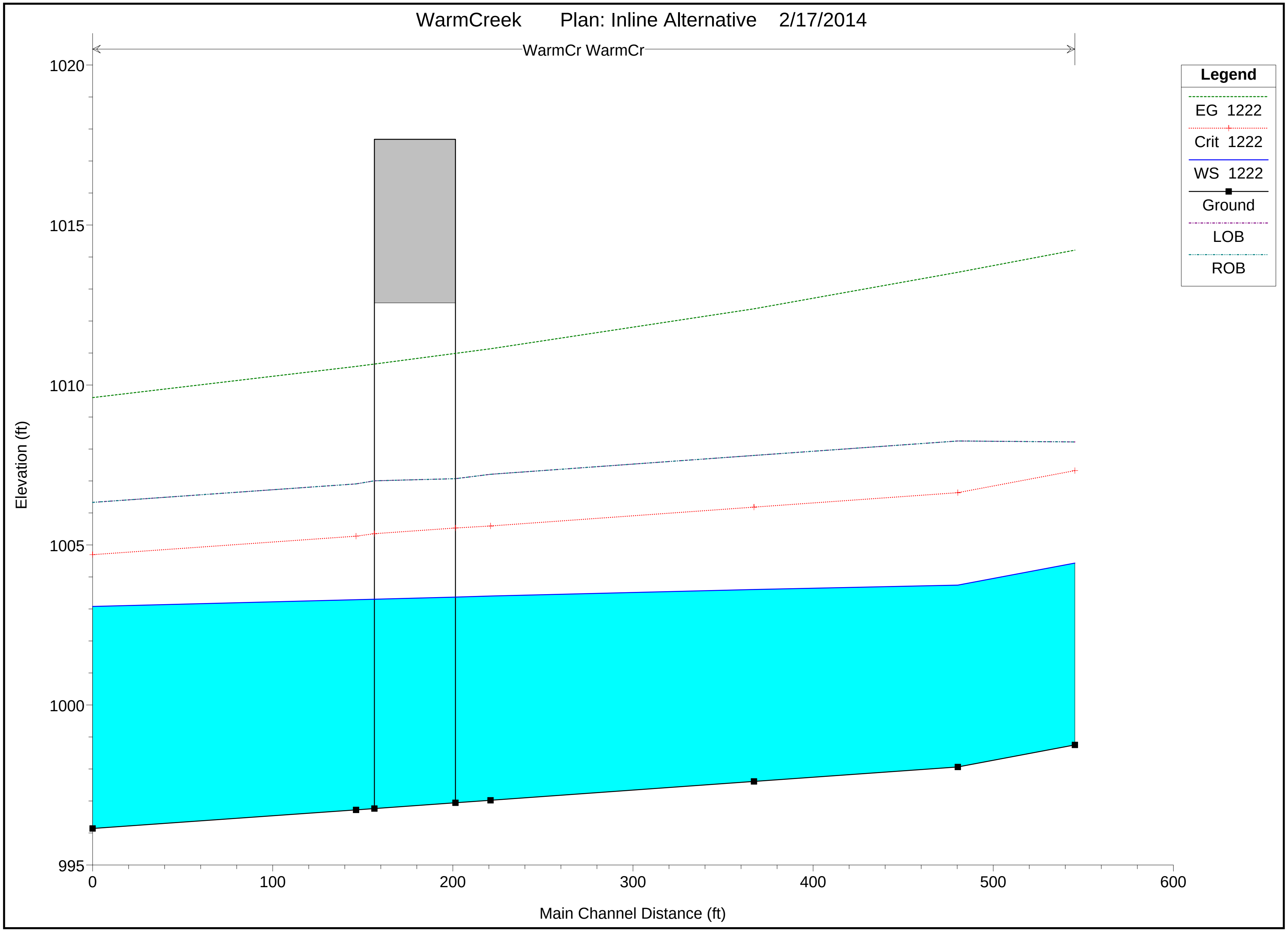
RS = 209 BR
.014
.014
.014
Elevation (ft)
Station (ft)
Legend
EG 1222
Crit 1222
WS 1222
Ground
Bank Sta
WarmCreek Plan: As-builts 2/11/2014
RS = 209 BR
.014
.014
.014
Elevation (ft)
Station (ft)
Legend
EG 1222
Crit 1222
WS 1222
Ground
Bank Sta
WarmCreek Plan: As-builts 2/11/2014
RS = 167.44
.014
Elevation (ft)
Station (ft)
Legend
EG 1222
Crit 1222
WS 1222
Ground
Bank Sta
WarmCreek Plan: As-builts 2/11/2014
RS = 21.17
.014
Elevation (ft)
Station (ft)
Legend
EG 1222
Crit 1222
WS 1222
Ground
Bank Sta

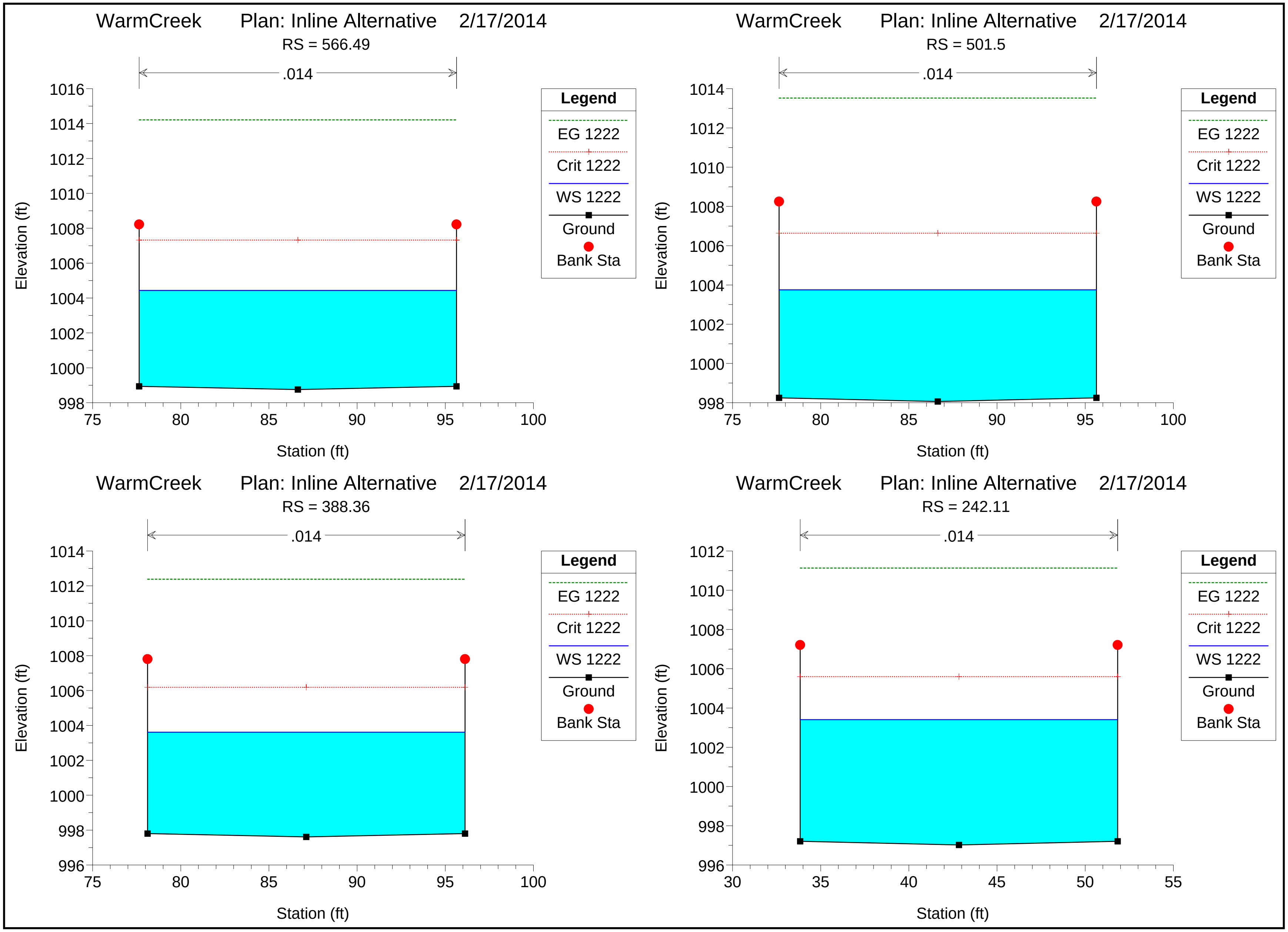


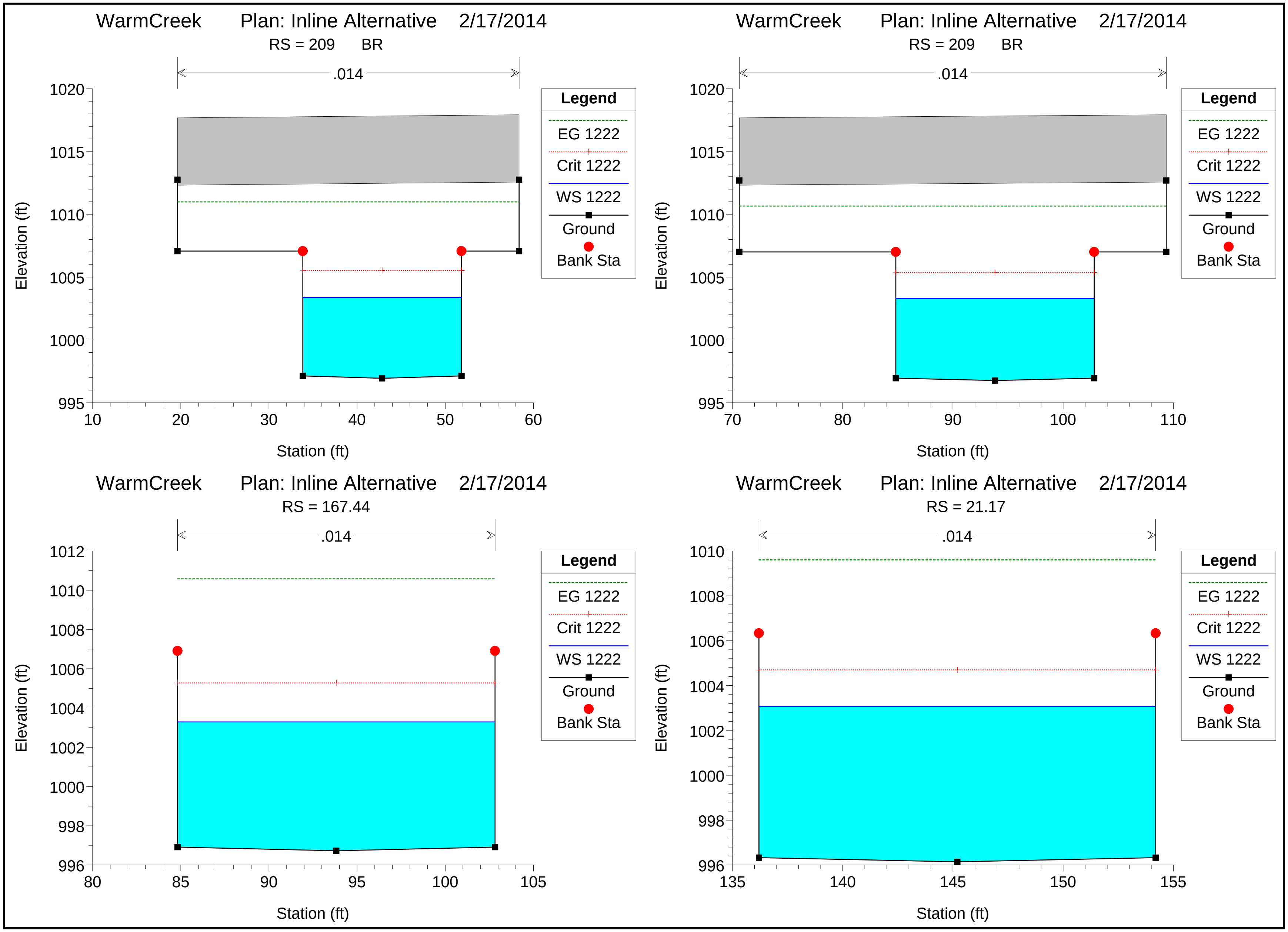
WarmCreek Plan: Offline Alternative 2/17/2014
WarmCr WarmCr
Legend
EG 1222
Crit 1222
WS 1222
Ground
LOB
ROB
Elevation (ft)
1020
1015
1010
1005
1000
995
0
100
200
300
400
500
600
Main Channel Distance (ft)


WarmCreek Plan: Offline Alternative 2/17/2014
RS = 566.49
.014
Elevation (ft)
Station (ft)
Legend
EG 1222
Crit 1222
WS 1222
Ground
Bank Sta
WarmCreek Plan: Offline Alternative 2/17/2014
RS = 501.5
.014
Elevation (ft)
Station (ft)
Legend
EG 1222
Crit 1222
WS 1222
Ground
Bank Sta
WarmCreek Plan: Offline Alternative 2/17/2014
RS = 388.36
.014
Elevation (ft)
Station (ft)
Legend
EG 1222
Crit 1222
WS 1222
Ground
Bank Sta
WarmCreek Plan: Offline Alternative 2/17/2014
RS = 242.11
.014
Elevation (ft)
Station (ft)
Legend
EG 1222
Crit 1222
WS 1222
Ground
Bank Sta


WarmCreek Plan: Offline Alternative 2/17/2014
RS = 209 BR
.014
Legend
EG 1222
Crit 1222
WS 1222
Ground
Bank Sta
Elevation (ft)
Station (ft)
WarmCreek Plan: Offline Alternative 2/17/2014
RS = 209 BR
.014
Legend
EG 1222
Crit 1222
WS 1222
Ground
Bank Sta
Elevation (ft)
Station (ft)
WarmCreek Plan: Offline Alternative 2/17/2014
RS = 167.44
.014
Legend
EG 1222
Crit 1222
WS 1222
Ground
Bank Sta
Elevation (ft)
Station (ft)
WarmCreek Plan: Offline Alternative 2/17/2014
RS = 21.17
.014
Legend
EG 1222
Crit 1222
WS 1222
Ground
Bank Sta
Elevation (ft)
Station (ft)


WarmCreek Plan: Inline Alternative 2/17/2014
WarmCr WarmCr
Legend
EG 1222
Crit 1222
WS 1222
Ground
LOB
ROB
Elevation (ft)
1020
1015
1010
1005
1000
995
0
100
200
300
400
500
600
Main Channel Distance (ft)


WarmCreek Plan: Inline Alternative 2/17/2014
RS = 566.49
.014
Elevation (ft)
Station (ft)
Legend
EG 1222
Crit 1222
WS 1222
Ground
Bank Sta
WarmCreek Plan: Inline Alternative 2/17/2014
RS = 501.5
.014
Elevation (ft)
Station (ft)
Legend
EG 1222
Crit 1222
WS 1222
Ground
Bank Sta
WarmCreek Plan: Inline Alternative 2/17/2014
RS = 388.36
.014
Elevation (ft)
Station (ft)
Legend
EG 1222
Crit 1222
WS 1222
Ground
Bank Sta
WarmCreek Plan: Inline Alternative 2/17/2014
RS = 242.11
.014
Elevation (ft)
Station (ft)
Legend
EG 1222
Crit 1222
WS 1222
Ground
Bank Sta



WarmCreek Plan: Inline Alternative 2/17/2014
RS = 209 BR
.014
Legend
EG 1222
Crit 1222
WS 1222
Ground
Bank Sta
Elevation (ft)
1020
1015
1010
1005
1000
995
10
20
30
40
50
60
Station (ft)
WarmCreek Plan: Inline Alternative 2/17/2014
RS = 209 BR
.014
Legend
EG 1222
Crit 1222
WS 1222
Ground
Bank Sta
Elevation (ft)
1020
1015
1010
1005
1000
995
70
80
90
100
110
Station (ft)
WarmCreek Plan: Inline Alternative 2/17/2014
RS = 167.44
.014
Legend
EG 1222
Crit 1222
WS 1222
Ground
Bank Sta
Elevation (ft)
1012
1010
1008
1006
1004
1002
1000
998
996
80
85
90
95
100
105
Station (ft)
WarmCreek Plan: Inline Alternative 2/17/2014
RS = 21.17
.014
Legend
EG 1222
Crit 1222
WS 1222
Ground
Bank Sta
Elevation (ft)
1010
1008
1006
1004
1002
1000
998
996
135
140
145
150
155
Station (ft)

# Attachment 3 – Hydraulic Analysis Results

HEC-RAS Plan: as-built River: WarmCr Reach: WarmCr Profile: 1222

| Reach | River Sta | Profile | Q Total | Min Ch El | W.S. Elev | Crit W.S. | E.G. Elev | E.G. Slope | Vel Chnl | Flow Area | Top Width | Froude # Chl |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | (cfs) | (ft) | (ft) | (ft) | (ft) | (ft/ft) | (ft/s) | (sq ft) | (ft) | |
| WarmCr | 566.49 | 1222 | 2525.00 | 998.75 | 1004.44 | 1007.32 | 1014.22 | 0.010642 | 25.10 | 100.62 | 18.00 | 1.87 |
| WarmCr | 501.5 | 1222 | 2525.00 | 998.06 | 1003.75 | 1006.63 | 1013.52 | 0.010635 | 25.09 | 100.64 | 18.00 | 1.87 |
| WarmCr | 388.36 | 1222 | 2525.00 | 997.61 | 1003.61 | 1006.19 | 1012.38 | 0.009134 | 23.77 | 106.24 | 18.00 | 1.72 |
| WarmCr | 242.11 | 1222 | 2525.00 | 997.02 | 1003.41 | 1005.60 | 1011.13 | 0.007651 | 22.31 | 113.20 | 18.00 | 1.57 |
| WarmCr | 209 | | Bridge | | | | | | | | | |
| WarmCr | 167.44 | 1222 | 2525.00 | 996.72 | 1003.29 | 1005.28 | 1010.59 | 0.007068 | 21.68 | 116.47 | 18.00 | 1.50 |
| WarmCr | 21.17 | 1222 | 2525.00 | 996.14 | 1003.08 | 1004.70 | 1009.61 | 0.006062 | 20.51 | 123.13 | 18.00 | 1.38 |

HEC-RAS Plan: Offline Alt River: WarmCr Reach: WarmCr Profile: 1222

| Reach | River Sta | Profile | Q Total | Min Ch El | W.S. Elev | Crit W.S. | E.G. Elev | E.G. Slope | Vel Chnl | Flow Area | Top Width | Froude # Chl |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | (cfs) | (ft) | (ft) | (ft) | (ft) | (ft/ft) | (ft/s) | (sq ft) | (ft) | |
| WarmCr | 566.49 | 1222 | 2525.00 | 998.75 | 1004.44 | 1007.32 | 1014.22 | 0.010642 | 25.10 | 100.62 | 18.00 | 1.87 |
| WarmCr | 501.5 | 1222 | 2525.00 | 998.06 | 1003.75 | 1006.63 | 1013.52 | 0.010635 | 25.09 | 100.64 | 18.00 | 1.87 |
| WarmCr | 388.36 | 1222 | 2525.00 | 997.61 | 1003.61 | 1006.19 | 1012.38 | 0.009134 | 23.77 | 106.24 | 18.00 | 1.72 |
| WarmCr | 242.11 | 1222 | 2525.00 | 997.02 | 1003.41 | 1005.60 | 1011.13 | 0.007651 | 22.31 | 113.20 | 18.00 | 1.57 |
| WarmCr | 209 | | Bridge | | | | | | | | | |
| WarmCr | 167.44 | 1222 | 2525.00 | 996.72 | 1003.29 | 1005.28 | 1010.58 | 0.007061 | 21.67 | 116.52 | 18.00 | 1.50 |
| WarmCr | 21.17 | 1222 | 2525.00 | 996.14 | 1003.08 | 1004.70 | 1009.61 | 0.006056 | 20.50 | 123.17 | 18.00 | 1.38 |

HEC-RAS  Plan: Inline Alt   River: WarmCr   Reach: WarmCr    Profile: 1222

| Reach | River Sta | Profile | Q Total | Min Ch El | W.S. Elev | Crit W.S. | E.G. Elev | E.G. Slope | Vel Chnl | Flow Area | Top Width | Froude # Chl |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | (cfs) | (ft) | (ft) | (ft) | (ft) | (ft/ft) | (ft/s) | (sq ft) | (ft) | |
| WarmCr | 566.49 | 1222 | 2525.00 | 998.75 | 1004.44 | 1007.32 | 1014.22 | 0.010642 | 25.10 | 100.62 | 18.00 | 1.87 |
| WarmCr | 501.5 | 1222 | 2525.00 | 998.06 | 1003.75 | 1006.63 | 1013.52 | 0.010635 | 25.09 | 100.64 | 18.00 | 1.87 |
| WarmCr | 388.36 | 1222 | 2525.00 | 997.61 | 1003.61 | 1006.19 | 1012.38 | 0.009134 | 23.77 | 106.24 | 18.00 | 1.72 |
| WarmCr | 242.11 | 1222 | 2525.00 | 997.02 | 1003.41 | 1005.60 | 1011.13 | 0.007651 | 22.31 | 113.20 | 18.00 | 1.57 |
| WarmCr | 209 | | Bridge | | | | | | | | | |
| WarmCr | 167.44 | 1222 | 2525.00 | 996.72 | 1003.29 | 1005.28 | 1010.58 | 0.007061 | 21.67 | 116.52 | 18.00 | 1.50 |
| WarmCr | 21.17 | 1222 | 2525.00 | 996.14 | 1003.08 | 1004.70 | 1009.61 | 0.006056 | 20.50 | 123.17 | 18.00 | 1.38 |

# Attachment 4 – Digital Information (CD)

# SANBAG Redlands Passenger Rail Project

Job Name: Hydraulic Impact Analysis – Twin Creek
Job Number: 170063
Client: SANBAG
Consultant: HDR Engineering, Inc.

This report and the analysis and design calculations contained herein have been prepared under the supervision of the following Registered Civil Engineer:

____________________________________ August 2012
Mark Seits, P.E. Date
CA 41103

# Table of Contents



# List of Attachments



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## List of Exhibits

## 1. Purpose

The rail from historic Warm Creek (that portion of Warm Creek that was not combined with East Twin Creek and Warm Creek Improvements) to Mill Creek Zanja is proposed to be improved as part of the Redlands Passenger Rail Project (RPRP) (see Exhibit 1). This report covers the hydraulic impact analysis on the rail from Twin Creek to the Santa Ana River. AT&SF Bridge 2.2 (Bridge 2.2) is the rail crossing over Twin Creek. No improvements will be made for the existing bridge. The rail operation will change from its existing freight-only operation to current standards required for regular passenger rail operations. As part of this project, recommendations, including hydraulic analysis, are being provided to assist in this process.

The purpose of the hydraulic modeling is: (1) to evaluate the hydraulic impact of Twin Creek on the rail from the Twin Creek crossing to the Santa Ana River crossing, analyze the existing hydraulic condition of the Twin Creek crossing to establish current conditions, considering Federal Emergency Management Agency (FEMA) models and updated site conditions; and (2) to evaluate the hydraulic impact of Twin Creek on Bridge 2.2.

## 2. Background

The RPRP will design a double track alignment for passenger and freight service from the proposed San Bernardino Transit Center east to the University of Redlands. The Redlands Corridor Strategic Plan (RCSP) was developed by San Bernardino Associated Governments (SANBAG) to address the transportation needs of the Redlands Corridor, assess the capability of transit service and multimodal improvements to meet mobility needs, and describe a course of action to implement transit service in the Redlands Corridor in a cost effective manner. The first phase of the RCSP calls for the development of a passenger rail service operating between the San Bernardino Transit Center and the University of Redlands, a distance of approximately nine miles.

The general hydraulic modeling approach was to initially review hydraulic models from FEMA to examine flooding conditions in the Twin Creek reach with AT&SF Bridge 2.2. A revised hydraulic model was developed of the project area based on additional information to model existing conditions through the bridge and to evaluate the water surface elevation for the 100-year flood.

The Twin Creek study reach is located from the confluence with the Santa Ana River downstream to approximately 500 feet upstream of Bridge 2.2. Exhibit 2 shows the limits of the analysis. Total reach length is approximately 9,200 feet. The reach upstream of Bridge 2.2 is a rectangular concrete channel. The channel transitions to a trapezoidal soft-bottom channel with riprap side slopes just downstream of Bridge 2.2. The channel was constructed in the late 1950s by the U.S. Army Corps of Engineers (USACE). Figure 1 shows a typical section of Twin Creek downstream of Bridge 2.2. Figure 2 shows the downstream face of existing AT&SF Bridge 2.2. Hydraulic analysis is required to evaluate whether the existing bridge meets current design requirements. There are four bridge structures in this reach. Table 1 shows the locations of the structures by HEC-RAS river station (RS).

**Figure 1: Twin Creek Downstream of AT&SF Bridge 2.2**

**Figure 2: Existing AT&SF Bridge 2.2 – Downstream Face**

**Table 1: Structures in Twin Creek Reach**

| Structure | Approximate RS Location |
|---|---|
| AT&SF Railroad Bridge 2.2 | 8705.59 |
| Central Ave | 6654.79 |
| Orange Show Rd | 4340 |
| Golf Cart Bridge | 1410 |

The existing effective FEMA HEC-2 model was obtained for Twin Creek which was named as Warm Creek in the model. It is dated August 1991. The HEC-2 model covers from the Santa Ana River confluence to Bridge 2.2. A more recent model prepared by Tetra Tech covers from the Santa Ana River confluence to downstream of Orange Show Road for the Lower Warm Creek levee certification project (Tetra Tech 2009). Tetra Tech provided the topographic map which was based on a January 14, 2008, flight. The topographic map covers from the Santa Ana River confluence to Central Avenue. The horizontal control is based on North American Datum (NAD) 1983 (National Geodetic Survey 1986) and the vertical control is based on North American Vertical Datum (NAVD) 1988 (National Geodetic Survey 1991).

Modeling of Twin Creek and Bridge 2.2 was conducted using the USACE Hydrologic Engineering Center River Analysis System (HEC-RAS v4.1) program (USACE 2010). All reference topography is based on the NAVD 1988 datum (National Geodetic Survey 1991). Due to the limitation of the recent data, the reach is broken into three sub-reaches. See Table 2 for reach description and limits.

**Table 2: Reach Limits**

| Channel Reach (River Station) | Limits | Source |
|---|---|---|
| Lower Reach (RS 31-4340) | Santa Ana River Confluence to downstream of Orange Show Road | Tetra Tech Lower Warm Creek Levee Certification |
| Middle Reach (RS 4479-6793) | Orange Show Road to Central Avenue | HDR model based on the topo provided by Tetra Tech |
| Upper Reach (RS 6843-9236) | Central Avenue to upstream of AT&SF Bridge 2.2 | FEMA HEC-2 model and As-built plans |

The standard freeboard criteria selected for the bridge (in the following priority) are shown below. For this project, the 50-year flow rate is not available; therefore, only the 100-year flow rate was evaluated.

1. 100-year water surface elevation below bridge low chord;
2. 100-year energy grade line (EGL) elevation below top of track subgrade and 50-year water surface [hydraulic grade line (HGL)] elevation below bridge low chord;
3. 50-year water surface (HGL) elevation below bridge low chord; and
4. No increase of water surface elevations within project area.

This report presents hydraulic analysis results; however, it does contain some assumptions and approximations. Prior to 100% design, the assumptions and approximations made within this report should be verified.

# 3. Hydrology

The Twin Creek 100-year flowrate from the FEMA 2008 Flood Insurance Study (FIS) is 13,500 cfs upstream of Santa Ana River confluence (Twin Creek is listed as Lower Warm Creek) which agrees with the discharge used in the effective HEC-2 model. Tetra Tech performed hydrologic analysis for Lower Warm Creek and the flowrate was determined to be 12,300 cfs at Orange Show Road and 70,000 cfs at the Santa Ana River. The 100-year discharge of 13,500 cfs was used for this evaluation of Bridge 2.2. With the Seven Oaks Dam in place, the Santa Ana River at E Street flood discharges have been reduced.

# 4. Hydraulic Modeling

## 4.1 Modeling Overview

Hydraulic modeling was conducted using the USACE HEC-RAS (v.4.1) program. Existing FEMA effective modeling was available for the Twin Creek reach. Tetra Tech prepared the Lower Warm Creek Levee certification in 2009. The hydraulic analysis from that study covers from the Santa Ana River confluence to downstream of Orange Show Road. It was used for the lower reach of the HDR model. Tetra Tech provided the topographic map flown in 2008 from Orange Show Road to Central Avenue. HDR developed the middle reach model based on this topographic information. The FEMA HEC-2 model was used for as the basis for the upper reach – from Central Avenue to the AT&SF bridge. Based on the as-built plan (USACE 1958a), the HEC-RAS model was then extended approximately 540 feet upstream of Bridge 2.2. The three reaches were combined to create the HDR HEC-RAS model. There are four bridge structures in this reach: Golf Cart bridge, Orange Show Road, Central Avenue, and the AT&SF railroad bridge.

For the middle reach modeling, channel geometry was generated based on the topographic map by using HEC-GeoRAS program (v.4.1.1), an extension for support of HEC-RAS using ArcGIS. An approximate centerline was laid out along the channel. Cross-sections were cut and perpendicular to the channel centerline. The cross-section interval is approximately 300 feet. Additional cross-sections were added at bridge locations.

The combined model is used to evaluate the hydraulic conditions of the existing Bridge 2.2 and the impact of Twin Creek on the railroad between Bridge 2.2 and the Santa Ana River confluence.

## 4.2 Model Inputs

### 4.2.1 Existing Condition

The original effective model used the HEC-2 (v. 1990) program. The model files were provided by FEMA. The reach is shown on the FEMA Flood Insurance Rate Map (FIRM) 06071C8683H. See Exhibit 4- FEMA FIRM 06071C8683H. The FIRM panel shows that the rail is located in FEMA

Zone A. The Twin Creek channel downstream of Bridge 2.2 is in Zone AE and the channel upstream of Bridge 2.2 is in Zone A. The limit of detailed study ends at just downstream of Bridge 2.2. The channel transitions from a trapezoid shape downstream of Bridge 2.2 to a concrete rectangular channel upstream of the Bridge. The model was modified as following:

- The HEC-2 model was assumed to be on NGVD 29 datum. The lower and middle reach were based on NAVD 88. The upper reach was converted to NAVD 88 by adding 2.5 feet to elevations in NGVD 29. The Corpscon program was used to determine the conversion factor (USACE 2004). The middle point coordinates (N34.089, W117.284) between Central Avenue and Bridge 2.2 were used to determine the conversion factor.
- Manning's *n* values were kept consistent with the existing models and verified with aerial imagery.
- Ineffective flow areas were added to cross-sections as needed.
- The lowest base of rail is at Elevation 1008.68 (NGVD29), which is at Elevation 1011.18 (NAVD 88) (P.E. RY. Bridge to Central Avenue Plans [USACE 1958b]).
- The bridge was modeled using the energy equation for low flow and the pressure/weir option for high flow.
- A rating curve from the Tetra Tech HEC-RAS levee certification model was used as the downstream boundary condition at the Santa Ana River.
- The model was run under mixed flow condition, because upstream of the bridge is concrete channel and downstream of the bridge is trapezoidal soft-bottom channel. The flow regime changes from supercritical to subcritical after passing through the bridge.
- Existing bridge geometries were kept the same as in the original levee certification and HEC-2 model.
- Orange Show Road bridge was not modeled due to no information was available. The bridge is over 4,000 feet downstream of the Bridge 2.2. The supercritical flow goes through the Bridge 2.2 and has a hydraulic jump downstream of the Bridge 2.2. Therefore, Orange Show Road bridge will not have an impact on the water surface at Bridge 2.2.

## 4.3 Model Results

A hydraulic analysis was conducted to generate a water surface profile for the channel and Bridge 2.2 for the 100-year flowrate. The flow runs supercritical upstream of the bridge and has a hydraulic jump just downstream of the bridge. The hydraulic jump occurs because the channel transitions from a 60-foot wide rectangular concrete channel upstream of the bridge and to an approximately 200-foot wide trapezoidal earthen bottom channel downstream of the bridge. Hydraulic results at river station 8713.44 which is just upstream of Bridge 2.2 are shown in Table 3. Figure 3 shows the profile at existing Bridge 2.2. Full hydraulic model results are shown in Attachment 2 (Hydraulic Analysis Results).

**Table 3: Hydraulic Results at Cross Section 8713.44**

| | | Existing Bridge |
|---|---|---|
| 100-Yr event | WSE | 995.63 |
| | EGL | 1009.65 |
| | Velocity | 30.05 |
| | Froude # | 1.93 |

WSE = water surface elevation (ft); EGL = energy grade line elevation (ft); VCH = main channel average velocity (ft/s); All elevations are NAVD 1988.

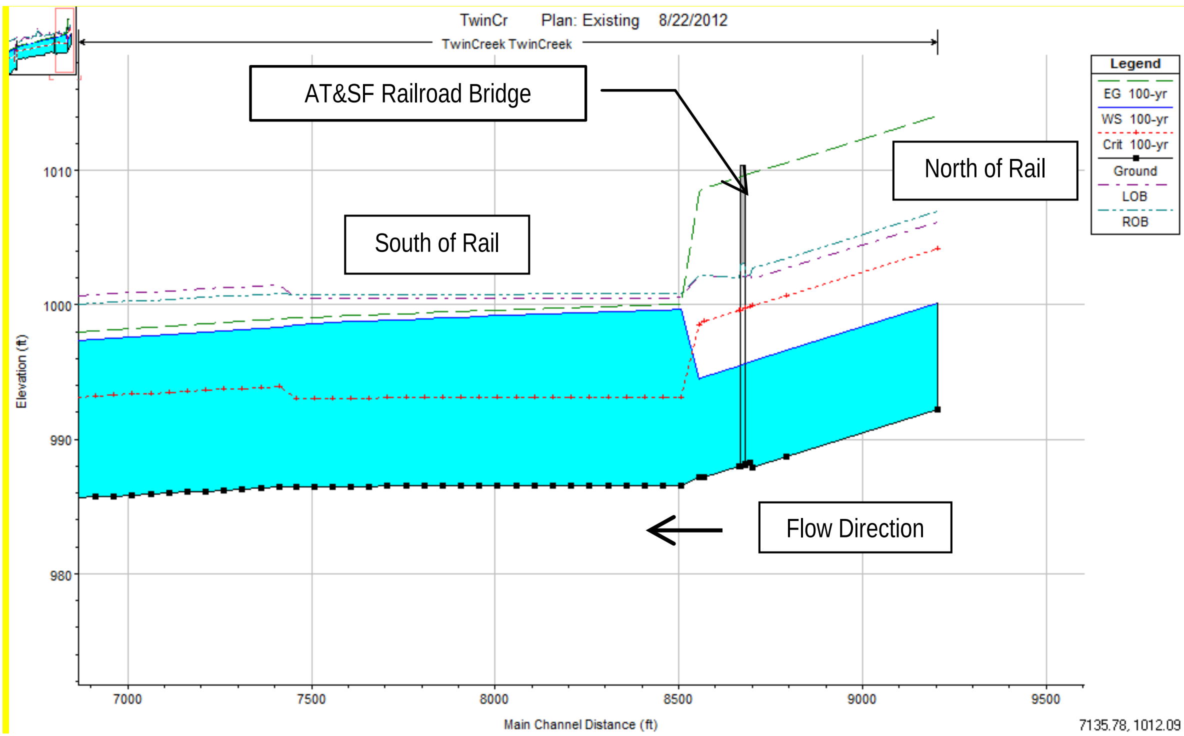



**Figure 3: Profile of Existing Condition**

The hydraulic criteria selected for the bridge (in the following priority) are presented below in Table 4. The existing bridge meets all criteria except the Energy Grade Line Elevation (EGL) criterion. Meeting 100 year criteria therefore meets 50-year by default. The reach upstream of Bridge 2.2 is a concrete channel. A high EGL is expected because the high velocity of approximately 30 feet per second creates a large velocity head. Because there is over 6 feet of freeboard between the 100-year water surface elevation and the bridge low chord, it would not be anticipated for debris to lodge under the bridge and cause the water surface elevation to reach the EGL. The EGL criterion could be exempted for this bridge over a concrete channel.

**Table 4: Hydraulic Freeboard Criteria (Existing Condition)**

| Criterion | Standard | Existing Model Results | Criterion Met? |
|---|---|---|---|
| 1. 100-yr WSE < Low Chord | Low Chord = 1002.01 | 100-yr WSE = 995.63 | Yes |
| 2. 100-yr EGL < Top of SBGD | Top of SBGD = 1007.5* | 100-yr EGL = 1009.65 | No |
| 3. Proposed WSE ≤ Existing WSE | Existing 100-yr WSE = 995.63 | Proposed 100-yr WSE = N/A | Yes |
| WSE = water surface elevation (ft); EGL = energy grade line elevation (ft); SBGD = subgrade. All elevations are NAVD 1988.<br>* Estimated based on the 1'countour. Top of rail is at 1010, subtract 2.5' to obtain the Top of SBGD at 1007.5 | | | |

## 4.4 Comparisons

Table 5 shows the comparison between FEMA Base Flood Elevation (BFE) and HDR model results. The most upstream BFE is available at Station 8250 and the existing AT&SF Bridge 2.2 is located at Station 8705. Based on the results, the HDR model water surface is higher than the BFE at upstream and middle portion, and lower than BFE at lower reach. The existing and proposed rail is at least 8.6 feet above the water surface elevation. The rail from downstream of Bridge 2.2 to Santa Ana confluence will not affect or be affected by the hydraulic impact of Twin Creek.

**Table 5: Comparison Between BFE and HDR Model**

| Station | BFE (feet) | HDR WS (feet) | Difference (feet) | Existing Rail Elevation (feet)* | Proposed TOR (feet) |
|---|---|---|---|---|---|
| 1530 | 992 | 990.38 | -1.62 | N/A | N/A |
| 2124 | 993 | 991.53 | -1.47 | N/A | N/A |
| 4114 | 994 | 994.04 | 0.04 | 1011 | 1013.0 |
| between (5625,5854) | 995 | 996.15 | 1.14 | 1007 | 1006.6 |
| 6793 | 996 | 997.10 | 1.10 | 1008 | 1008.6 |
| 7210 | 997 | 997.92 | 0.92 | 1008 | 1007.2 |
| 7646 | 998 | 998.75 | 0.75 | 1008 | 1007.3 |
| 8250 | 999 | 999.40 | 0.40 | 1008 | 1010 |
| *Rail elevations are approximate. They were measured from the contour along the rail. | | | | | |

Based on the hydraulic analysis, the 100-year flow is contained in the channel for the study reach. The FIRM shows the railroad is in Zone A. It shows a breakout just upstream of Bridge 2.2. This might be due to the subcritical flow regime used in the original HEC-2 model. Since there is a concrete channel upstream and through Bridge 2.2, a mixed flow regime is considered appropriate to use to calculate the water surface. In that case, flow is within the channel upstream of Bridge 2.2 also.

# 5. Conclusions

Using the data and resources available, the hydraulic conditions were modeled for Bridge 2.2 for existing condition. The existing bridge meets hydraulic criteria.

The rail and water surface elevation from downstream of Bridge 2.2 to Santa Ana confluence were compared; the rail will not affect or be affected by Twin Creek at existing condition. The 100-year water surface is contained within the channel for the study reach.

If there were a flow breakout from the channel as shown on the FIRM panel, the area outside of the channel is higher on both sides (including the rail), so overflow will be contained within channel section (i.e., no breakout to the south); it is uncertain if breakout could occur further upstream from the bridge (would require additional data to extend model). If an upstream breakout did occur, it would likely flow south in a shallow flow condition to the Santa Ana River.

## 6. References

County of San Bernardino. 1986. San Bernardino County Hydrology Manual.

Federal Emergency Management Agency (FEMA).1991. FEMA Effective Model for Santa Ana River. HEC-2 format.

Federal Emergency Management Agency. 2008. San Bernardino County Flood Insurance Study.

National Geodetic Survey. 1986. North American Datum (NAD) 1983.

National Geodetic Survey. 1991. North American Vertical Datum (NAVD) 88.

Tetra Tech. 2009. Lower Warm Creek Levees Levee Certification Report.

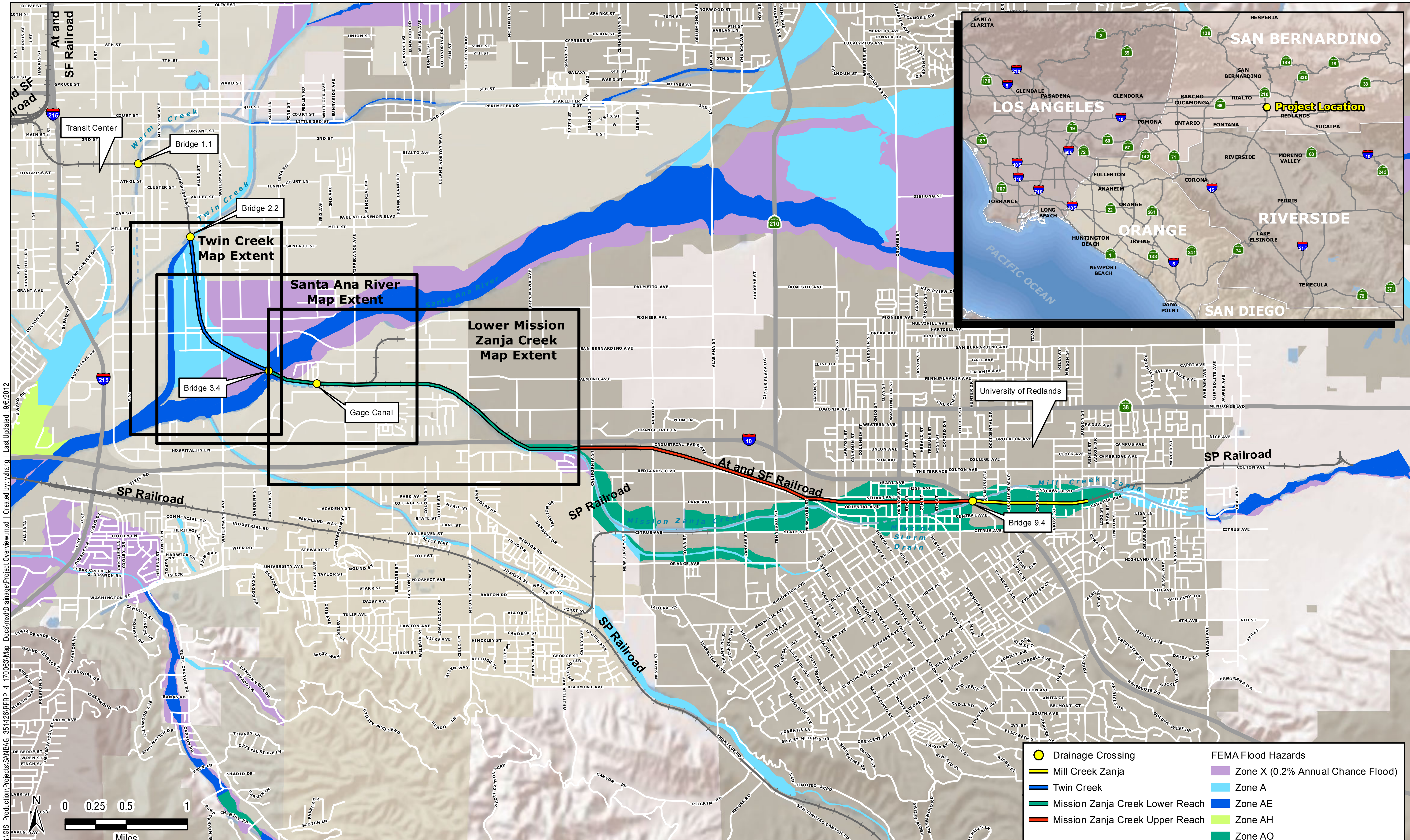
U.S. Army Corps of Engineers (USACE). 1958a. East Twin and Warm Creeks Channel, Central Avenue to Santa Ana River, Sta 159+16.05 to Sta 90+00 (Mile 1.50 to Mile 0.19).

U.S. Army Corps of Engineers. 1958b. East Twin and Warm Creeks Channel, P.E. RY. Bridge to Central Avenue Plans.

U.S. Army Corps of Engineers. 2004. Corpscon 6.0.1.

U.S. Army Corps of Engineers. 2010. HEC-RAS v.4.1 User's Manual and Technical Reference Manual.

## Exhibit 1: RPRP Project Overview

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ONE COMPANY | *Many Solutions*

# Project Overview
**EXHIBIT 1**

SANBAG | Redlands Passenger Rail Project | Hydraulic Impact Report

**Exhibit 2: Twin Creek Reach Limits**


# Twin Creek

**EXHIBIT 2**

SANBAG | Redlands Passenger Rail Project | Twin Creek Report

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# Exhibit 3: Modeling Overview – Cross-Sections

**Exhibit 3 – Modeling Overview – Cross Sections**

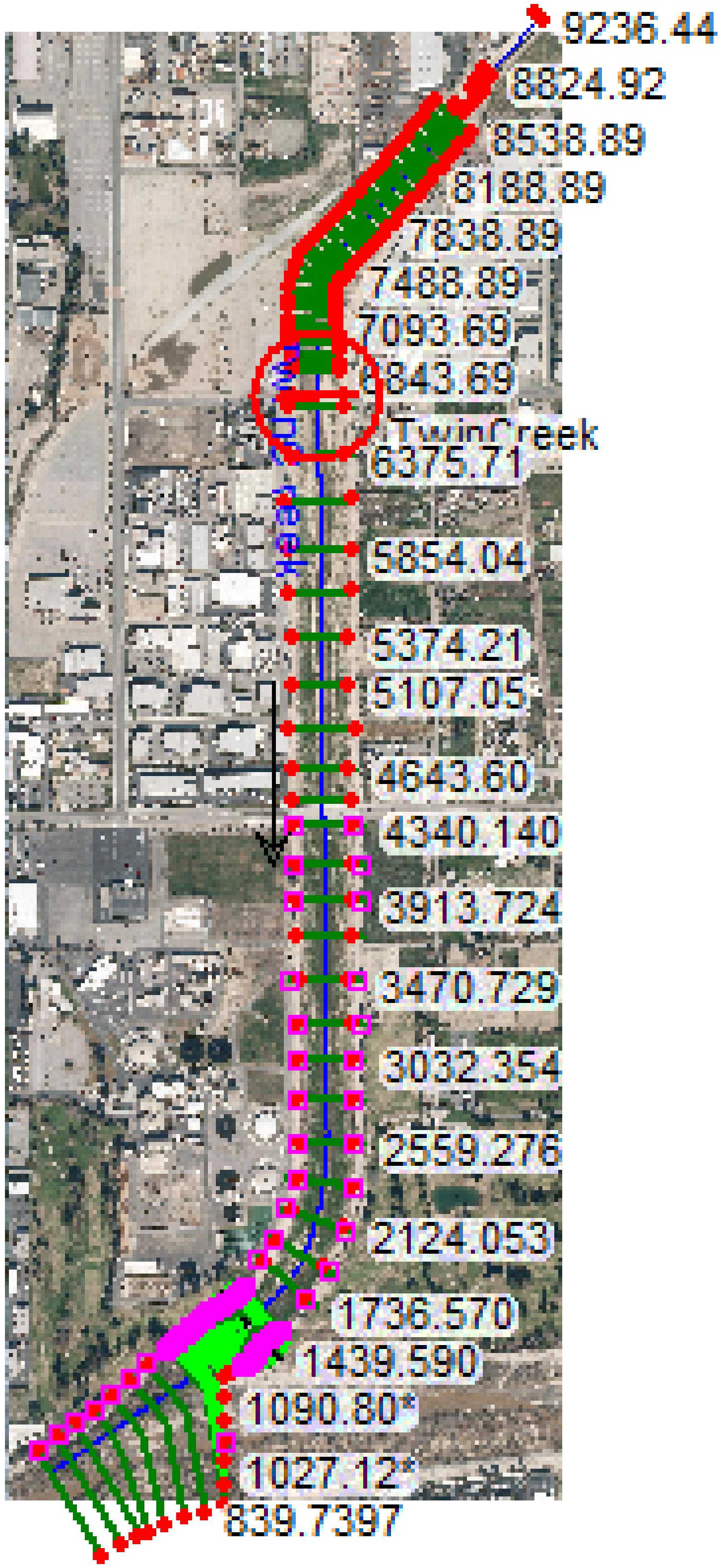
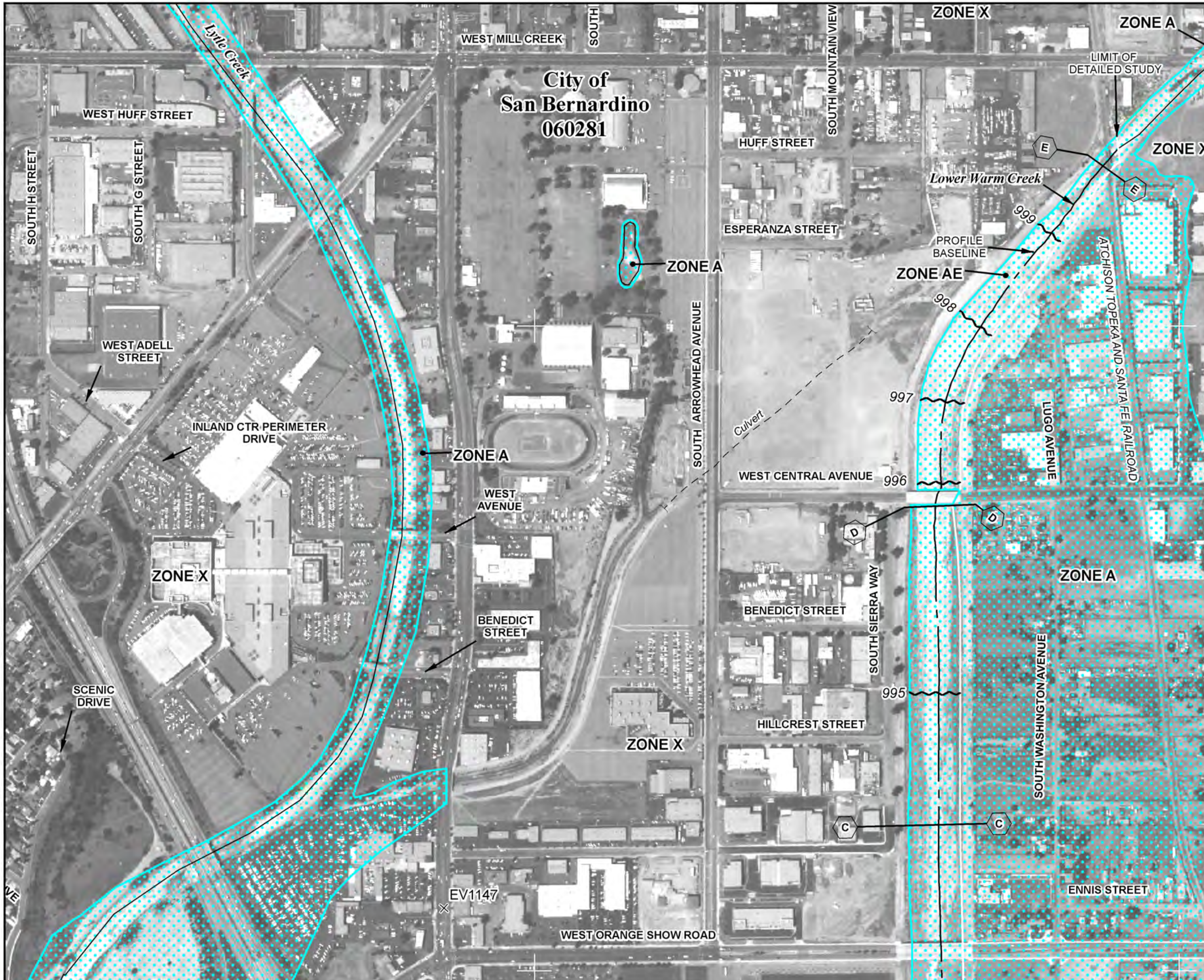


**Exhibit 4: FEMA FIRM 06071C Panel 8683H**




ional Flood Insurance Program at 1-800-638-6620.

MAP SCALE 1" = 500'

250 0 500 1000 FEET

METERS

NFIP

NATIONAL FLOOD INSURANCE PROGRAM

PANEL 8683H

# FIRM
## FLOOD INSURANCE RATE MAP

**SAN BERNARDINO COUNTY, CALIFORNIA**
**AND INCORPORATED AREAS**

**PANEL 8683 OF 9400**

(SEE MAP INDEX FOR FIRM PANEL LAYOUT)

CONTAINS:

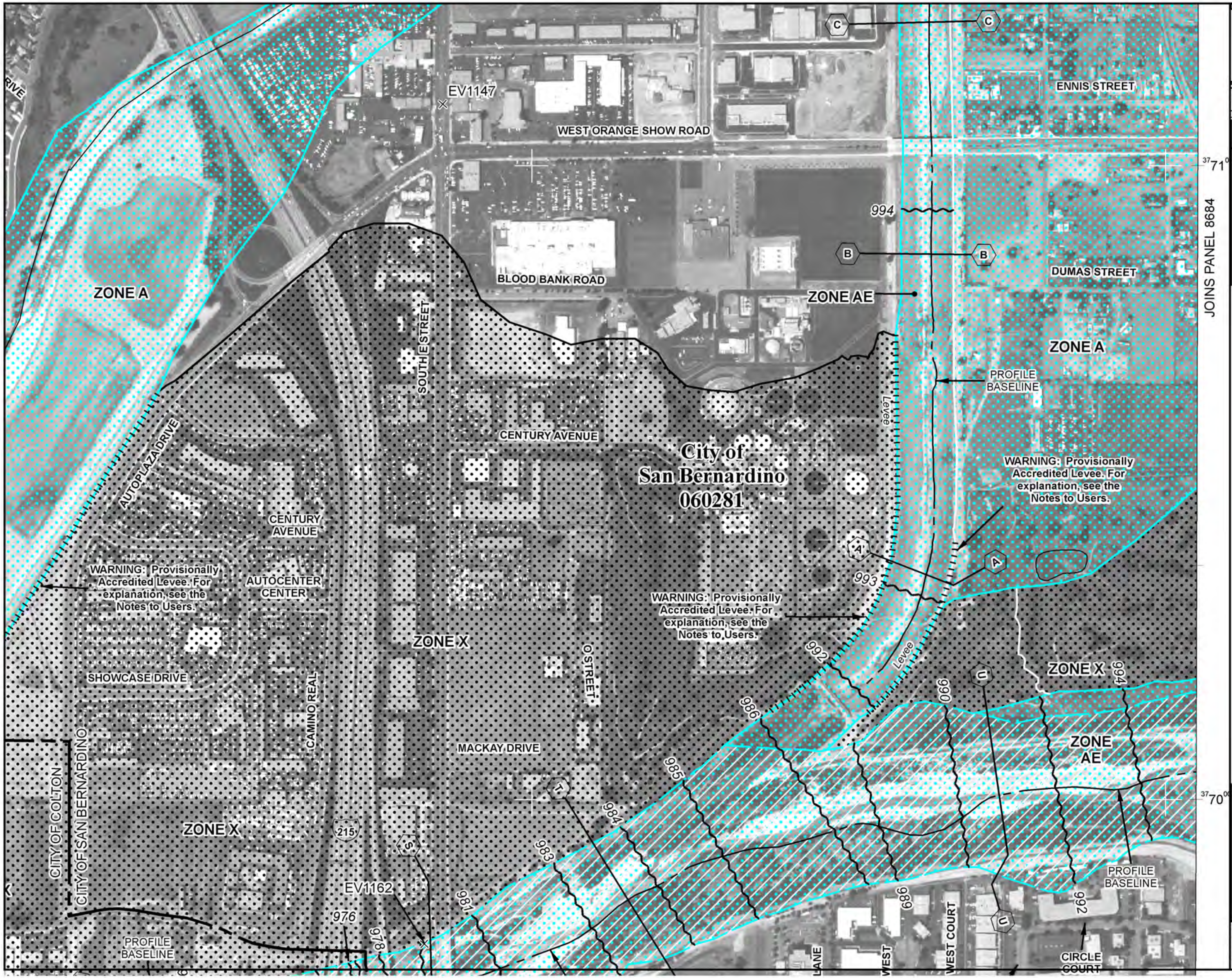
| COMMUNITY | NUMBER | PANEL | SUFFIX |
|---|---|---|---|
| COLTON, CITY OF | 060273 | 8683 | H |
| SAN BERNARDINO, CITY OF | 060281 | 8683 | H |

Notice to User: The **Map Number** shown below should be used when placing map orders; the **Community Number** shown above should be used on insurance applications for the subject community.

**MAP NUMBER**
**06071C8683H**

**MAP REVISED**
**AUGUST 28, 2008**

Federal Emergency Management Agency




ional Flood Insurance Program at 1-800-638-6620.

MAP SCALE 1" = 500'

50 0 500 1000 FEET

METERS

JOINS PANEL 8684

NFIP

NATIONAL FLOOD INSURANCE PROGRAM

PANEL 8683H

# FIRM

## FLOOD INSURANCE RATE MAP

**SAN BERNARDINO COUNTY, CALIFORNIA**
**AND INCORPORATED AREAS**

**PANEL 8683 OF 9400**

(SEE MAP INDEX FOR FIRM PANEL LAYOUT)

CONTAINS:

| COMMUNITY | NUMBER | PANEL | SUFFIX |
|---|---|---|---|
| COLTON, CITY OF | 060273 | 8683 | H |
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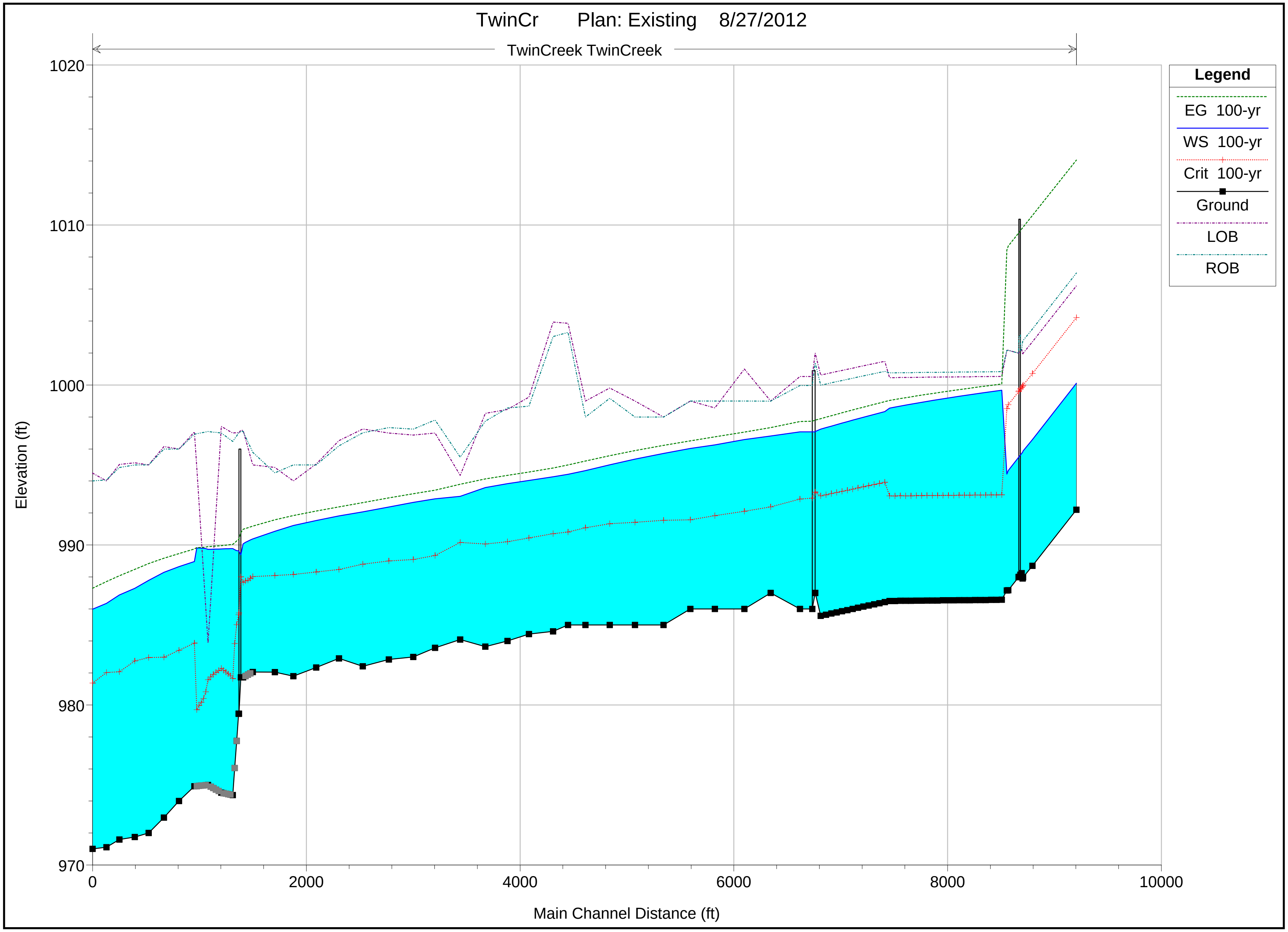
**MAP NUMBER**
**06071C8683H**

**MAP REVISED**
**AUGUST 28, 2008**

Federal Emergency Management Agency

# Attachment 1 - HEC-RAS Modeling Exhibits



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Crit 100-yr
Ground
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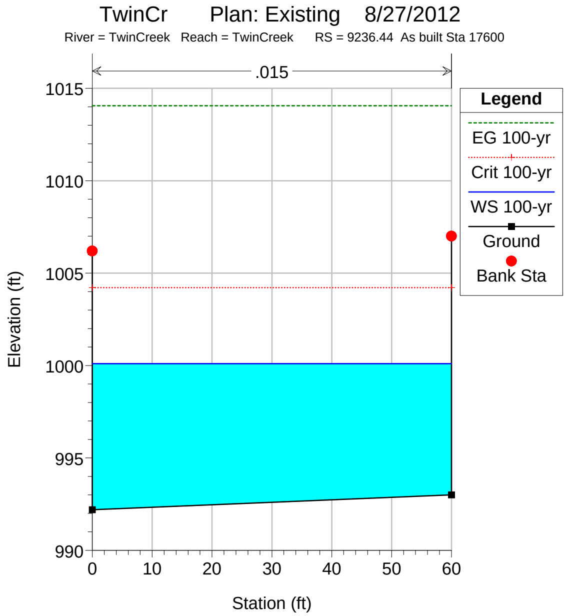
8000
10000
Main Channel Distance (ft)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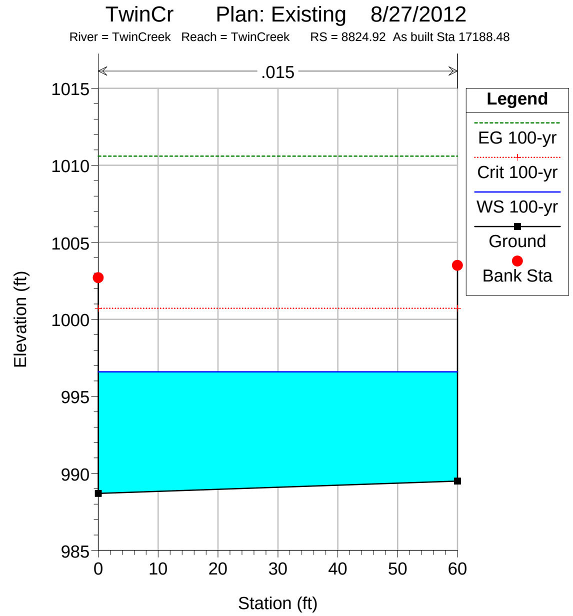
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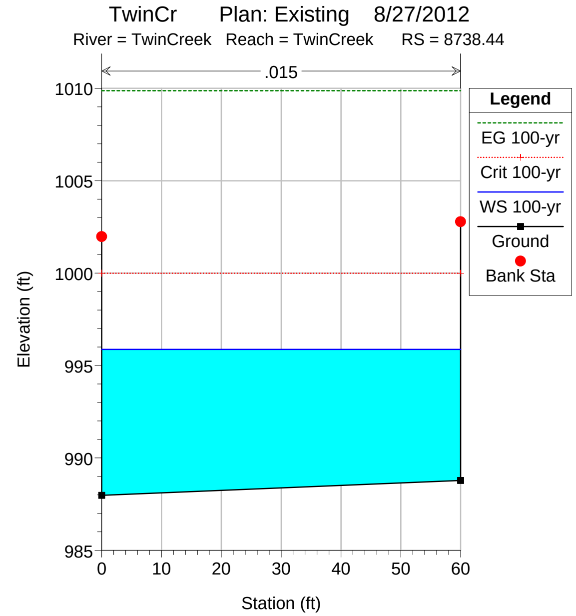
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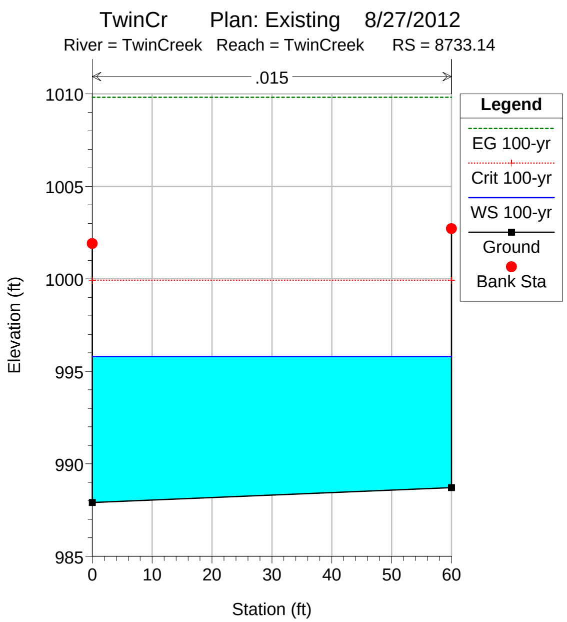
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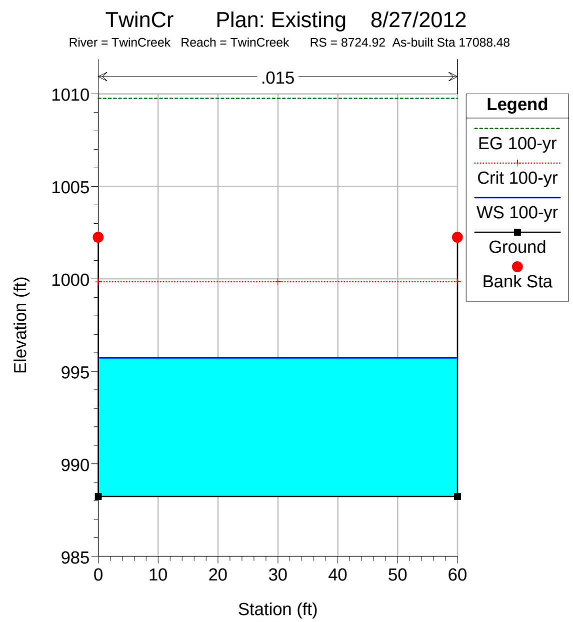
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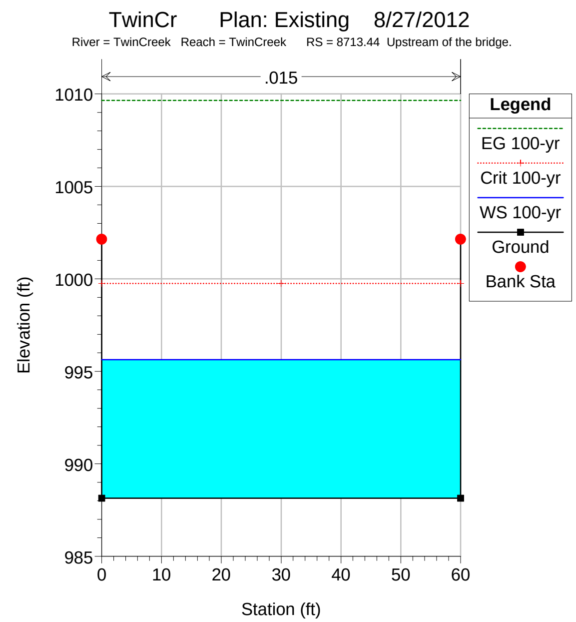
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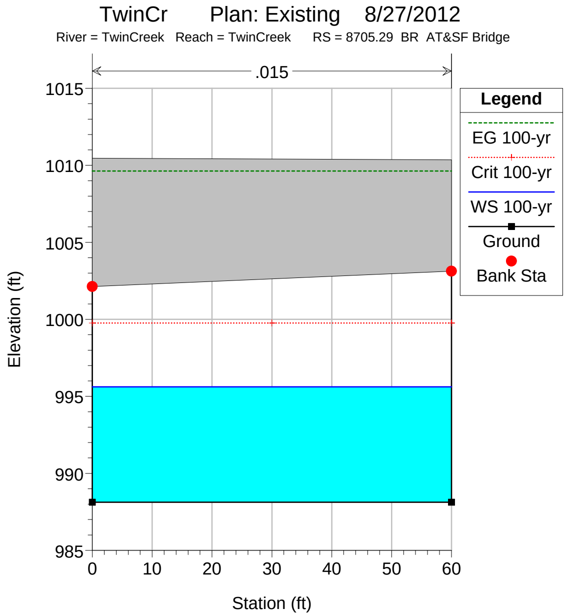
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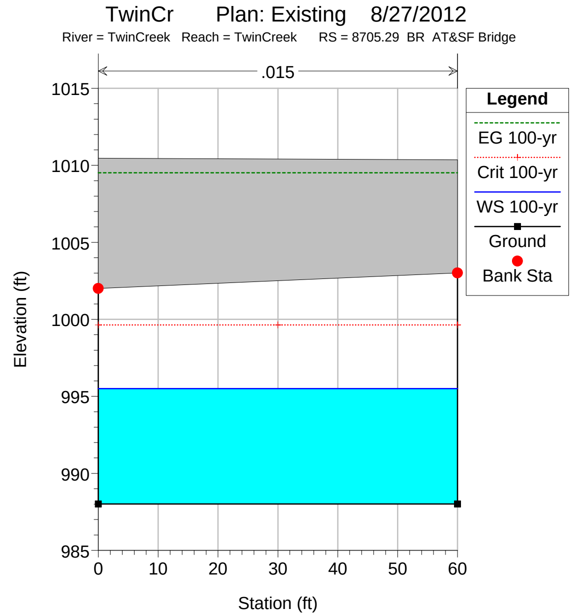
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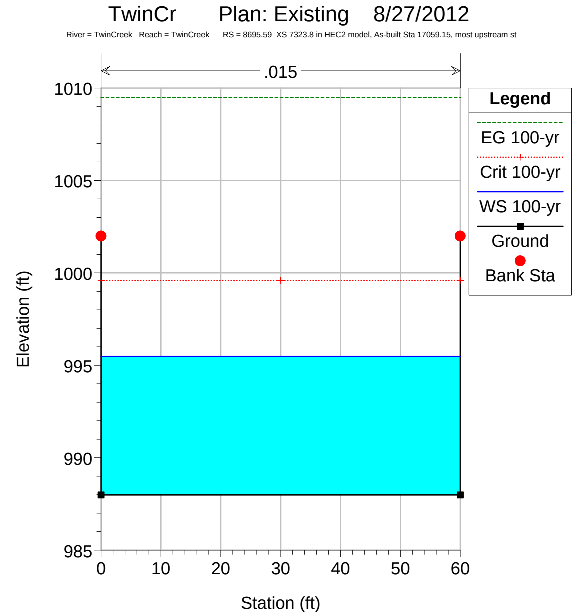
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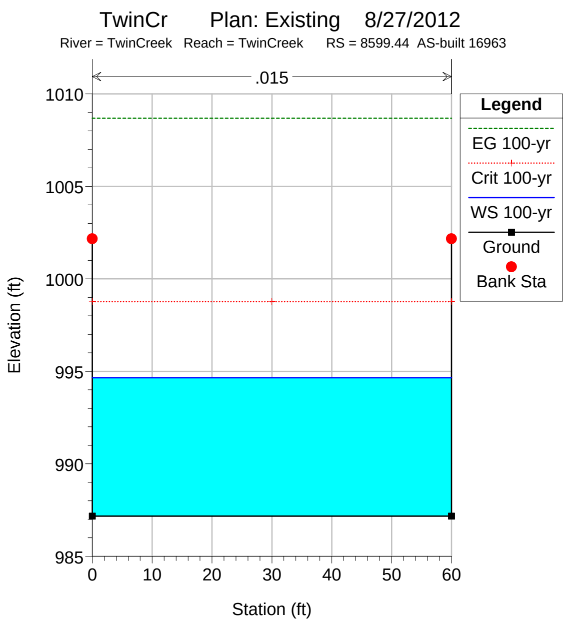
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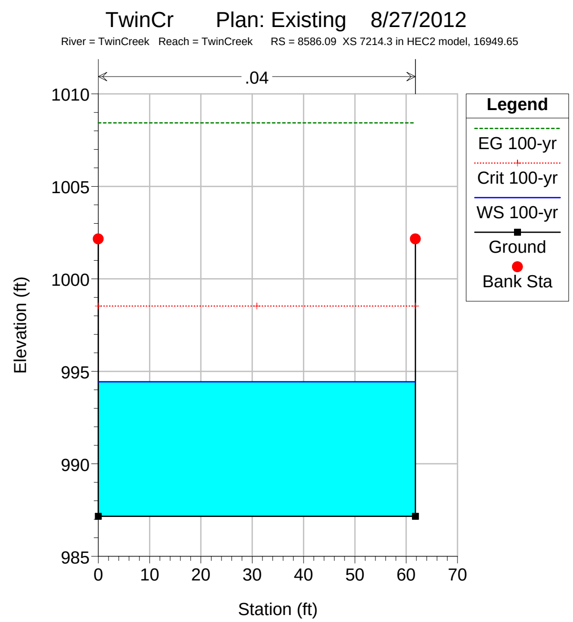
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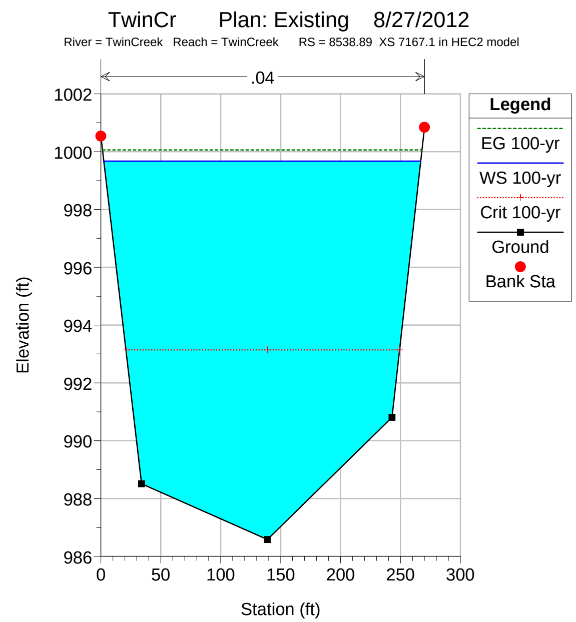
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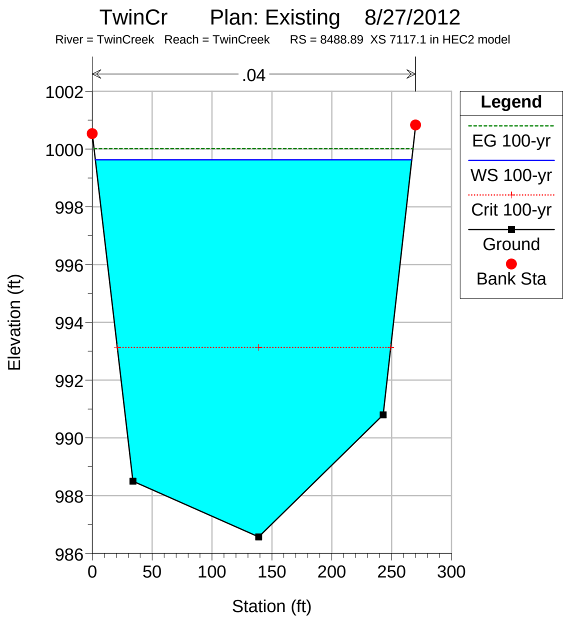
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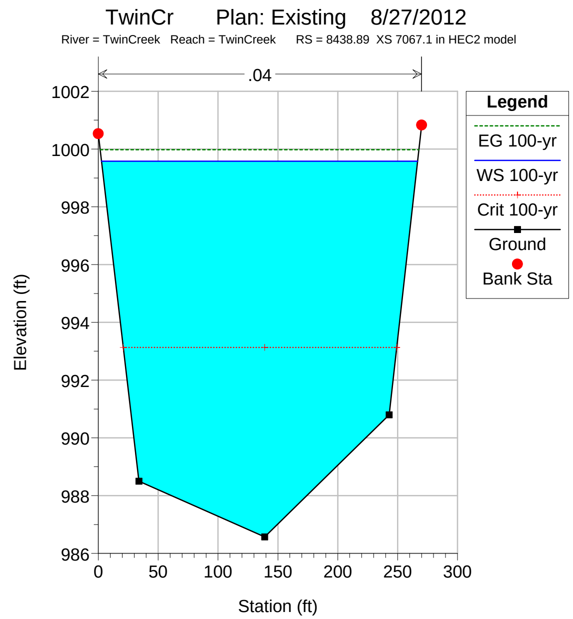
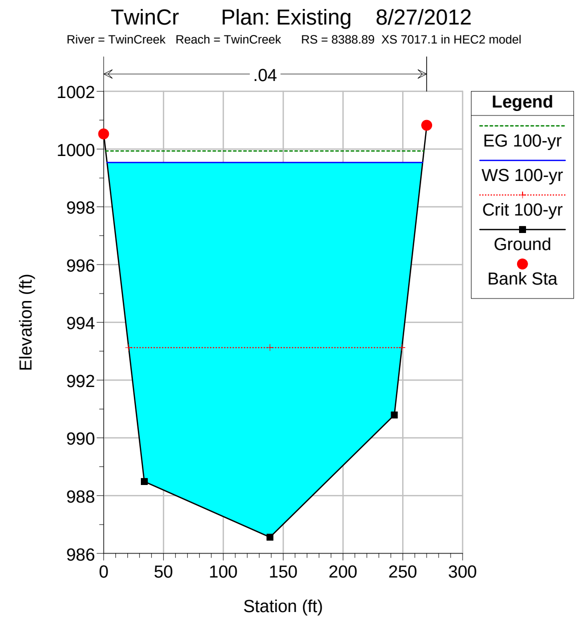
Elevation (ft)
Station (ft)


TwinCr Plan: Existing 8/27/2012
River = TwinCreek Reach = TwinCreek RS = 8438.89 XS 7067.1 in HEC2 model
.04
Legend
EG 100-yr
WS 100-yr
Crit 100-yr
Ground
Bank Sta
Elevation (ft)
Station (ft)


TwinCr Plan: Existing 8/27/2012
River = TwinCreek Reach = TwinCreek RS = 8388.89 XS 7017.1 in HEC2 model
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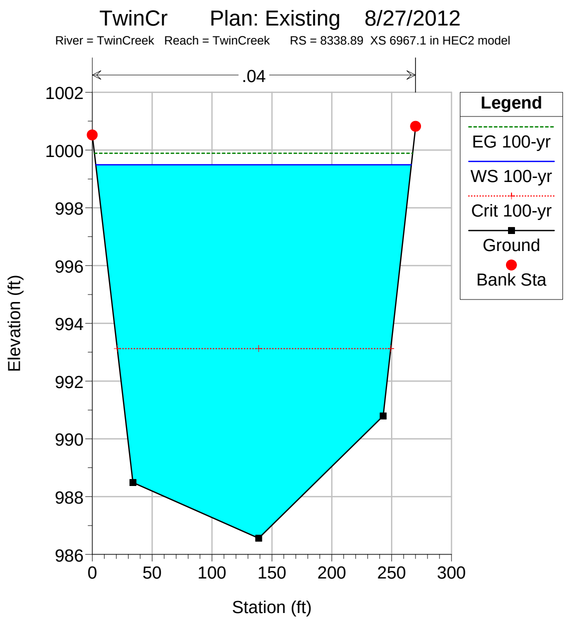
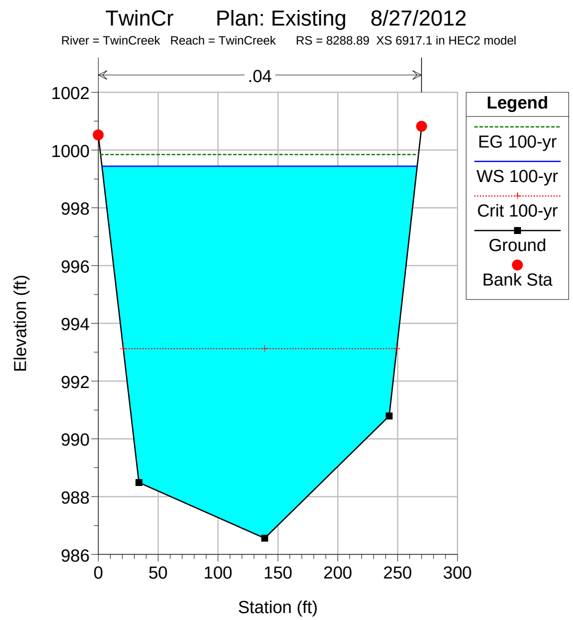
Legend
EG 100-yr
WS 100-yr
Crit 100-yr
Ground
Bank Sta
Elevation (ft)
Station (ft)


TwinCr Plan: Existing 8/27/2012
River = TwinCreek Reach = TwinCreek RS = 8338.89 XS 6967.1 in HEC2 model
.04
Legend
EG 100-yr
WS 100-yr
Crit 100-yr
Ground
Bank Sta
Elevation (ft)
Station (ft)


TwinCr Plan: Existing 8/27/2012
River = TwinCreek Reach = TwinCreek RS = 8288.89 XS 6917.1 in HEC2 model
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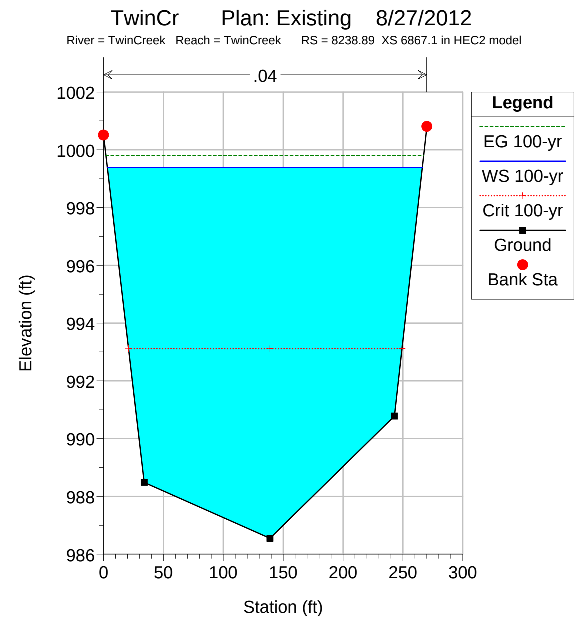
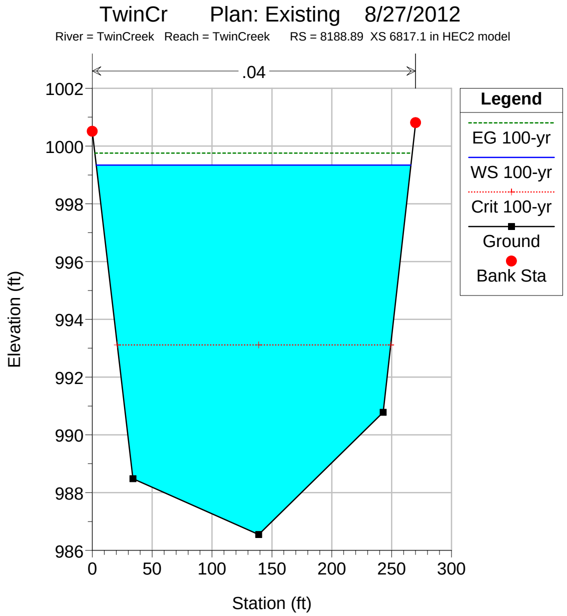
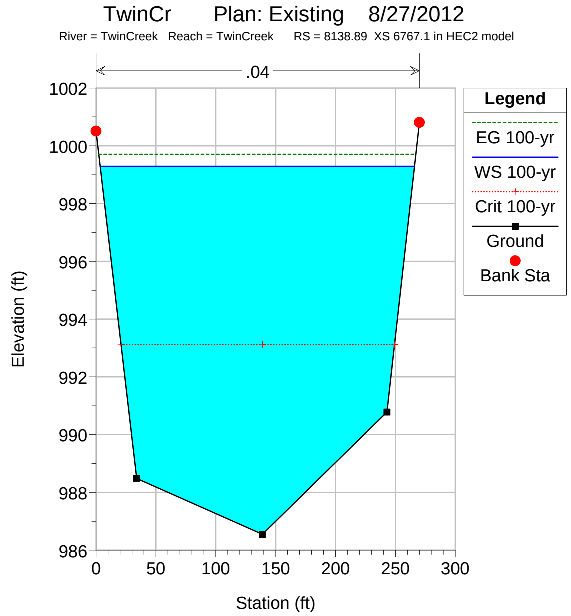
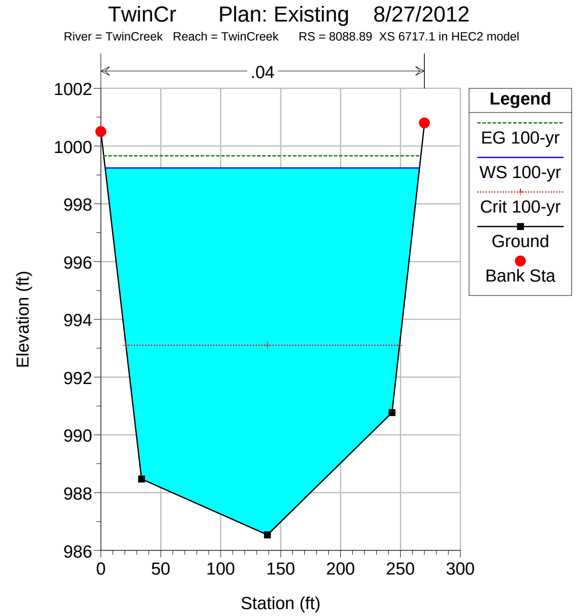
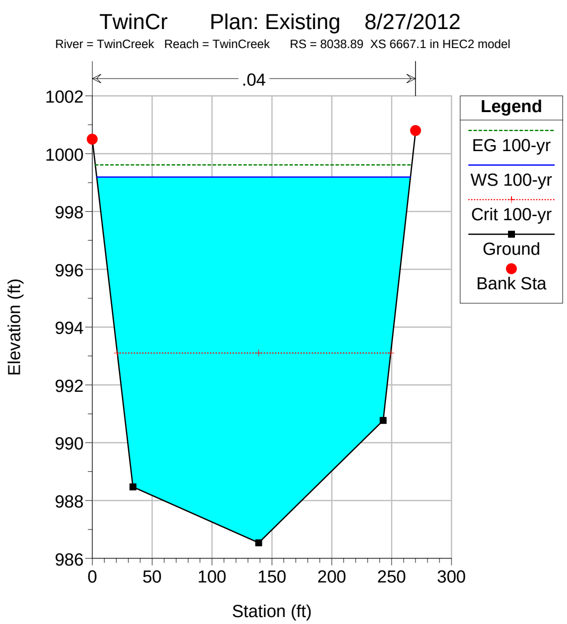
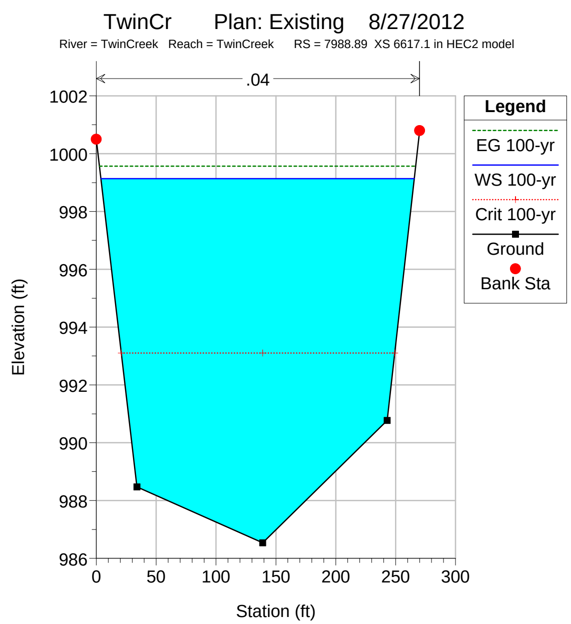
Legend
EG 100-yr
WS 100-yr
Crit 100-yr
Ground
Bank Sta
Elevation (ft)
Station (ft)


TwinCr Plan: Existing 8/27/2012
River = TwinCreek Reach = TwinCreek RS = 8238.89 XS 6867.1 in HEC2 model
.04
Legend
EG 100-yr
WS 100-yr
Crit 100-yr
Ground
Bank Sta
Elevation (ft)
Station (ft)


TwinCr Plan: Existing 8/27/2012
River = TwinCreek Reach = TwinCreek RS = 8188.89 XS 6817.1 in HEC2 model
.04
Legend
EG 100-yr
WS 100-yr
Crit 100-yr
Ground
Bank Sta
Elevation (ft)
Station (ft)

TwinCr Plan: Existing 8/27/2012
River = TwinCreek Reach = TwinCreek RS = 8138.89 XS 6767.1 in HEC2 model
.04
Legend
EG 100-yr
WS 100-yr
Crit 100-yr
Ground
Bank Sta
Elevation (ft)
Station (ft)

TwinCr Plan: Existing 8/27/2012
River = TwinCreek Reach = TwinCreek RS = 8088.89 XS 6717.1 in HEC2 model
.04
Legend
EG 100-yr
WS 100-yr
Crit 100-yr
Ground
Bank Sta
Elevation (ft)
Station (ft)

TwinCr Plan: Existing 8/27/2012
River = TwinCreek Reach = TwinCreek RS = 8038.89 XS 6667.1 in HEC2 model
.04
Legend
EG 100-yr
WS 100-yr
Crit 100-yr
Ground
Bank Sta
Elevation (ft)
Station (ft)

TwinCr Plan: Existing 8/27/2012
River = TwinCreek Reach = TwinCreek RS = 7988.89 XS 6617.1 in HEC2 model
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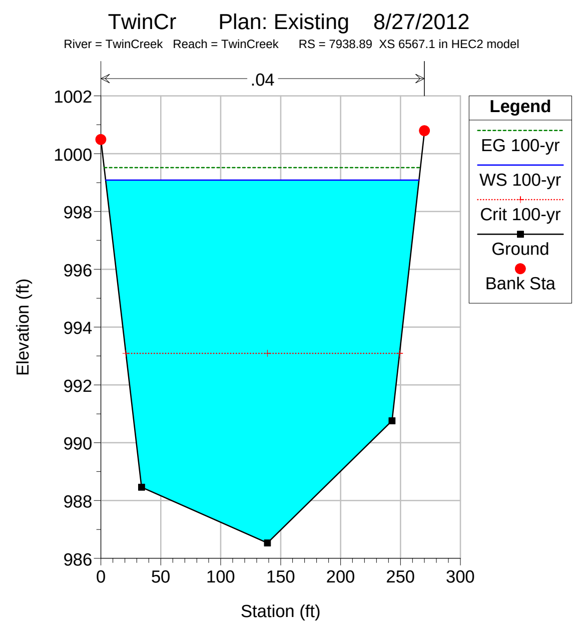
Legend
EG 100-yr
WS 100-yr
Crit 100-yr
Ground
Bank Sta
Elevation (ft)
Station (ft)

TwinCr Plan: Existing 8/27/2012
River = TwinCreek Reach = TwinCreek RS = 7938.89 XS 6567.1 in HEC2 model
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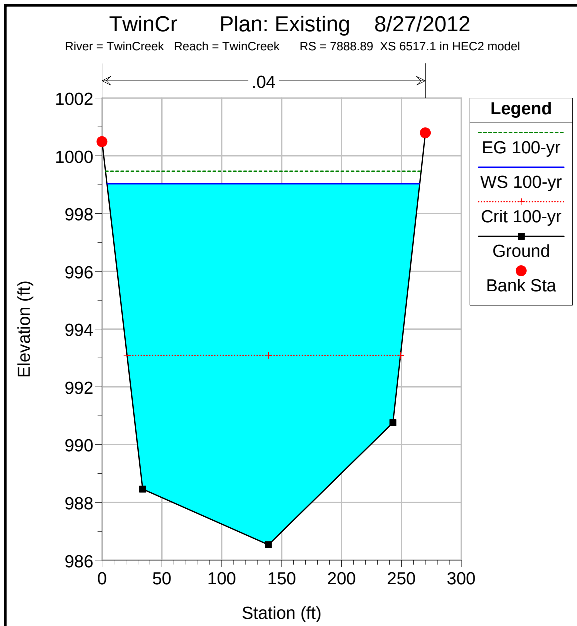
Legend
EG 100-yr
WS 100-yr
Crit 100-yr
Ground
Bank Sta
Elevation (ft)
Station (ft)


TwinCr Plan: Existing 8/27/2012
River = TwinCreek Reach = TwinCreek RS = 7888.89 XS 6517.1 in HEC2 model
.04
Legend
EG 100-yr
WS 100-yr
Crit 100-yr
Ground
Bank Sta
Elevation (ft)
Station (ft)
1002
1000
998
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994
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986
0
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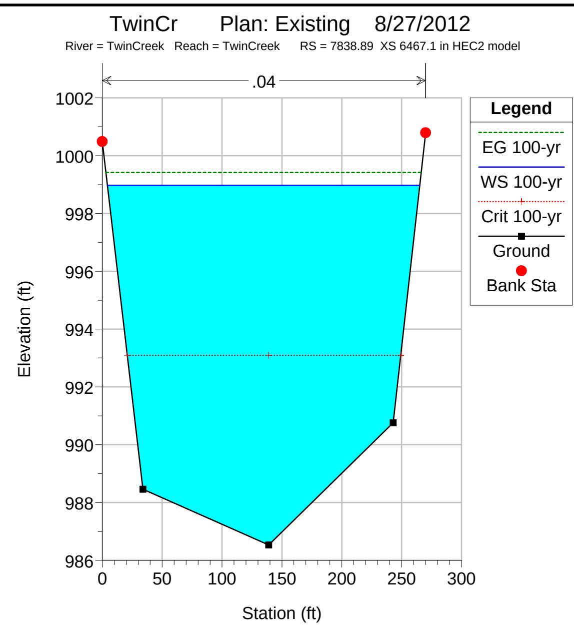
100
150
200
250
300


TwinCr Plan: Existing 8/27/2012
River = TwinCreek Reach = TwinCreek RS = 7838.89 XS 6467.1 in HEC2 model
.04
Legend
EG 100-yr
WS 100-yr
Crit 100-yr
Ground
Bank Sta
Elevation (ft)
Station (ft)
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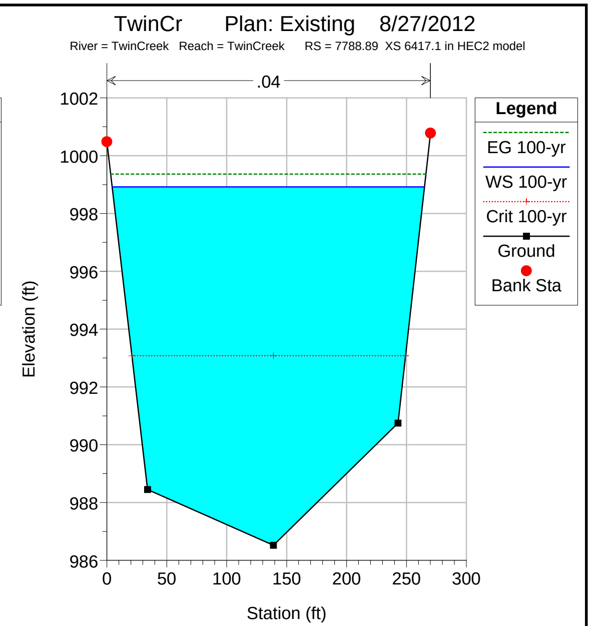
TwinCr Plan: Existing 8/27/2012
River = TwinCreek Reach = TwinCreek RS = 7788.89 XS 6417.1 in HEC2 model
.04
Legend
EG 100-yr
WS 100-yr
Crit 100-yr
Ground
Bank Sta
Elevation (ft)
Station (ft)
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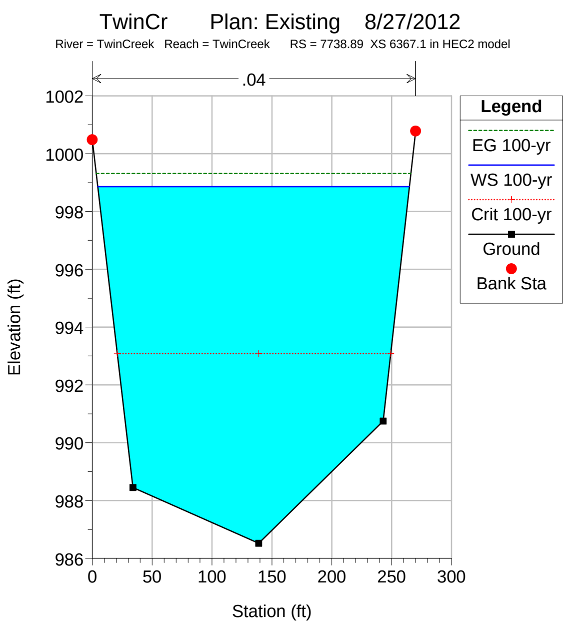
TwinCr Plan: Existing 8/27/2012
River = TwinCreek Reach = TwinCreek RS = 7738.89 XS 6367.1 in HEC2 model
.04
Legend
EG 100-yr
WS 100-yr
Crit 100-yr
Ground
Bank Sta
Elevation (ft)
Station (ft)
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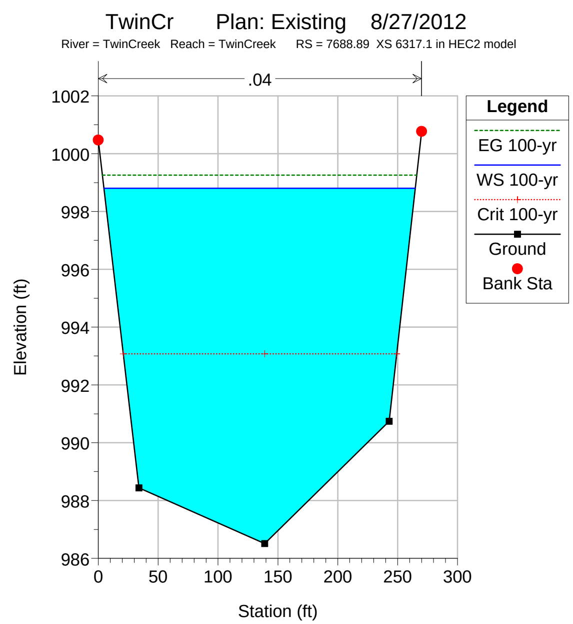
TwinCr Plan: Existing 8/27/2012
River = TwinCreek Reach = TwinCreek RS = 7688.89 XS 6317.1 in HEC2 model
.04
Legend
EG 100-yr
WS 100-yr
Crit 100-yr
Ground
Bank Sta
Elevation (ft)
Station (ft)
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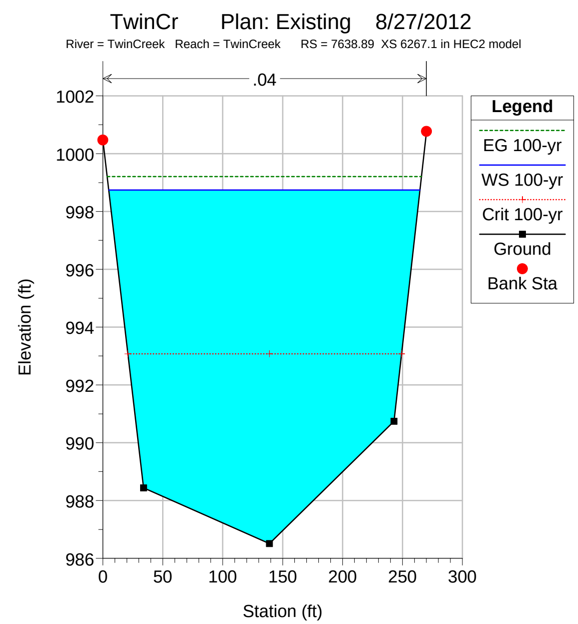
TwinCr Plan: Existing 8/27/2012
River = TwinCreek Reach = TwinCreek RS = 7638.89 XS 6267.1 in HEC2 model
.04
Legend
EG 100-yr
WS 100-yr
Crit 100-yr
Ground
Bank Sta
Elevation (ft)
Station (ft)
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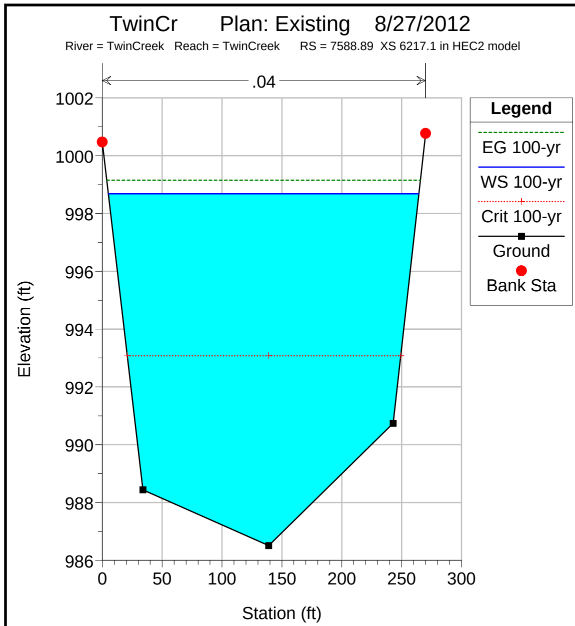
TwinCr Plan: Existing 8/27/2012
River = TwinCreek Reach = TwinCreek RS = 7588.89 XS 6217.1 in HEC2 model
.04
Legend
EG 100-yr
WS 100-yr
Crit 100-yr
Ground
Bank Sta
Elevation (ft)
1002
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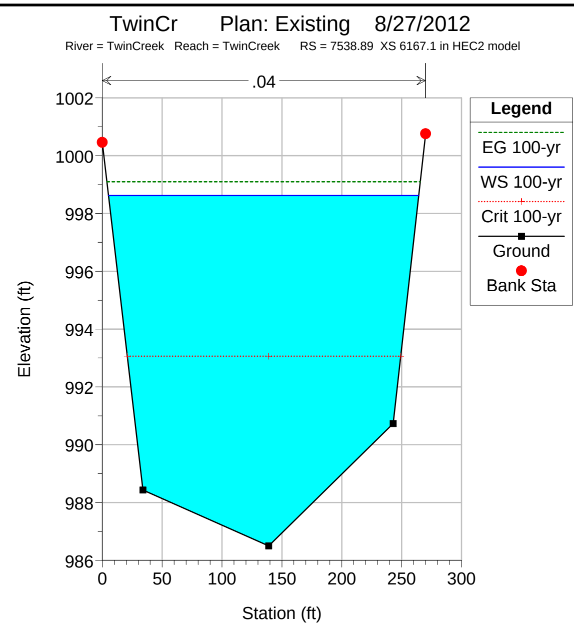
990
988
986
0 50 100 150 200 250 300
Station (ft)


TwinCr Plan: Existing 8/27/2012
River = TwinCreek Reach = TwinCreek RS = 7538.89 XS 6167.1 in HEC2 model
.04
Legend
EG 100-yr
WS 100-yr
Crit 100-yr
Ground
Bank Sta
Elevation (ft)
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990
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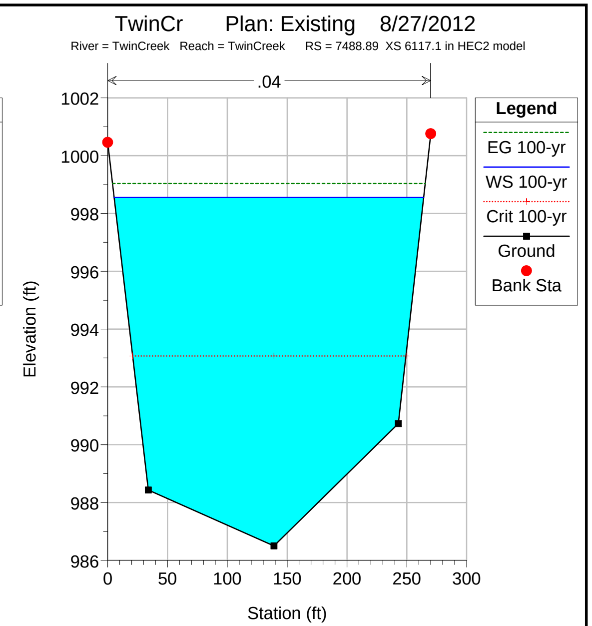
986
0 50 100 150 200 250 300
Station (ft)


TwinCr Plan: Existing 8/27/2012
River = TwinCreek Reach = TwinCreek RS = 7488.89 XS 6117.1 in HEC2 model
.04
Legend
EG 100-yr
WS 100-yr
Crit 100-yr
Ground
Bank Sta
Elevation (ft)
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990
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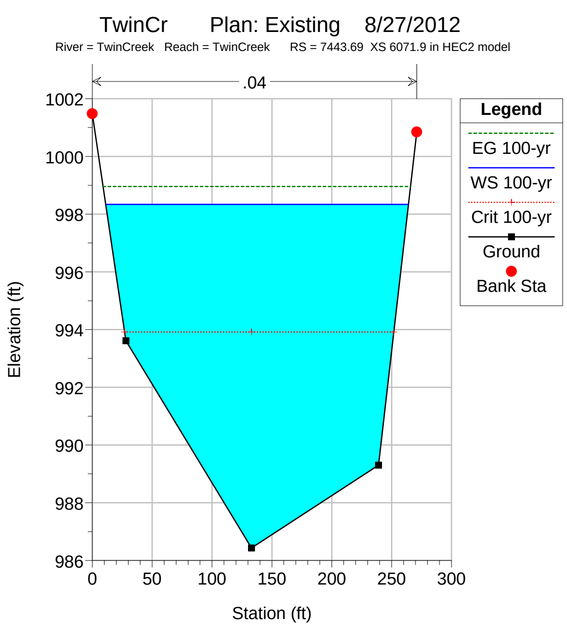
986
0 50 100 150 200 250 300
Station (ft)


TwinCr Plan: Existing 8/27/2012
River = TwinCreek Reach = TwinCreek RS = 7443.69 XS 6071.9 in HEC2 model
.04
Legend
EG 100-yr
WS 100-yr
Crit 100-yr
Ground
Bank Sta
Elevation (ft)
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994
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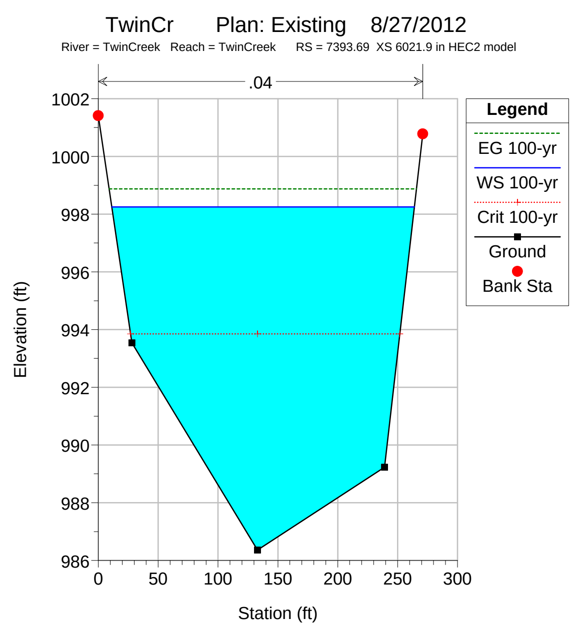
990
988
986
0 50 100 150 200 250 300
Station (ft)


TwinCr Plan: Existing 8/27/2012
River = TwinCreek Reach = TwinCreek RS = 7393.69 XS 6021.9 in HEC2 model
.04
Legend
EG 100-yr
WS 100-yr
Crit 100-yr
Ground
Bank Sta
Elevation (ft)
1002
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998
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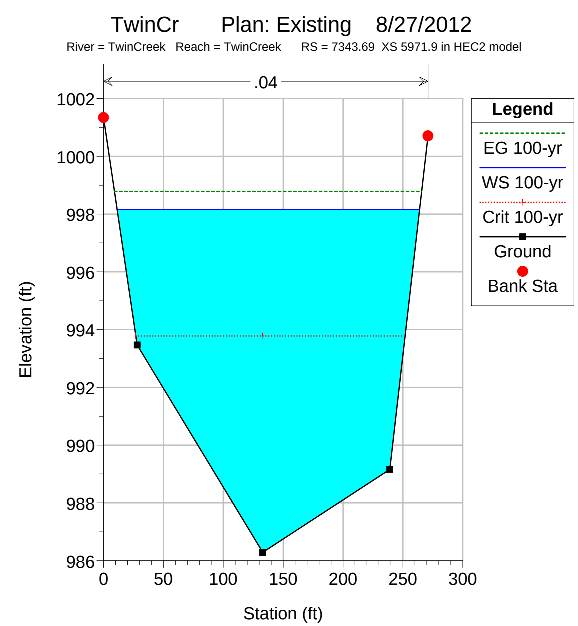
994
992
990
988
986
0 50 100 150 200 250 300
Station (ft)


TwinCr Plan: Existing 8/27/2012
River = TwinCreek Reach = TwinCreek RS = 7343.69 XS 5971.9 in HEC2 model
.04
Legend
EG 100-yr
WS 100-yr
Crit 100-yr
Ground
Bank Sta
Elevation (ft)
1002
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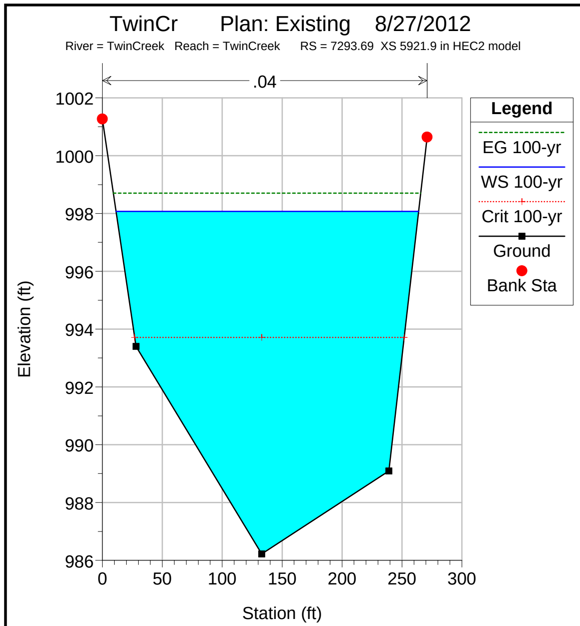
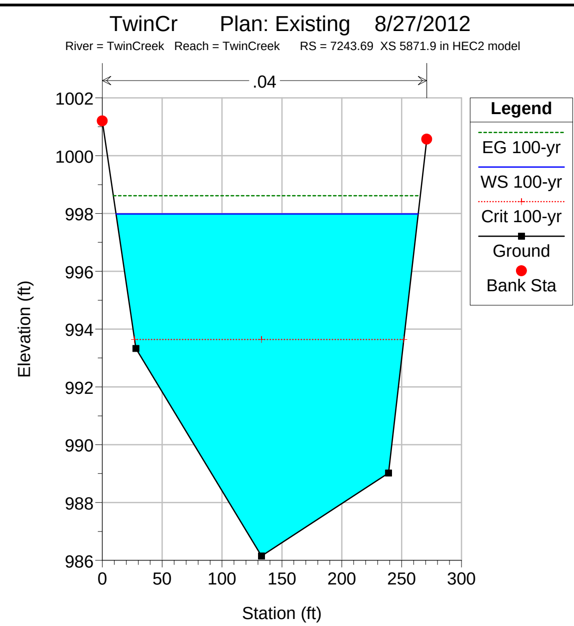
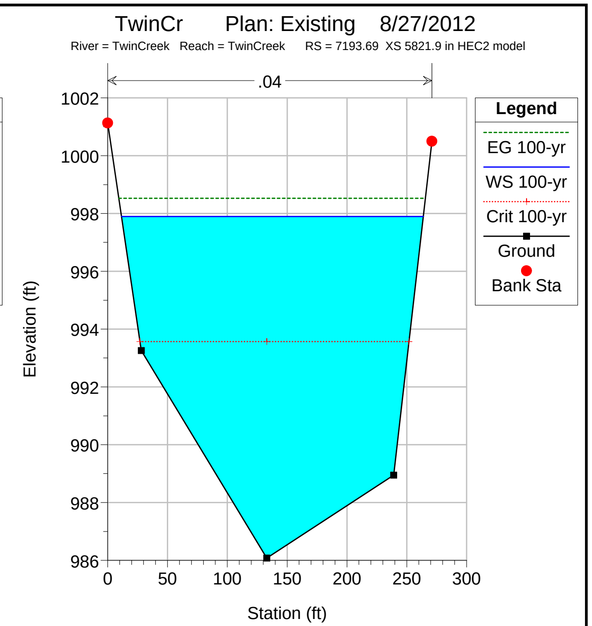
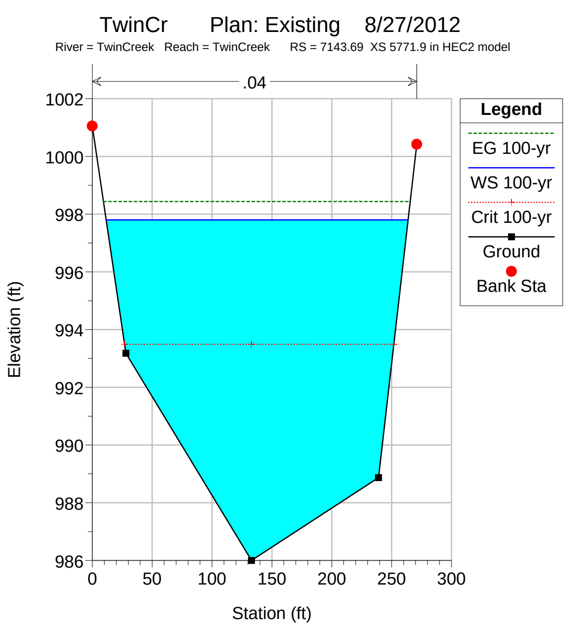
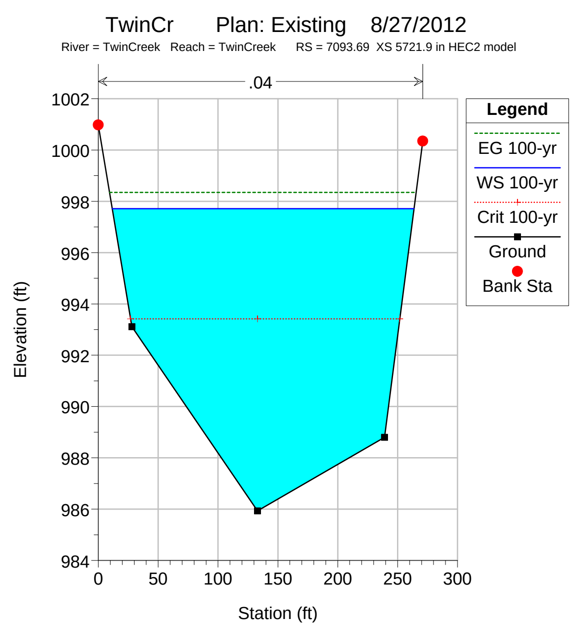
998
996
994
992
990
988
986
0 50 100 150 200 250 300
Station (ft)

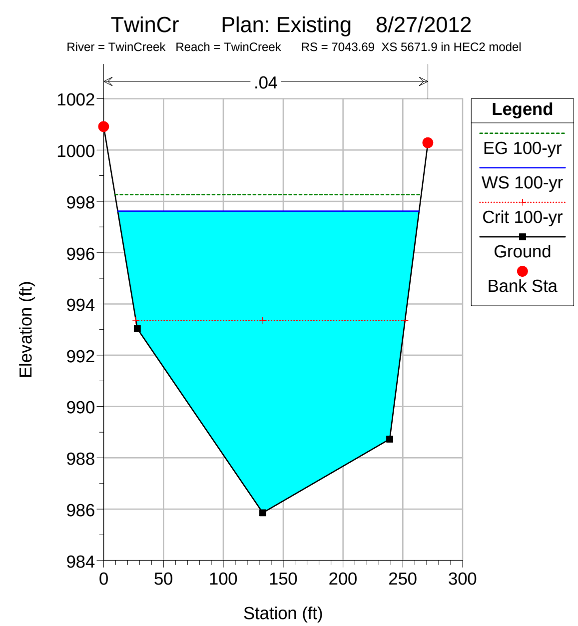

TwinCr Plan: Existing 8/27/2012
River = TwinCreek Reach = TwinCreek RS = 7293.69 XS 5921.9 in HEC2 model
.04
Elevation (ft)
Station (ft)
Legend
EG 100-yr
WS 100-yr
Crit 100-yr
Ground
Bank Sta

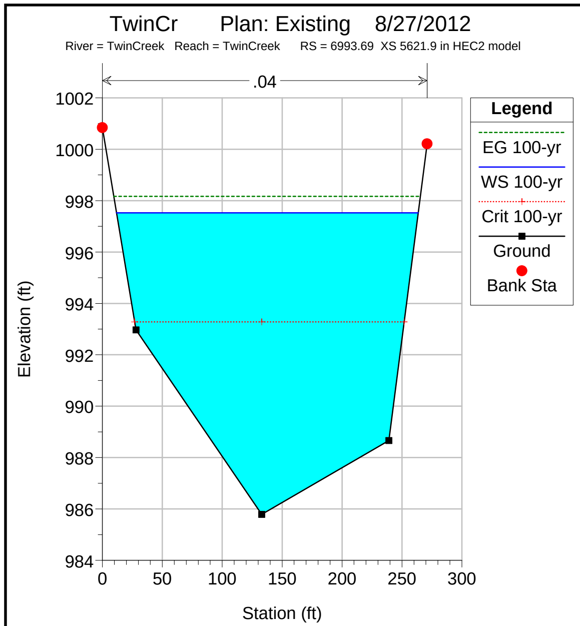

TwinCr Plan: Existing 8/27/2012
River = TwinCreek Reach = TwinCreek RS = 7243.69 XS 5871.9 in HEC2 model
.04
Elevation (ft)
Station (ft)
Legend
EG 100-yr
WS 100-yr
Crit 100-yr
Ground
Bank Sta

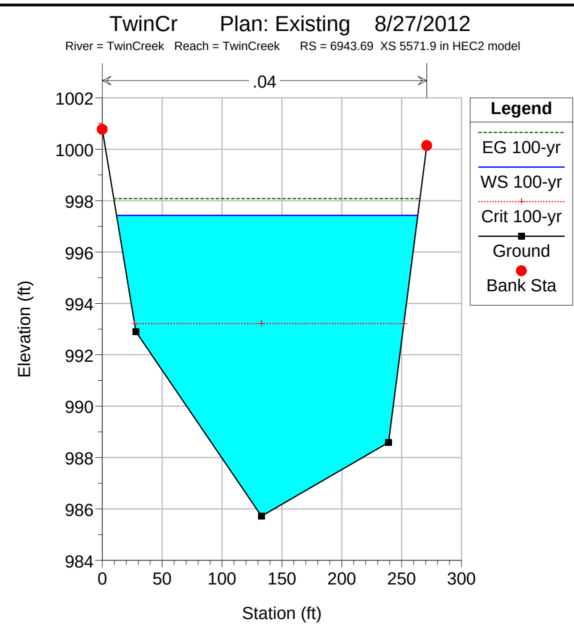

TwinCr Plan: Existing 8/27/2012
River = TwinCreek Reach = TwinCreek RS = 7193.69 XS 5821.9 in HEC2 model
.04
Elevation (ft)
Station (ft)
Legend
EG 100-yr
WS 100-yr
Crit 100-yr
Ground
Bank Sta

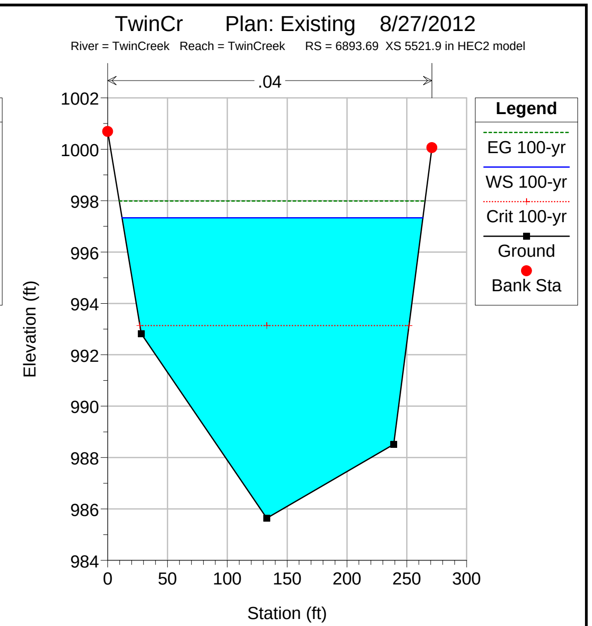

TwinCr Plan: Existing 8/27/2012
River = TwinCreek Reach = TwinCreek RS = 7143.69 XS 5771.9 in HEC2 model
.04
Elevation (ft)
Station (ft)
Legend
EG 100-yr
WS 100-yr
Crit 100-yr
Ground
Bank Sta

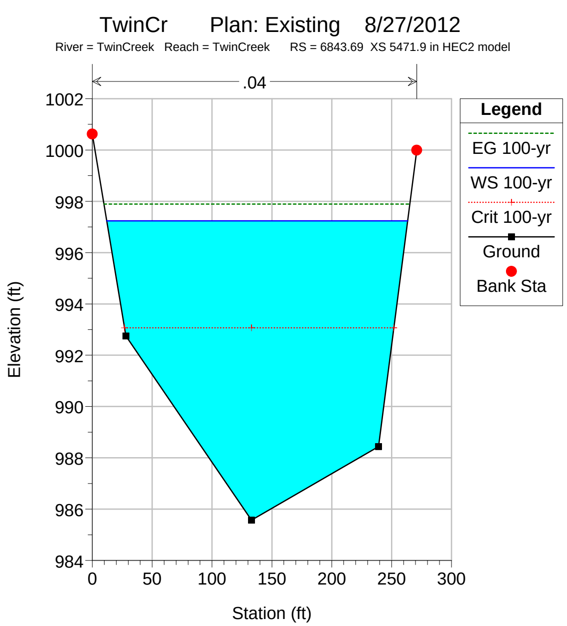

TwinCr Plan: Existing 8/27/2012
River = TwinCreek Reach = TwinCreek RS = 7093.69 XS 5721.9 in HEC2 model
.04
Elevation (ft)
Station (ft)
Legend
EG 100-yr
WS 100-yr
Crit 100-yr
Ground
Bank Sta


TwinCr Plan: Existing 8/27/2012
River = TwinCreek Reach = TwinCreek RS = 7043.69 XS 5671.9 in HEC2 model
.04
Elevation (ft)
Station (ft)
Legend
EG 100-yr
WS 100-yr
Crit 100-yr
Ground
Bank Sta


TwinCr Plan: Existing 8/27/2012
River = TwinCreek Reach = TwinCreek RS = 6993.69 XS 5621.9 in HEC2 model
.04
Elevation (ft)
Station (ft)
Legend
EG 100-yr
WS 100-yr
Crit 100-yr
Ground
Bank Sta


TwinCr Plan: Existing 8/27/2012
River = TwinCreek Reach = TwinCreek RS = 6943.69 XS 5571.9 in HEC2 model
.04
Elevation (ft)
Station (ft)
Legend
EG 100-yr
WS 100-yr
Crit 100-yr
Ground
Bank Sta


TwinCr Plan: Existing 8/27/2012
River = TwinCreek Reach = TwinCreek RS = 6893.69 XS 5521.9 in HEC2 model
.04
Elevation (ft)
Station (ft)
Legend
EG 100-yr
WS 100-yr
Crit 100-yr
Ground
Bank Sta


TwinCr Plan: Existing 8/27/2012
River = TwinCreek Reach = TwinCreek RS = 6843.69 XS 5471.9 in HEC2 model
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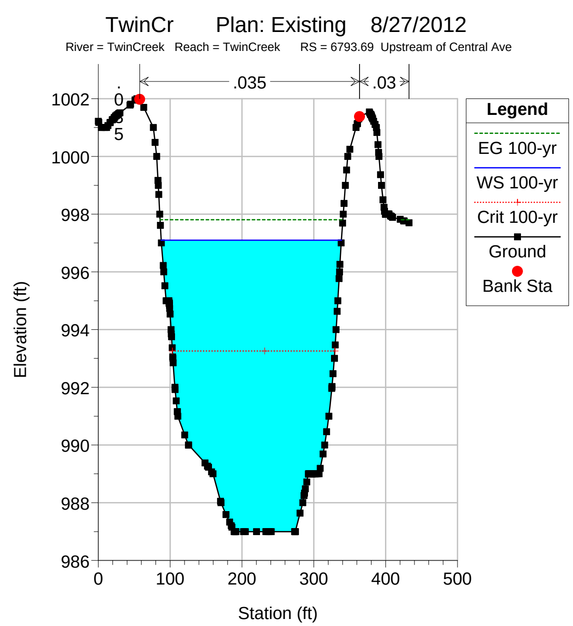
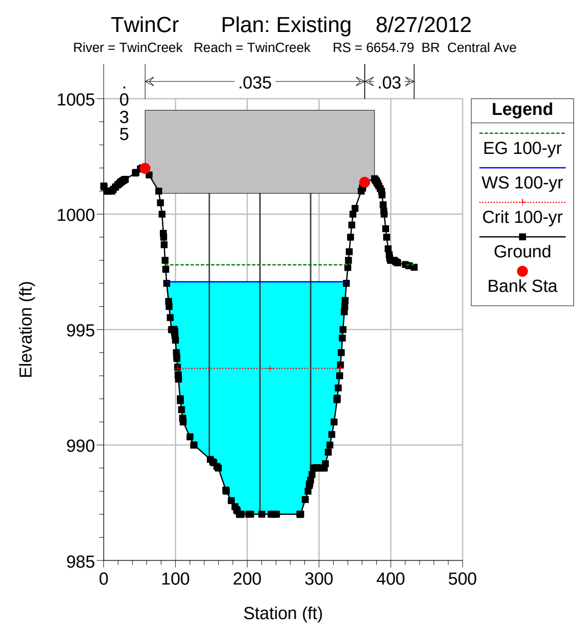
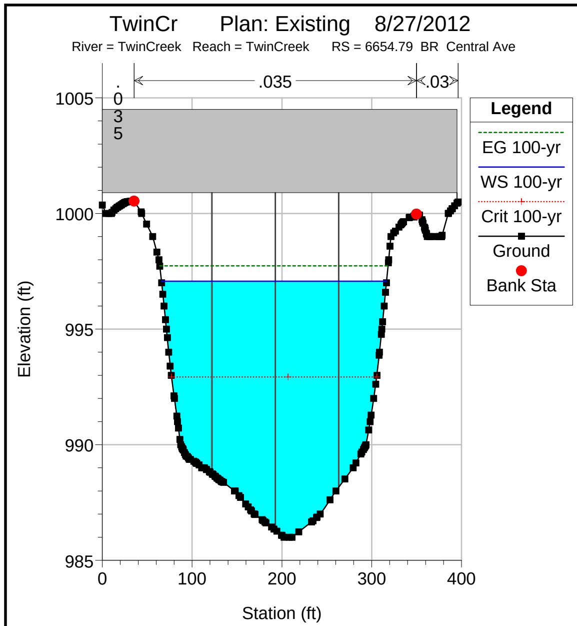
Elevation (ft)
Station (ft)
Legend
EG 100-yr
WS 100-yr
Crit 100-yr
Ground
Bank Sta


TwinCr Plan: Existing 8/27/2012
River = TwinCreek Reach = TwinCreek RS = 6793.69 Upstream of Central Ave
.035
.03
Elevation (ft)
Station (ft)
Legend
EG 100-yr
WS 100-yr
Crit 100-yr
Ground
Bank Sta


TwinCr Plan: Existing 8/27/2012
River = TwinCreek Reach = TwinCreek RS = 6654.79 BR Central Ave
.035
.03
Elevation (ft)
Station (ft)
Legend
EG 100-yr
WS 100-yr
Crit 100-yr
Ground
Bank Sta


TwinCr Plan: Existing 8/27/2012
River = TwinCreek Reach = TwinCreek RS = 6654.79 BR Central Ave
.035
.03
Legend
EG 100-yr
WS 100-yr
Crit 100-yr
Ground
Bank Sta
Elevation (ft)
Station (ft)
1005
1000
995
990
985
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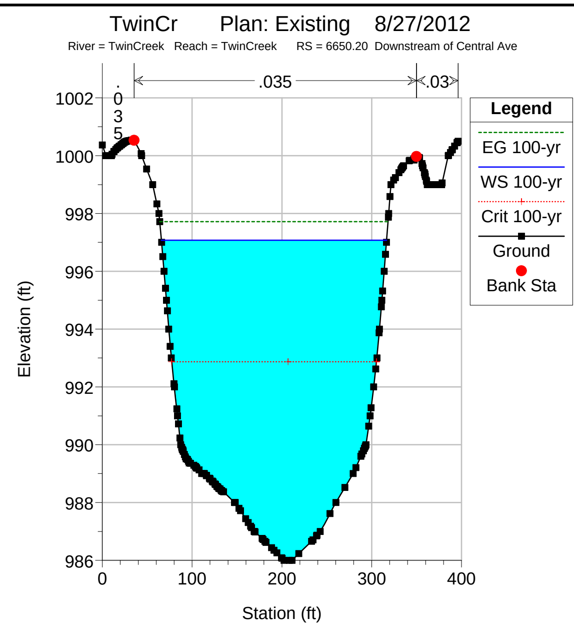
100
200
300
400


TwinCr Plan: Existing 8/27/2012
River = TwinCreek Reach = TwinCreek RS = 6650.20 Downstream of Central Ave
.035
.03
Legend
EG 100-yr
WS 100-yr
Crit 100-yr
Ground
Bank Sta
Elevation (ft)
Station (ft)
1002
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998
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994
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990
988
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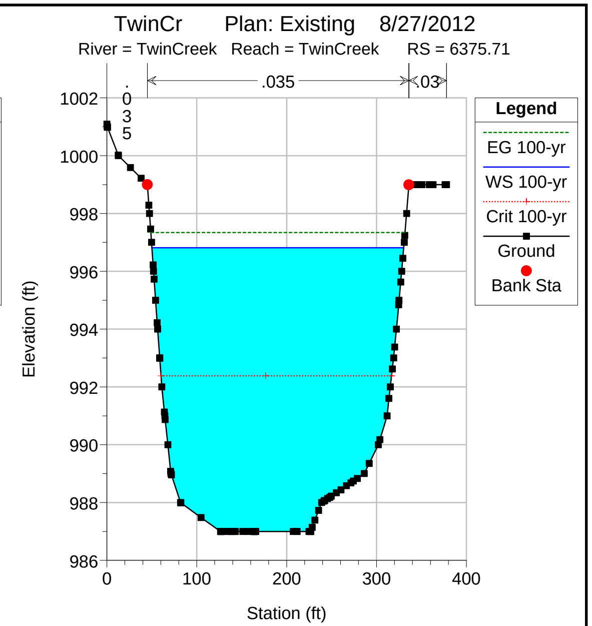
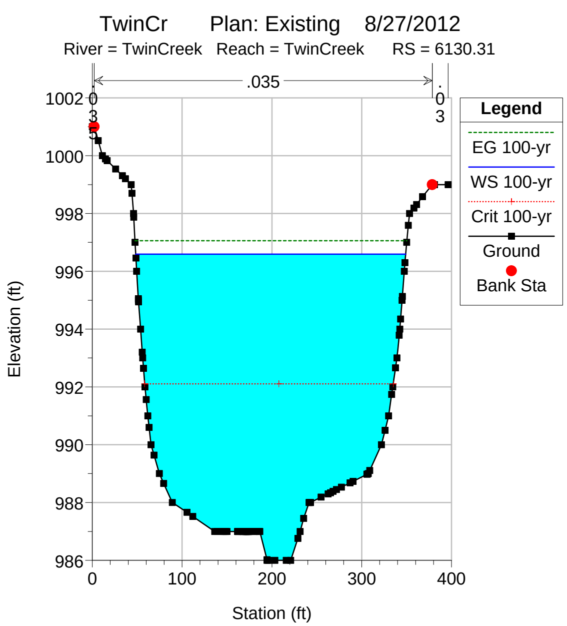
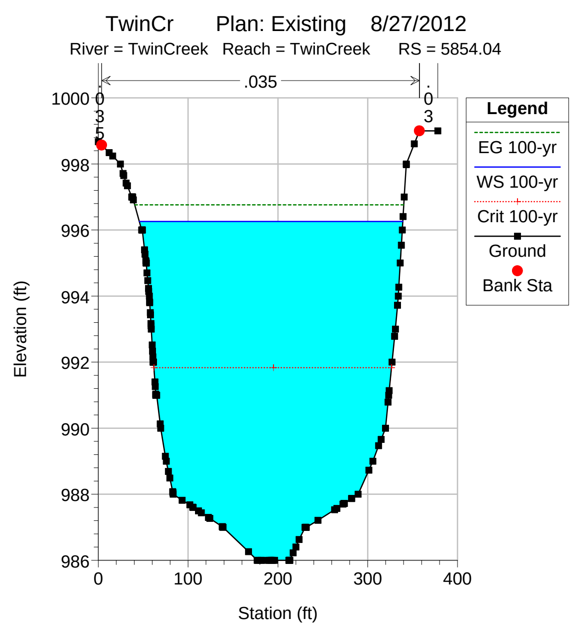
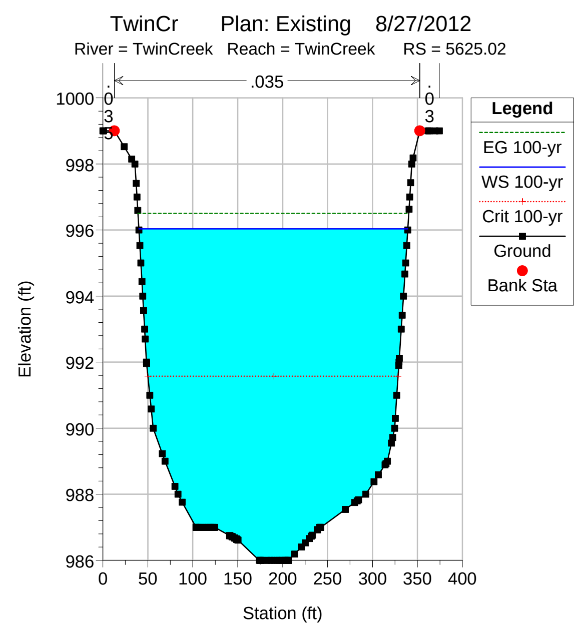
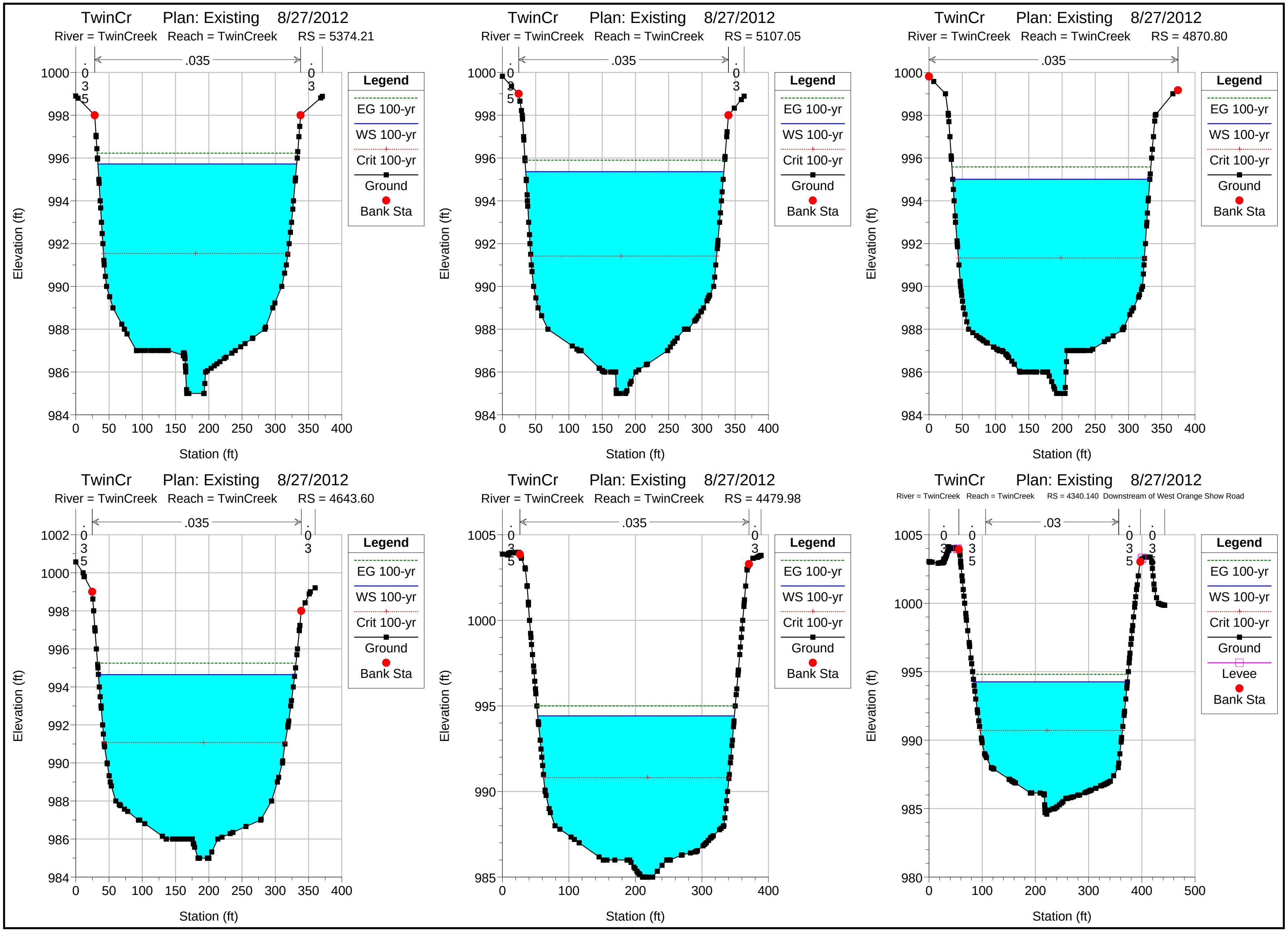
200
300
400


TwinCr Plan: Existing 8/27/2012
River = TwinCreek Reach = TwinCreek RS = 6375.71
.035
.03
Legend
EG 100-yr
WS 100-yr
Crit 100-yr
Ground
Bank Sta
Elevation (ft)
Station (ft)
1002
1000
998
996
994
992
990
988
986
0
100
200
300
400

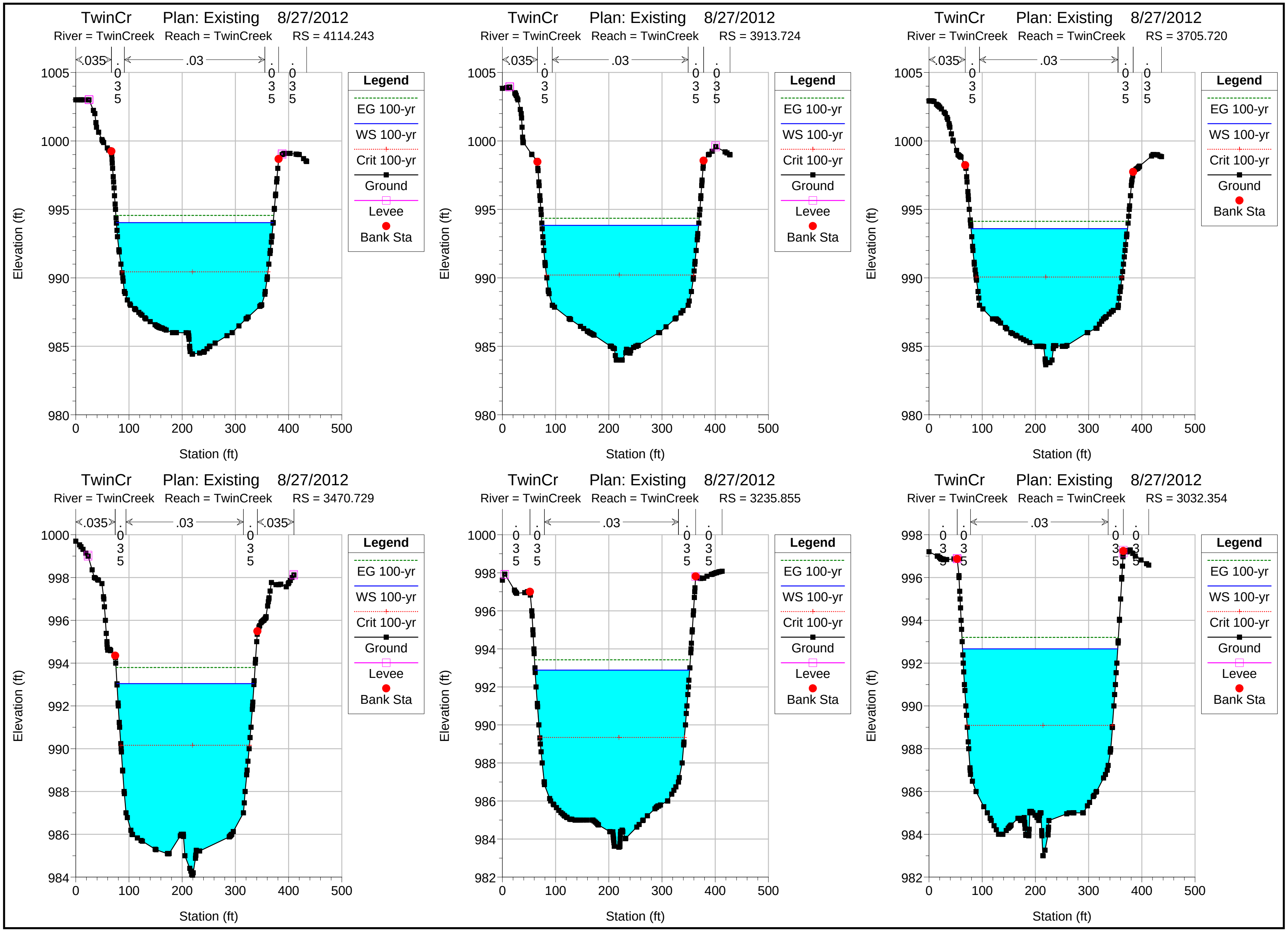

TwinCr Plan: Existing 8/27/2012
River = TwinCreek Reach = TwinCreek RS = 6130.31
.035
Legend
EG 100-yr
WS 100-yr
Crit 100-yr
Ground
Bank Sta
Elevation (ft)
Station (ft)
1002
1000
998
996
994
992
990
988
986
0
100
200
300
400

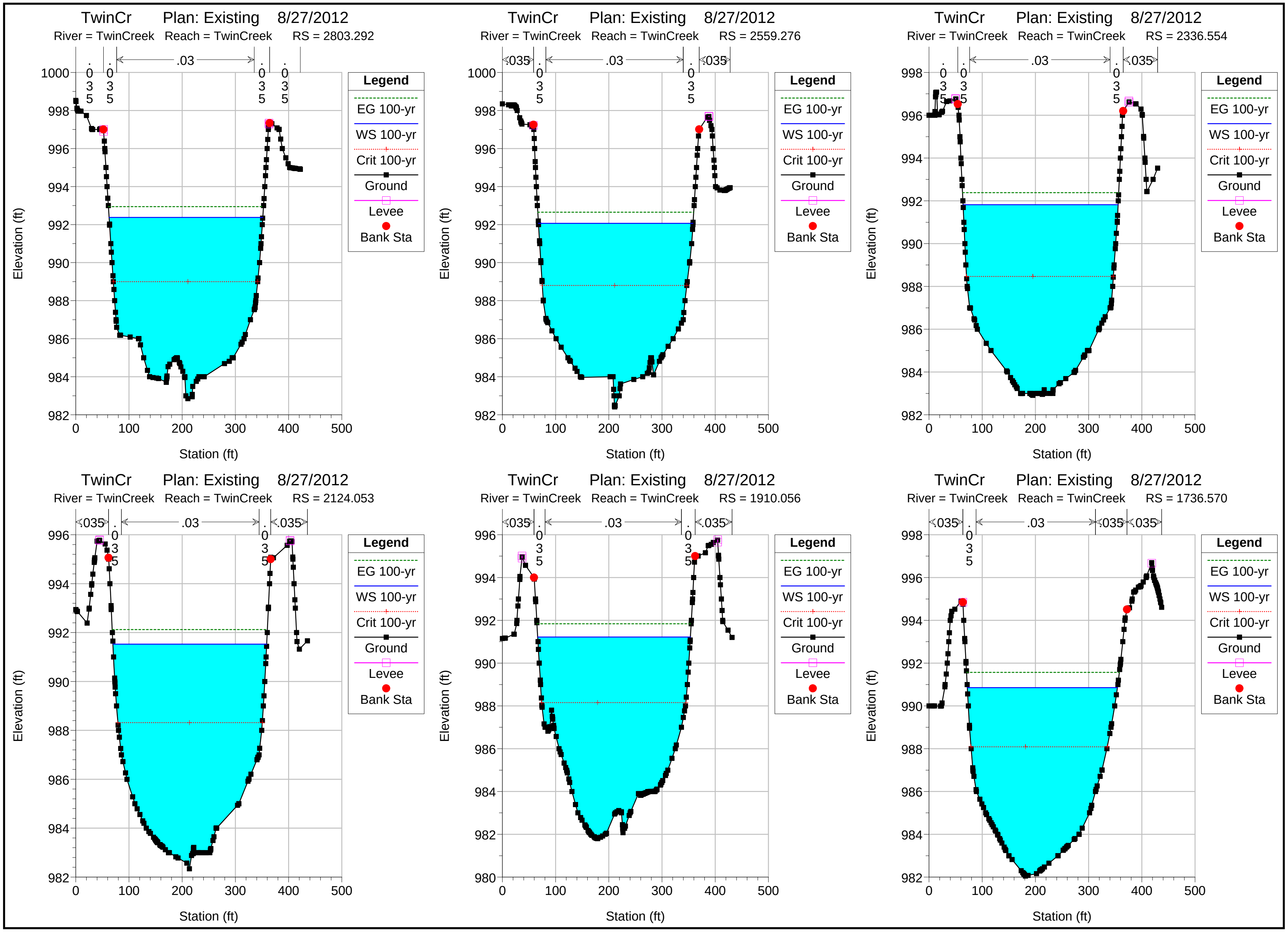

TwinCr Plan: Existing 8/27/2012
River = TwinCreek Reach = TwinCreek RS = 5854.04
.035
Legend
EG 100-yr
WS 100-yr
Crit 100-yr
Ground
Bank Sta
Elevation (ft)
Station (ft)
1000
998
996
994
992
990
988
986
0
100
200
300
400


TwinCr Plan: Existing 8/27/2012
River = TwinCreek Reach = TwinCreek RS = 5625.02
.035
Legend
EG 100-yr
WS 100-yr
Crit 100-yr
Ground
Bank Sta
Elevation (ft)
Station (ft)
1000
998
996
994
992
990
988
986
0
50
100
150
200
250
300
350
400

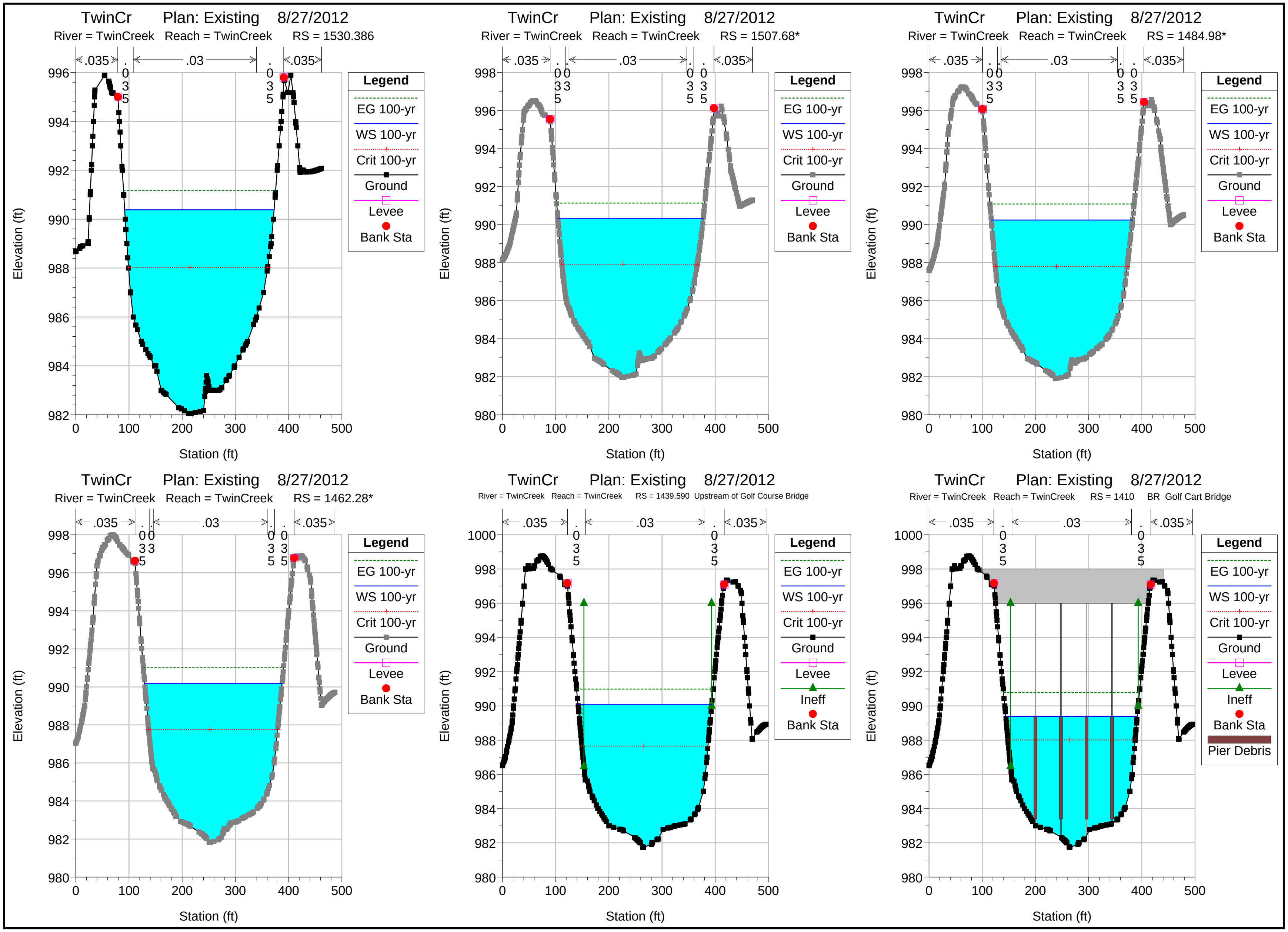


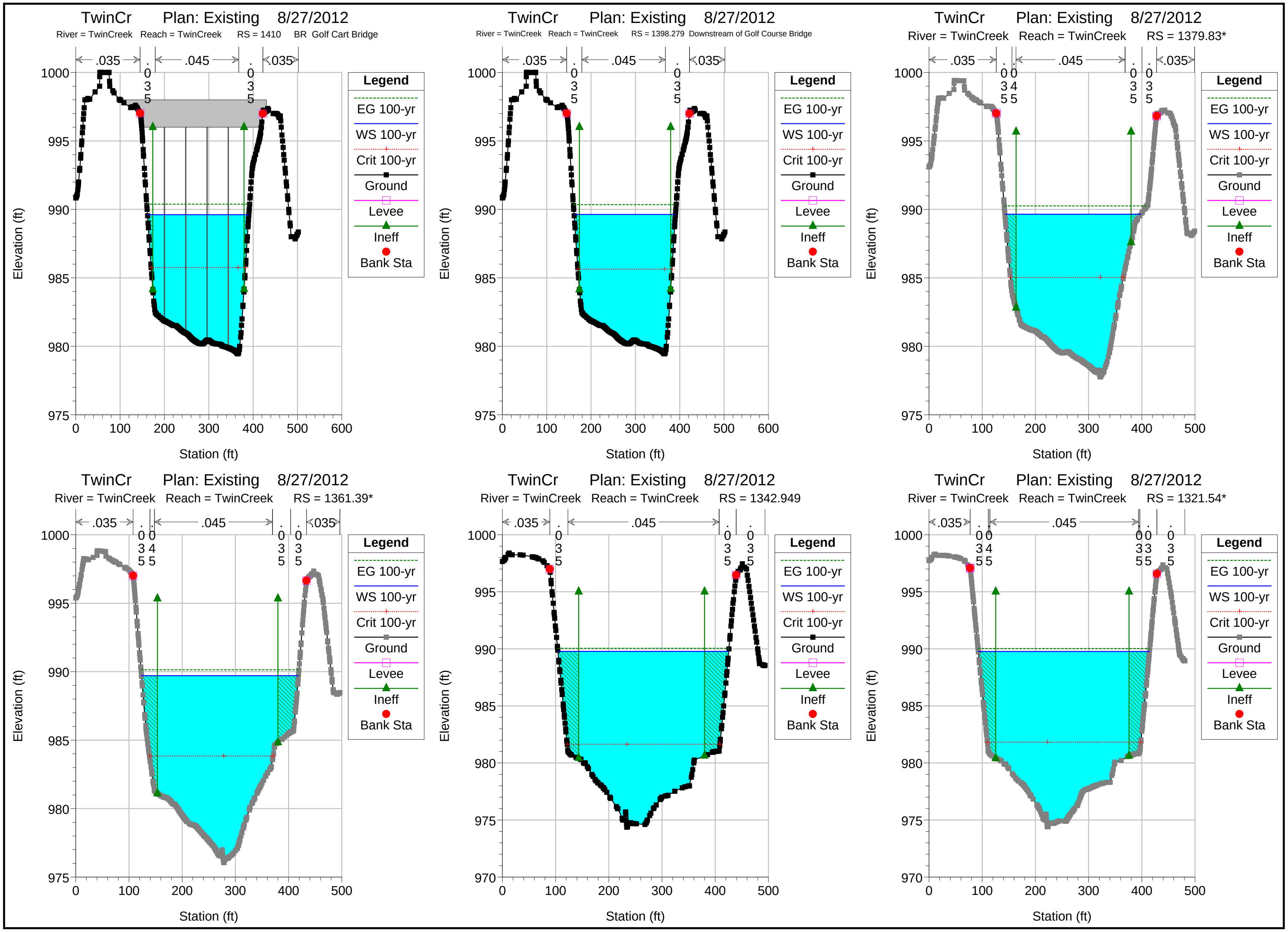
TwinCr Plan: Existing 8/27/2012
River = TwinCreek Reach = TwinCreek RS = 5374.21
.035
Legend
EG 100-yr
WS 100-yr
Crit 100-yr
Ground
Bank Sta
Elevation (ft)
Station (ft)
TwinCr Plan: Existing 8/27/2012
River = TwinCreek Reach = TwinCreek RS = 5107.05
.035
Legend
EG 100-yr
WS 100-yr
Crit 100-yr
Ground
Bank Sta
Elevation (ft)
Station (ft)
TwinCr Plan: Existing 8/27/2012
River = TwinCreek Reach = TwinCreek RS = 4870.80
.035
Legend
EG 100-yr
WS 100-yr
Crit 100-yr
Ground
Bank Sta
Elevation (ft)
Station (ft)
TwinCr Plan: Existing 8/27/2012
River = TwinCreek Reach = TwinCreek RS = 4643.60
.035
Legend
EG 100-yr
WS 100-yr
Crit 100-yr
Ground
Bank Sta
Elevation (ft)
Station (ft)
TwinCr Plan: Existing 8/27/2012
River = TwinCreek Reach = TwinCreek RS = 4479.98
.035
Legend
EG 100-yr
WS 100-yr
Crit 100-yr
Ground
Bank Sta
Elevation (ft)
Station (ft)
TwinCr Plan: Existing 8/27/2012
River = TwinCreek Reach = TwinCreek RS = 4340.140 Downstream of West Orange Show Road
.03
Legend
EG 100-yr
WS 100-yr
Crit 100-yr
Ground
Levee
Bank Sta
Elevation (ft)
Station (ft)


TwinCr Plan: Existing 8/27/2012
River = TwinCreek Reach = TwinCreek RS = 4114.243
TwinCr Plan: Existing 8/27/2012
River = TwinCreek Reach = TwinCreek RS = 3913.724
TwinCr Plan: Existing 8/27/2012
River = TwinCreek Reach = TwinCreek RS = 3705.720
TwinCr Plan: Existing 8/27/2012
River = TwinCreek Reach = TwinCreek RS = 3470.729
TwinCr Plan: Existing 8/27/2012
River = TwinCreek Reach = TwinCreek RS = 3235.855
TwinCr Plan: Existing 8/27/2012
River = TwinCreek Reach = TwinCreek RS = 3032.354
Legend
EG 100-yr
WS 100-yr
Crit 100-yr
Ground
Levee
Bank Sta
Elevation (ft)
Station (ft)

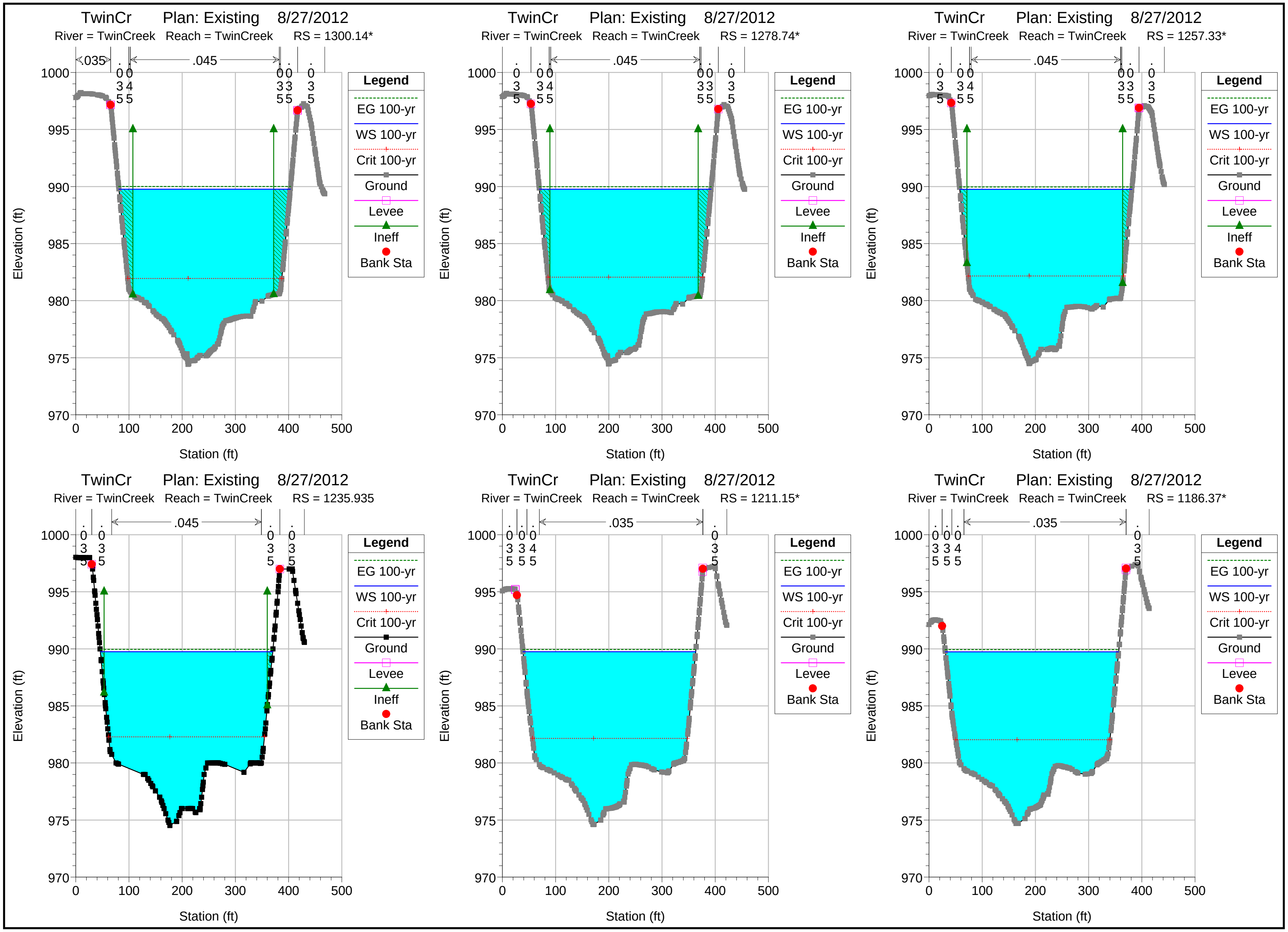


TwinCr Plan: Existing 8/27/2012
River = TwinCreek Reach = TwinCreek RS = 2803.292
.03
.035
Elevation (ft)
Station (ft)
Legend
EG 100-yr
WS 100-yr
Crit 100-yr
Ground
Levee
Bank Sta
TwinCr Plan: Existing 8/27/2012
River = TwinCreek Reach = TwinCreek RS = 2559.276
.035
.03
Elevation (ft)
Station (ft)
TwinCr Plan: Existing 8/27/2012
River = TwinCreek Reach = TwinCreek RS = 2336.554
.035
.03
Elevation (ft)
Station (ft)
TwinCr Plan: Existing 8/27/2012
River = TwinCreek Reach = TwinCreek RS = 2124.053
.035
.03
Elevation (ft)
Station (ft)
TwinCr Plan: Existing 8/27/2012
River = TwinCreek Reach = TwinCreek RS = 1910.056
.035
.03
Elevation (ft)
Station (ft)
TwinCr Plan: Existing 8/27/2012
River = TwinCreek Reach = TwinCreek RS = 1736.570
.035
.03
Elevation (ft)
Station (ft)

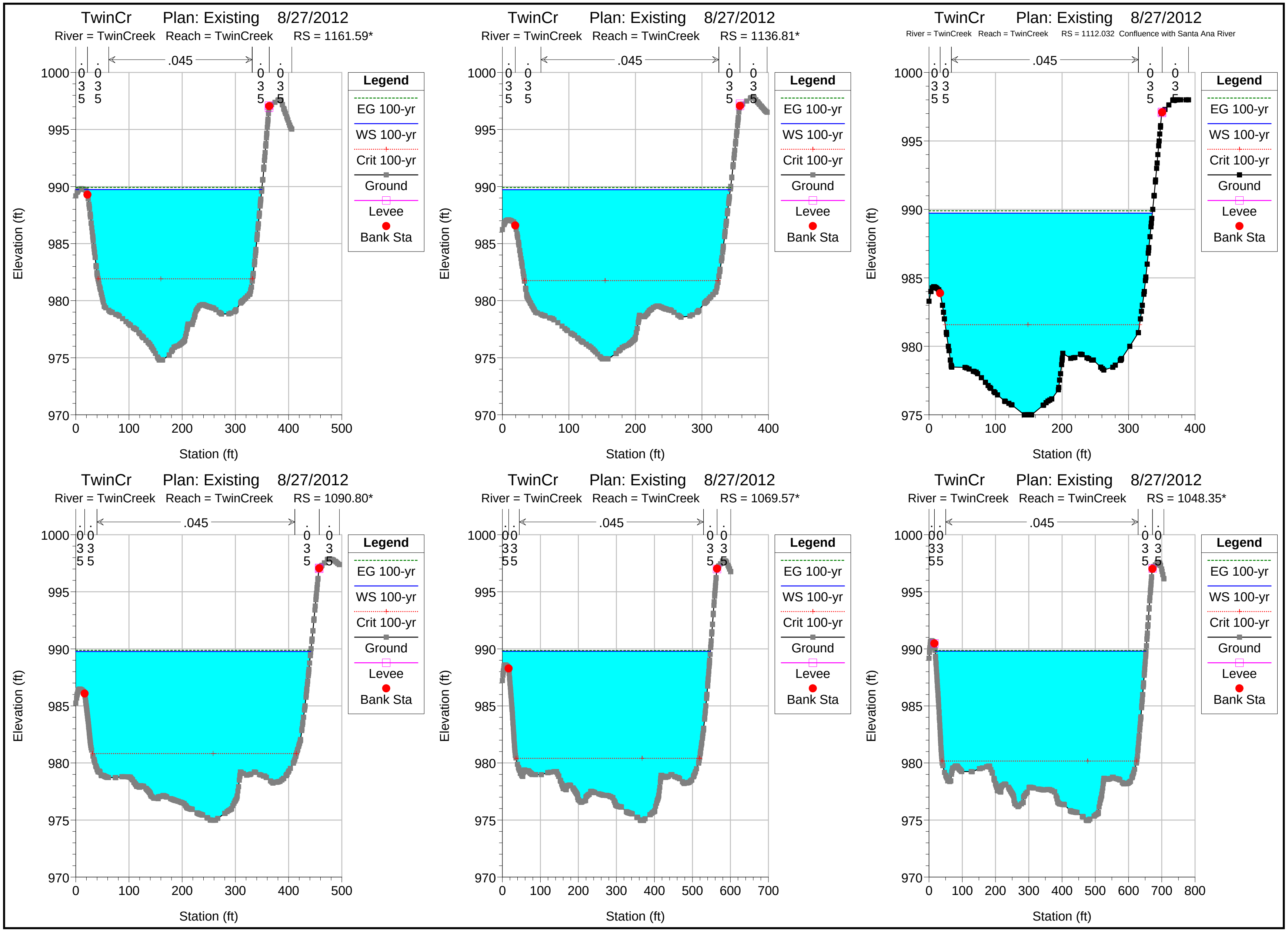

TwinCr Plan: Existing 8/27/2012
River = TwinCreek Reach = TwinCreek RS = 1530.386
TwinCr Plan: Existing 8/27/2012
River = TwinCreek Reach = TwinCreek RS = 1507.68*
TwinCr Plan: Existing 8/27/2012
River = TwinCreek Reach = TwinCreek RS = 1484.98*
TwinCr Plan: Existing 8/27/2012
River = TwinCreek Reach = TwinCreek RS = 1462.28*
TwinCr Plan: Existing 8/27/2012
River = TwinCreek Reach = TwinCreek RS = 1439.590 Upstream of Golf Course Bridge
TwinCr Plan: Existing 8/27/2012
River = TwinCreek Reach = TwinCreek RS = 1410 BR Golf Cart Bridge
.035
.03
Legend
EG 100-yr
WS 100-yr
Crit 100-yr
Ground
Levee
Ineff
Bank Sta
Pier Debris
Elevation (ft)
Station (ft)

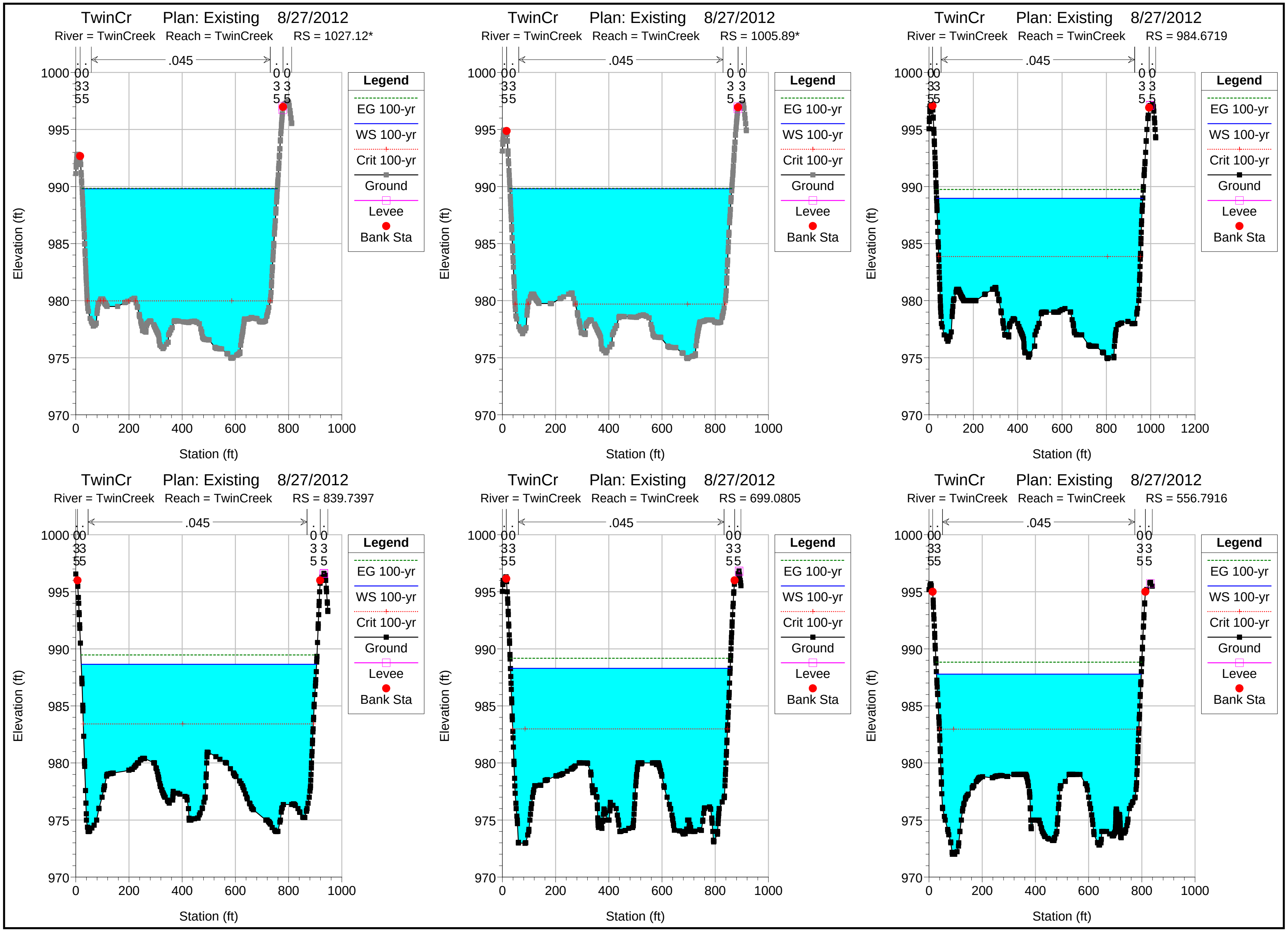


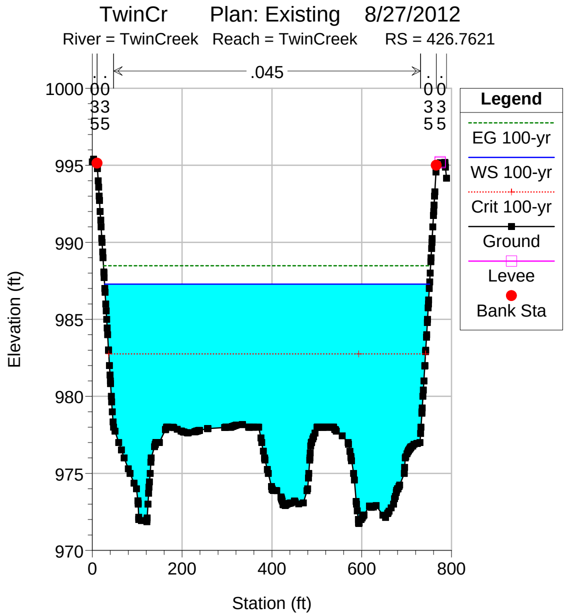
TwinCr Plan: Existing 8/27/2012
River = TwinCreek Reach = TwinCreek RS = 1410 BR Golf Cart Bridge
TwinCr Plan: Existing 8/27/2012
River = TwinCreek Reach = TwinCreek RS = 1398.279 Downstream of Golf Course Bridge
TwinCr Plan: Existing 8/27/2012
River = TwinCreek Reach = TwinCreek RS = 1379.83*
TwinCr Plan: Existing 8/27/2012
River = TwinCreek Reach = TwinCreek RS = 1361.39*
TwinCr Plan: Existing 8/27/2012
River = TwinCreek Reach = TwinCreek RS = 1342.949
TwinCr Plan: Existing 8/27/2012
River = TwinCreek Reach = TwinCreek RS = 1321.54*
.035
.045
Elevation (ft)
Station (ft)
Legend
EG 100-yr
WS 100-yr
Crit 100-yr
Ground
Levee
Ineff
Bank Sta

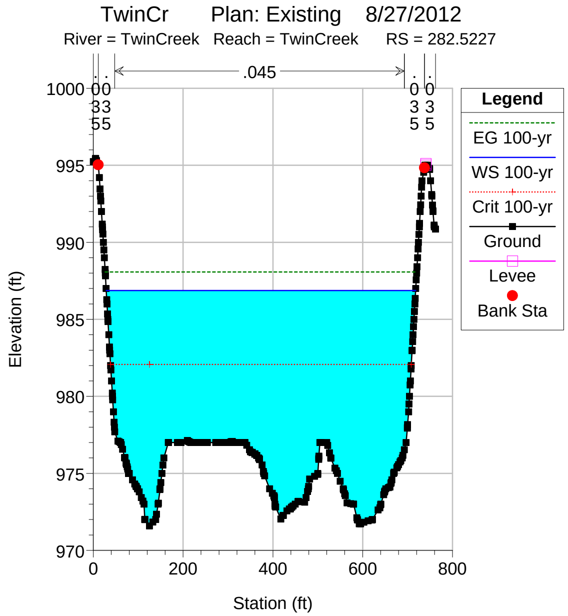


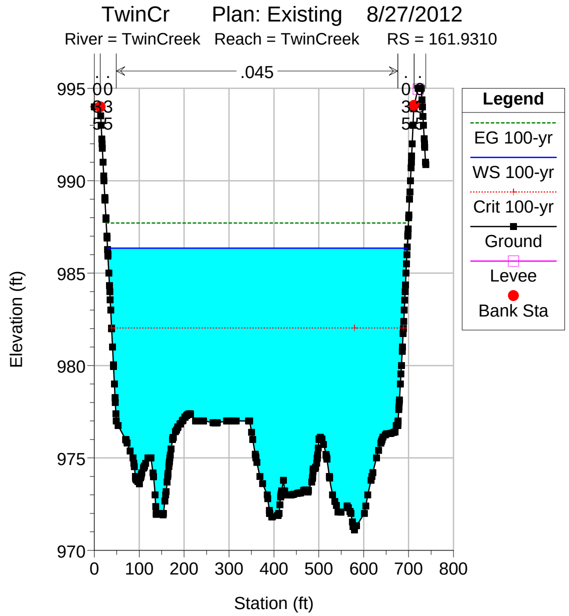
TwinCr Plan: Existing 8/27/2012
River = TwinCreek Reach = TwinCreek RS = 1300.14*
.035
.045
Elevation (ft)
Station (ft)
Legend
EG 100-yr
WS 100-yr
Crit 100-yr
Ground
Levee
Ineff
Bank Sta
TwinCr Plan: Existing 8/27/2012
River = TwinCreek Reach = TwinCreek RS = 1278.74*
.045
Elevation (ft)
Station (ft)
Legend
EG 100-yr
WS 100-yr
Crit 100-yr
Ground
Levee
Ineff
Bank Sta
TwinCr Plan: Existing 8/27/2012
River = TwinCreek Reach = TwinCreek RS = 1257.33*
.045
Elevation (ft)
Station (ft)
Legend
EG 100-yr
WS 100-yr
Crit 100-yr
Ground
Levee
Ineff
Bank Sta
TwinCr Plan: Existing 8/27/2012
River = TwinCreek Reach = TwinCreek RS = 1235.935
.045
Elevation (ft)
Station (ft)
Legend
EG 100-yr
WS 100-yr
Crit 100-yr
Ground
Levee
Ineff
Bank Sta
TwinCr Plan: Existing 8/27/2012
River = TwinCreek Reach = TwinCreek RS = 1211.15*
.035
Elevation (ft)
Station (ft)
Legend
EG 100-yr
WS 100-yr
Crit 100-yr
Ground
Levee
Bank Sta
TwinCr Plan: Existing 8/27/2012
River = TwinCreek Reach = TwinCreek RS = 1186.37*
.035
Elevation (ft)
Station (ft)
Legend
EG 100-yr
WS 100-yr
Crit 100-yr
Ground
Levee
Bank Sta

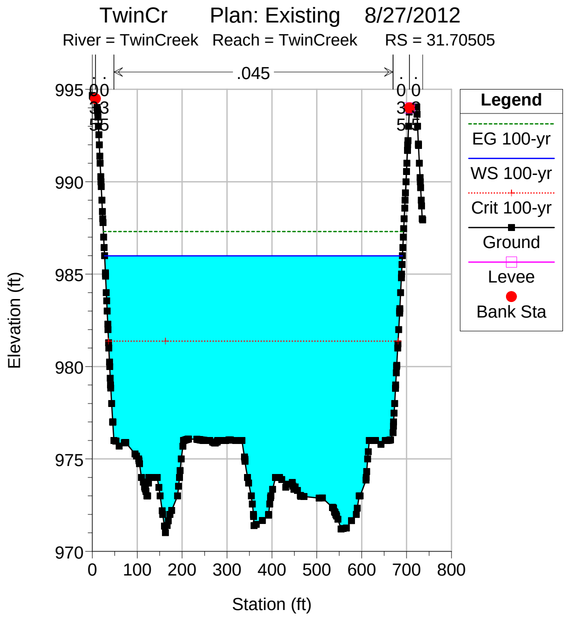

TwinCr Plan: Existing 8/27/2012
River = TwinCreek Reach = TwinCreek RS = 1161.59*
.045
Legend
EG 100-yr
WS 100-yr
Crit 100-yr
Ground
Levee
Bank Sta
Elevation (ft)
Station (ft)
TwinCr Plan: Existing 8/27/2012
River = TwinCreek Reach = TwinCreek RS = 1136.81*
TwinCr Plan: Existing 8/27/2012
River = TwinCreek Reach = TwinCreek RS = 1112.032 Confluence with Santa Ana River
TwinCr Plan: Existing 8/27/2012
River = TwinCreek Reach = TwinCreek RS = 1090.80*
TwinCr Plan: Existing 8/27/2012
River = TwinCreek Reach = TwinCreek RS = 1069.57*
TwinCr Plan: Existing 8/27/2012
River = TwinCreek Reach = TwinCreek RS = 1048.35*


TwinCr Plan: Existing 8/27/2012
River = TwinCreek Reach = TwinCreek RS = 1027.12*
.045
Legend
EG 100-yr
WS 100-yr
Crit 100-yr
Ground
Levee
Bank Sta
Elevation (ft)
Station (ft)
TwinCr Plan: Existing 8/27/2012
River = TwinCreek Reach = TwinCreek RS = 1005.89*
.045
Legend
EG 100-yr
WS 100-yr
Crit 100-yr
Ground
Levee
Bank Sta
Elevation (ft)
Station (ft)
TwinCr Plan: Existing 8/27/2012
River = TwinCreek Reach = TwinCreek RS = 984.6719
.045
Legend
EG 100-yr
WS 100-yr
Crit 100-yr
Ground
Levee
Bank Sta
Elevation (ft)
Station (ft)
TwinCr Plan: Existing 8/27/2012
River = TwinCreek Reach = TwinCreek RS = 839.7397
.045
Legend
EG 100-yr
WS 100-yr
Crit 100-yr
Ground
Levee
Bank Sta
Elevation (ft)
Station (ft)
TwinCr Plan: Existing 8/27/2012
River = TwinCreek Reach = TwinCreek RS = 699.0805
.045
Legend
EG 100-yr
WS 100-yr
Crit 100-yr
Ground
Levee
Bank Sta
Elevation (ft)
Station (ft)
TwinCr Plan: Existing 8/27/2012
River = TwinCreek Reach = TwinCreek RS = 556.7916
.045
Legend
EG 100-yr
WS 100-yr
Crit 100-yr
Ground
Levee
Bank Sta
Elevation (ft)
Station (ft)


TwinCr Plan: Existing 8/27/2012
River = TwinCreek Reach = TwinCreek RS = 426.7621
.045
Legend
EG 100-yr
WS 100-yr
Crit 100-yr
Ground
Levee
Bank Sta
Elevation (ft)
Station (ft)


TwinCr Plan: Existing 8/27/2012
River = TwinCreek Reach = TwinCreek RS = 282.5227
.045
Legend
EG 100-yr
WS 100-yr
Crit 100-yr
Ground
Levee
Bank Sta
Elevation (ft)
Station (ft)


TwinCr Plan: Existing 8/27/2012
River = TwinCreek Reach = TwinCreek RS = 161.9310
.045
Legend
EG 100-yr
WS 100-yr
Crit 100-yr
Ground
Levee
Bank Sta
Elevation (ft)
Station (ft)


TwinCr Plan: Existing 8/27/2012
River = TwinCreek Reach = TwinCreek RS = 31.70505
.045
Legend
EG 100-yr
WS 100-yr
Crit 100-yr
Ground
Levee
Bank Sta
Elevation (ft)
Station (ft)

# Attachment 2 – Hydraulic Analysis Results

HEC-RAS  Plan: Existing   River: TwinCreek   Reach: TwinCreek    Profile: 100-yr

| Reach | River Sta | Profile | Q Total | Min Ch El | W.S. Elev | Crit W.S. | E.G. Elev | E.G. Slope | Vel Chnl | Flow Area | Top Width | Froude # Chl |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | (cfs) | (ft) | (ft) | (ft) | (ft) | (ft/ft) | (ft/s) | (sq ft) | (ft) | |
| TwinCreek | 9236.44 | 100-yr | 13500.00 | 992.20 | 1000.11 | 1004.21 | 1014.06 | 0.008393 | 29.98 | 450.34 | 60.00 | 1.93 |
| TwinCreek | 8824.92 | 100-yr | 13500.00 | 988.70 | 996.59 | 1000.71 | 1010.60 | 0.008442 | 30.03 | 449.50 | 60.00 | 1.93 |
| TwinCreek | 8738.44 | 100-yr | 13500.00 | 987.98 | 995.87 | 999.99 | 1009.87 | 0.008429 | 30.02 | 449.71 | 60.00 | 1.93 |
| TwinCreek | 8733.14 | 100-yr | 13500.00 | 987.91 | 995.80 | 999.92 | 1009.82 | 0.008459 | 30.05 | 449.19 | 60.00 | 1.94 |
| TwinCreek | 8724.92 | 100-yr | 13500.00 | 988.24 | 995.73 | 999.85 | 1009.75 | 0.008461 | 30.06 | 449.14 | 60.00 | 1.94 |
| TwinCreek | 8713.44 | 100-yr | 13500.00 | 988.14 | 995.63 | 999.75 | 1009.65 | 0.008451 | 30.05 | 449.32 | 60.00 | 1.93 |
| TwinCreek | 8705.29 | | Bridge | | | | | | | | | |
| TwinCreek | 8695.59 | 100-yr | 13500.00 | 987.99 | 995.48 | 999.58 | 1009.49 | 0.008446 | 30.04 | 449.41 | 60.00 | 1.93 |
| TwinCreek | 8599.44 | 100-yr | 13500.00 | 987.17 | 994.66 | 998.76 | 1008.69 | 0.008462 | 30.06 | 449.13 | 60.00 | 1.94 |
| TwinCreek | 8586.09 | 100-yr | 13500.00 | 987.16 | 994.43 | 998.53 | 1008.44 | 0.061477 | 30.03 | 449.53 | 61.81 | 1.96 |
| TwinCreek | 8538.89 | 100-yr | 13500.00 | 986.58 | 999.67 | 993.14 | 1000.06 | 0.000836 | 5.01 | 2696.81 | 264.40 | 0.28 |
| TwinCreek | 8488.89 | 100-yr | 13500.00 | 986.57 | 999.63 | 993.13 | 1000.02 | 0.000845 | 5.02 | 2687.61 | 264.21 | 0.28 |
| TwinCreek | 8438.89 | 100-yr | 13500.00 | 986.57 | 999.58 | 993.13 | 999.98 | 0.000856 | 5.05 | 2675.39 | 263.96 | 0.28 |
| TwinCreek | 8388.89 | 100-yr | 13500.00 | 986.56 | 999.54 | 993.12 | 999.93 | 0.000866 | 5.06 | 2665.91 | 263.76 | 0.28 |
| TwinCreek | 8338.89 | 100-yr | 13500.00 | 986.56 | 999.49 | 993.12 | 999.89 | 0.000878 | 5.09 | 2653.39 | 263.50 | 0.28 |
| TwinCreek | 8288.89 | 100-yr | 13500.00 | 986.56 | 999.44 | 993.12 | 999.85 | 0.000891 | 5.11 | 2640.69 | 263.23 | 0.28 |
| TwinCreek | 8238.89 | 100-yr | 13500.00 | 986.55 | 999.39 | 993.11 | 999.80 | 0.000901 | 5.13 | 2630.70 | 263.02 | 0.29 |
| TwinCreek | 8188.89 | 100-yr | 13500.00 | 986.55 | 999.34 | 993.11 | 999.76 | 0.000915 | 5.16 | 2617.65 | 262.75 | 0.29 |
| TwinCreek | 8138.89 | 100-yr | 13500.00 | 986.55 | 999.29 | 993.11 | 999.71 | 0.000929 | 5.18 | 2604.41 | 262.47 | 0.29 |
| TwinCreek | 8088.89 | 100-yr | 13500.00 | 986.54 | 999.24 | 993.10 | 999.66 | 0.000941 | 5.20 | 2593.84 | 262.25 | 0.29 |
| TwinCreek | 8038.89 | 100-yr | 13500.00 | 986.54 | 999.19 | 993.10 | 999.61 | 0.000956 | 5.23 | 2580.23 | 261.96 | 0.29 |
| TwinCreek | 7988.89 | 100-yr | 13500.00 | 986.54 | 999.14 | 993.10 | 999.57 | 0.000972 | 5.26 | 2566.37 | 261.67 | 0.30 |
| TwinCreek | 7938.89 | 100-yr | 13500.00 | 986.53 | 999.08 | 993.09 | 999.52 | 0.000985 | 5.28 | 2555.16 | 261.43 | 0.30 |
| TwinCreek | 7888.89 | 100-yr | 13500.00 | 986.53 | 999.03 | 993.09 | 999.47 | 0.001002 | 5.31 | 2540.87 | 261.13 | 0.30 |
| TwinCreek | 7838.89 | 100-yr | 13500.00 | 986.53 | 998.97 | 993.09 | 999.42 | 0.001020 | 5.34 | 2526.33 | 260.82 | 0.30 |
| TwinCreek | 7788.89 | 100-yr | 13500.00 | 986.52 | 998.92 | 993.08 | 999.37 | 0.001034 | 5.37 | 2514.42 | 260.57 | 0.30 |
| TwinCreek | 7738.89 | 100-yr | 13500.00 | 986.52 | 998.86 | 993.08 | 999.31 | 0.001053 | 5.40 | 2499.40 | 260.25 | 0.31 |
| TwinCreek | 7688.89 | 100-yr | 13500.00 | 986.51 | 998.80 | 993.07 | 999.26 | 0.001070 | 5.43 | 2487.00 | 259.99 | 0.31 |
| TwinCreek | 7638.89 | 100-yr | 13500.00 | 986.51 | 998.74 | 993.07 | 999.21 | 0.001090 | 5.46 | 2471.45 | 259.66 | 0.31 |
| TwinCreek | 7588.89 | 100-yr | 13500.00 | 986.51 | 998.68 | 993.07 | 999.15 | 0.001112 | 5.50 | 2455.56 | 259.32 | 0.31 |
| TwinCreek | 7538.89 | 100-yr | 13500.00 | 986.50 | 998.62 | 993.07 | 999.09 | 0.001130 | 5.53 | 2442.26 | 259.04 | 0.32 |
| TwinCreek | 7488.89 | 100-yr | 13500.00 | 986.50 | 998.55 | 993.07 | 999.04 | 0.001154 | 5.57 | 2425.46 | 258.68 | 0.32 |
| TwinCreek | 7443.69 | 100-yr | 13500.00 | 986.43 | 998.34 | 993.92 | 998.96 | 0.001703 | 6.32 | 2136.81 | 252.87 | 0.38 |
| TwinCreek | 7393.69 | 100-yr | 13500.00 | 986.36 | 998.25 | 993.85 | 998.87 | 0.001714 | 6.33 | 2132.26 | 252.76 | 0.38 |
| TwinCreek | 7343.69 | 100-yr | 13500.00 | 986.29 | 998.16 | 993.78 | 998.79 | 0.001726 | 6.35 | 2127.54 | 252.64 | 0.39 |
| TwinCreek | 7293.69 | 100-yr | 13500.00 | 986.22 | 998.07 | 993.71 | 998.70 | 0.001738 | 6.36 | 2122.63 | 252.52 | 0.39 |
| TwinCreek | 7243.69 | 100-yr | 13500.00 | 986.15 | 997.98 | 993.64 | 998.61 | 0.001750 | 6.38 | 2117.54 | 252.39 | 0.39 |
| TwinCreek | 7193.69 | 100-yr | 13500.00 | 986.08 | 997.89 | 993.57 | 998.53 | 0.001764 | 6.39 | 2112.26 | 252.26 | 0.39 |
| TwinCreek | 7143.69 | 100-yr | 13500.00 | 986.00 | 997.80 | 993.49 | 998.44 | 0.001770 | 6.40 | 2109.78 | 252.19 | 0.39 |
| TwinCreek | 7093.69 | 100-yr | 13500.00 | 985.93 | 997.71 | 993.42 | 998.35 | 0.001784 | 6.42 | 2104.19 | 252.05 | 0.39 |
| TwinCreek | 7043.69 | 100-yr | 13500.00 | 985.86 | 997.62 | 993.35 | 998.26 | 0.001800 | 6.43 | 2098.38 | 251.91 | 0.39 |
| TwinCreek | 6993.69 | 100-yr | 13500.00 | 985.79 | 997.52 | 993.28 | 998.17 | 0.001815 | 6.45 | 2092.32 | 251.75 | 0.39 |
| TwinCreek | 6943.69 | 100-yr | 13500.00 | 985.72 | 997.43 | 993.21 | 998.08 | 0.001832 | 6.47 | 2086.02 | 251.60 | 0.40 |
| TwinCreek | 6893.69 | 100-yr | 13500.00 | 985.64 | 997.33 | 993.13 | 997.99 | 0.001842 | 6.48 | 2082.49 | 251.51 | 0.40 |
| TwinCreek | 6843.69 | 100-yr | 13500.00 | 985.57 | 997.24 | 993.07 | 997.90 | 0.001859 | 6.50 | 2076.06 | 251.35 | 0.40 |
| TwinCreek | 6793.69 | 100-yr | 13500.00 | 987.00 | 997.10 | 993.26 | 997.80 | 0.001609 | 6.75 | 1999.73 | 250.90 | 0.42 |
| TwinCreek | 6654.79 | | Bridge | | | | | | | | | |
| TwinCreek | 6650.20 | 100-yr | 13500.00 | 986.00 | 997.07 | 992.87 | 997.72 | 0.001376 | 6.44 | 2095.49 | 250.84 | 0.39 |
| TwinCreek | 6375.71 | 100-yr | 13500.00 | 987.00 | 996.81 | 992.38 | 997.34 | 0.001136 | 5.82 | 2319.66 | 280.21 | 0.36 |
| TwinCreek | 6130.31 | 100-yr | 13500.00 | 986.00 | 996.59 | 992.11 | 997.06 | 0.001023 | 5.49 | 2460.83 | 300.61 | 0.34 |
| TwinCreek | 5854.04 | 100-yr | 13500.00 | 986.00 | 996.26 | 991.83 | 996.76 | 0.001117 | 5.69 | 2373.17 | 293.30 | 0.35 |
| TwinCreek | 5625.02 | 100-yr | 13500.00 | 986.00 | 996.03 | 991.58 | 996.50 | 0.001029 | 5.51 | 2452.19 | 299.20 | 0.34 |
| TwinCreek | 5374.21 | 100-yr | 13500.00 | 985.00 | 995.72 | 991.54 | 996.23 | 0.001162 | 5.71 | 2365.05 | 298.97 | 0.36 |
| TwinCreek | 5107.05 | 100-yr | 13500.00 | 985.00 | 995.36 | 991.42 | 995.90 | 0.001268 | 5.87 | 2299.90 | 297.72 | 0.37 |
| TwinCreek | 4870.80 | 100-yr | 13500.00 | 985.00 | 995.01 | 991.33 | 995.58 | 0.001407 | 6.07 | 2225.77 | 296.33 | 0.39 |
| TwinCreek | 4643.60 | 100-yr | 13500.00 | 985.00 | 994.65 | 991.07 | 995.25 | 0.001514 | 6.22 | 2170.21 | 295.15 | 0.40 |
| TwinCreek | 4479.98 | 100-yr | 13500.00 | 985.00 | 994.41 | 990.81 | 995.00 | 0.001459 | 6.14 | 2197.32 | 295.61 | 0.40 |
| TwinCreek | 4340.140 | 100-yr | 12300.00 | 984.60 | 994.26 | 990.71 | 994.81 | 0.001112 | 5.96 | 2065.38 | 288.66 | 0.39 |
| TwinCreek | 4114.243 | 100-yr | 12300.00 | 984.43 | 994.04 | 990.44 | 994.56 | 0.001043 | 5.81 | 2115.23 | 294.56 | 0.38 |
| TwinCreek | 3913.724 | 100-yr | 12300.00 | 984.00 | 993.83 | 990.20 | 994.35 | 0.001024 | 5.77 | 2132.30 | 294.36 | 0.38 |
| TwinCreek | 3705.720 | 100-yr | 12300.00 | 983.65 | 993.59 | 990.06 | 994.13 | 0.001098 | 5.90 | 2083.97 | 293.86 | 0.39 |
| TwinCreek | 3470.729 | 100-yr | 12300.00 | 984.09 | 993.04 | 990.16 | 993.80 | 0.001620 | 6.97 | 1765.07 | 257.56 | 0.47 |
| TwinCreek | 3235.855 | 100-yr | 12300.00 | 983.57 | 992.88 | 989.34 | 993.42 | 0.001090 | 5.91 | 2082.45 | 290.50 | 0.39 |
| TwinCreek | 3032.354 | 100-yr | 12300.00 | 983.00 | 992.66 | 989.09 | 993.20 | 0.001077 | 5.88 | 2091.31 | 291.59 | 0.39 |
| TwinCreek | 2803.292 | 100-yr | 12300.00 | 982.85 | 992.37 | 989.00 | 992.94 | 0.001162 | 6.05 | 2033.20 | 288.79 | 0.40 |
| TwinCreek | 2559.276 | 100-yr | 12300.00 | 982.42 | 992.07 | 988.80 | 992.65 | 0.001225 | 6.13 | 2006.66 | 290.48 | 0.41 |
| TwinCreek | 2336.554 | 100-yr | 12300.00 | 982.91 | 991.82 | 988.47 | 992.38 | 0.001148 | 6.02 | 2044.29 | 291.33 | 0.40 |
| TwinCreek | 2124.053 | 100-yr | 12300.00 | 982.34 | 991.53 | 988.31 | 992.12 | 0.001248 | 6.19 | 1987.60 | 288.91 | 0.42 |
| TwinCreek | 1910.056 | 100-yr | 12300.00 | 981.80 | 991.22 | 988.16 | 991.84 | 0.001343 | 6.34 | 1940.28 | 286.96 | 0.43 |
| TwinCreek | 1736.570 | 100-yr | 12300.00 | 982.05 | 990.85 | 988.09 | 991.57 | 0.001710 | 6.80 | 1807.66 | 282.02 | 0.47 |
| TwinCreek | 1530.386 | 100-yr | 12300.00 | 982.06 | 990.38 | 988.02 | 991.18 | 0.002007 | 7.17 | 1715.05 | 280.74 | 0.51 |
| TwinCreek | 1507.68* | 100-yr | 12300.00 | 981.98 | 990.31 | 987.92 | 991.13 | 0.002014 | 7.27 | 1692.32 | 273.04 | 0.51 |
| TwinCreek | 1484.98* | 100-yr | 12300.00 | 981.90 | 990.24 | 987.80 | 991.08 | 0.002015 | 7.36 | 1671.24 | 265.41 | 0.52 |
| TwinCreek | 1462.28* | 100-yr | 12300.00 | 981.81 | 990.17 | 987.75 | 991.03 | 0.002016 | 7.45 | 1651.05 | 258.11 | 0.52 |
| TwinCreek | 1439.590 | 100-yr | 12300.00 | 981.73 | 990.07 | 987.65 | 990.98 | 0.001958 | 7.67 | 1603.97 | 251.06 | 0.52 |

HEC-RAS Plan: Existing River: TwinCreek Reach: TwinCreek Profile: 100-yr (Continued)

| Reach | River Sta | Profile | Q Total | Min Ch El | W.S. Elev | Crit W.S. | E.G. Elev | E.G. Slope | Vel Chnl | Flow Area | Top Width | Froude # Chl |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | (cfs) | (ft) | (ft) | (ft) | (ft) | (ft/ft) | (ft/s) | (sq ft) | (ft) | |
| TwinCreek | 1410 | | Bridge | | | | | | | | | |
| TwinCreek | 1398.279 | 100-yr | 12300.00 | 979.45 | 989.63 | 985.64 | 990.35 | 0.002268 | 6.80 | 1808.90 | 228.61 | 0.40 |
| TwinCreek | 1379.83* | 100-yr | 12300.00 | 977.76 | 989.65 | 985.02 | 990.25 | 0.001870 | 6.26 | 1963.37 | 255.64 | 0.37 |
| TwinCreek | 1361.39* | 100-yr | 12300.00 | 976.06 | 989.71 | 983.84 | 990.14 | 0.001126 | 5.28 | 2329.91 | 295.06 | 0.29 |
| TwinCreek | 1342.949 | 100-yr | 12300.00 | 974.37 | 989.77 | 981.65 | 990.04 | 0.000551 | 4.16 | 2957.14 | 321.02 | 0.21 |
| TwinCreek | 1321.54* | 100-yr | 12300.00 | 974.40 | 989.77 | 981.82 | 990.02 | 0.000535 | 4.03 | 3050.41 | 321.58 | 0.20 |
| TwinCreek | 1300.14* | 100-yr | 12300.00 | 974.43 | 989.77 | 981.94 | 990.00 | 0.000519 | 3.91 | 3145.33 | 322.16 | 0.20 |
| TwinCreek | 1278.74* | 100-yr | 12300.00 | 974.46 | 989.76 | 982.06 | 989.99 | 0.000503 | 3.80 | 3240.72 | 322.74 | 0.20 |
| TwinCreek | 1257.33* | 100-yr | 12300.00 | 974.49 | 989.76 | 982.16 | 989.97 | 0.000486 | 3.69 | 3328.96 | 323.33 | 0.19 |
| TwinCreek | 1235.935 | 100-yr | 12300.00 | 974.52 | 989.75 | 982.29 | 989.96 | 0.000483 | 3.64 | 3380.84 | 323.92 | 0.19 |
| TwinCreek | 1211.15* | 100-yr | 12300.00 | 974.62 | 989.75 | 982.16 | 989.94 | 0.000322 | 3.57 | 3448.76 | 324.49 | 0.19 |
| TwinCreek | 1186.37* | 100-yr | 12300.00 | 974.71 | 989.74 | 982.04 | 989.93 | 0.000311 | 3.53 | 3486.48 | 325.75 | 0.19 |
| TwinCreek | 1161.59* | 100-yr | 12300.00 | 974.81 | 989.73 | 981.91 | 989.92 | 0.000438 | 3.48 | 3535.71 | 339.05 | 0.19 |
| TwinCreek | 1136.81* | 100-yr | 12300.00 | 974.90 | 989.73 | 981.76 | 989.91 | 0.000405 | 3.41 | 3637.82 | 342.71 | 0.18 |
| TwinCreek | 1112.032 | 100-yr | 12300.00 | 975.00 | 989.73 | 981.58 | 989.90 | 0.000384 | 3.34 | 3720.00 | 335.86 | 0.17 |
| TwinCreek | 1090.80* | 100-yr | 12300.00 | 974.99 | 989.77 | 980.82 | 989.87 | 0.000211 | 2.50 | 4947.05 | 441.68 | 0.13 |
| TwinCreek | 1069.57* | 100-yr | 12300.00 | 974.97 | 989.79 | 980.41 | 989.86 | 0.000139 | 2.01 | 6131.31 | 547.28 | 0.10 |
| TwinCreek | 1048.35* | 100-yr | 12300.00 | 974.96 | 989.80 | 980.17 | 989.85 | 0.000098 | 1.69 | 7286.33 | 634.22 | 0.09 |
| TwinCreek | 1027.12* | 100-yr | 12300.00 | 974.95 | 989.81 | 979.98 | 989.84 | 0.000073 | 1.46 | 8435.77 | 734.17 | 0.08 |
| TwinCreek | 1005.89* | 100-yr | 12300.00 | 974.93 | 989.81 | 979.71 | 989.84 | 0.000057 | 1.29 | 9556.63 | 834.14 | 0.07 |
| TwinCreek | 984.6719 | 100-yr | 70000.00 | 974.92 | 988.97 | 983.87 | 989.75 | 0.001951 | 7.10 | 9858.95 | 930.13 | 0.38 |
| TwinCreek | 839.7397 | 100-yr | 70000.00 | 974.00 | 988.65 | 983.42 | 989.46 | 0.001955 | 7.25 | 9652.98 | 884.50 | 0.39 |
| TwinCreek | 699.0805 | 100-yr | 70000.00 | 972.96 | 988.29 | 982.99 | 989.17 | 0.002041 | 7.53 | 9290.01 | 825.78 | 0.40 |
| TwinCreek | 556.7916 | 100-yr | 70000.00 | 972.00 | 987.79 | 982.97 | 988.84 | 0.002483 | 8.22 | 8516.67 | 769.54 | 0.44 |
| TwinCreek | 426.7621 | 100-yr | 70000.00 | 971.75 | 987.29 | 982.75 | 988.48 | 0.002826 | 8.75 | 7995.85 | 723.74 | 0.46 |
| TwinCreek | 282.5227 | 100-yr | 70000.00 | 971.59 | 986.87 | 982.07 | 988.08 | 0.002691 | 8.81 | 7942.37 | 689.00 | 0.46 |
| TwinCreek | 161.9310 | 100-yr | 70000.00 | 971.11 | 986.35 | 982.03 | 987.71 | 0.003160 | 9.36 | 7477.97 | 667.45 | 0.49 |
| TwinCreek | 31.70505 | 100-yr | 70000.00 | 971.01 | 985.99 | 981.37 | 987.30 | 0.002943 | 9.19 | 7616.46 | 663.36 | 0.48 |

# Attachment 3 – Digital Information (CD)

## SANBAG Redlands Passenger Rail Project

Job Name: Hydraulic Impact Analysis – Santa Ana River Bridge 3.4
Job Number: 170063
Client: SANBAG
Consultant: HDR Engineering, Inc.

This report and the analysis and design calculations contained herein have been prepared under the supervision of the following Registered Civil Engineer:

______________________________________ February 2014

Mark Seits, P.E. Date
CA 41103

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## List of Exhibits

# 1. Purpose

The rail from historic Warm Creek (that portion of Warm Creek that was not combined with East Twin Creek and Warm Creek Improvements) to Mill Creek Zanja is proposed to be improved as part of the Redlands Passenger Rail Project (RPRP) (see Exhibit 1).This report covers the hydraulic impacts for AT&SF Bridge 3.4 (Bridge 3.4), which is a railroad crossing over Santa Ana River. The improvements are proposed to reconstruct the bridge from its existing freight-only operation to current standards required for regular passenger rail operations. As part of this project, recommendations, including hydraulic analysis, are being provided to assist in this process.

The purpose of the hydraulic modeling is to: (1) to analyze the existing hydraulic condition of the Santa Ana River to establish current conditions considering Federal Emergency Management Agency (FEMA) models and updated site conditions; (2) evaluate the hydraulic impact on the rail from proposed Bridge 3.4; and (3) evaluate the potential hydraulic impacts of proposed Bridge 3.4 on the proposed passenger rail.

# 2. Background

The RPRP will design a double track alignment for passenger and freight service from the proposed San Bernardino Transit Center east to the University of Redlands. The Redlands Corridor Strategic Plan (RCSP) was developed by San Bernardino Associated Governments (SANBAG) to address the transportation needs of the Redlands Corridor, assess the capability of transit service and multimodal improvements to meet mobility needs, and describe a course of action to implement transit service in the Redlands Corridor in a cost-effective manner. The first phase of the RCSP calls for the development of a passenger rail service operating between the San Bernardino Transit Center and the University of Redlands, a distance of approximately nine miles. Exhibit 1 shows the overall project.

The general hydraulic modeling approach was to initially review hydraulic models from FEMA to examine flooding conditions in the Santa Ana River reach with Bridge 3.4. Exhibit 2 shows the limits of the analysis. A revised hydraulic model was developed of the project area based on the additional information obtained to model existing and proposed conditions through the bridge and to evaluate the relative changes in water surface for a 100-year flood. The proposed bridge will be designed per structure, constructability, and geotechnical and hydraulic issues.

The Santa Ana River model reach in this study is located between River Mile (RM) 28.3 to RM 29.64, from approximately 1,660 feet downstream of AT&SF Bridge 3.4 to 700 feet upstream of Tippecanoe Avenue (see Exhibit 2). Total reach length is approximately 7,000 feet. The reach is a soft-bottom channel with riprap side slopes. Figure 1 shows Bridge 3.4 downstream face in the Santa Ana River. Figure 2 shows the rail on existing Bridge 3.4. Hydraulic analyses are required to evaluate the existing and proposed bridges to determine if they meet current design requirements. There are three structures in the reach, as shown below in Table 1.

**Table 1: Structures in Santa Ana River Reach**

| Structure | Approximate Location (RM) |
|---|---|
| AT&SF Railroad Bridge 3.4 | 28.62 |
| Orange Show Road | 29.06 |
| Tippecanoe Avenue | 29.51 |

The existing effective FEMA model for the Santa Ana River was obtained and used as the base model. The model was revised based upon information contained in the WRC (2003) report prepared to model proposed river trail improvements. Modeling of the Santa Ana River and Bridge 3.4 was conducted using the U.S. Army Corps of Engineers (USACE) Hydrologic Engineering Center River Analysis System (HEC-RAS v4.1) program. All reference topography is based on the NGVD 1929 datum.

The standard freeboard criteria selected for the bridge (in the following priority) are shown below. For this project, because the 50-year flow rate is not available, only the 100-year flow rate was evaluated.

1. 100-year water surface elevation below low chord;
2. 100-year energy grade line (EGL) elevation below top of subgrade and 50-year water surface [hydraulic grade line (HGL)] elevation below low chord;
3. 50-year water surface (HGL) elevation below low chord; and
4. No increase of water surface elevations within project area.

**Figure 1: Santa Ana River, AT&SF Bridge 3.4 Downstream Face**

A draft FEMA "no rise" certificate is included within this report. Bridge 3.4 is within a FEMA floodway and therefore this certification is required to document that no change to 100-year base flood elevation will occur due to bridge replacement.

This report presents hydraulic analysis results; however, it does contain some assumptions and approximations. Prior to 100% design, the assumptions and approximations made within this report should be verified. Primarily, these include the proposed bridge geometry.

**Figure 2: Existing AT&SF Bridge 3.4**

## 3. Hydrology

The 100-year flowrate for the Santa Ana River tabulated in the San Bernardino County Flood Insurance Study (FIS) is 113,000 cfs upstream of Warm Creek. The 100-year Santa Ana River flow rate contained in the effective FEMA model and in the WRC report and model are less. The flowrate of 113,000 cfs is believed to be the flowrate before the construction of Seven Oaks dam upstream of the reach. The 100-year flowrate in Santa Ana River FEMA and WRC model are the same and are verified with "Santa Ana River Trail Hydraulic Design and Analysis" and "Santa Ana River Mainstream Project, Feature Design Memorandum No. 2" reports. The 100-year flowrates in the FEMA model are shown in Table 2 and indicate a flow change location just downstream of Bridge 3.4. The 100-year discharge at Bridge 3.4 is 33,000 cfs and was used for this evaluation.

**Table 2: Hydrology - Flowrates**

| Channel Reach (River Mile) | 100-Year Flood Discharge (cfs) |
|---|---|
| RM 27.91 to RM 28.57 | 36,500 |
| RM 28.58 to RM 33.27 | 33,000 |
| **Note:** Flowrates are in cubic feet per second (cfs) | |

# 4. Hydraulic Modeling

## 4.1 Modeling Overview

Hydraulic modeling was conducted using the USACE HEC-RAS (v.4.1) program. The existing FEMA effective model was available in HEC-2 format for the Santa Ana River reach. The FEMA effective models were broken into several reaches. Bridge 3.4 is located in the reach from River Mile (RM) 28.30 to 29.64, which covers from downstream of Bridge 3.4 to upstream of Tippecanoe Bridge. The HEC-2 model was originally modeled in July 1987, then revised in January 1990. There are two structures in the model –Bridge 3.4 and Tippecanoe Bridge. Bridge 3.4 is located at RM 28.615.

The original HEC-2 model does not include the Orange Show Bridge. Also, bridge piers were modeled as one pier with the total pier width in the HEC-2 model. WRC Consulting Services prepared "Santa Ana River Trail, Alabama Street to Waterman Avenue, Hydraulic Design and Analysis" in 2003 and updated the original effective model. The WRC model reach ranges from RM 26.98 to 33.37. There are three models in the WRC report:

- ***Model 1*** – Original FEMA effective HEC-2 model prepared by the USACE.
- ***Model 2*** – Converted Model 1 to the HEC-RAS format, added an additional bridge at Orange Show Road, revised bridge pier data to match existing, and added channel geometry from RM 28.10 to 29.51 based on as-built plan data.
- ***Model 3*** – Prepared from Model 2 for the proposed trail ramps and removed them from flow conveyance.

Only a hard copy of the WRC report was available. Digital copies of the HEC-RAS models described in the report were not available. Since the report has tabulation of the HEC-RAS input and output data, HDR first converted the effective FEMA HEC-2 model to HEC-RAS format, then revised the HEC-RAS model per the WRC report Model 2 input data printout to duplicate Model 2. The bridge pier widths were revised again based on the as-built/survey data in the WRC report. This HEC-RAS model was then used to address the impact of the proposed improvements to Bridge 3.4. The 100-year flowrate was used to compare between the existing bridge and the proposed condition to see if the proposed condition has any hydraulic impacts.

## 4.2 Model Inputs

### 4.2.1 FEMA Effective Model

The effective HEC-2 model was obtained from FEMA. The original model was run with the HEC-2 (v.1991) program. The digital model files were provided by FEMA. Model results are shown in Table 7. The floodplain boundaries are shown on FEMA Flood Insurance Rate Map (FIRM) panel 06071C8684H. See Exhibit 4: FEMA FIRM 06071C8684H.

### 4.2.2 Duplicate Effective Model (HEC-2)

The HEC-2 model provided by FEMA was run by HDR using the HEC-2 (1991) program. The results run by HDR match the FEMA Effective model results and the WRC Model 1 results. As explained, Model 1 in the WRC report is the same model as the FEMA Effective Model prepared by the U.S. Army Corps of Engineers.

### 4.2.3 Corrected Effective Model (HEC-RAS)

The Duplicate Effective HEC-2 model was imported to HEC-RAS (v4.1). Water surface results match exactly just downstream of Bridge 3.4 but are over 4 feet lower in the HEC-RAS model just upstream of the bridge as shown in Table 7. The discrepancy is attributed to differences in the way that HEC-2 and HEC-RAS are computing bridge hydraulic losses. The Corrected Effective Model was then developed based on the information available in WRC report. Model 2 in WRC report added an additional bridge at Orange Show Road, added channel geometry from River Mile (RM) 28.10 to 29.51, and revised pier data at all bridges.

As explained, the WRC HEC-RAS digital model was not available, but the input and output of the HEC-RAS model were contained in the WRC report. The Corrected Effective HEC-RAS model HDR created was intended to duplicate the WRC Model 2. The results between the duplicate HEC-RAS model and the output from the WRC report were compared. The results agreed and the differences are within 0.01 feet. Some modeling detail notes include:

- Manning's *n* values were kept the same as in the effective FEMA model (overbank=0.075, channel=0.04).
- Ineffective flow areas were added to cross-sections as needed.
- The bridges were modeled using the Highest Energy Answer for low flow and the pressure/weir option for high flow.
- The downstream boundary condition used known water surface, it was kept from the HEC-2 model.
- The model was run under subcritical flow conditions.
- Note that several cross sections downstream of Bridge 3.4 and one cross section upstream do not have enough ground geometry to contain the water in the cross section. Geometry revisions were not made to these cross sections.

#### 4.2.4 Existing Conditions Model (HEC-RAS)

WRC completed survey and as-built plans review for Bridge 3.4. The actual pier width is 6.5 feet compared to 7.6 feet used in WRC Model 2 and in the Corrected Effective HEC-RAS model. The pier width was adjusted to 6.5 feet and this revised model was named the Existing Conditions Model. The pier width for Orange Show Rd and Tippecanoe Ave Bridge were not changed. The actual pier width for Orange Show Rd Bridge and Tippecanoe Ave Bridge is 1.6 feet. Considering 2 feet debris on each side of the pier, the resulting pier width is approximately the same as in WRC Model 2. The Existing Conditions Model was used to evaluate the hydraulics for the existing and proposed conditions. In summary:

- Existing bridge geometry was kept the same for all bridges, except the pier width for Bridge 3.4 was corrected to 6.5 feet per WRC survey/as-built review.

- Per the discussion in the FIS, the Santa Ana River has medium debris potential. Since Bridge 3.4 pier size is over six feet, pier debris accumulation was not applied following typical procedures used by the Los Angeles District USACE.

#### 4.2.5 Proposed Condition Bridge Model (HEC-RAS)

Proposed condition channel geometry and modeling approach for Bridge 3.4 are identical to the existing conditions bridge model for all cross sections outside of the bridge area. A total of two bridge alternatives were analyzed. Bridge alternative design plans can be found at Exhibit 5. The model was modified as following:

- Two alternatives were proposed for Bridge 3.4 replacement. Proposed conditions for Bridge 3.4 were taken from the design plans.
- For Offline Alternative, the proposed design includes a W40X431 steel beam with five piers. The total span is 366.75 feet. The abutments were assumed to be sloped at a 2:1 inclination to meet grade at the channel bottom. Bridge profile was assumed to be steel beam with concrete tie, subgrade and rails.
- For In-line Alternative, the proposed design includes a W40X431 steel beam with five piers. The total span is 372.08 feet. The abutments were assumed to be sloped at a 2:1 inclination to meet grade at the channel bottom. Bridge profile was assumed to be steel beam with concrete tie, subgrade and rails.
- The proposed condition survey was based on NAVD 88 vertical datum. The Corpscon program was used to convert elevations in NAVD 88 to NGVD 29. The conversion relationship of NAVD 88 – NGVD 29 = 2.5 feet was used based on the proposed bridge location (N34.07515, W117.2721).

### 4.3 Model Results

Table 3 shows the Existing Conditions Model hydraulic results for Cross Section 28.62 upstream of Bridge 3.4. Figure 3 shows the profile of the existing AT&SF Bridge. Figure 4 shows the cross section view of the existing Bridge 3.4 and Figure 5 shows the cross-section view of the Offline Alternative bridge. The In-line Alternative bridge is generally similar to Offline Alternative. The model exhibits for the existing and proposed condition profile and cross sections can be found in Attachment 1.

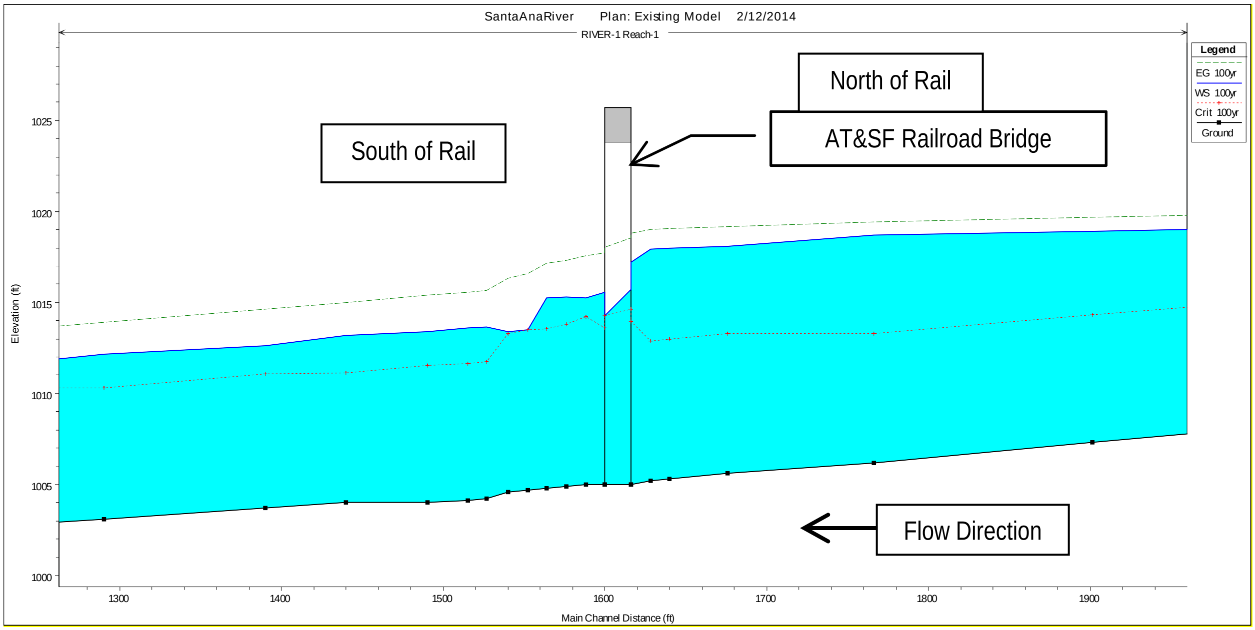
**Table 3: Existing Conditions Model Results for Cross-Section 28.62 (Upstream of Bridge 3.4)**

| | **100-Year** |
|---|---|
| WSE | 1017.19 ft |
| EGL | 1018.79 ft |
| VCH | 10.18 ft/s |
| WSE = water surface elevation, EGL = energy grade line elevation, VCH = main channel average velocity. All elevations are NGVD 1929. | |

The results obtained from 100-year flow rate analysis of Bridge 3.4 are shown in Table 4. Full hydraulic model results are shown in Attachment 2 (Hydraulic Analysis Results).

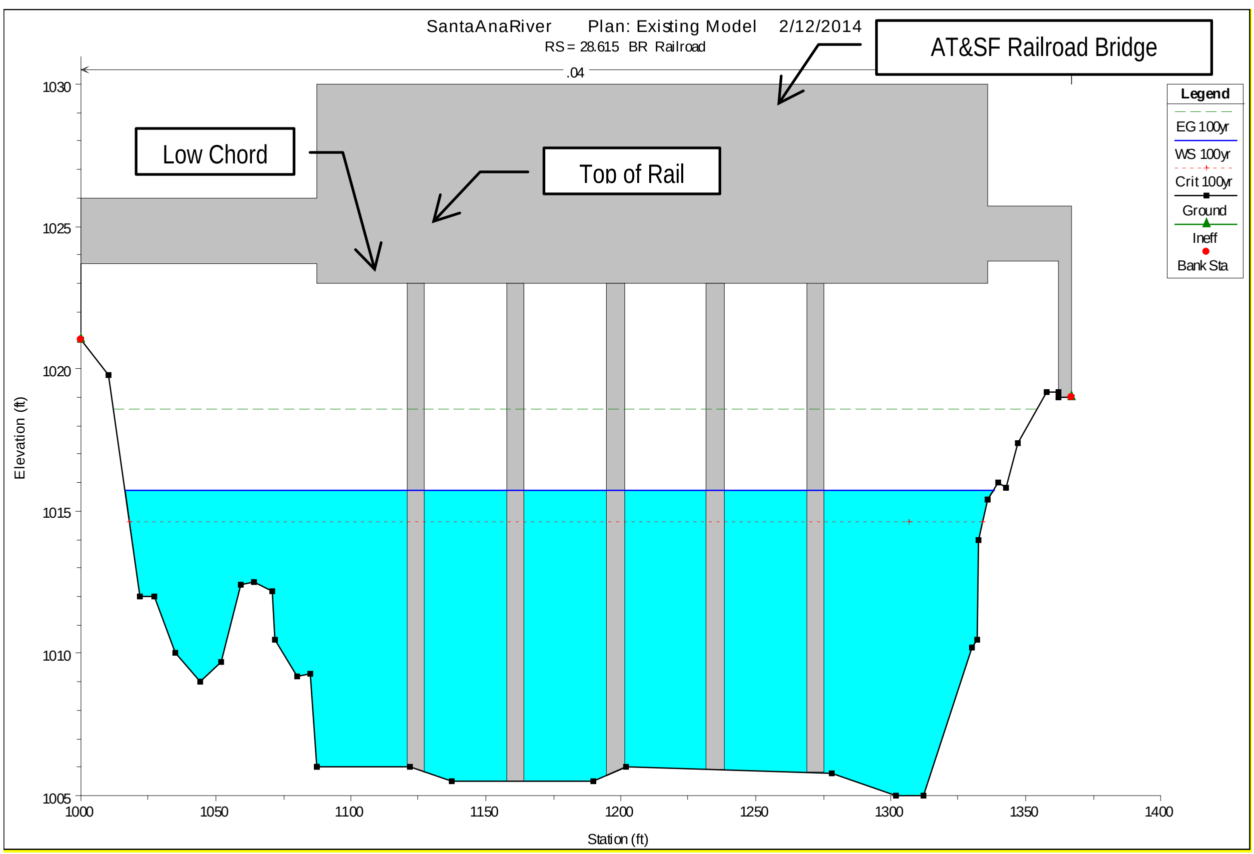
**Table 4: AT&SF Bridge 3.4 (28.617) Hydraulic Results**

| | | **Existing Bridge** | **Offline Alternative** | **In-line Alternative** |
|---|---|---|---|---|
| 100-Yr event | WSE | 1017.19 ft | 1017.12 ft | 1017.09 ft |
| | EGL | 1018.79 ft | 1018.42 ft | 1018.40 ft |
| | Velocity | 15.6 ft/s | 11.43 ft/s | 11.43 ft/s |
| | Froude # | 0.82 | 0.68 | 0.67 |
| WSE = water surface elevation; EGL = energy grade line elevation; VCH = main channel average velocity; All elevations are NGVD 1929. | | | | |




EG = energy grade line (ft), WS = water surface (ft), yr = year

**Figure 3: Profile of Existing Condition**




EG = energy grade line (ft), WS = water surface (ft), yr = year

**Figure 4: Cross-Section of Existing Conditions Upstream of Bridge 3.4**

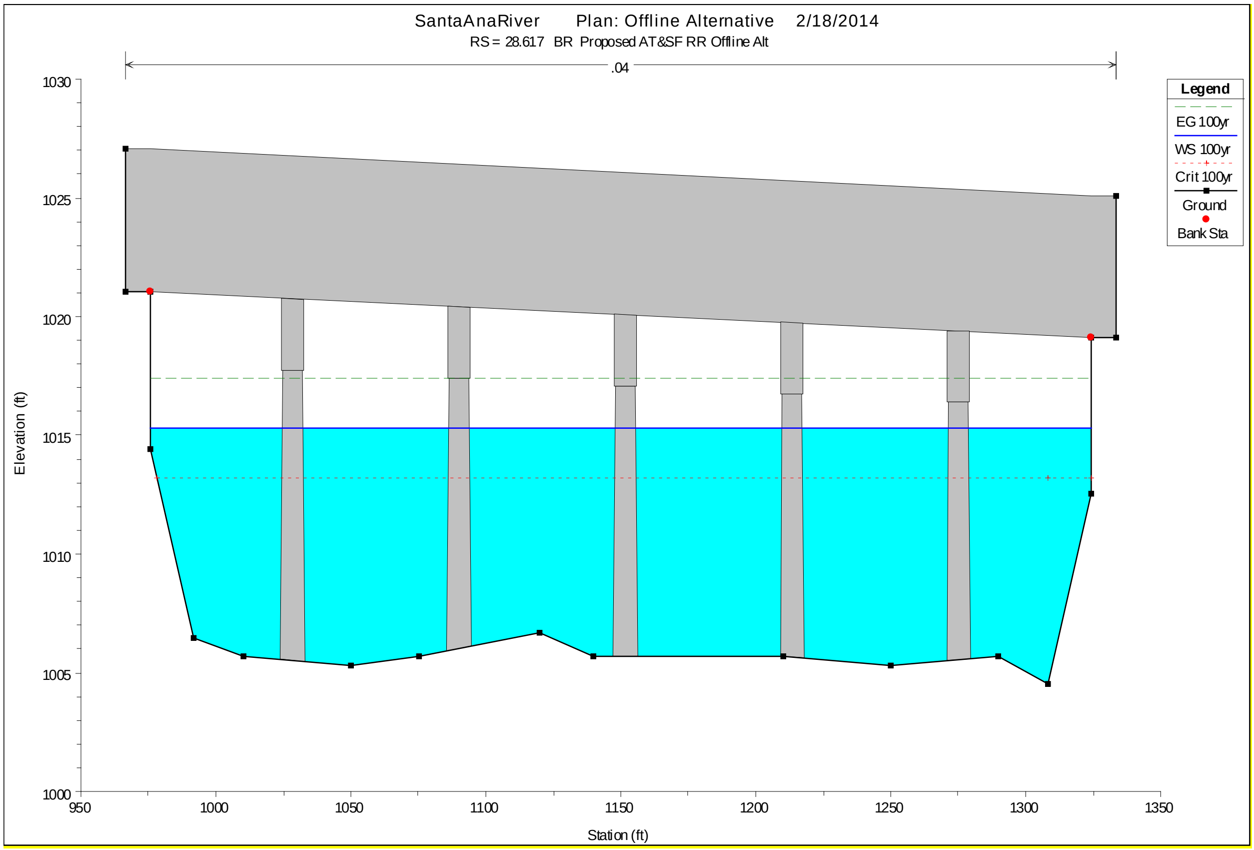



**Figure 5: Cross-Section of Proposed Conditions Upstream Face of Bridge 3.4 (Offline Alternative)**

The freeboard criteria selected for the bridge (in the following priority) are presented below in Table 5 and Table 6 for Offline Alternative and In-line Alternative, respectively. The 100-year EGL is below the top of subgrade, meeting 100 year criteria, and also below the low chord, therefore meeting 50-year criteria by default. The alternatives meet all criteria.

**Table 5: Hydraulic Freeboard Criteria (Offline Alternative)**

| Criterion | Standard | Proposed Model Results | Criterion Met? |
|---|---|---|---|
| 1. 100-yr WSE < Low Chord | Low Chord = 1019.12 | 100-yr WSE = 1017.12 | Yes |
| 2. 100-yr EGL < Top of SBGD | Top of SBGD = 1022.15 | 100-yr EGL = 1018.42 | Yes |
| 3. Proposed WSE ≤ Existing WSE | Existing 100-yr WSE = 1017.19 | Proposed 100-yr WSE = 1017.12 | Yes |
| WSE = water surface elevation (ft); EGL = energy grade line elevation (ft); SBGD = subgrade. All elevations are NGVD 1929. | | | |

**Table 6: Hydraulic Freeboard Criteria (In-line Alternative)**

| Criterion | Standard | Proposed Model Results | Criterion Met? |
|---|---|---|---|
| 1. 100-yr WSE < Low Chord | Low Chord = 1019.12 | 100-yr WSE = 1017.09 | Yes |
| 2. 100-yr EGL < Top of SBGD | Top of SBGD = 1022.15 | 100-yr EGL = 1018.40 | Yes |
| 3. Proposed WSE ≤ Existing WSE | Existing 100-yr WSE = 1017.19 | Proposed 100-yr WSE = 1017.09 | Yes |
| WSE = water surface elevation (ft); EGL = energy grade line elevation (ft); SBGD = subgrade. All elevations are NGVD 1929. | | | |

The results of the hydraulic analysis upstream and downstream of the Bridge 3.4 are shown in Table 7. For both Alternatives, the results show no rise in the study reach.

**Table 7: Hydraulic Analysis Results (ft, NGVD29)**

| *River Station* | *FEMA Effective HEC-2* | *Duplicate Effective HEC-RAS* | *Corrected Effective* | *Existing* | *Offline Alternative* | *In-Line Alternative* | *Offline Alt-Existing* | *In-Line Alt-Existing* |
|---|---|---|---|---|---|---|---|---|
| 29.01 | 1025.27 | 1025.14 | 1025.01 | 1025.01 | 1025.01 | 1025.01 | 0 | 0 |
| 28.95 | 1024.34 | 1023.97 | 1023.97 | 1023.97 | 1023.97 | 1023.97 | 0 | 0 |
| 28.84 | 1023.16 | 1021.56 | 1021.55 | 1021.51 | 1021.4 | 1021.4 | -0.11 | -0.11 |
| 28.737 | 1022.57 | 1019.79 | 1019.75 | 1019.65 | 1019.2 | 1019.18 | -0.45 | -0.47 |
| 28.673 | 1022.27 | 1019.09 | 1019.04 | 1018.9 | 1018.26 | 1018.24 | -0.64 | -0.66 |
| 28.647 | 1022.18 | 1018.9 | 1018.85 | 1018.7 | 1018.02 | 1017.99 | -0.68 | -0.71 |
| 28.63 | 1021.92 | 1018.34 | 1018.28 | 1018.1 | 1017.26 | 1017.23 | -0.84 | -0.87 |
| 28.626 | - | - | - | 1017.98 | 1017.12 | 1017.09 | -0.86 | -0.89 |
| 28.624 | 1021.84 | 1018.23 | 1018.17 | 1017.97 | - | - | - | - |
| 28.622 | 1021.81 | 1018.19 | 1018.13 | 1017.93 | - | - | - | - |
| 28.62 | 1021.63 | 1017.53 | 1017.46 | 1017.19 | - | - | - | - |
| 28.615/28.617 | | | | Railroad Bridge | | | | |
| 28.61 | 1015.58 | 1015.58 | 1015.58 | 1015.58 | 1015.28 | 1015.28 | -0.3 | -0.3 |
| 28.608 | 1015.30 | 1015.29 | 1015.28 | 1015.28 | 1015.28 | 1015.28 | 0 | 0 |
| 28.606 | 1015.32 | 1015.3 | 1015.29 | 1015.29 | 1015.29 | 1015.29 | 0 | 0 |
| 28.604 | 1015.30 | 1015.28 | 1015.27 | 1015.27 | 1015.27 | 1015.27 | 0 | 0 |
| 28.602 | 1013.49 | 1013.52 | 1013.52 | 1013.52 | 1013.52 | 1013.52 | 0 | 0 |
| 28.6 | 1013.41 | 1013.38 | 1013.38 | 1013.38 | 1013.38 | 1013.38 | 0 | 0 |
| 28.597 | 1013.67 | 1013.65 | 1013.65 | 1013.65 | 1013.65 | 1013.65 | 0 | 0 |
| 28.595 | 1013.61 | 1013.59 | 1013.59 | 1013.59 | 1013.59 | 1013.59 | 0 | 0 |
| 28.59 | 1013.38 | 1013.37 | 1013.37 | 1013.37 | 1013.37 | 1013.37 | 0 | 0 |
| 28.58 | 1013.22 | 1013.21 | 1013.21 | 1013.21 | 1013.21 | 1013.21 | 0 | 0 |

## 5. Conclusions

Using the data and resources available, the hydraulic conditions for both existing and proposed conditions were modeled for Bridge 3.4. The results of the modeling indicate that the proposed bridge improvements result in a slightly lower water surface and velocity; the proposed bridge will meet freeboard criteria. A draft FEMA "No-Rise" Certificate was completed for the proposed bridge. It will be finalized after the preferred alternative is selected.

## 6. References

Federal Emergency Management Agency (FEMA). 1987. FEMA Effective Model for Santa Ana River. HEC-2 format.

Federal Emergency Management Agency. 2008. Flood Insurance Study, San Bernardino County, California.

Federal Emergency Management Agency. 2008. San Bernardino County Flood Insurance Study.

HDR, Inc. 2012. SANBAG Redlands Passenger Rail Project Plans.

National Geodetic Survey. 1991. North American Vertical Datum (NAVD) 88.

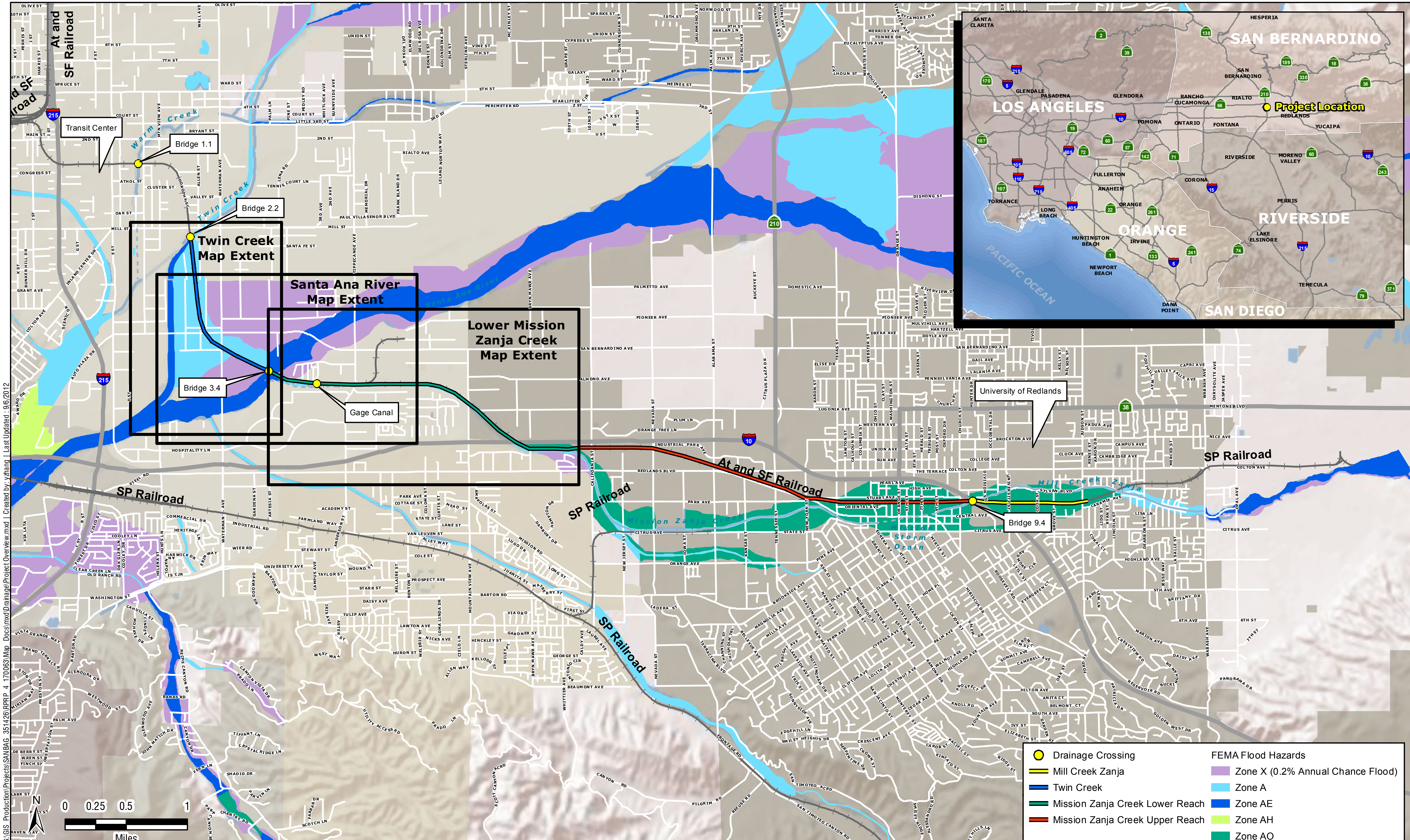
National Geodetic Survey. 1929. National Geodetic Vertical Datum (NGVD) 29.

U.S. Army Corps of Engineers (USACE). 1991. Santa Ana River Mainstream Project, CA. Feature Design Memorandum No. 2, Seven Oaks Dam Floodway Delineation (including 500-Year and Seven Oaks Dam Failure Floodplains) Report and Plates.

U.S. Army Corps of Engineers. 2010. HEC-RAS v.4.1 User's Manual and Technical Reference Manual

WRC Consulting Services, Inc. 2003. Santa Ana River Trail, Alabama Street to Waterman Avenue, Hydraulic Design and Analysis.

**Exhibit 1: RPRP Project Overview**

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# Project Overview

**EXHIBIT 1**

SANBAG | Redlands Passenger Rail Project | Hydraulic Impact Report

**Exhibit 2: Santa Ana River Reach Limits**

| Path:G:\GIS_Production\Projects\SANBAG_351426\RPRP_4_170063\Map_Docs\mxd\Drainage\SAR93.mxd | Created by: VZhang | Last Updated : 01-24-12


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# Santa Ana River

**EXHIBIT 2**

SANBAG | Redlands Passenger Rail Project | Santa Ana River Report

**Exhibit 3: Modeling Overview–Cross-Sections**

**Exhibit 3 – Modeling Overview – Cross Sections**

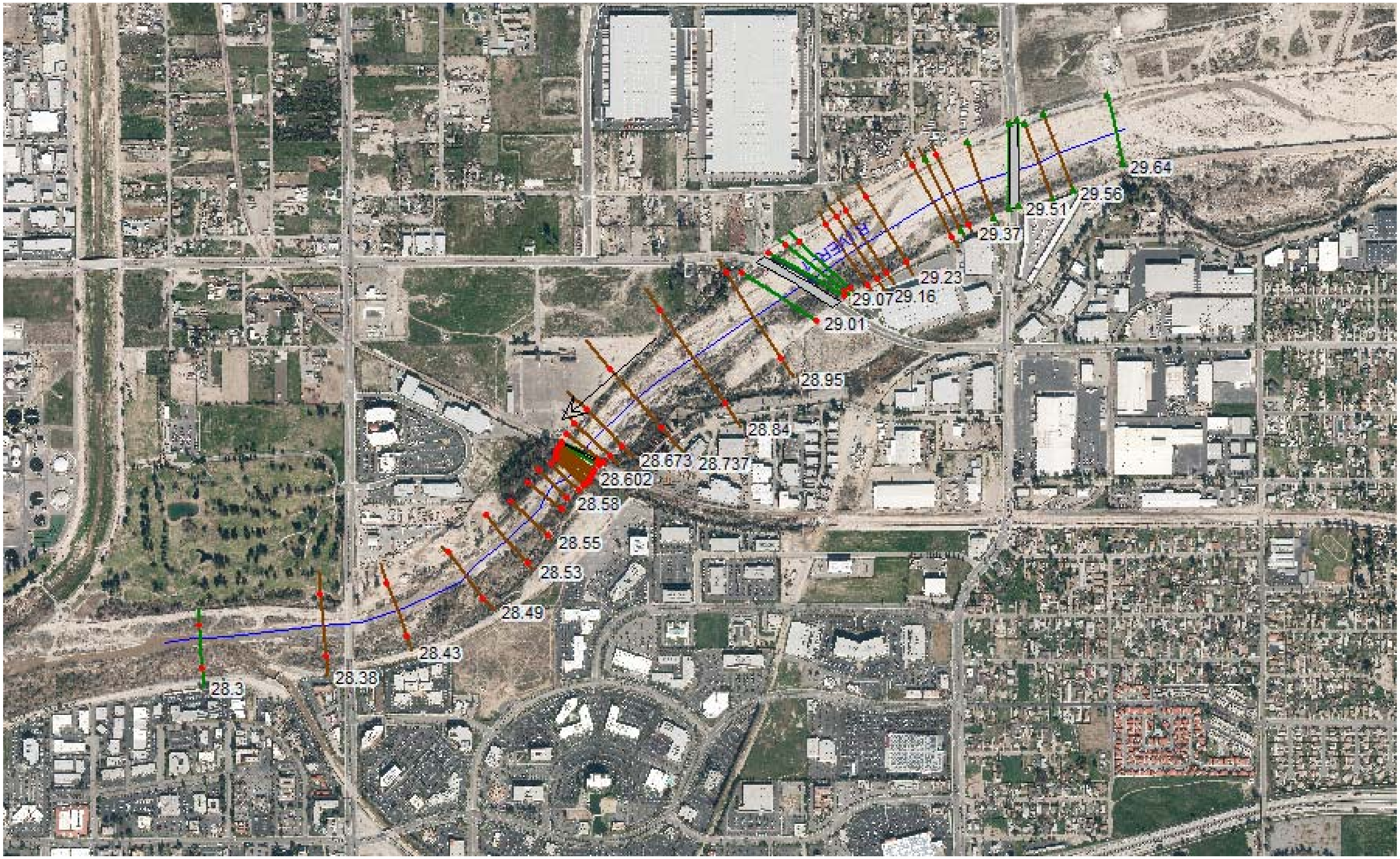


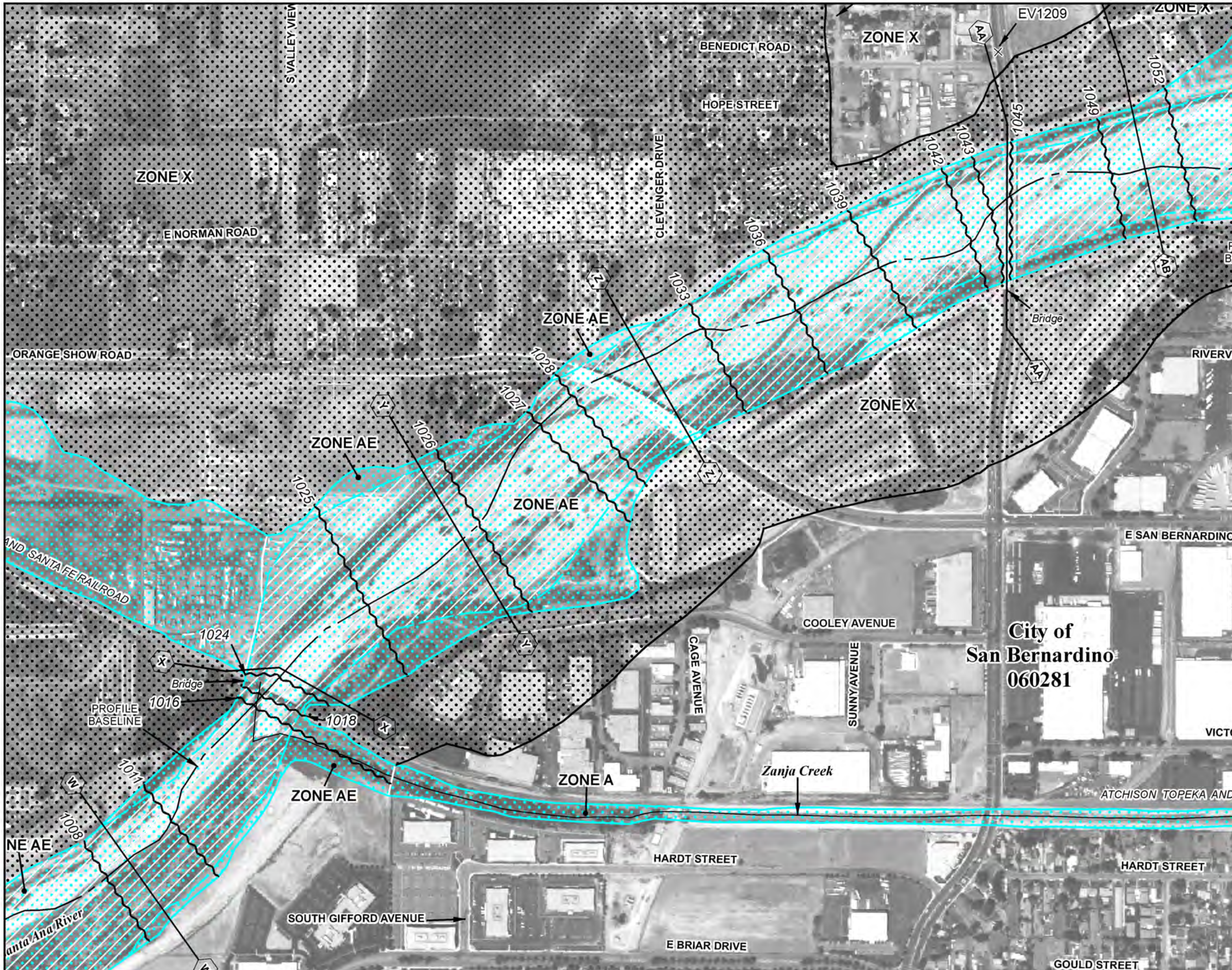
**Exhibit 4: FEMA FIRM 06071C Panel 8684H**

ional Flood Insurance Program at 1-800-638-6620.

MAP SCALE 1" = 500'

250 0 500 1000 FEET

METERS




NFIP

PANEL 8684H

NATIONAL FLOOD INSURANCE PROGRAM

# FIRM
## FLOOD INSURANCE RATE MAP

SAN BERNARDINO COUNTY, CALIFORNIA
AND INCORPORATED AREAS

PANEL 8684 OF 9400

(SEE MAP INDEX FOR FIRM PANEL LAYOUT)

CONTAINS:

| COMMUNITY | NUMBER | PANEL | SUFFIX |
|---|---|---|---|
| LOMA LINDA, CITY OF | 065042 | 8684 | H |
| SAN BERNARDINO, CITY OF | 060281 | 8684 | H |

Notice to User: The **Map Number** shown below should be used when placing map orders; the **Community Number** shown above should be used on insurance applications for the subject community.

MAP NUMBER
06071C8684H

MAP REVISED
AUGUST 28, 2008

Federal Emergency Management Agency

## Exhibit 5: Proposed Bridge Alternative Plans

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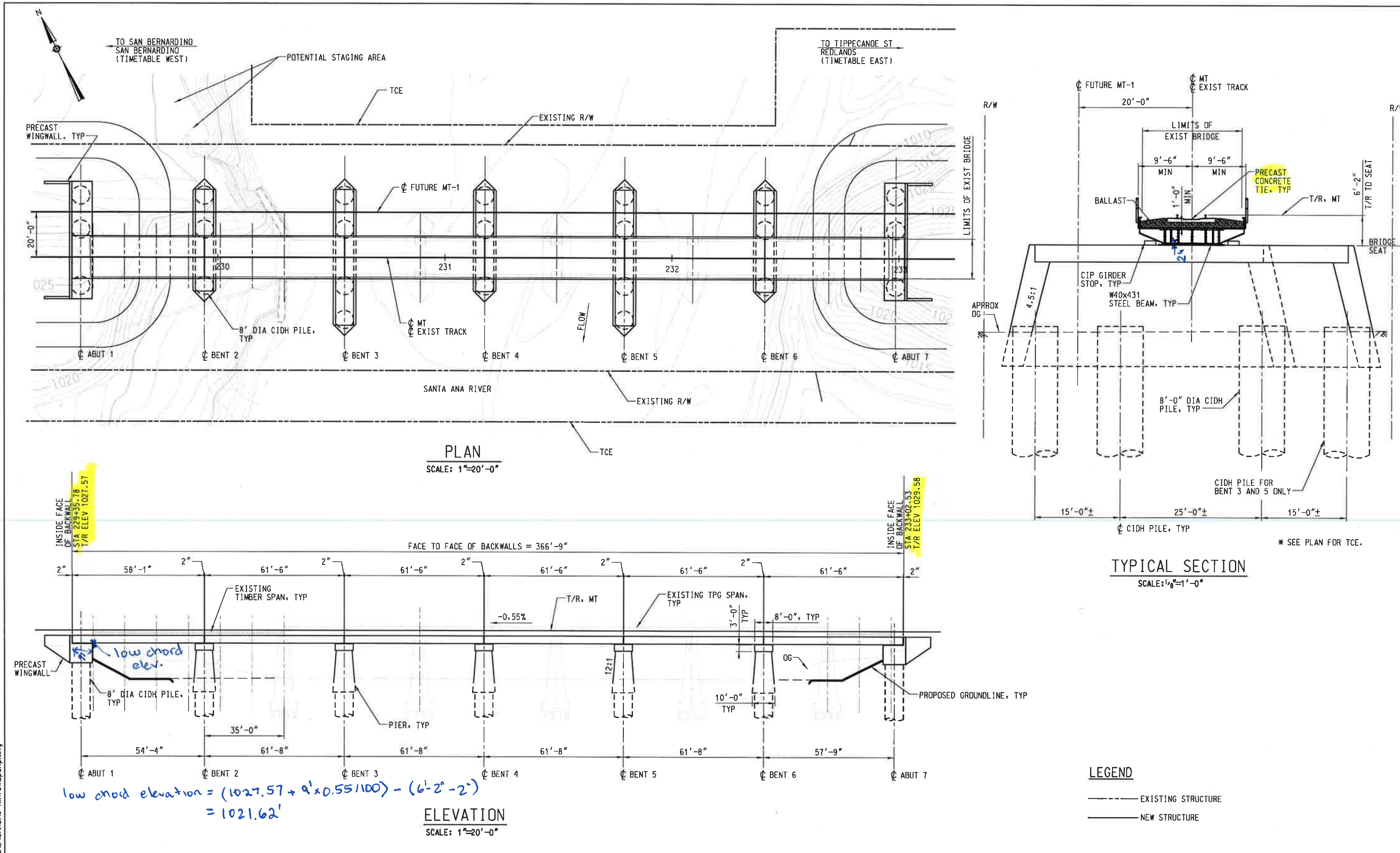



| REV. | DATE | | BY | SUB. | APP. |
|---|---|---|---|---|---|

DESIGNED BY V. TRUONG/J. ZHU
DRAWN BY R. ZHAO
CHECKED BY B. REZNIKOV
APPROVED BY M. BORAKS
DATE FEB 2013

SANBAG Working Together — SAN BERNARDINO ASSOCIATED GOVERNMENTS

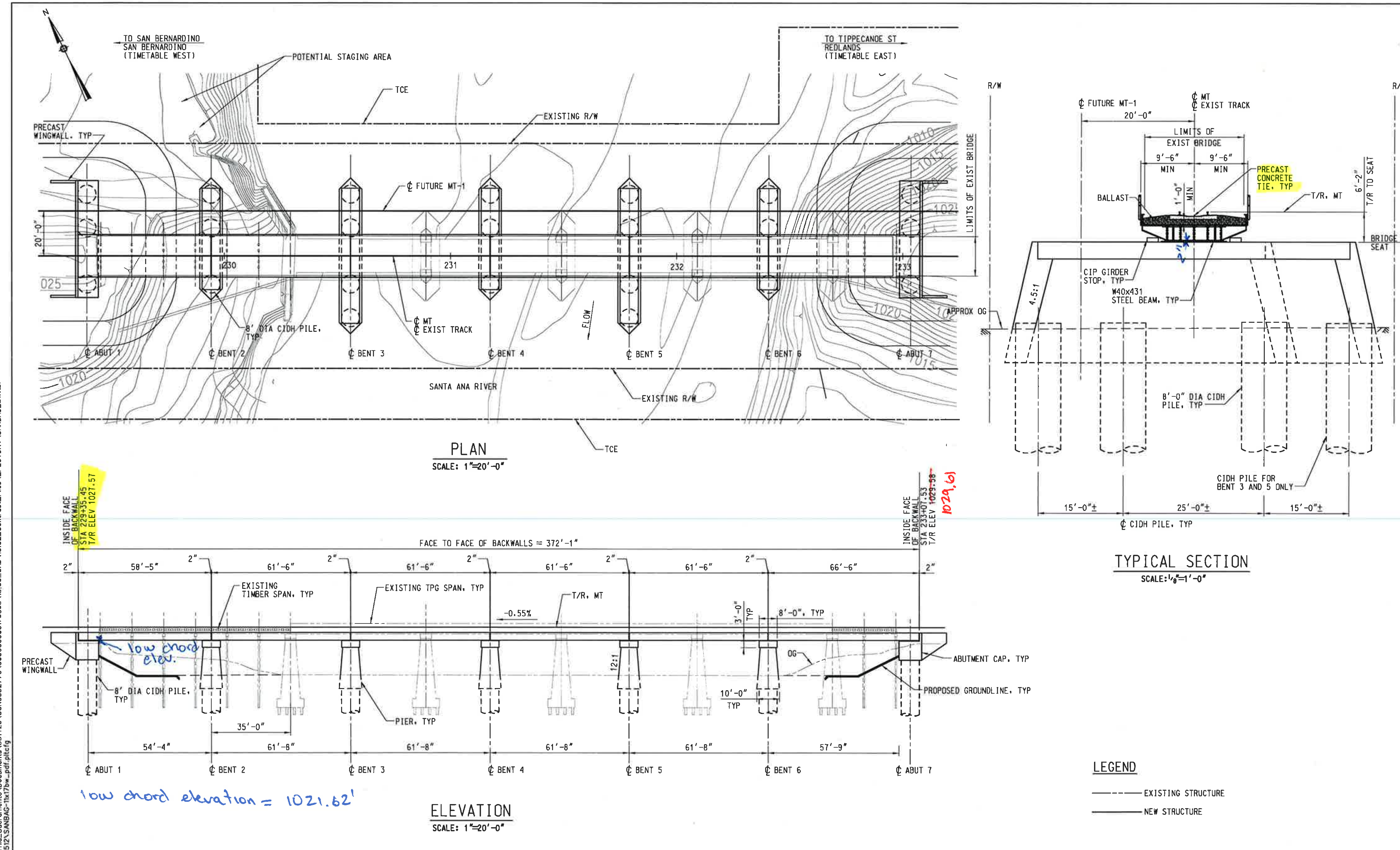
HDR — ONE COMPANY Many Solutions — HDR Engineering, Inc.

SUBMITTED: PROJECT MANAGER
APPROVED:

**30% SUBMITTAL**
NOT FOR CONSTRUCTION

# REDLANDS PASSENGER RAIL PROJECT
OFFLINE ALTERNATIVE
BRIDGE 3.4
GENERAL PLAN

CONTRACT NO.
DRAWING NO. SB-06301
REVISION
SHEET NO.
SCALE AS NOTED




| REV. | DATE | | BY | SUB. | APP. |
|---|---|---|---|---|---|

DESIGNED BY V. TRUONG/J. ZHU
DRAWN BY R. ZHAO
CHECKED BY B. REZNIKOV
APPROVED BY M. BORAKS
DATE FEB 2013

SANBAG Governments Working Together — SAN BERNARDINO ASSOCIATED GOVERNMENTS

HDR ONE COMPANY Many Solutions — HDR Engineering, Inc.

SUBMITTED: ______ PROJECT MANAGER

APPROVED: ______

**30% SUBMITTAL**
NOT FOR CONSTRUCTION

**REDLANDS PASSENGER RAIL PROJECT**
IN-LINE ALTERNATIVE
BRIDGE 3.4
GENERAL PLAN

CONTRACT NO.
DRAWING NO. SB-06304
REVISION | SHEET NO.
SCALE AS NOTED

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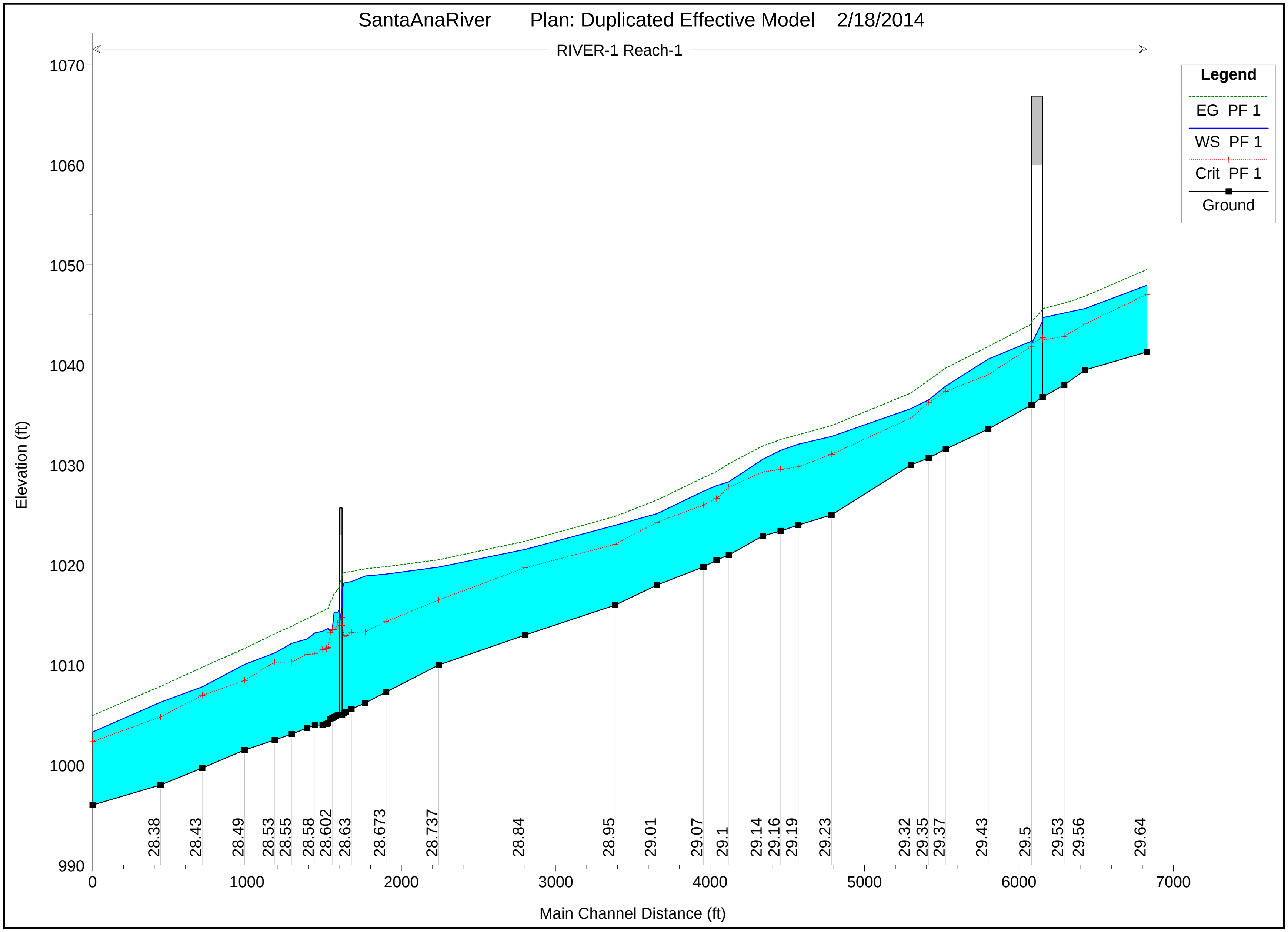
# Attachment 1 - HEC-RAS Modeling Exhibits



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RIVER-1 Reach-1
Legend
EG PF 1
WS PF 1
Crit PF 1
Ground
Elevation (ft)
Main Channel Distance (ft)
1070
1060
1050
1040
1030
1020
1010
1000
990
0
1000
2000
3000
4000
5000
6000
7000
28.38
28.43
28.49
28.53
28.55
28.58
28.602
28.63
28.673
28.737
28.84
28.95
29.01
29.07
29.1
29.14
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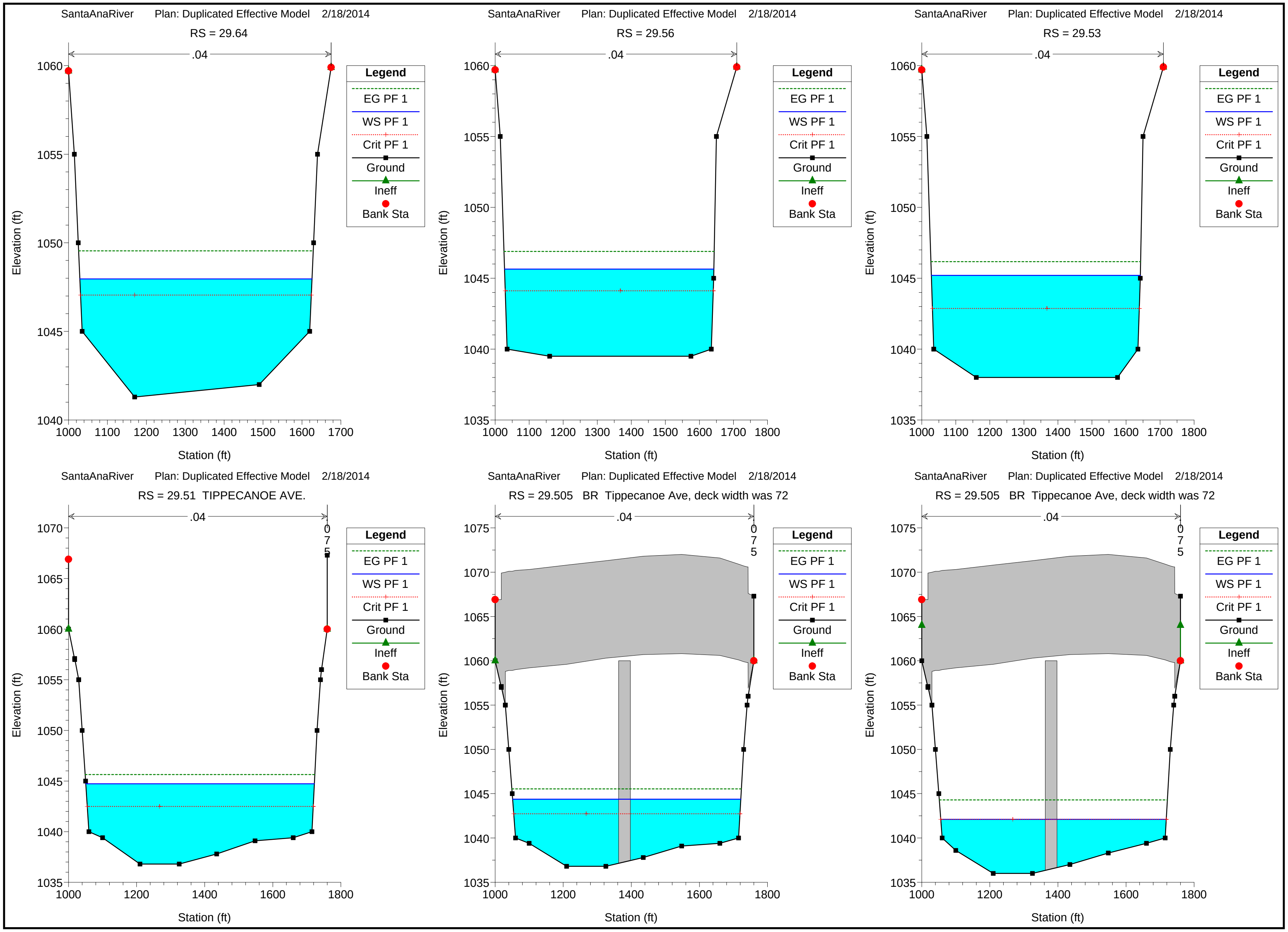
29.19
29.23
29.32
29.35
29.37
29.43
29.5
29.53
29.56
29.64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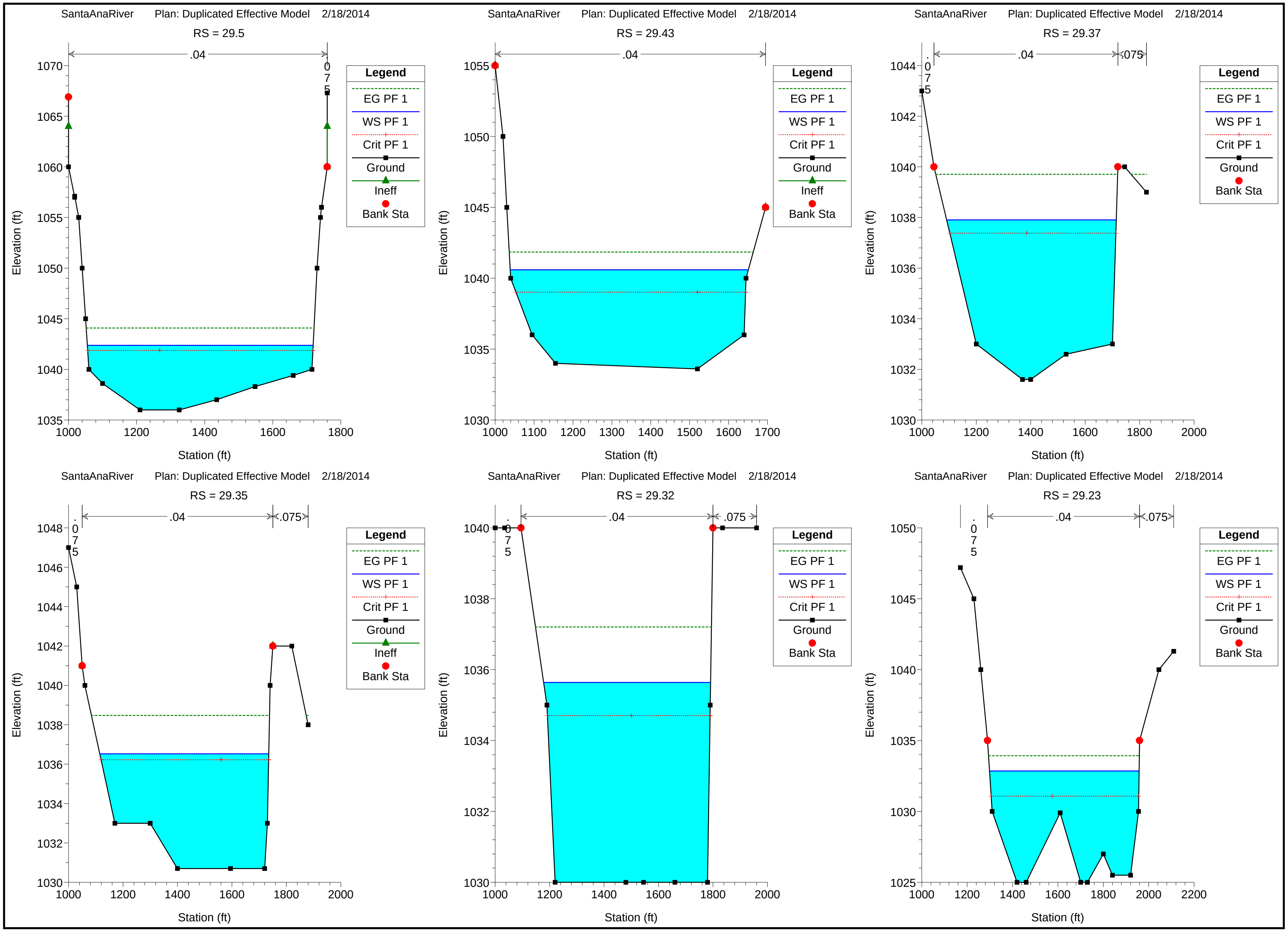
RS = 29.64
.04
Legend
EG PF 1
WS PF 1
Crit PF 1
Ground
Ineff
Bank Sta
Elevation (ft)
Station (ft)
SantaAnaRiver Plan: Duplicated Effective Model 2/18/2014
RS = 29.56
SantaAnaRiver Plan: Duplicated Effective Model 2/18/2014
RS = 29.53
SantaAnaRiver Plan: Duplicated Effective Model 2/18/2014
RS = 29.51 TIPPECANOE AVE.
SantaAnaRiver Plan: Duplicated Effective Model 2/18/2014
RS = 29.505 BR Tippecanoe Ave, deck width was 72
SantaAnaRiver Plan: Duplicated Effective Model 2/18/2014
RS = 29.505 BR Tippecanoe Ave, deck width was 72



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RS = 29.5
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Legend
EG PF 1
WS PF 1
Crit PF 1
Ground
Ineff
Bank Sta
Elevation (ft)
Station (ft)
SantaAnaRiver Plan: Duplicated Effective Model 2/18/2014
RS = 29.43
.04
Legend
EG PF 1
WS PF 1
Crit PF 1
Ground
Ineff
Bank Sta
Elevation (ft)
Station (ft)
SantaAnaRiver Plan: Duplicated Effective Model 2/18/2014
RS = 29.37
.04
.075
Legend
EG PF 1
WS PF 1
Crit PF 1
Ground
Bank Sta
Elevation (ft)
Station (ft)
SantaAnaRiver Plan: Duplicated Effective Model 2/18/2014
RS = 29.35
.04
.075
Legend
EG PF 1
WS PF 1
Crit PF 1
Ground
Ineff
Bank Sta
Elevation (ft)
Station (ft)
SantaAnaRiver Plan: Duplicated Effective Model 2/18/2014
RS = 29.32
.04
.075
Legend
EG PF 1
WS PF 1
Crit PF 1
Ground
Bank Sta
Elevation (ft)
Station (ft)
SantaAnaRiver Plan: Duplicated Effective Model 2/18/2014
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Crit PF 1
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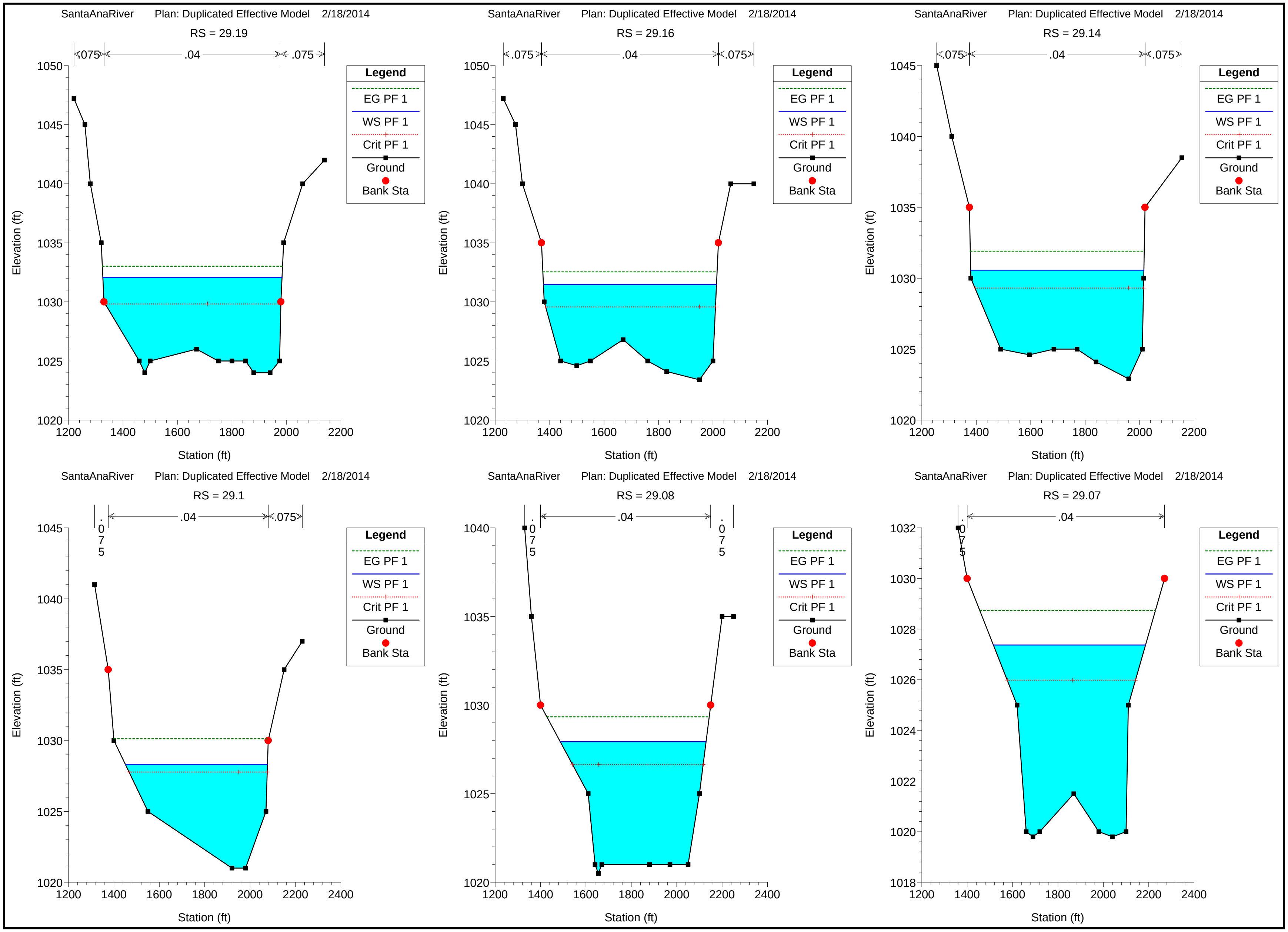
Bank Sta
Elevation (ft)
Station (ft)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RS = 29.14
RS = 29.1
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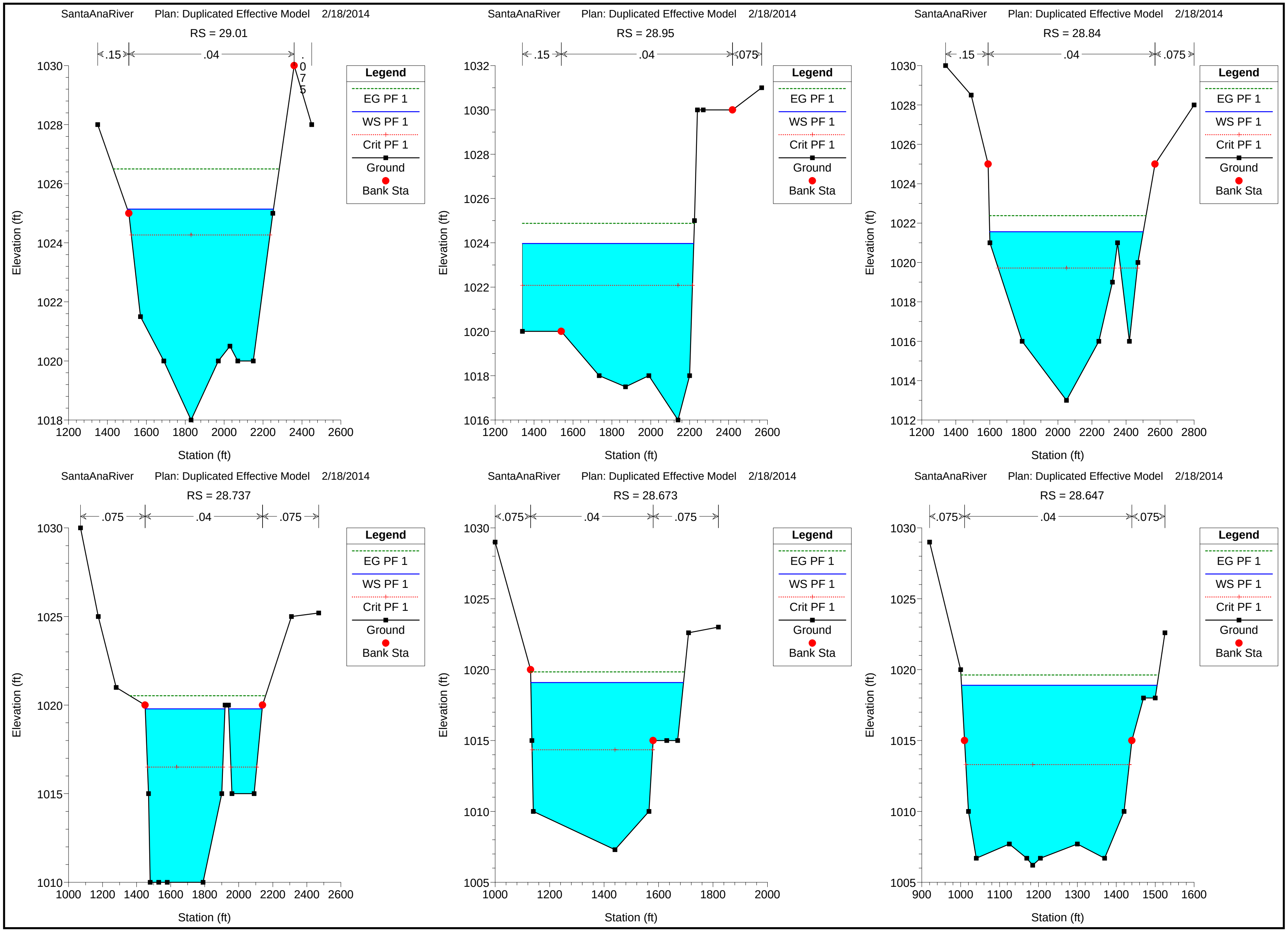
Crit PF 1
Ground
Bank Sta
Elevation (ft)
Station (ft)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Elevation (ft)
Station (ft)
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EG PF 1
WS PF 1
Crit PF 1
Ground
Bank Sta
SantaAnaRiver Plan: Duplicated Effective Model 2/18/2014
RS = 28.95
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.04
.075
Elevation (ft)
Station (ft)
Legend
EG PF 1
WS PF 1
Crit PF 1
Ground
Bank Sta
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.15
.04
.075
Elevation (ft)
Station (ft)
Legend
EG PF 1
WS PF 1
Crit PF 1
Ground
Bank Sta
SantaAnaRiver Plan: Duplicated Effective Model 2/18/2014
RS = 28.737
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.04
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Elevation (ft)
Station (ft)
Legend
EG PF 1
WS PF 1
Crit PF 1
Ground
Bank Sta
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RS = 28.673
.075
.04
.075
Elevation (ft)
Station (ft)
Legend
EG PF 1
WS PF 1
Crit PF 1
Ground
Bank Sta
SantaAnaRiver Plan: Duplicated Effective Model 2/18/2014
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.04
.075
Elevation (ft)
Station (ft)
Legend
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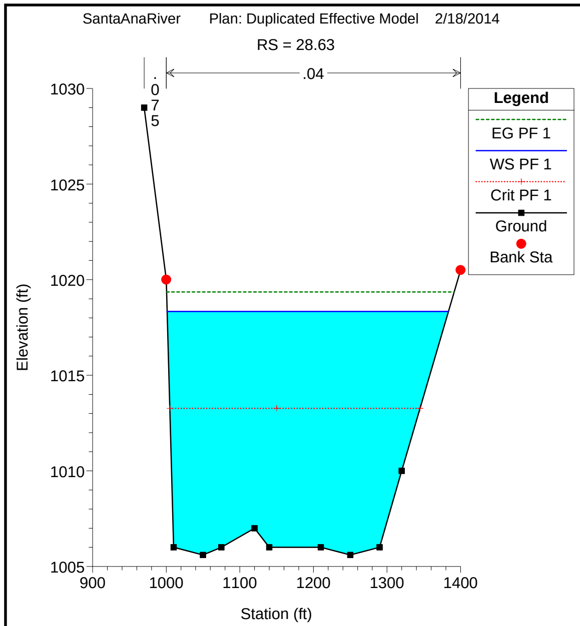
WS PF 1
Crit PF 1
Ground
Bank Sta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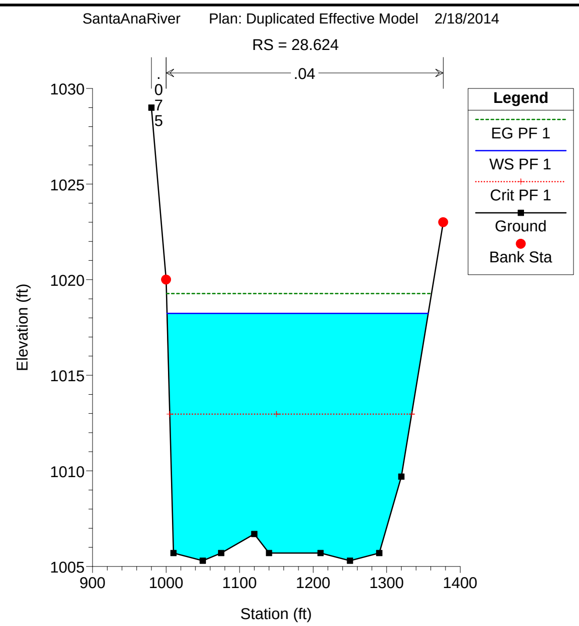
Elevation (ft)
Station (ft)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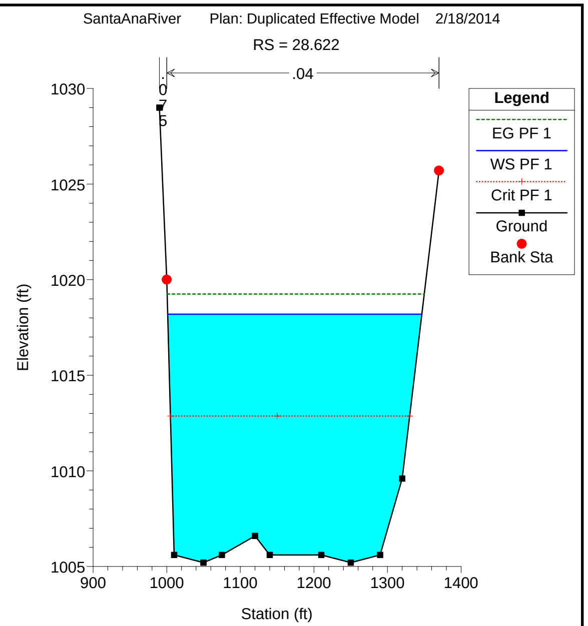
Bank Sta
Elevation (ft)
Station (ft)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Legend
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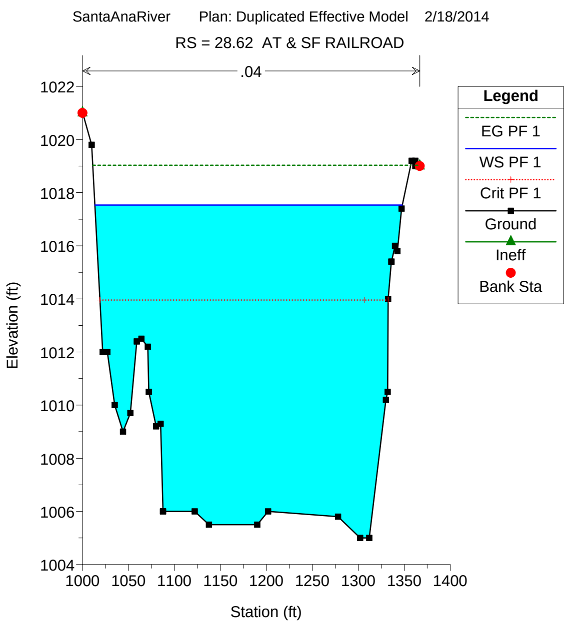
WS PF 1
Crit PF 1
Ground
Bank Sta
Elevation (ft)
Station (ft)


SantaAnaRiver Plan: Duplicated Effective Model 2/18/2014
RS = 28.62 AT & SF RAILROAD
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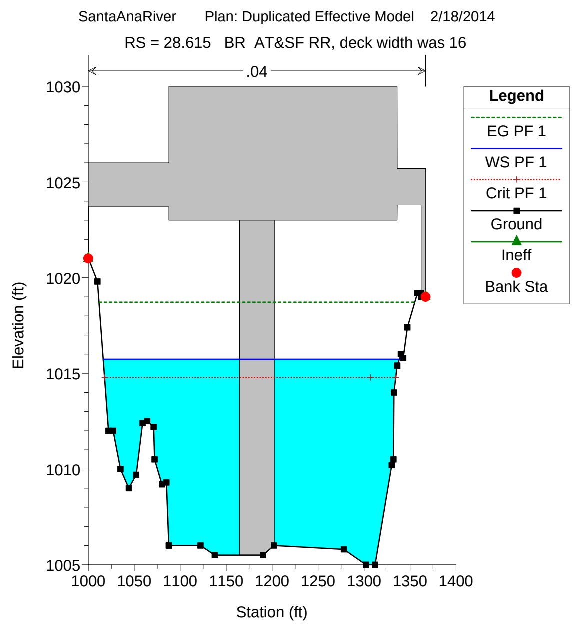
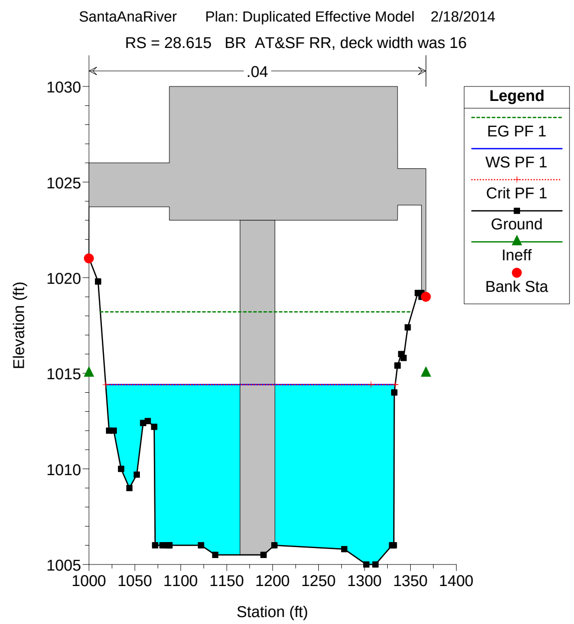
Legend
EG PF 1
WS PF 1
Crit PF 1
Ground
Ineff
Bank Sta
Elevation (ft)
Station (ft)


SantaAnaRiver Plan: Duplicated Effective Model 2/18/2014
RS = 28.615 BR AT&SF RR, deck width was 16
.04
Legend
EG PF 1
WS PF 1
Crit PF 1
Ground
Ineff
Bank Sta
Elevation (ft)
Station (ft)


SantaAnaRiver Plan: Duplicated Effective Model 2/18/2014
RS = 28.615 BR AT&SF RR, deck width was 16
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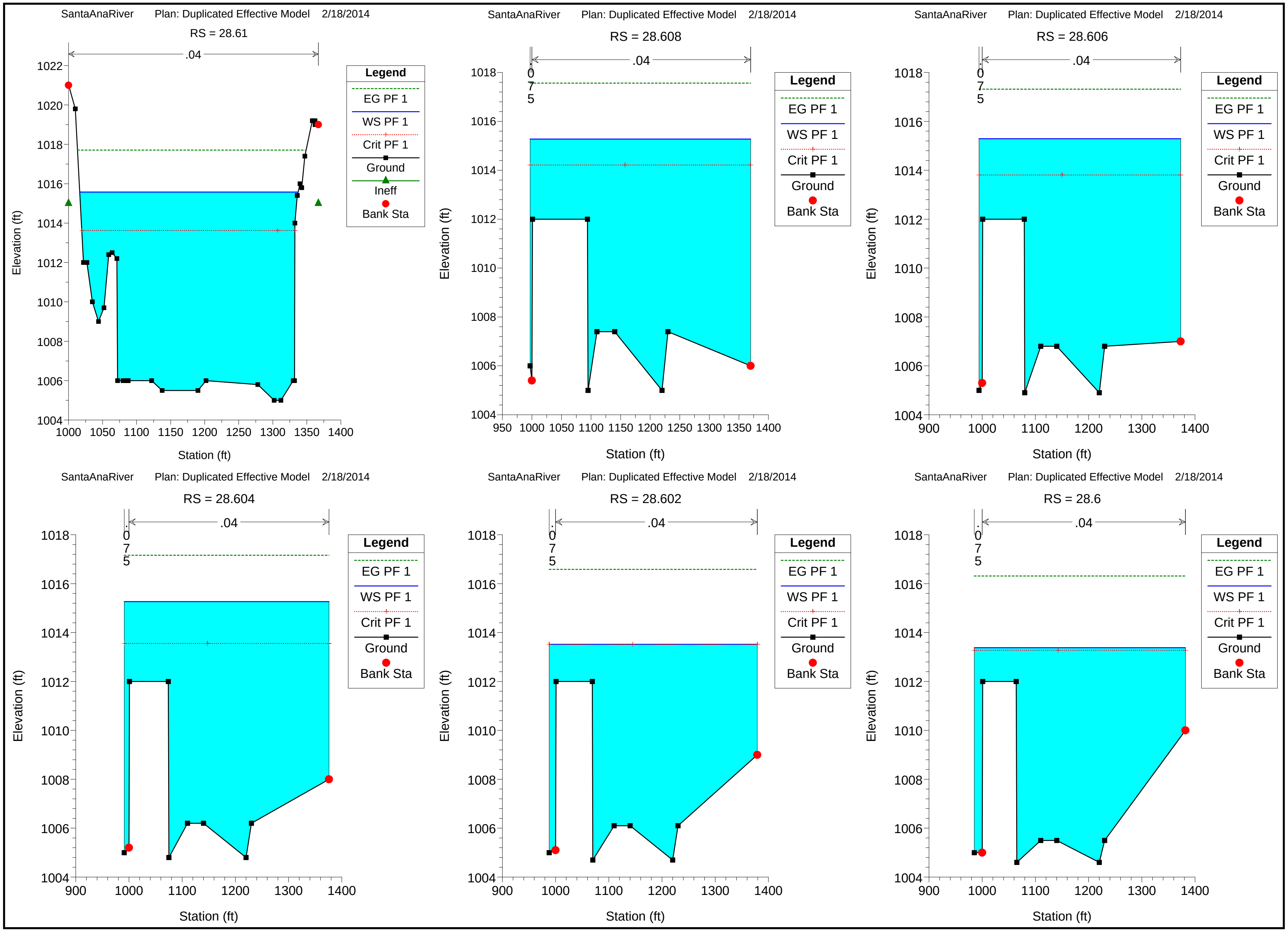
Elevation (ft)
Station (ft)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Elevation (ft)
Station (ft)
Legend
EG PF 1
WS PF 1
Crit PF 1
Ground
Ineff
Bank Sta
SantaAnaRiver Plan: Duplicated Effective Model 2/18/2014
RS = 28.608
.04
0
7
5
Elevation (ft)
Station (ft)
Legend
EG PF 1
WS PF 1
Crit PF 1
Ground
Bank Sta
SantaAnaRiver Plan: Duplicated Effective Model 2/18/2014
RS = 28.606
.04
Elevation (ft)
Station (ft)
Legend
EG PF 1
WS PF 1
Crit PF 1
Ground
Bank Sta
SantaAnaRiver Plan: Duplicated Effective Model 2/18/2014
RS = 28.604
.04
Elevation (ft)
Station (ft)
Legend
EG PF 1
WS PF 1
Crit PF 1
Ground
Bank Sta
SantaAnaRiver Plan: Duplicated Effective Model 2/18/2014
RS = 28.602
.04
Elevation (ft)
Station (ft)
Legend
EG PF 1
WS PF 1
Crit PF 1
Ground
Bank Sta
SantaAnaRiver Plan: Duplicated Effective Model 2/18/2014
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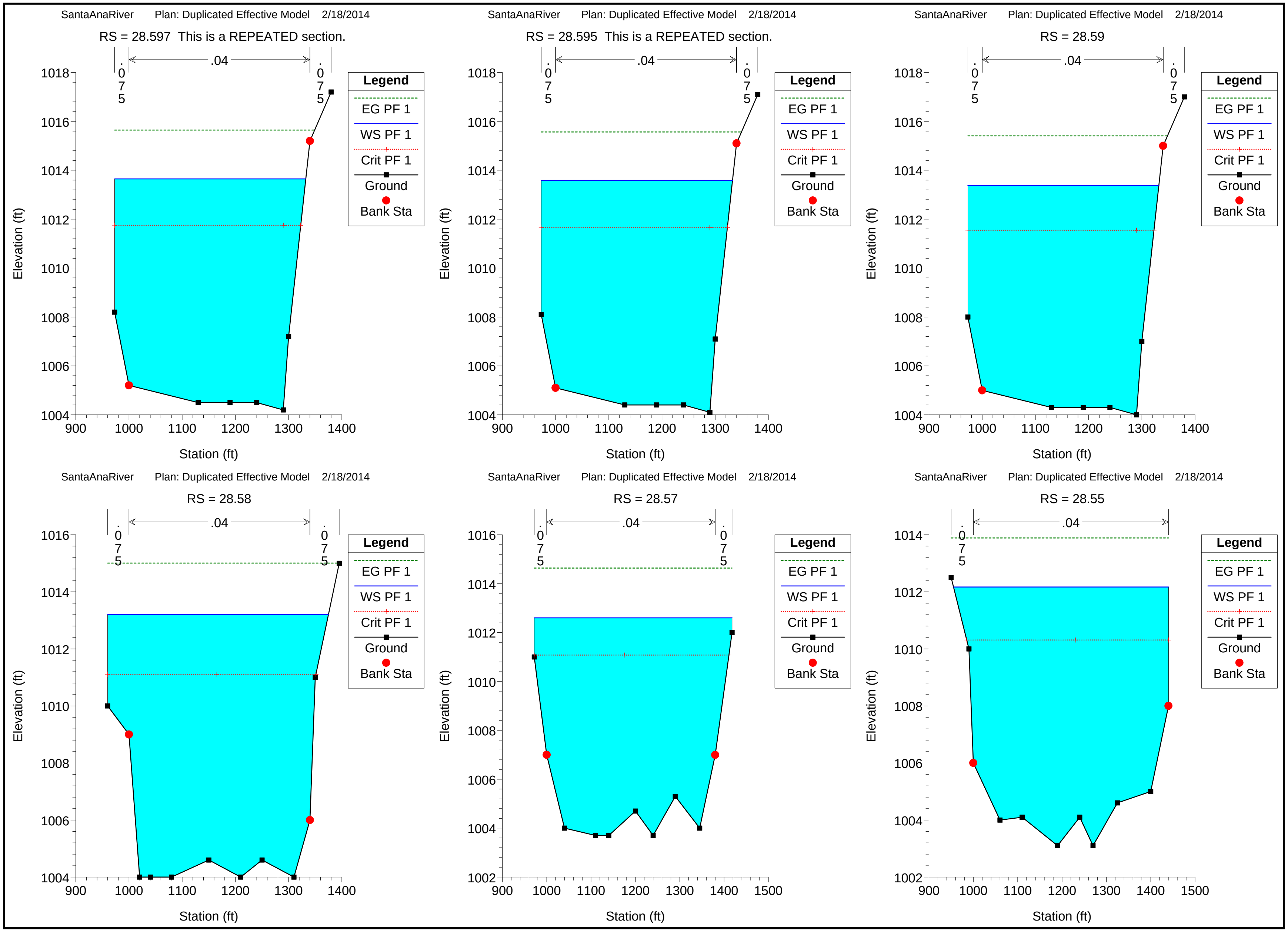
Elevation (ft)
Station (ft)
Legend
EG PF 1
WS PF 1
Crit PF 1
Ground
Bank Sta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RS = 28.597 This is a REPEATED section.
RS = 28.595 This is a REPEATED section.
RS = 28.59
RS = 28.58
RS = 28.57
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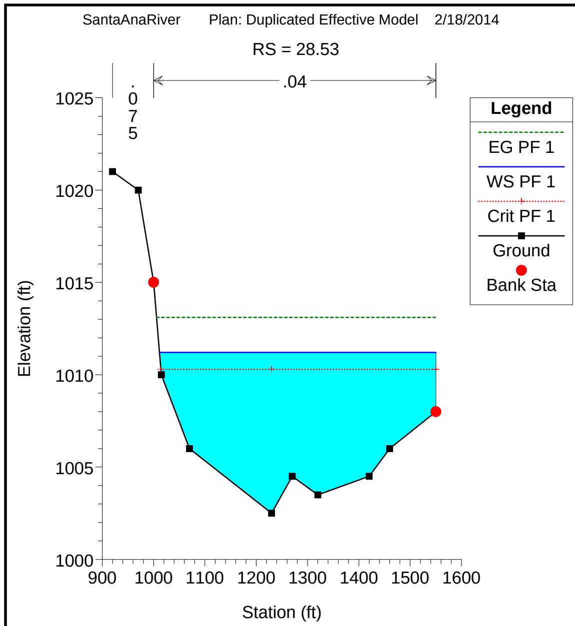
.04
.075
Legend
EG PF 1
WS PF 1
Crit PF 1
Ground
Bank Sta
Elevation (ft)
Station (ft)


SantaAnaRiver Plan: Duplicated Effective Model 2/18/2014
RS = 28.53
.075
.04
Legend
EG PF 1
WS PF 1
Crit PF 1
Ground
Bank Sta
Elevation (ft)
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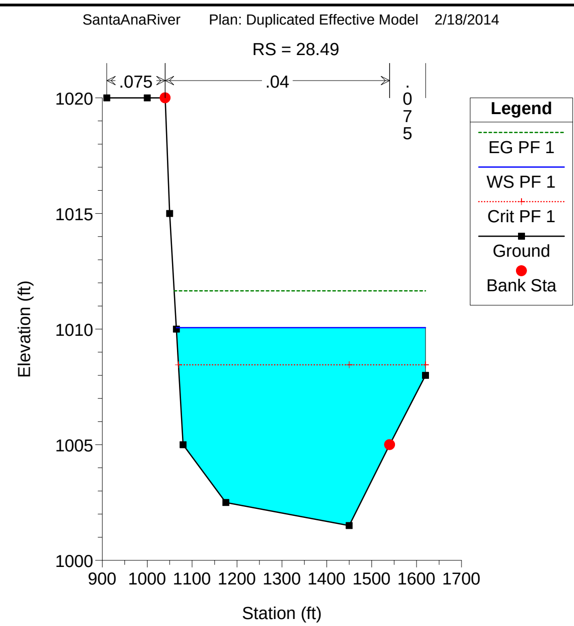
1010
1015
1020
1025
900
1000
1100
1200
1300
1400
1500
1600
Station (ft)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RS = 28.49
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.04
.075
Legend
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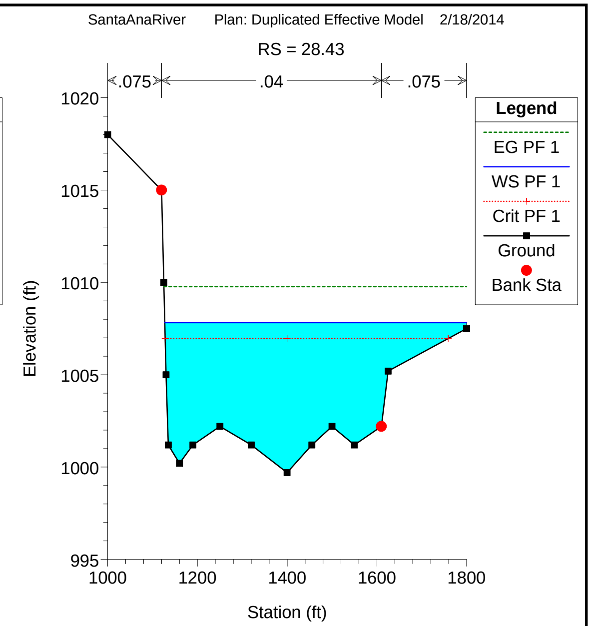
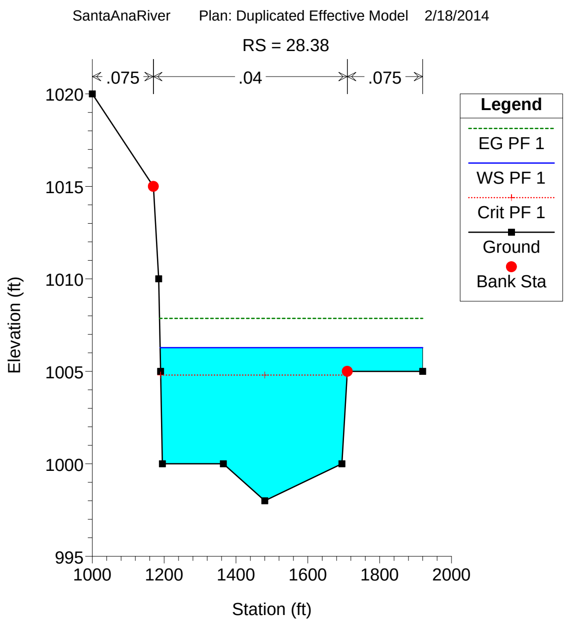
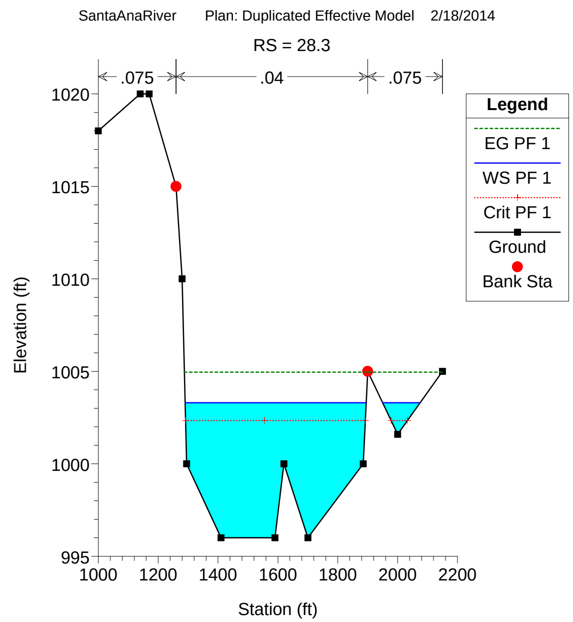
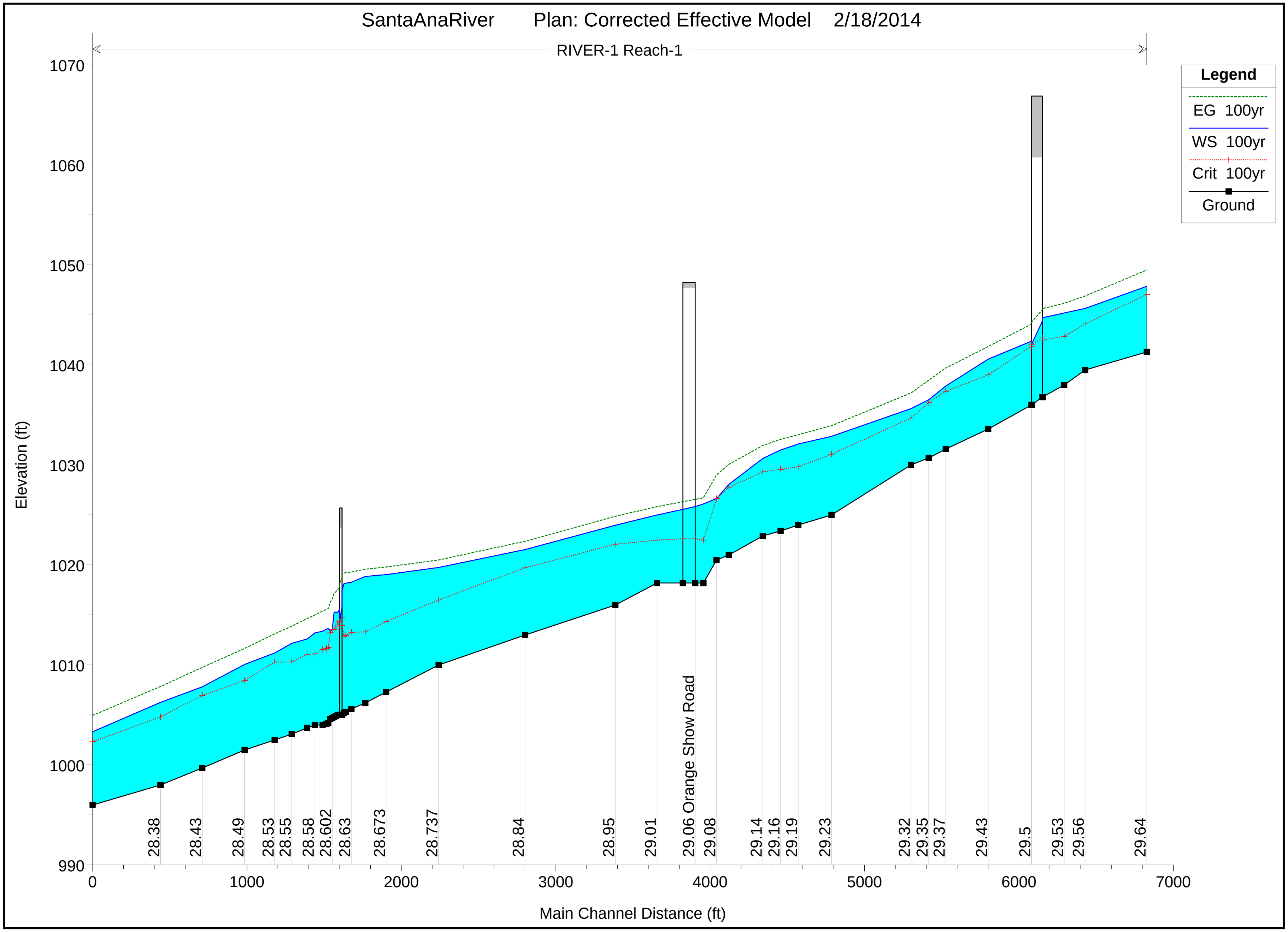
WS PF 1
Crit PF 1
Ground
Bank Sta
Elevation (ft)
1000
1005
1010
1015
1020
900
1000
1100
1200
1300
1400
1500
1600
1700
Station (ft)

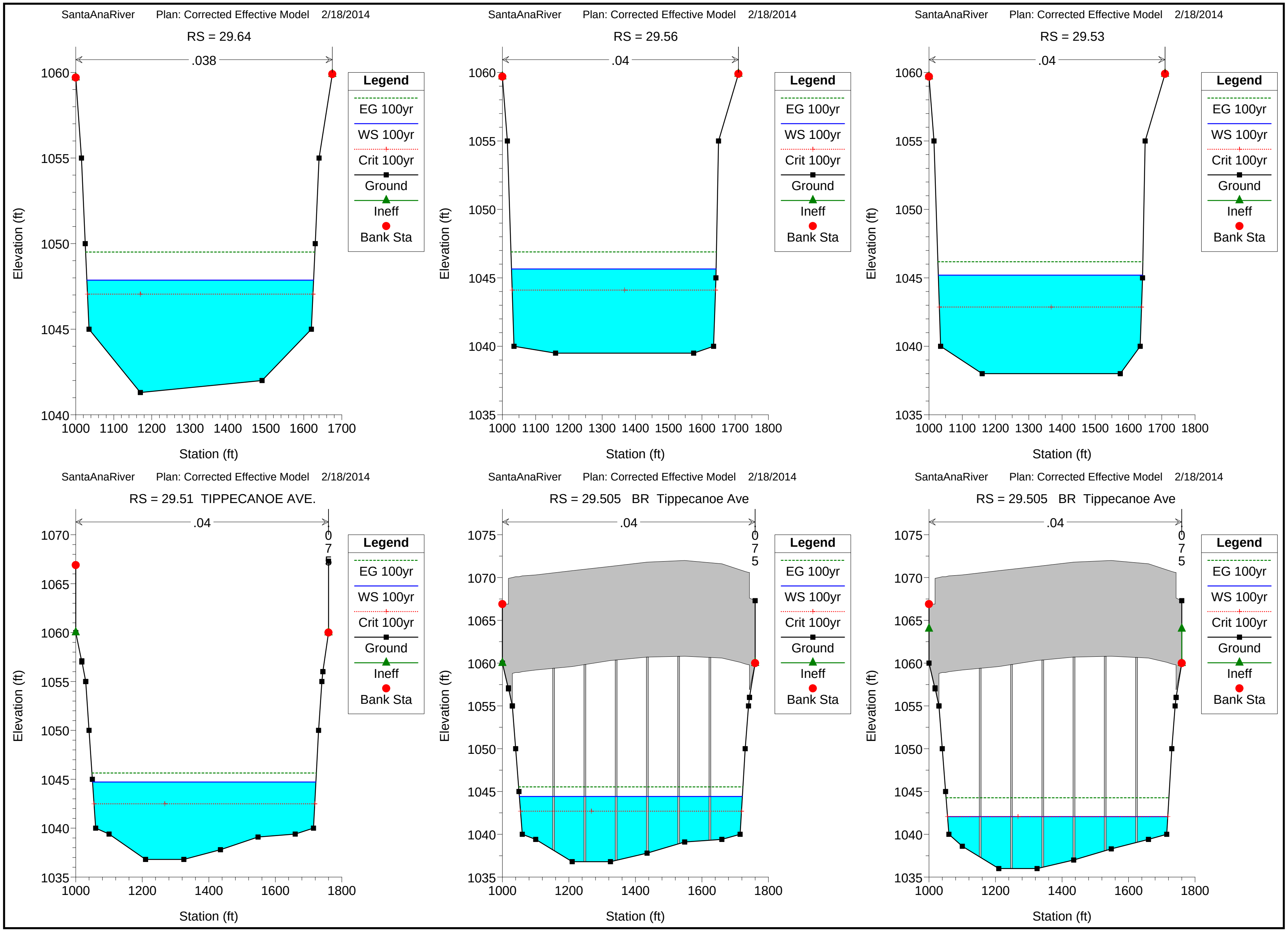

SantaAnaRiver Plan: Duplicated Effective Model 2/18/2014
RS = 28.43
.075
.04
.075
Legend
EG PF 1
WS PF 1
Crit PF 1
Ground
Bank Sta
Elevation (ft)
995
1000
1005
1010
1015
1020
1000
1200
1400
1600
1800
Station (ft)


SantaAnaRiver Plan: Duplicated Effective Model 2/18/2014
RS = 28.38
.075
.04
.075
Legend
EG PF 1
WS PF 1
Crit PF 1
Ground
Bank Sta
Elevation (ft)
995
1000
1005
1010
1015
1020
1000
1200
1400
1600
1800
2000
Station (ft)

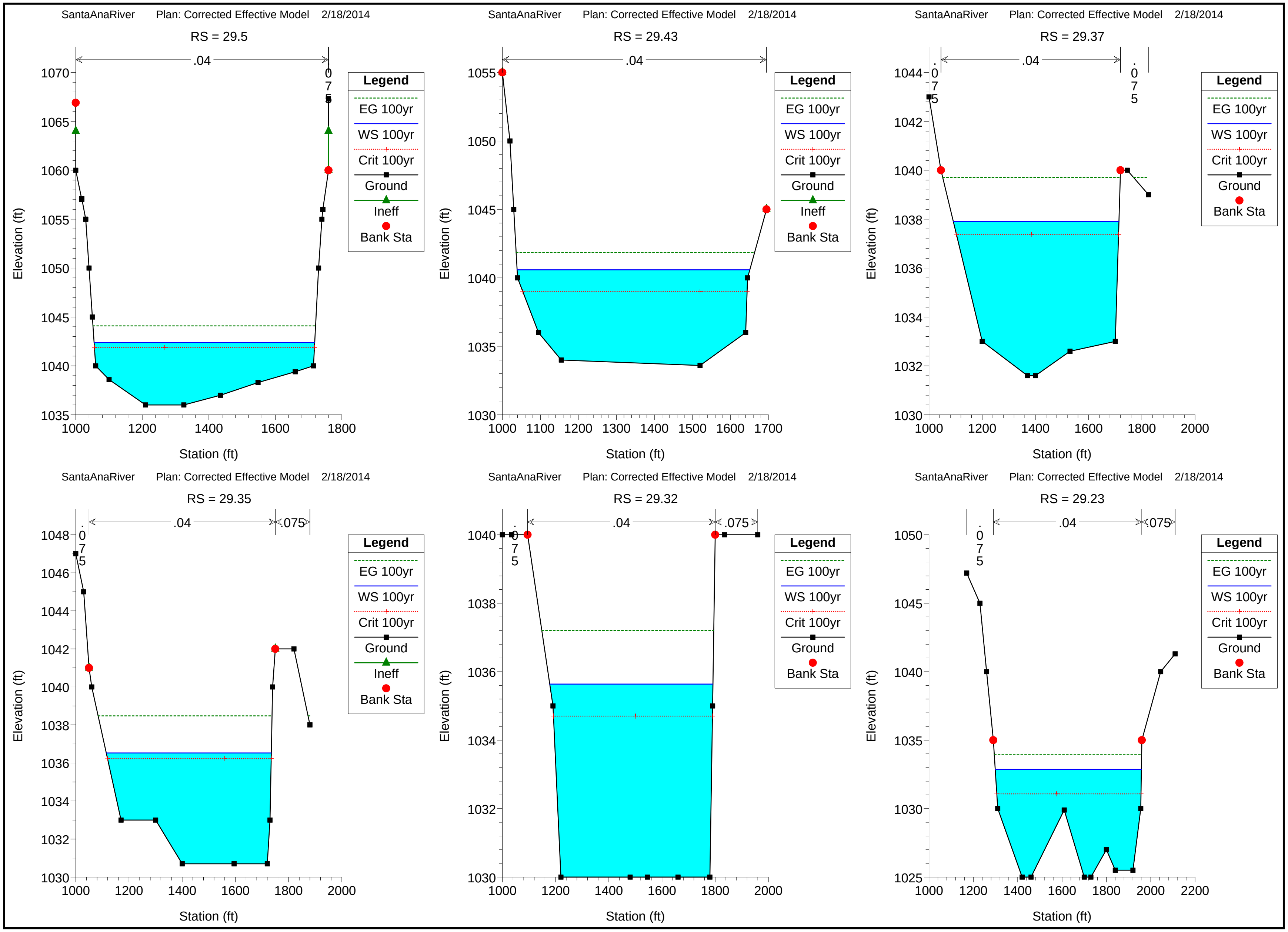

SantaAnaRiver Plan: Duplicated Effective Model 2/18/2014
RS = 28.3
.075
.04
.075
Legend
EG PF 1
WS PF 1
Crit PF 1
Ground
Bank Sta
Elevation (ft)
995
1000
1005
1010
1015
1020
1000
1200
1400
1600
1800
2000
2200
Station (ft)

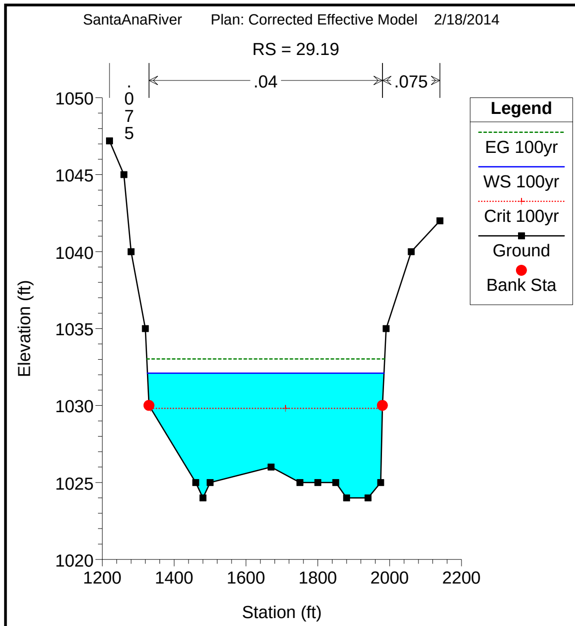


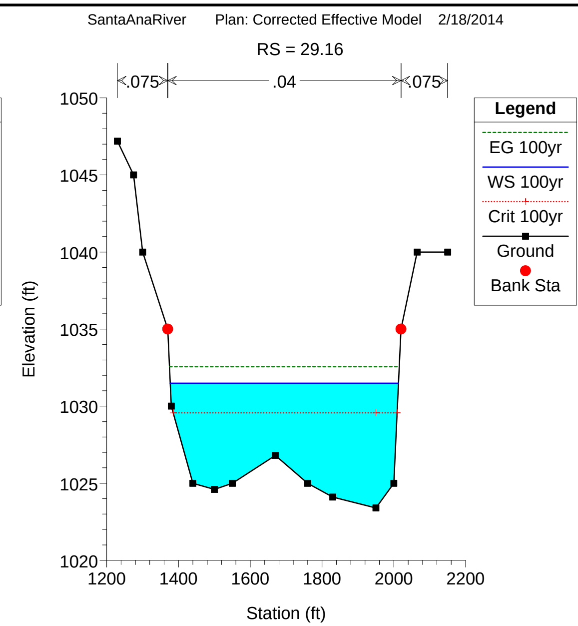
SantaAnaRiver Plan: Corrected Effective Model 2/18/2014
RIVER-1 Reach-1
Legend
EG 100yr
WS 100yr
Crit 100yr
Ground
Elevation (ft)
Main Channel Distance (ft)
1070
1060
1050
1040
1030
1020
1010
1000
990
0
1000
2000
3000
4000
5000
6000
7000
28.38
28.43
28.49
28.53
28.55
28.58
28.602
28.63
28.673
28.737
28.84
28.95
29.01
29.06 Orange Show Road
29.08
29.14
29.16
29.19
29.23
29.32
29.35
29.37
29.43
29.5
29.53
29.56
29.64

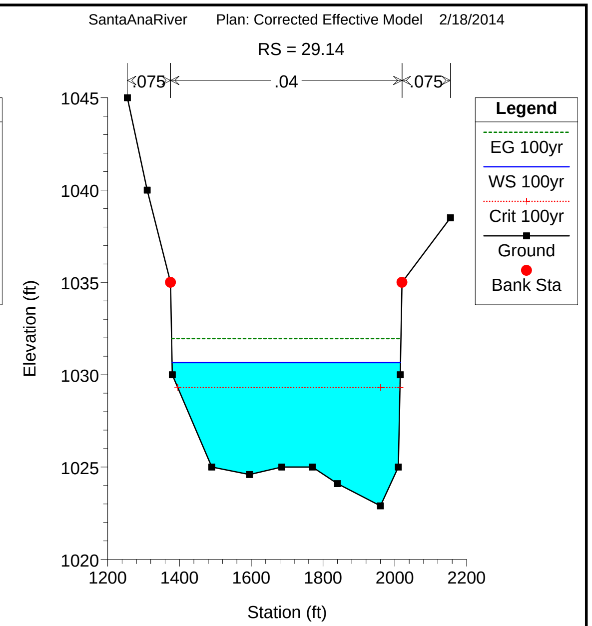


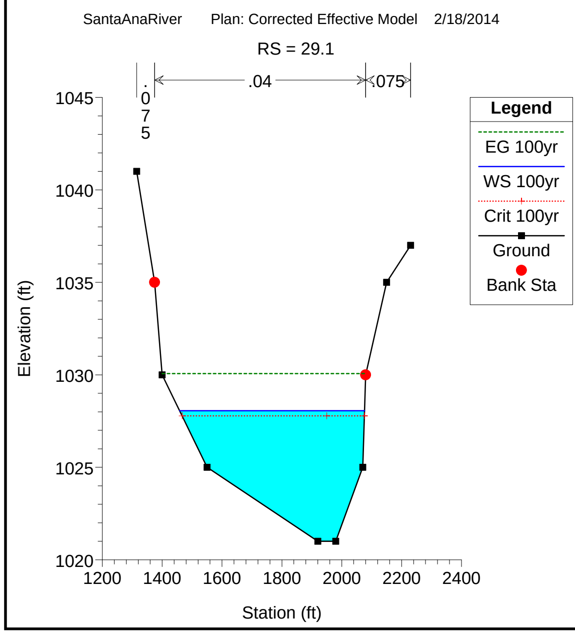
SantaAnaRiver Plan: Corrected Effective Model 2/18/2014
RS = 29.64
.038
Legend
EG 100yr
WS 100yr
Crit 100yr
Ground
Ineff
Bank Sta
Elevation (ft)
Station (ft)
SantaAnaRiver Plan: Corrected Effective Model 2/18/2014
RS = 29.56
.04
Legend
EG 100yr
WS 100yr
Crit 100yr
Ground
Ineff
Bank Sta
Elevation (ft)
Station (ft)
SantaAnaRiver Plan: Corrected Effective Model 2/18/2014
RS = 29.53
.04
Legend
EG 100yr
WS 100yr
Crit 100yr
Ground
Ineff
Bank Sta
Elevation (ft)
Station (ft)
SantaAnaRiver Plan: Corrected Effective Model 2/18/2014
RS = 29.51 TIPPECANOE AVE.
.04
Legend
EG 100yr
WS 100yr
Crit 100yr
Ground
Ineff
Bank Sta
Elevation (ft)
Station (ft)
SantaAnaRiver Plan: Corrected Effective Model 2/18/2014
RS = 29.505 BR Tippecanoe Ave
.04
Legend
EG 100yr
WS 100yr
Crit 100yr
Ground
Ineff
Bank Sta
Elevation (ft)
Station (ft)
SantaAnaRiver Plan: Corrected Effective Model 2/18/2014
RS = 29.505 BR Tippecanoe Ave
.04
Legend
EG 100yr
WS 100yr
Crit 100yr
Ground
Ineff
Bank Sta
Elevation (ft)
Station (ft)

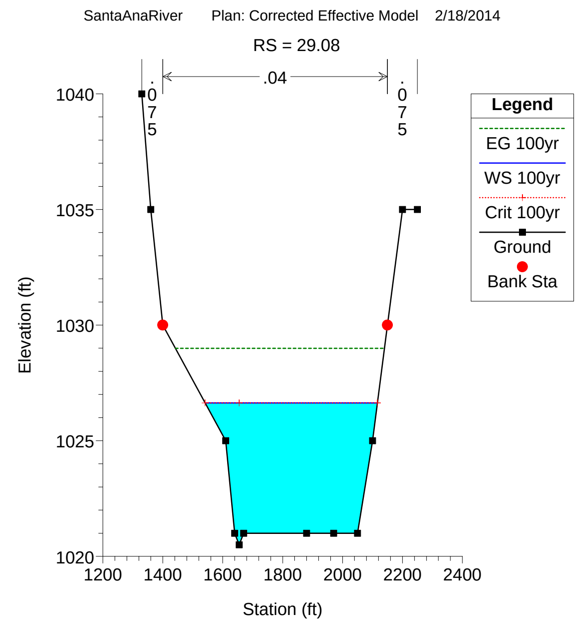

SantaAnaRiver Plan: Corrected Effective Model 2/18/2014
RS = 29.5
.04
.075
Legend
EG 100yr
WS 100yr
Crit 100yr
Ground
Ineff
Bank Sta
Elevation (ft)
Station (ft)
SantaAnaRiver Plan: Corrected Effective Model 2/18/2014
RS = 29.43
.04
Legend
EG 100yr
WS 100yr
Crit 100yr
Ground
Ineff
Bank Sta
Elevation (ft)
Station (ft)
SantaAnaRiver Plan: Corrected Effective Model 2/18/2014
RS = 29.37
.075
.04
.075
Legend
EG 100yr
WS 100yr
Crit 100yr
Ground
Bank Sta
Elevation (ft)
Station (ft)
SantaAnaRiver Plan: Corrected Effective Model 2/18/2014
RS = 29.35
.075
.04
.075
Legend
EG 100yr
WS 100yr
Crit 100yr
Ground
Ineff
Bank Sta
Elevation (ft)
Station (ft)
SantaAnaRiver Plan: Corrected Effective Model 2/18/2014
RS = 29.32
.075
.04
.075
Legend
EG 100yr
WS 100yr
Crit 100yr
Ground
Bank Sta
Elevation (ft)
Station (ft)
SantaAnaRiver Plan: Corrected Effective Model 2/18/2014
RS = 29.23
.075
.04
.075
Legend
EG 100yr
WS 100yr
Crit 100yr
Ground
Bank Sta
Elevation (ft)
Station (ft)

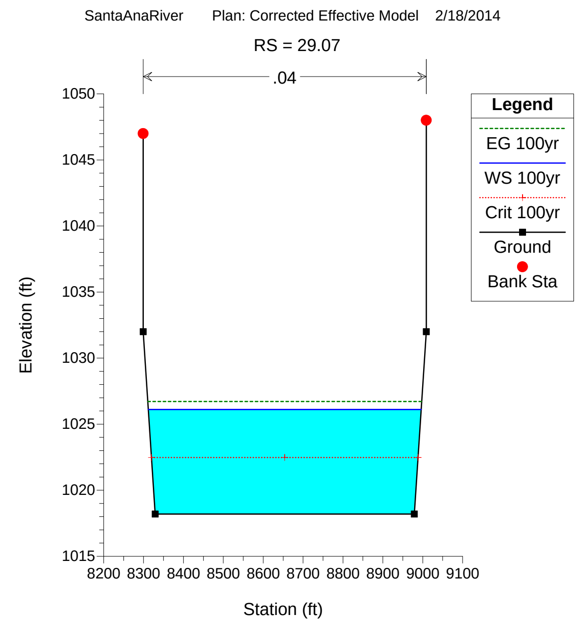

SantaAnaRiver Plan: Corrected Effective Model 2/18/2014
RS = 29.19
.075 .04 .075
Legend
EG 100yr
WS 100yr
Crit 100yr
Ground
Bank Sta
Elevation (ft)
1020 1025 1030 1035 1040 1045 1050
Station (ft)
1200 1400 1600 1800 2000 2200

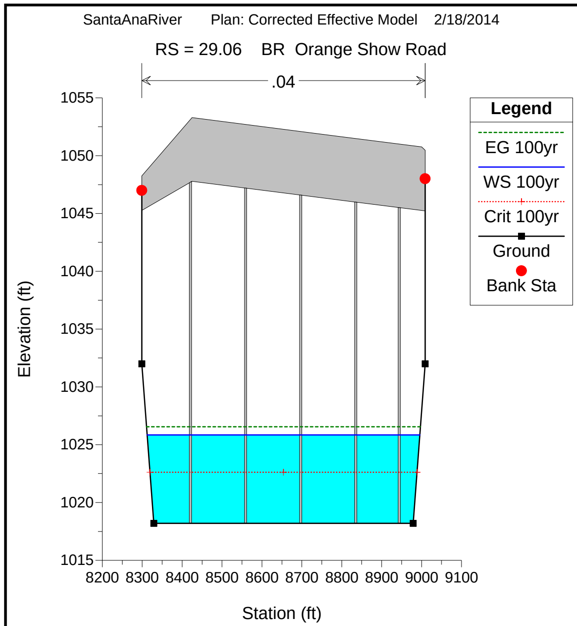
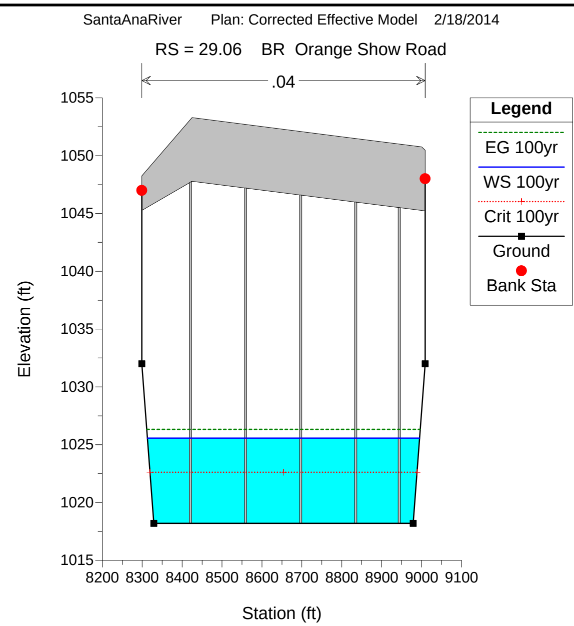
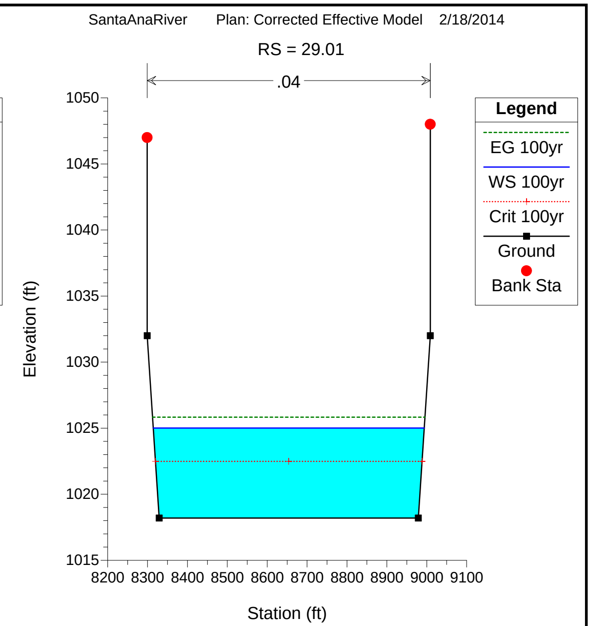
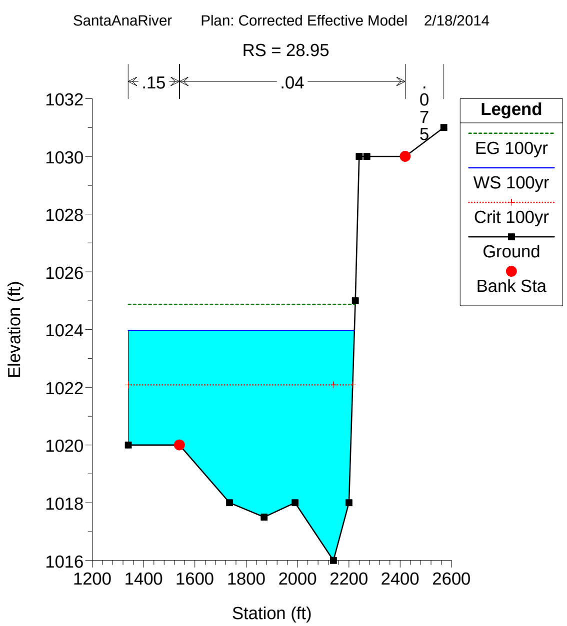
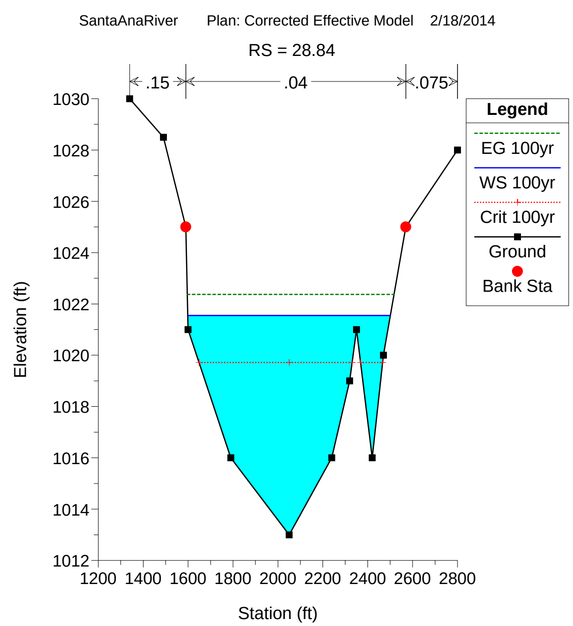
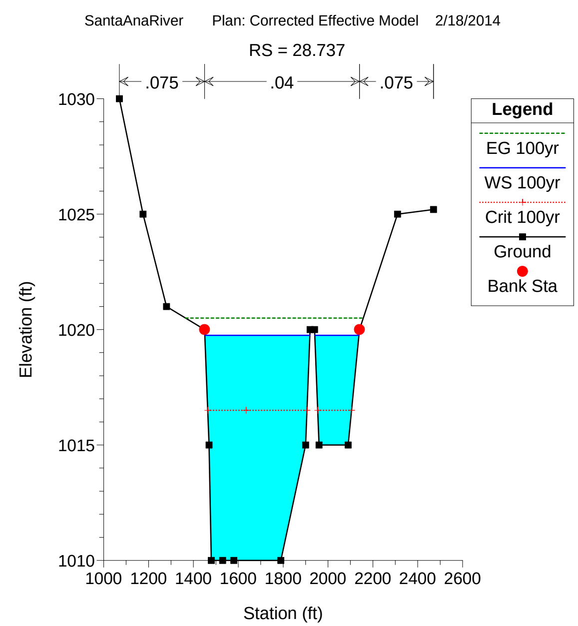

SantaAnaRiver Plan: Corrected Effective Model 2/18/2014
RS = 29.16
.075 .04 .075
Legend
EG 100yr
WS 100yr
Crit 100yr
Ground
Bank Sta
Elevation (ft)
1020 1025 1030 1035 1040 1045 1050
Station (ft)
1200 1400 1600 1800 2000 2200

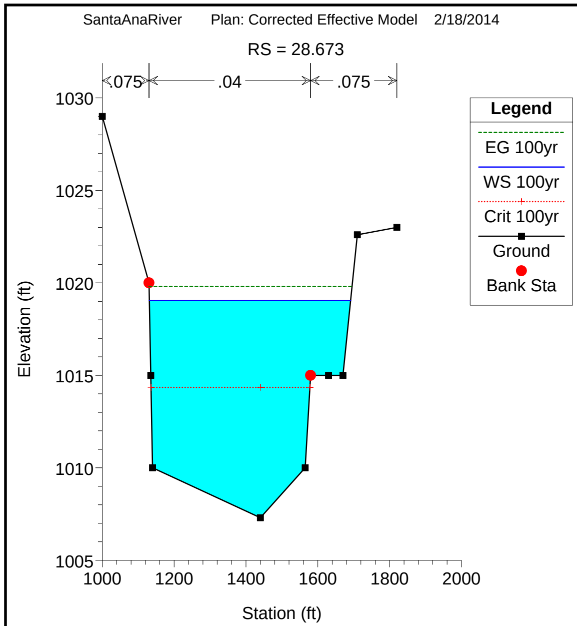

SantaAnaRiver Plan: Corrected Effective Model 2/18/2014
RS = 29.14
.075 .04 .075
Legend
EG 100yr
WS 100yr
Crit 100yr
Ground
Bank Sta
Elevation (ft)
1020 1025 1030 1035 1040 1045
Station (ft)
1200 1400 1600 1800 2000 2200

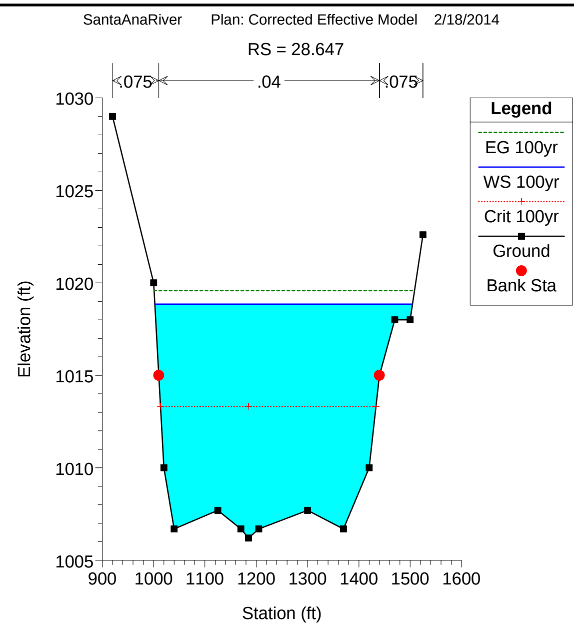

SantaAnaRiver Plan: Corrected Effective Model 2/18/2014
RS = 29.1
.075 .04 .075
Legend
EG 100yr
WS 100yr
Crit 100yr
Ground
Bank Sta
Elevation (ft)
1020 1025 1030 1035 1040 1045
Station (ft)
1200 1400 1600 1800 2000 2200 2400

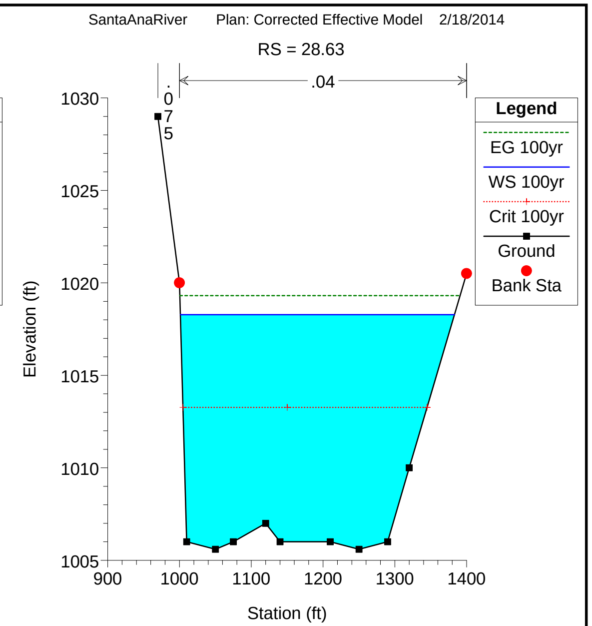

SantaAnaRiver Plan: Corrected Effective Model 2/18/2014
RS = 29.08
.075 .04 .075
Legend
EG 100yr
WS 100yr
Crit 100yr
Ground
Bank Sta
Elevation (ft)
1020 1025 1030 1035 1040
Station (ft)
1200 1400 1600 1800 2000 2200 2400

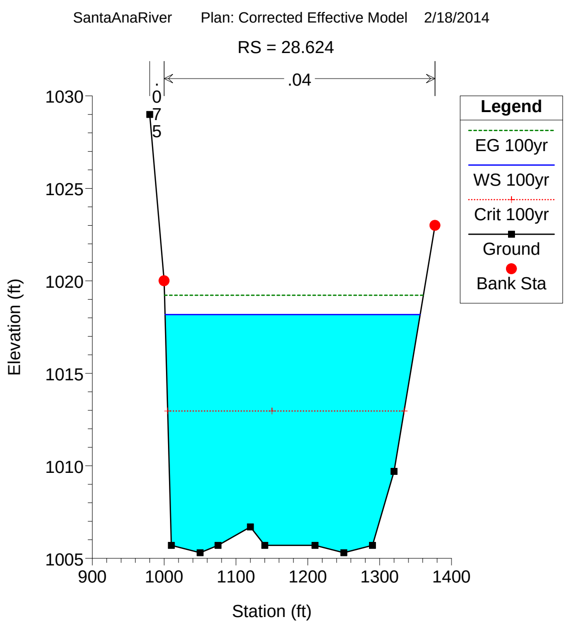

SantaAnaRiver Plan: Corrected Effective Model 2/18/2014
RS = 29.07
.04
Legend
EG 100yr
WS 100yr
Crit 100yr
Ground
Bank Sta
Elevation (ft)
1015 1020 1025 1030 1035 1040 1045 1050
Station (ft)
8200 8300 8400 8500 8600 8700 8800 8900 9000 9100

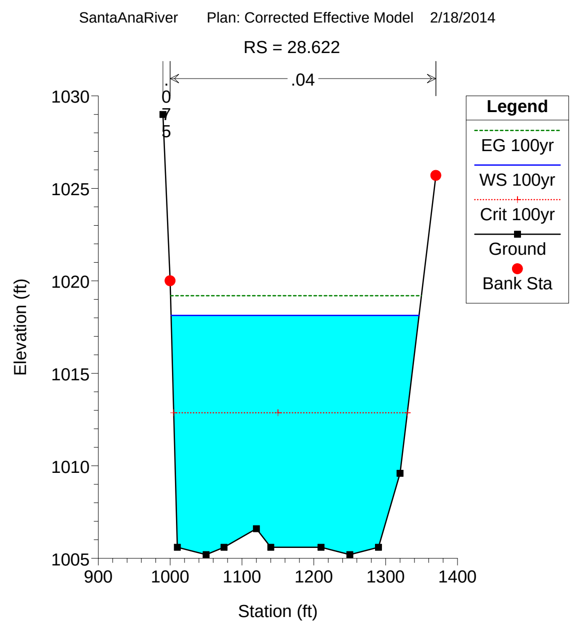

SantaAnaRiver Plan: Corrected Effective Model 2/18/2014
RS = 29.06 BR Orange Show Road
.04
Legend
EG 100yr
WS 100yr
Crit 100yr
Ground
Bank Sta
Elevation (ft)
Station (ft)

SantaAnaRiver Plan: Corrected Effective Model 2/18/2014
RS = 29.06 BR Orange Show Road
.04
Legend
EG 100yr
WS 100yr
Crit 100yr
Ground
Bank Sta
Elevation (ft)
Station (ft)

SantaAnaRiver Plan: Corrected Effective Model 2/18/2014
RS = 29.01
.04
Legend
EG 100yr
WS 100yr
Crit 100yr
Ground
Bank Sta
Elevation (ft)
Station (ft)

SantaAnaRiver Plan: Corrected Effective Model 2/18/2014
RS = 28.95
.15
.04
.075
Legend
EG 100yr
WS 100yr
Crit 100yr
Ground
Bank Sta
Elevation (ft)
Station (ft)

SantaAnaRiver Plan: Corrected Effective Model 2/18/2014
RS = 28.84
.15
.04
.075
Legend
EG 100yr
WS 100yr
Crit 100yr
Ground
Bank Sta
Elevation (ft)
Station (ft)

SantaAnaRiver Plan: Corrected Effective Model 2/18/2014
RS = 28.737
.075
.04
.075
Legend
EG 100yr
WS 100yr
Crit 100yr
Ground
Bank Sta
Elevation (ft)
Station (ft)

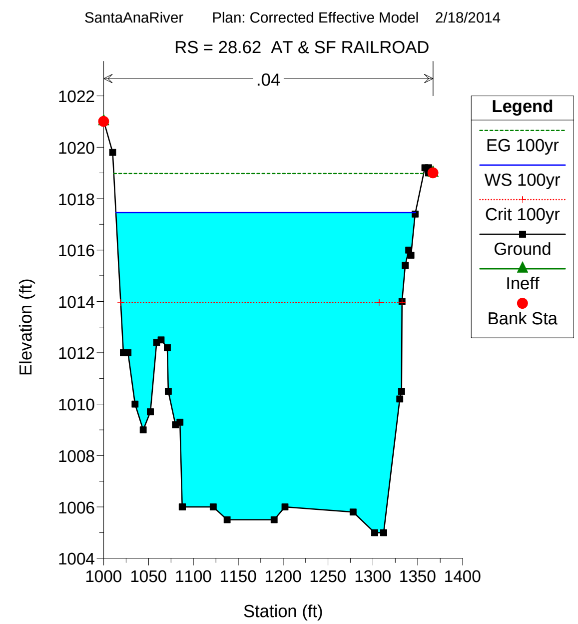

SantaAnaRiver Plan: Corrected Effective Model 2/18/2014
RS = 28.673
.075
.04
.075
Elevation (ft)
Station (ft)
Legend
EG 100yr
WS 100yr
Crit 100yr
Ground
Bank Sta

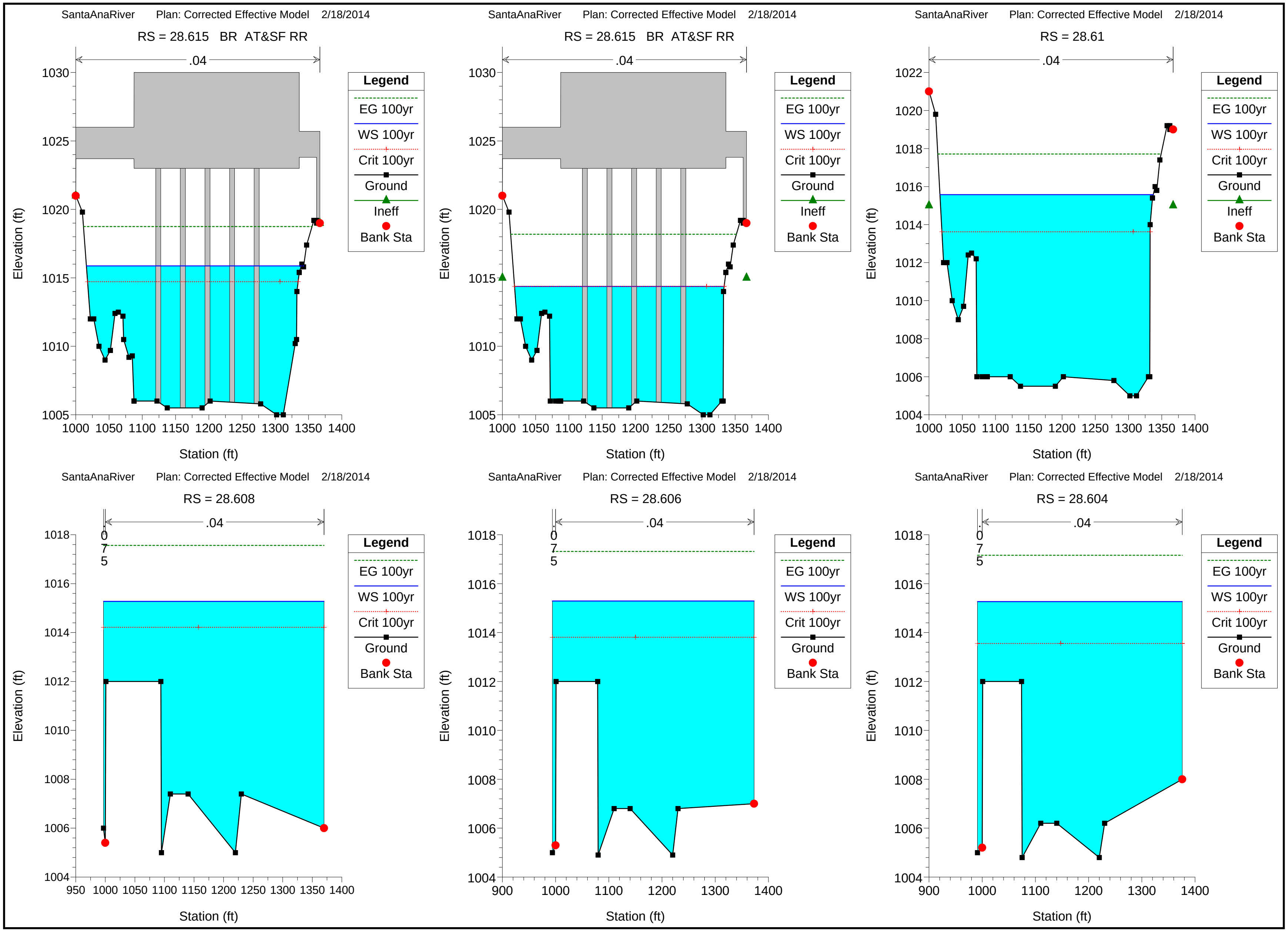

SantaAnaRiver Plan: Corrected Effective Model 2/18/2014
RS = 28.647
.075
.04
.075
Elevation (ft)
Station (ft)
Legend
EG 100yr
WS 100yr
Crit 100yr
Ground
Bank Sta

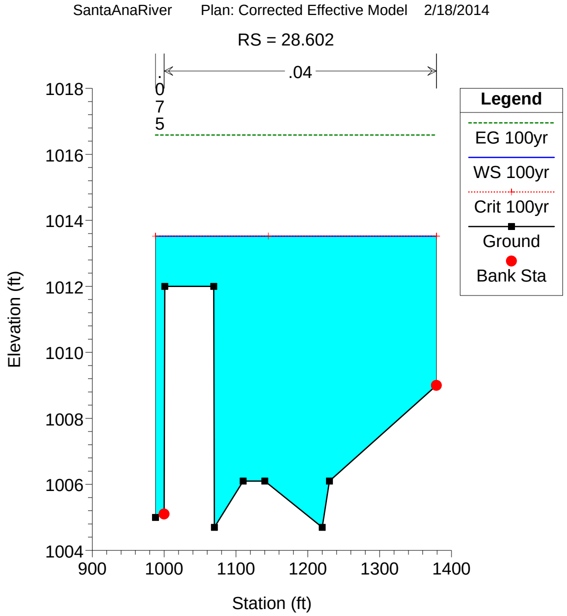

SantaAnaRiver Plan: Corrected Effective Model 2/18/2014
RS = 28.63
.075
.04
Elevation (ft)
Station (ft)
Legend
EG 100yr
WS 100yr
Crit 100yr
Ground
Bank Sta

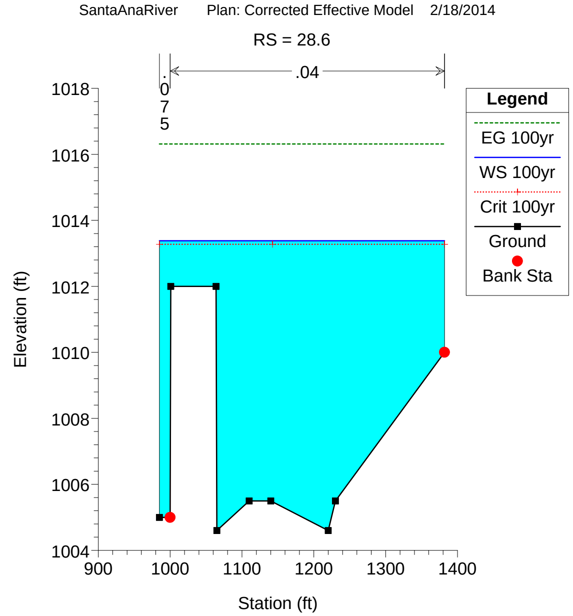

SantaAnaRiver Plan: Corrected Effective Model 2/18/2014
RS = 28.624
.075
.04
Elevation (ft)
Station (ft)
Legend
EG 100yr
WS 100yr
Crit 100yr
Ground
Bank Sta

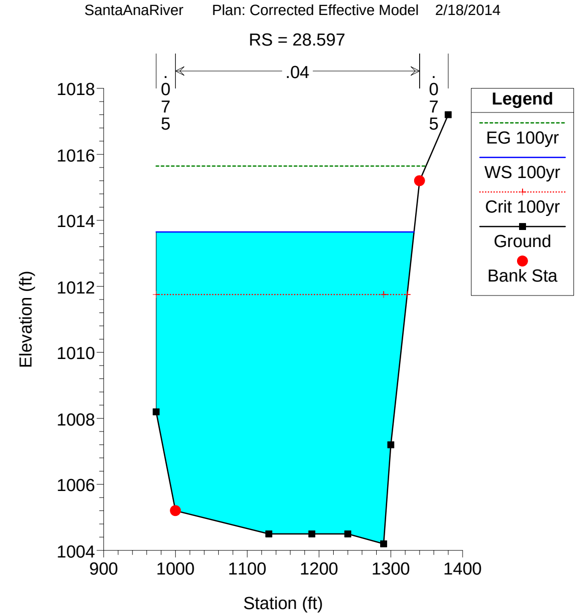

SantaAnaRiver Plan: Corrected Effective Model 2/18/2014
RS = 28.622
.075
.04
Elevation (ft)
Station (ft)
Legend
EG 100yr
WS 100yr
Crit 100yr
Ground
Bank Sta

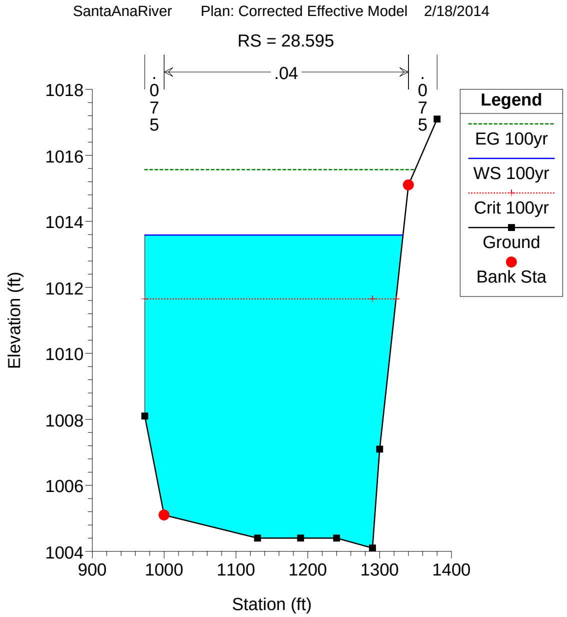

SantaAnaRiver Plan: Corrected Effective Model 2/18/2014
RS = 28.62 AT & SF RAILROAD
.04
Elevation (ft)
Station (ft)
Legend
EG 100yr
WS 100yr
Crit 100yr
Ground
Ineff
Bank Sta

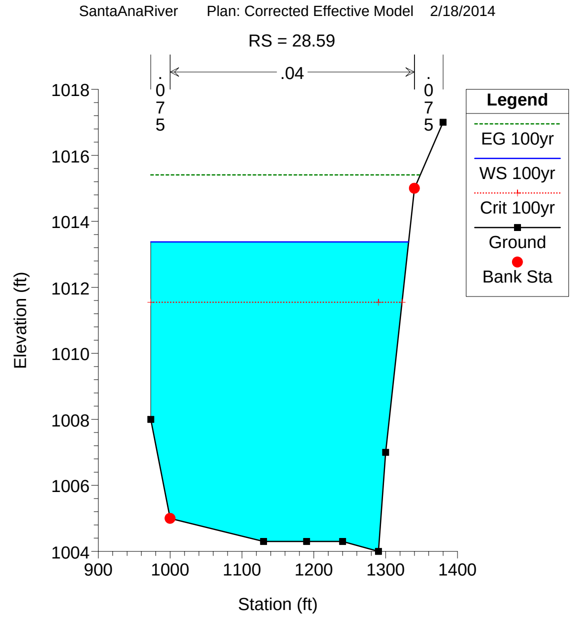

SantaAnaRiver Plan: Corrected Effective Model 2/18/2014
RS = 28.615 BR AT&SF RR
.04
Elevation (ft)
Station (ft)
Legend
EG 100yr
WS 100yr
Crit 100yr
Ground
Ineff
Bank Sta
SantaAnaRiver Plan: Corrected Effective Model 2/18/2014
RS = 28.615 BR AT&SF RR
.04
Elevation (ft)
Station (ft)
Legend
EG 100yr
WS 100yr
Crit 100yr
Ground
Ineff
Bank Sta
SantaAnaRiver Plan: Corrected Effective Model 2/18/2014
RS = 28.61
.04
Elevation (ft)
Station (ft)
Legend
EG 100yr
WS 100yr
Crit 100yr
Ground
Ineff
Bank Sta
SantaAnaRiver Plan: Corrected Effective Model 2/18/2014
RS = 28.608
.04
0
7
5
Elevation (ft)
Station (ft)
Legend
EG 100yr
WS 100yr
Crit 100yr
Ground
Bank Sta
SantaAnaRiver Plan: Corrected Effective Model 2/18/2014
RS = 28.606
.04
0
7
5
Elevation (ft)
Station (ft)
Legend
EG 100yr
WS 100yr
Crit 100yr
Ground
Bank Sta
SantaAnaRiver Plan: Corrected Effective Model 2/18/2014
RS = 28.604
.04
0
7
5
Elevation (ft)
Station (ft)
Legend
EG 100yr
WS 100yr
Crit 100yr
Ground
Bank Sta

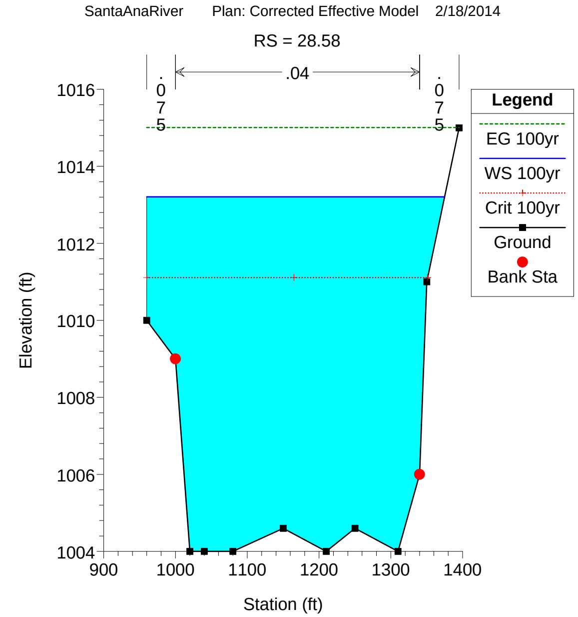

SantaAnaRiver Plan: Corrected Effective Model 2/18/2014
RS = 28.602
.04
.075
Legend
EG 100yr
WS 100yr
Crit 100yr
Ground
Bank Sta
Elevation (ft)
1004
1006
1008
1010
1012
1014
1016
1018
Station (ft)
900
1000
1100
1200
1300
1400

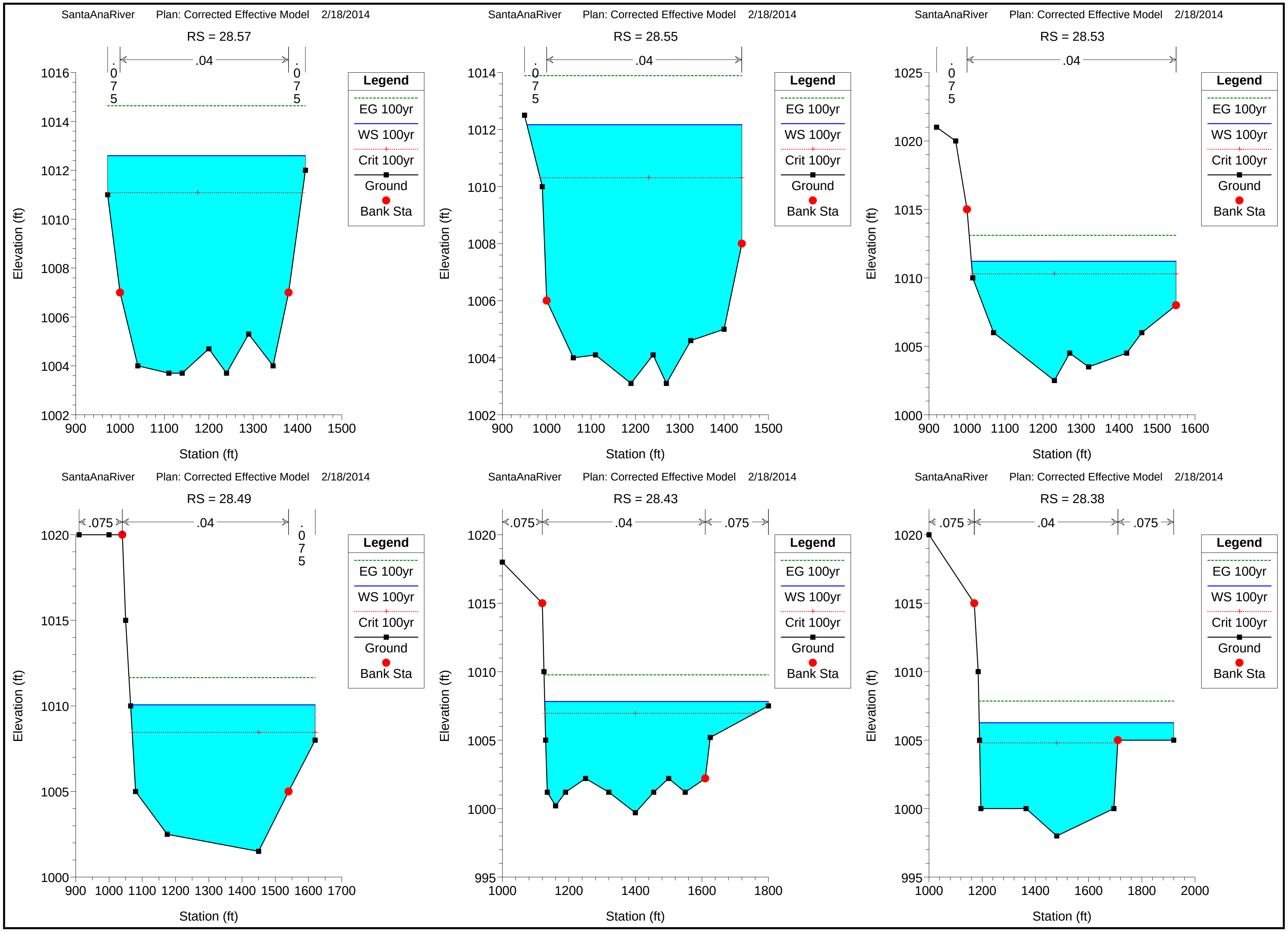

SantaAnaRiver Plan: Corrected Effective Model 2/18/2014
RS = 28.6
.04
.075
Legend
EG 100yr
WS 100yr
Crit 100yr
Ground
Bank Sta
Elevation (ft)
1004
1006
1008
1010
1012
1014
1016
1018
Station (ft)
900
1000
1100
1200
1300
1400

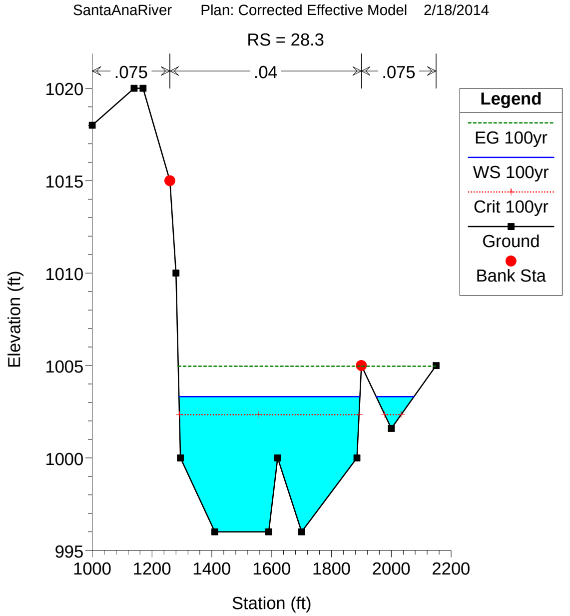

SantaAnaRiver Plan: Corrected Effective Model 2/18/2014
RS = 28.597
.075
.04
.075
Legend
EG 100yr
WS 100yr
Crit 100yr
Ground
Bank Sta
Elevation (ft)
1004
1006
1008
1010
1012
1014
1016
1018
Station (ft)
900
1000
1100
1200
1300
1400


SantaAnaRiver Plan: Corrected Effective Model 2/18/2014
RS = 28.595
.075
.04
.075
Legend
EG 100yr
WS 100yr
Crit 100yr
Ground
Bank Sta
Elevation (ft)
1004
1006
1008
1010
1012
1014
1016
1018
Station (ft)
900
1000
1100
1200
1300
1400

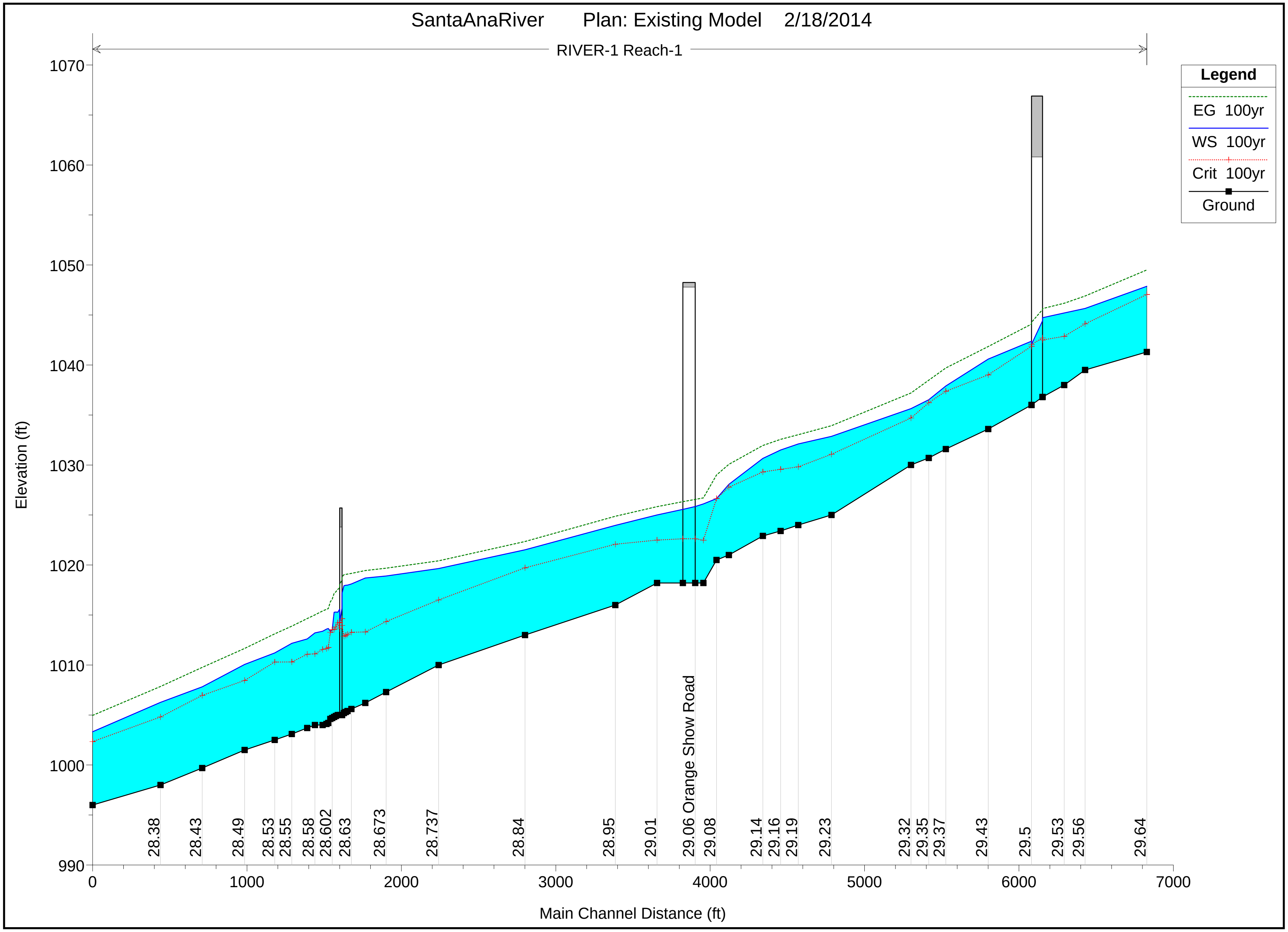

SantaAnaRiver Plan: Corrected Effective Model 2/18/2014
RS = 28.59
.075
.04
.075
Legend
EG 100yr
WS 100yr
Crit 100yr
Ground
Bank Sta
Elevation (ft)
1004
1006
1008
1010
1012
1014
1016
1018
Station (ft)
900
1000
1100
1200
1300
1400


SantaAnaRiver Plan: Corrected Effective Model 2/18/2014
RS = 28.58
.075
.04
.075
Legend
EG 100yr
WS 100yr
Crit 100yr
Ground
Bank Sta
Elevation (ft)
1004
1006
1008
1010
1012
1014
1016
Station (ft)
900
1000
1100
1200
1300
1400

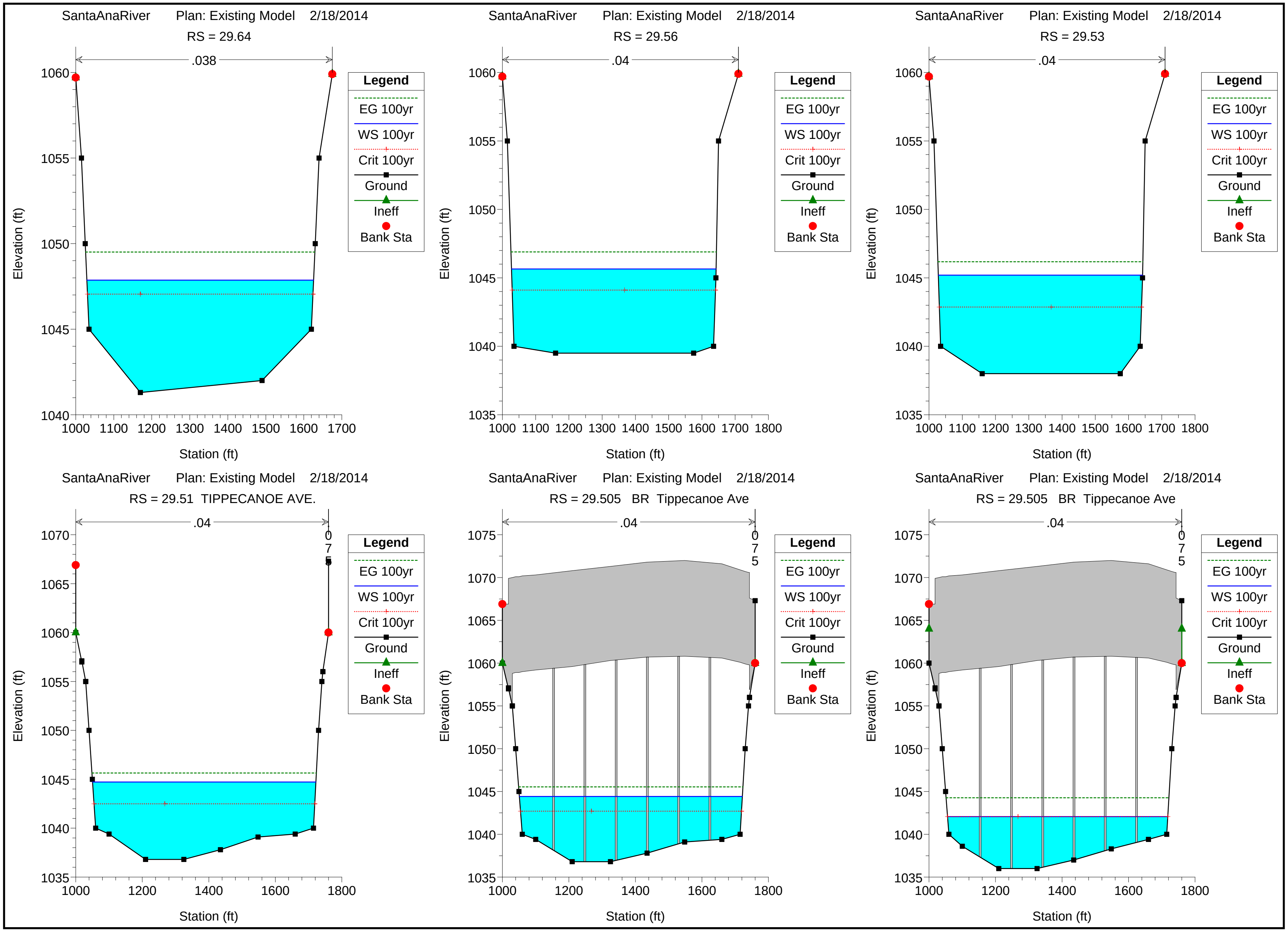

SantaAnaRiver Plan: Corrected Effective Model 2/18/2014
RS = 28.57
RS = 28.55
RS = 28.53
RS = 28.49
RS = 28.43
RS = 28.38
.04
.075
Legend
EG 100yr
WS 100yr
Crit 100yr
Ground
Bank Sta
Elevation (ft)
Station (ft)

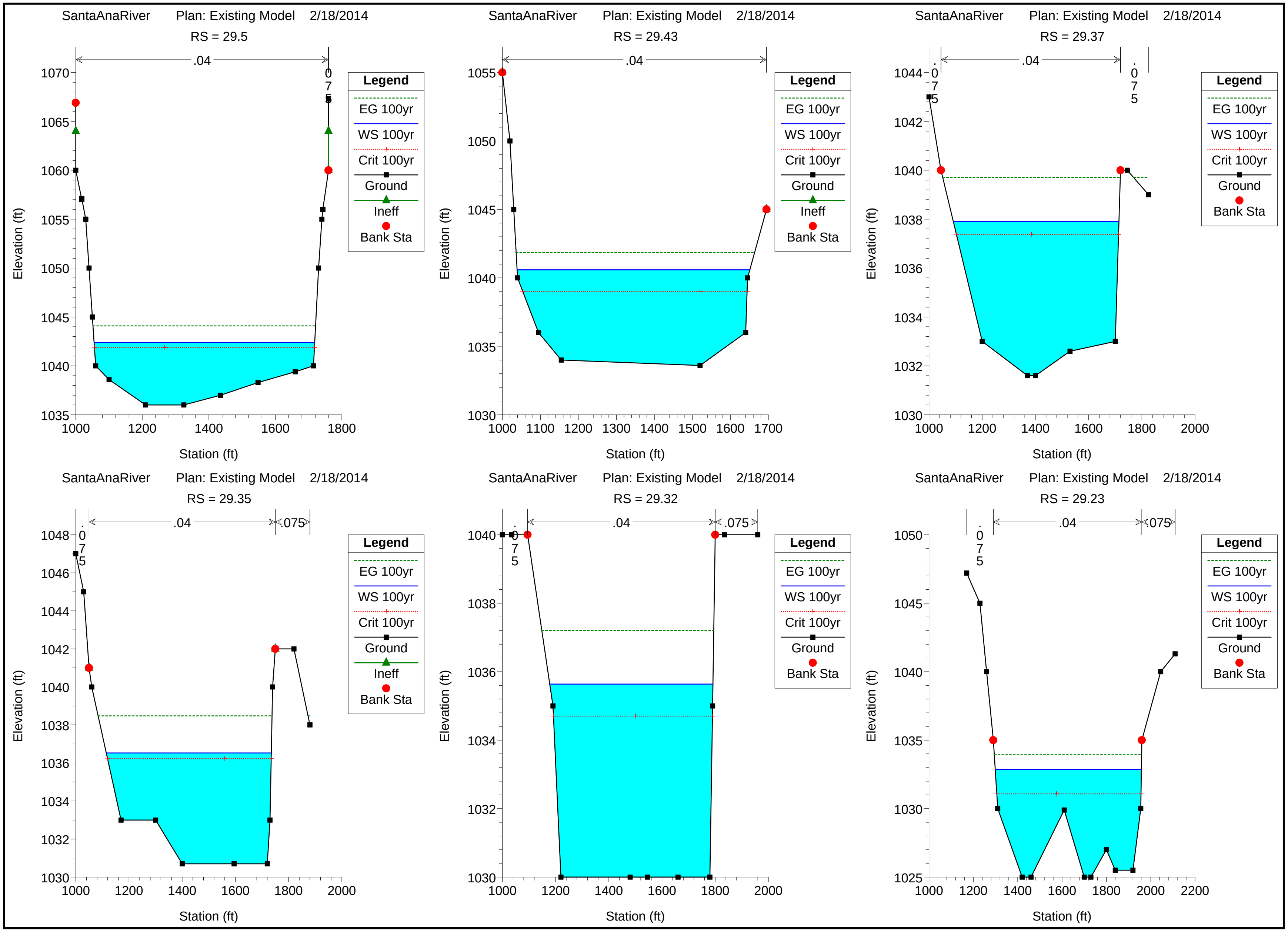


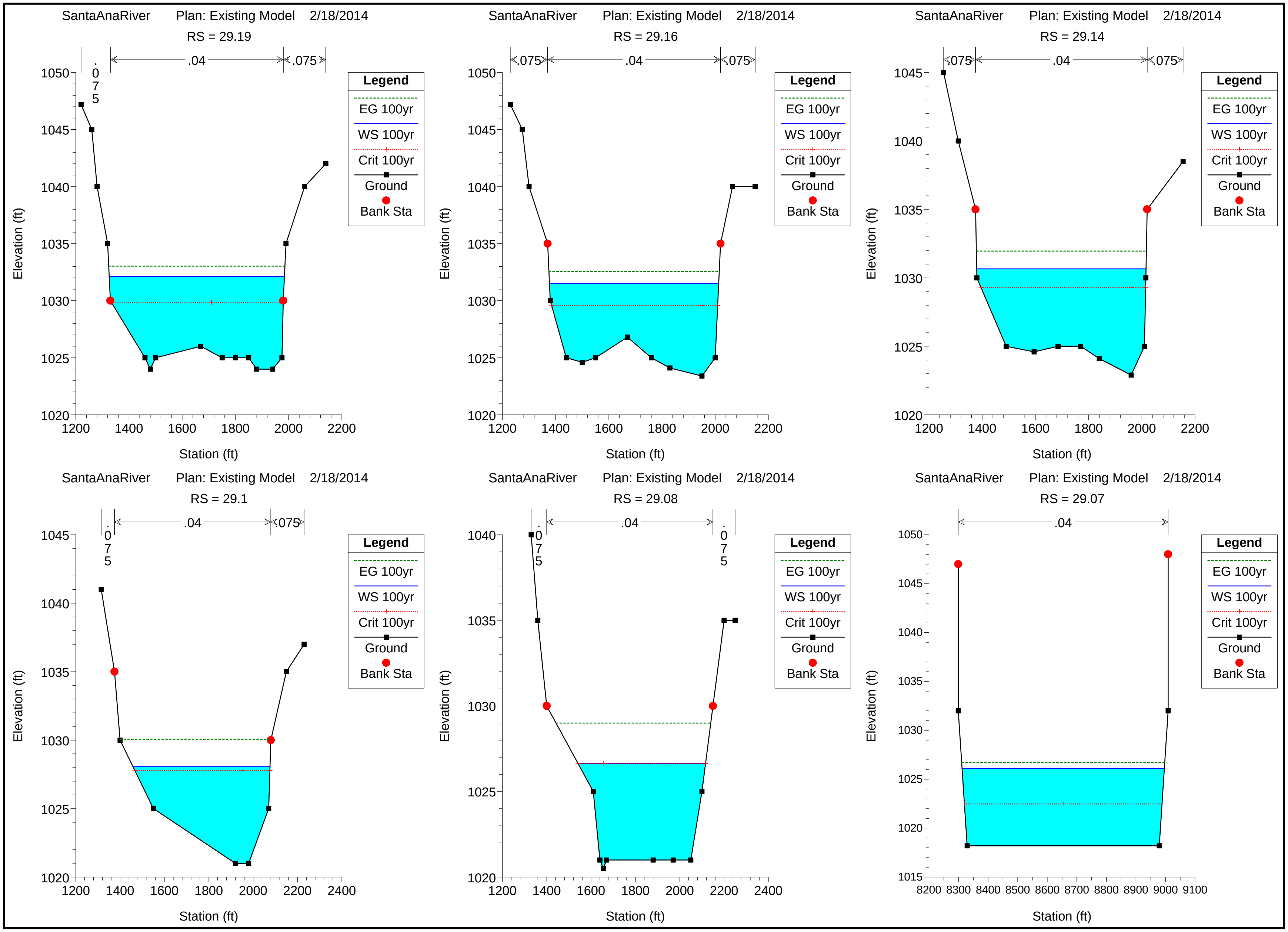
SantaAnaRiver Plan: Corrected Effective Model 2/18/2014
RS = 28.3
.075
.04
.075
Legend
EG 100yr
WS 100yr
Crit 100yr
Ground
Bank Sta
Elevation (ft)
1020
1015
1010
1005
1000
995
1000
1200
1400
1600
1800
2000
2200
Station (ft)

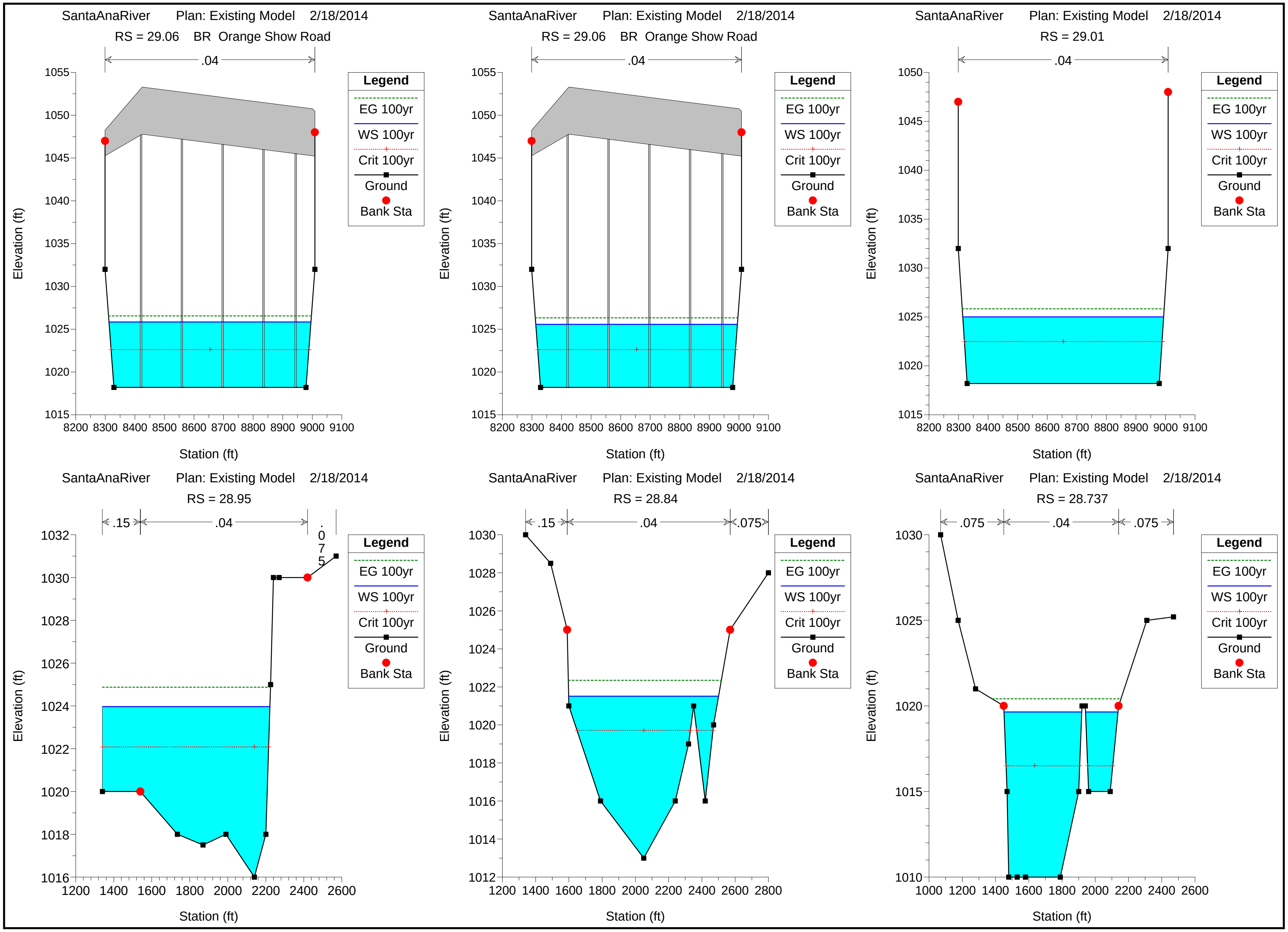


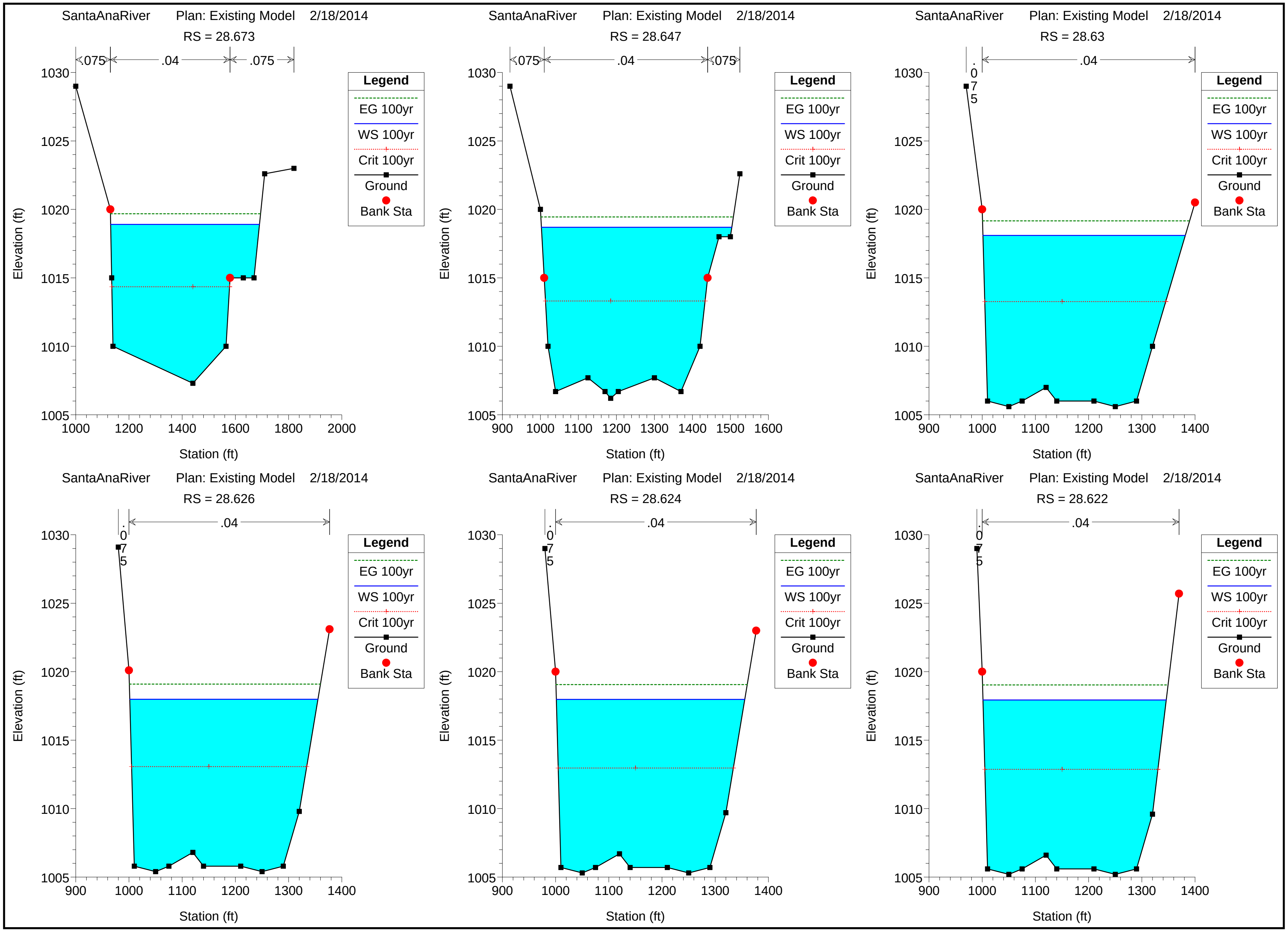
SantaAnaRiver Plan: Existing Model 2/18/2014
RIVER-1 Reach-1
Legend
EG 100yr
WS 100yr
Crit 100yr
Ground
Elevation (ft)
Main Channel Distance (ft)
Orange Show Road
1070
1060
1050
1040
1030
1020
1010
1000
990
0
1000
2000
3000
4000
5000
6000
7000
28.38
28.43
28.49
28.53
28.55
28.58
28.602
28.63
28.673
28.737
28.84
28.95
29.01
29.06
29.08
29.14
29.16
29.19
29.23
29.32
29.35
29.37
29.43
29.5
29.53
29.56
29.64

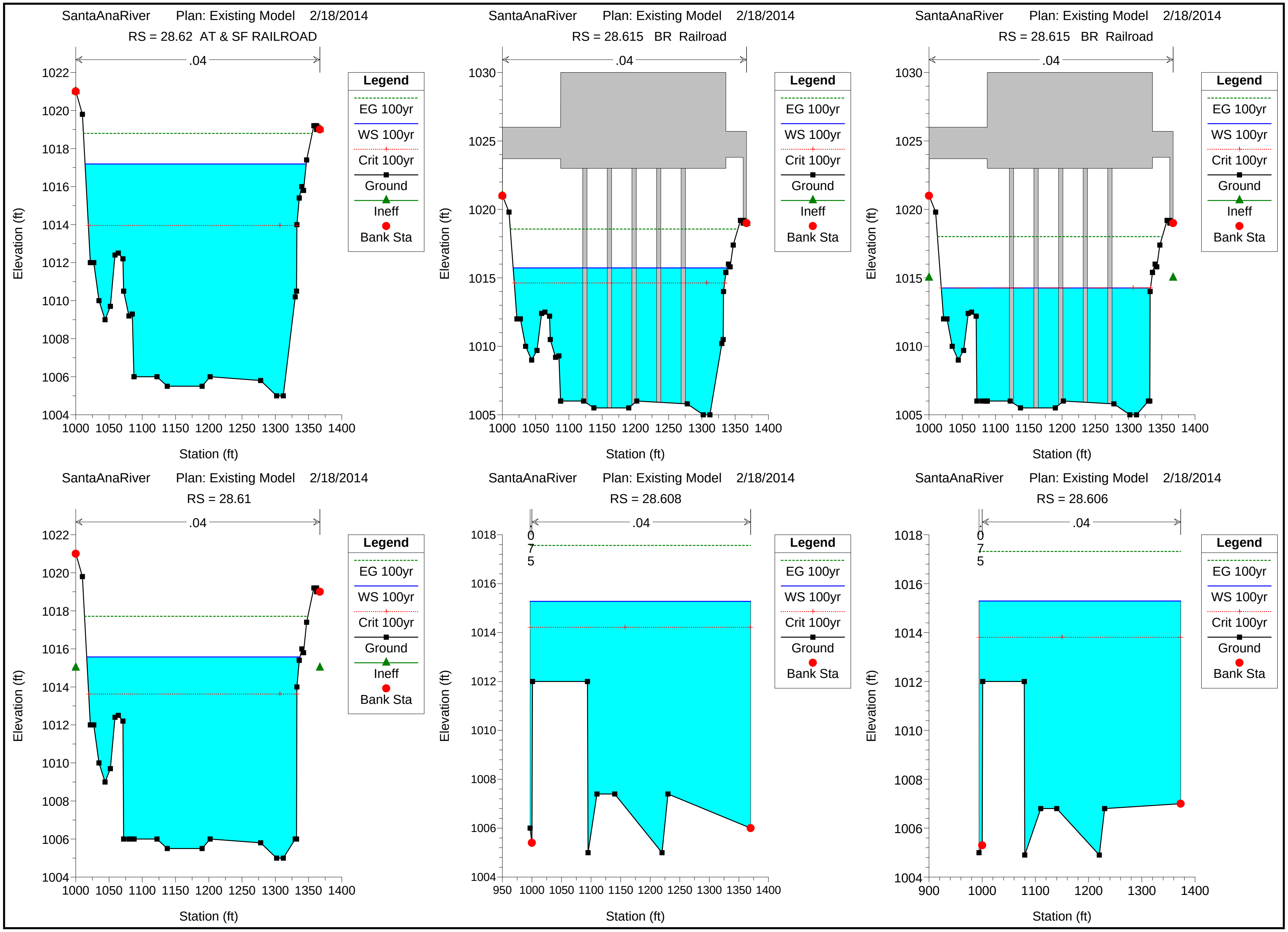

SantaAnaRiver Plan: Existing Model 2/18/2014
RS = 29.64
.038
Legend
EG 100yr
WS 100yr
Crit 100yr
Ground
Ineff
Bank Sta
Elevation (ft)
Station (ft)
SantaAnaRiver Plan: Existing Model 2/18/2014
RS = 29.56
.04
SantaAnaRiver Plan: Existing Model 2/18/2014
RS = 29.53
.04
SantaAnaRiver Plan: Existing Model 2/18/2014
RS = 29.51 TIPPECANOE AVE.
.04
SantaAnaRiver Plan: Existing Model 2/18/2014
RS = 29.505 BR Tippecanoe Ave
.04
SantaAnaRiver Plan: Existing Model 2/18/2014
RS = 29.505 BR Tippecanoe Ave
.04

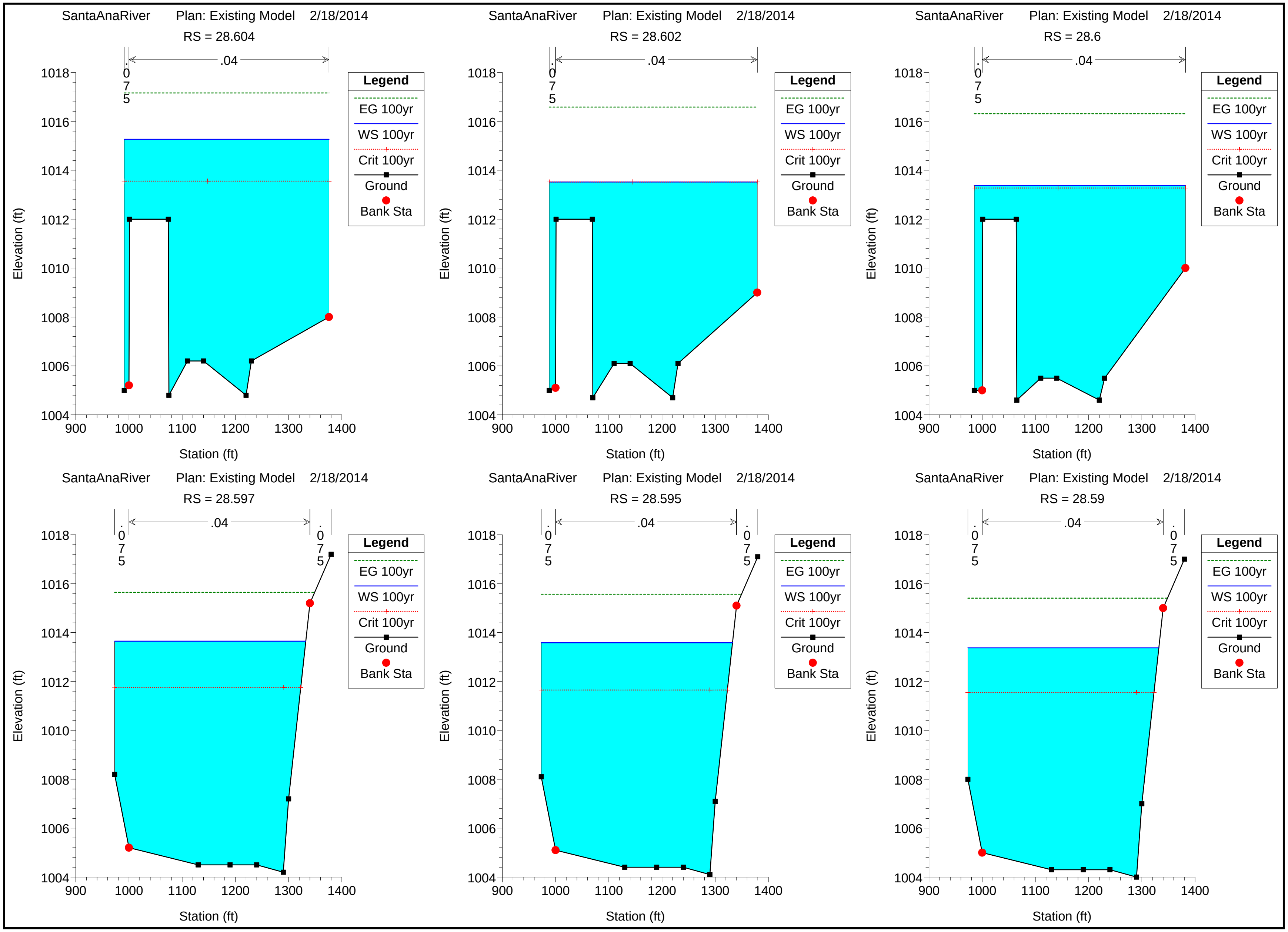

SantaAnaRiver Plan: Existing Model 2/18/2014
RS = 29.5
RS = 29.43
RS = 29.37
RS = 29.35
RS = 29.32
RS = 29.23
.04
.075
Legend
EG 100yr
WS 100yr
Crit 100yr
Ground
Ineff
Bank Sta
Elevation (ft)
Station (ft)

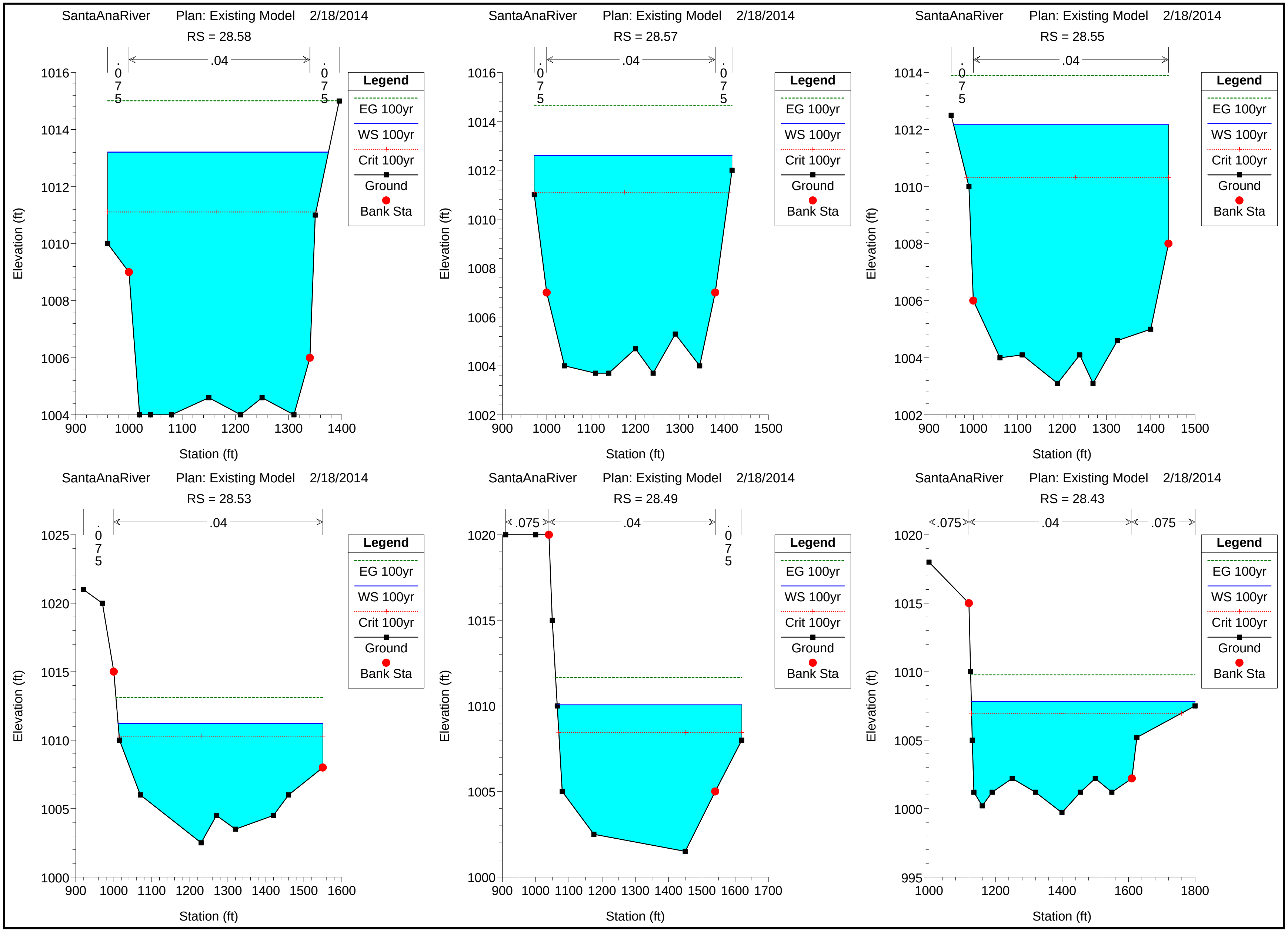

SantaAnaRiver Plan: Existing Model 2/18/2014
RS = 29.19
.075
.04
.075
Legend
EG 100yr
WS 100yr
Crit 100yr
Ground
Bank Sta
Elevation (ft)
Station (ft)
SantaAnaRiver Plan: Existing Model 2/18/2014
RS = 29.16
.075
.04
.075
Legend
EG 100yr
WS 100yr
Crit 100yr
Ground
Bank Sta
Elevation (ft)
Station (ft)
SantaAnaRiver Plan: Existing Model 2/18/2014
RS = 29.14
.075
.04
.075
Legend
EG 100yr
WS 100yr
Crit 100yr
Ground
Bank Sta
Elevation (ft)
Station (ft)
SantaAnaRiver Plan: Existing Model 2/18/2014
RS = 29.1
.075
.04
.075
Legend
EG 100yr
WS 100yr
Crit 100yr
Ground
Bank Sta
Elevation (ft)
Station (ft)
SantaAnaRiver Plan: Existing Model 2/18/2014
RS = 29.08
.075
.04
.075
Legend
EG 100yr
WS 100yr
Crit 100yr
Ground
Bank Sta
Elevation (ft)
Station (ft)
SantaAnaRiver Plan: Existing Model 2/18/2014
RS = 29.07
.04
Legend
EG 100yr
WS 100yr
Crit 100yr
Ground
Bank Sta
Elevation (ft)
Station (ft)


SantaAnaRiver Plan: Existing Model 2/18/2014
RS = 29.06 BR Orange Show Road
.04
Legend
EG 100yr
WS 100yr
Crit 100yr
Ground
Bank Sta
Elevation (ft)
Station (ft)
SantaAnaRiver Plan: Existing Model 2/18/2014
RS = 29.06 BR Orange Show Road
.04
Legend
EG 100yr
WS 100yr
Crit 100yr
Ground
Bank Sta
Elevation (ft)
Station (ft)
SantaAnaRiver Plan: Existing Model 2/18/2014
RS = 29.01
.04
Legend
EG 100yr
WS 100yr
Crit 100yr
Ground
Bank Sta
Elevation (ft)
Station (ft)
SantaAnaRiver Plan: Existing Model 2/18/2014
RS = 28.95
.15
.04
.075
Legend
EG 100yr
WS 100yr
Crit 100yr
Ground
Bank Sta
Elevation (ft)
Station (ft)
SantaAnaRiver Plan: Existing Model 2/18/2014
RS = 28.84
.15
.04
.075
Legend
EG 100yr
WS 100yr
Crit 100yr
Ground
Bank Sta
Elevation (ft)
Station (ft)
SantaAnaRiver Plan: Existing Model 2/18/2014
RS = 28.737
.075
.04
.075
Legend
EG 100yr
WS 100yr
Crit 100yr
Ground
Bank Sta
Elevation (ft)
Station (ft)

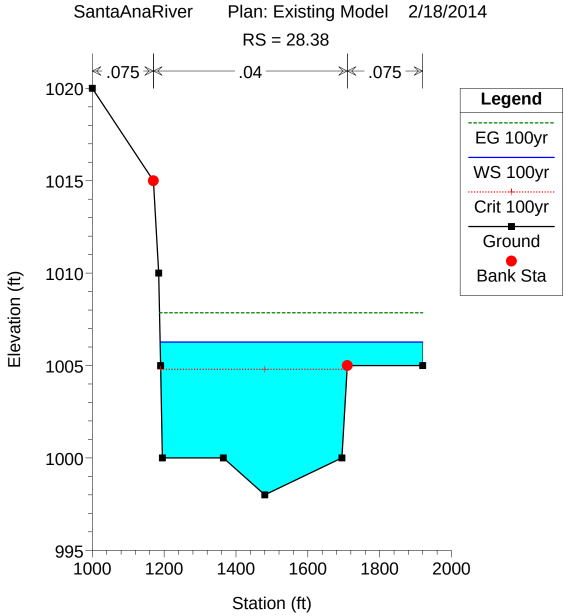

SantaAnaRiver Plan: Existing Model 2/18/2014
RS = 28.673
.075
.04
.075
Elevation (ft)
Station (ft)
Legend
EG 100yr
WS 100yr
Crit 100yr
Ground
Bank Sta
SantaAnaRiver Plan: Existing Model 2/18/2014
RS = 28.647
.075
.04
.075
Elevation (ft)
Station (ft)
Legend
EG 100yr
WS 100yr
Crit 100yr
Ground
Bank Sta
SantaAnaRiver Plan: Existing Model 2/18/2014
RS = 28.63
.075
.04
Elevation (ft)
Station (ft)
Legend
EG 100yr
WS 100yr
Crit 100yr
Ground
Bank Sta
SantaAnaRiver Plan: Existing Model 2/18/2014
RS = 28.626
.075
.04
Elevation (ft)
Station (ft)
Legend
EG 100yr
WS 100yr
Crit 100yr
Ground
Bank Sta
SantaAnaRiver Plan: Existing Model 2/18/2014
RS = 28.624
.075
.04
Elevation (ft)
Station (ft)
Legend
EG 100yr
WS 100yr
Crit 100yr
Ground
Bank Sta
SantaAnaRiver Plan: Existing Model 2/18/2014
RS = 28.622
.075
.04
Elevation (ft)
Station (ft)
Legend
EG 100yr
WS 100yr
Crit 100yr
Ground
Bank Sta

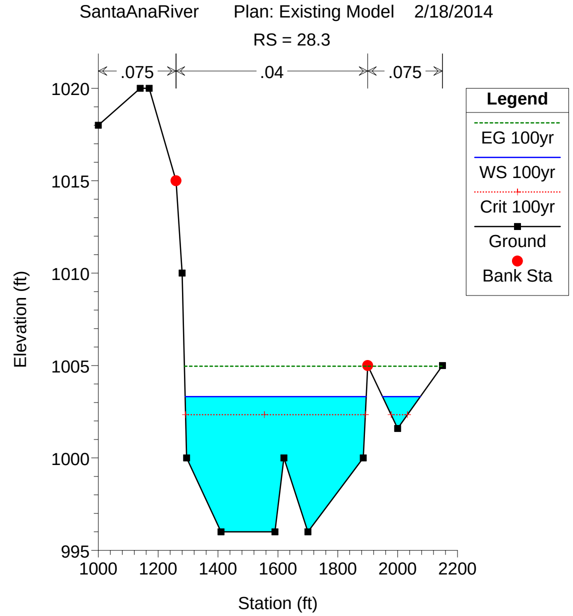

SantaAnaRiver Plan: Existing Model 2/18/2014
RS = 28.62 AT & SF RAILROAD
.04
Legend
EG 100yr
WS 100yr
Crit 100yr
Ground
Ineff
Bank Sta
Elevation (ft)
Station (ft)
SantaAnaRiver Plan: Existing Model 2/18/2014
RS = 28.615 BR Railroad
.04
Legend
EG 100yr
WS 100yr
Crit 100yr
Ground
Ineff
Bank Sta
Elevation (ft)
Station (ft)
SantaAnaRiver Plan: Existing Model 2/18/2014
RS = 28.615 BR Railroad
.04
Legend
EG 100yr
WS 100yr
Crit 100yr
Ground
Ineff
Bank Sta
Elevation (ft)
Station (ft)
SantaAnaRiver Plan: Existing Model 2/18/2014
RS = 28.61
.04
Legend
EG 100yr
WS 100yr
Crit 100yr
Ground
Ineff
Bank Sta
Elevation (ft)
Station (ft)
SantaAnaRiver Plan: Existing Model 2/18/2014
RS = 28.608
.04
0
7
5
Legend
EG 100yr
WS 100yr
Crit 100yr
Ground
Bank Sta
Elevation (ft)
Station (ft)
SantaAnaRiver Plan: Existing Model 2/18/2014
RS = 28.606
.04
0
7
5
Legend
EG 100yr
WS 100yr
Crit 100yr
Ground
Bank Sta
Elevation (ft)
Station (ft)

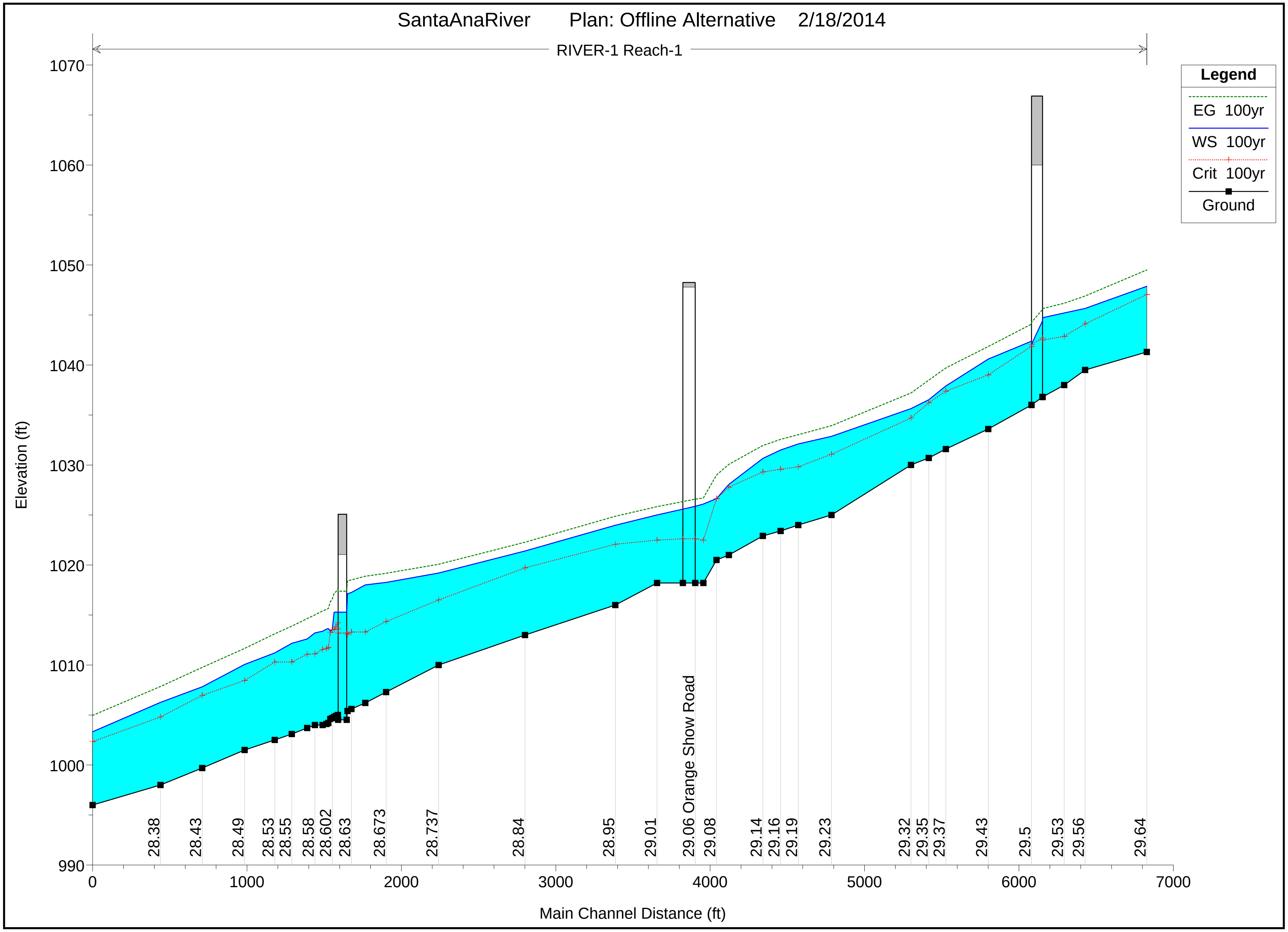

SantaAnaRiver Plan: Existing Model 2/18/2014
RS = 28.604
.04
.075
Legend
EG 100yr
WS 100yr
Crit 100yr
Ground
Bank Sta
Elevation (ft)
1004 1006 1008 1010 1012 1014 1016 1018
Station (ft)
900 1000 1100 1200 1300 1400
SantaAnaRiver Plan: Existing Model 2/18/2014
RS = 28.602
.04
.075
Legend
EG 100yr
WS 100yr
Crit 100yr
Ground
Bank Sta
Elevation (ft)
Station (ft)
SantaAnaRiver Plan: Existing Model 2/18/2014
RS = 28.6
.04
.075
Legend
EG 100yr
WS 100yr
Crit 100yr
Ground
Bank Sta
Elevation (ft)
Station (ft)
SantaAnaRiver Plan: Existing Model 2/18/2014
RS = 28.597
.075
.04
.075
Legend
EG 100yr
WS 100yr
Crit 100yr
Ground
Bank Sta
Elevation (ft)
Station (ft)
SantaAnaRiver Plan: Existing Model 2/18/2014
RS = 28.595
.075
.04
.075
Legend
EG 100yr
WS 100yr
Crit 100yr
Ground
Bank Sta
Elevation (ft)
Station (ft)
SantaAnaRiver Plan: Existing Model 2/18/2014
RS = 28.59
.075
.04
.075
Legend
EG 100yr
WS 100yr
Crit 100yr
Ground
Bank Sta
Elevation (ft)
Station (ft)



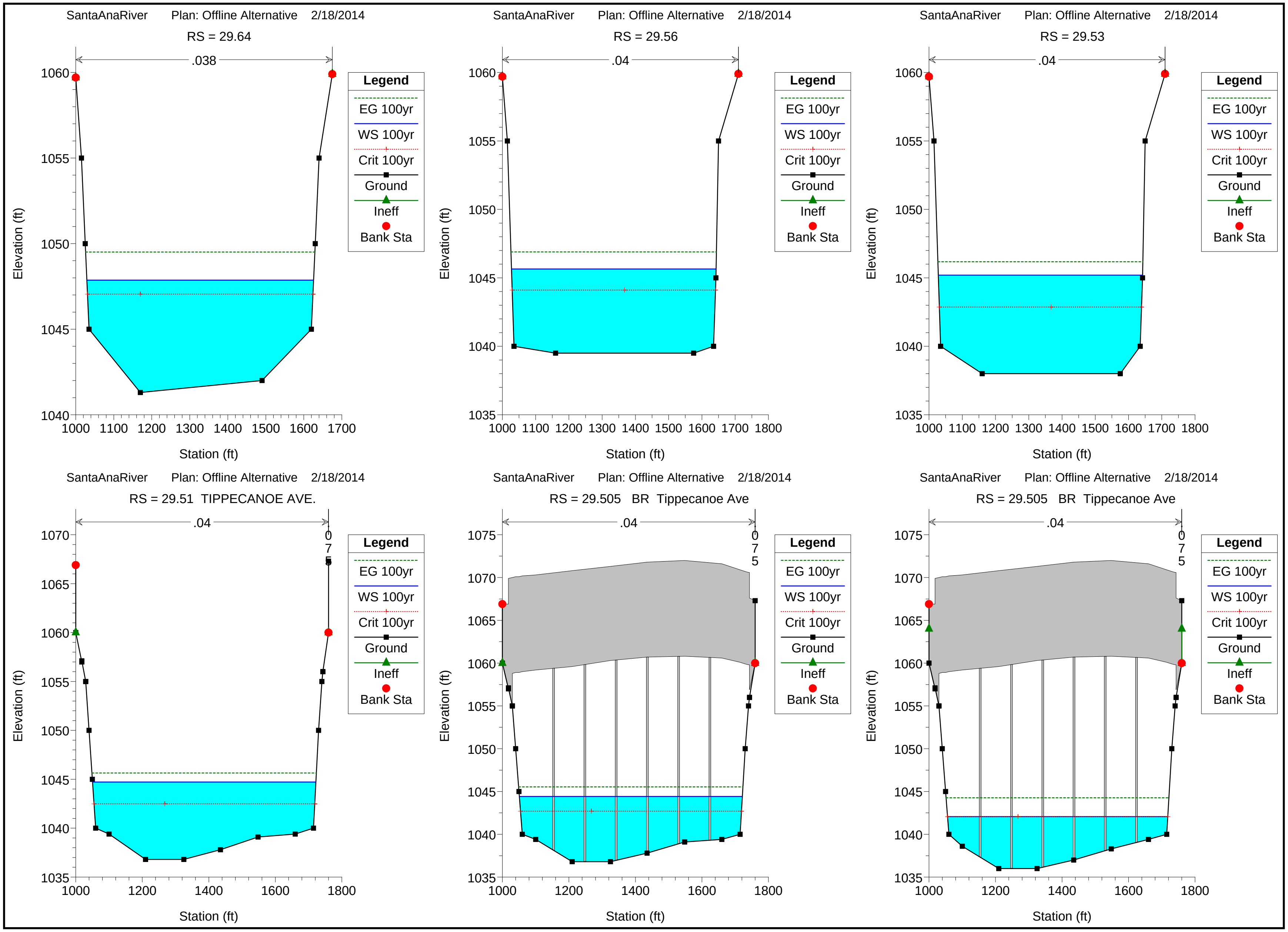
SantaAnaRiver Plan: Existing Model 2/18/2014
RS = 28.58
SantaAnaRiver Plan: Existing Model 2/18/2014
RS = 28.57
SantaAnaRiver Plan: Existing Model 2/18/2014
RS = 28.55
SantaAnaRiver Plan: Existing Model 2/18/2014
RS = 28.53
SantaAnaRiver Plan: Existing Model 2/18/2014
RS = 28.49
SantaAnaRiver Plan: Existing Model 2/18/2014
RS = 28.43
.075
.04
Legend
EG 100yr
WS 100yr
Crit 100yr
Ground
Bank Sta
Elevation (ft)
Station (ft)

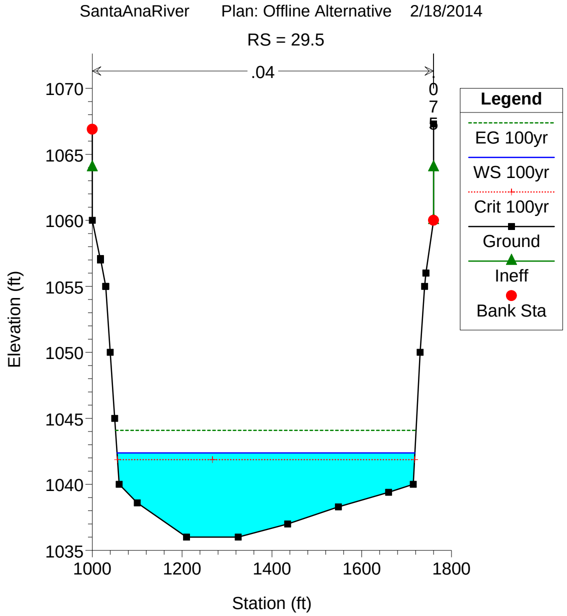

SantaAnaRiver Plan: Existing Model 2/18/2014
RS = 28.38
.075
.04
.075
Legend
EG 100yr
WS 100yr
Crit 100yr
Ground
Bank Sta
Elevation (ft)
Station (ft)
1020
1015
1010
1005
1000
995
1000
1200
1400
1600
1800
2000


SantaAnaRiver Plan: Existing Model 2/18/2014
RS = 28.3
.075
.04
.075
Legend
EG 100yr
WS 100yr
Crit 100yr
Ground
Bank Sta
Elevation (ft)
Station (ft)
1020
1015
1010
1005
1000
995
1000
1200
1400
1600
1800
2000
2200



SantaAnaRiver Plan: Offline Alternative 2/18/2014
RIVER-1 Reach-1
Legend
EG 100yr
WS 100yr
Crit 100yr
Ground
Elevation (ft)
Main Channel Distance (ft)
Orange Show Road
28.38
28.43
28.49
28.53
28.55
28.58
28.602
28.63
28.673
28.737
28.84
28.95
29.01
29.06
29.08
29.14
29.16
29.19
29.23
29.32
29.35
29.37
29.43
29.5
29.53
29.56
29.64


SantaAnaRiver Plan: Offline Alternative 2/18/2014
RS = 29.64
.038
Legend
EG 100yr
WS 100yr
Crit 100yr
Ground
Ineff
Bank Sta
Elevation (ft)
Station (ft)
SantaAnaRiver Plan: Offline Alternative 2/18/2014
RS = 29.56
.04
Legend
EG 100yr
WS 100yr
Crit 100yr
Ground
Ineff
Bank Sta
Elevation (ft)
Station (ft)
SantaAnaRiver Plan: Offline Alternative 2/18/2014
RS = 29.53
.04
Legend
EG 100yr
WS 100yr
Crit 100yr
Ground
Ineff
Bank Sta
Elevation (ft)
Station (ft)
SantaAnaRiver Plan: Offline Alternative 2/18/2014
RS = 29.51 TIPPECANOE AVE.
.04
0
7
5
Legend
EG 100yr
WS 100yr
Crit 100yr
Ground
Ineff
Bank Sta
Elevation (ft)
Station (ft)
SantaAnaRiver Plan: Offline Alternative 2/18/2014
RS = 29.505 BR Tippecanoe Ave
.04
0
7
5
Legend
EG 100yr
WS 100yr
Crit 100yr
Ground
Ineff
Bank Sta
Elevation (ft)
Station (ft)
SantaAnaRiver Plan: Offline Alternative 2/18/2014
RS = 29.505 BR Tippecanoe Ave
.04
0
7
5
Legend
EG 100yr
WS 100yr
Crit 100yr
Ground
Ineff
Bank Sta
Elevation (ft)
Station (ft)


SantaAnaRiver Plan: Offline Alternative 2/18/2014
RS = 29.5
.04
.075
Legend
EG 100yr
WS 100yr
Crit 100yr
Ground
Ineff
Bank Sta
Elevation (ft)
Station (ft)
1035
1040
1045
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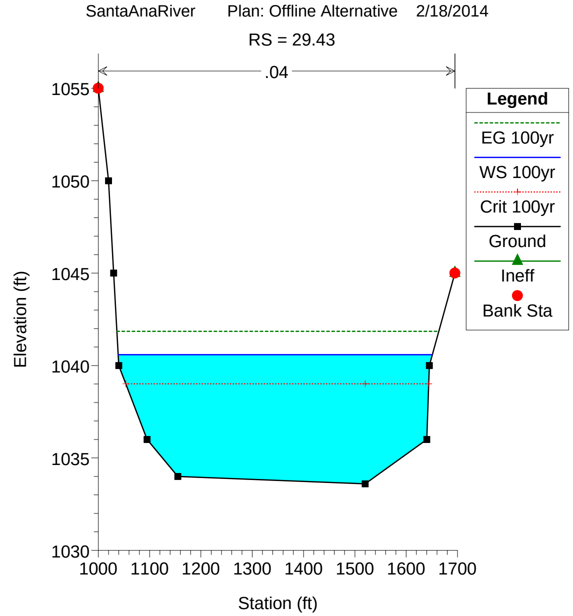
1000
1200
1400
1600
1800


SantaAnaRiver Plan: Offline Alternative 2/18/2014
RS = 29.43
.04
Legend
EG 100yr
WS 100yr
Crit 100yr
Ground
Ineff
Bank Sta
Elevation (ft)
Station (ft)
1030
1035
1040
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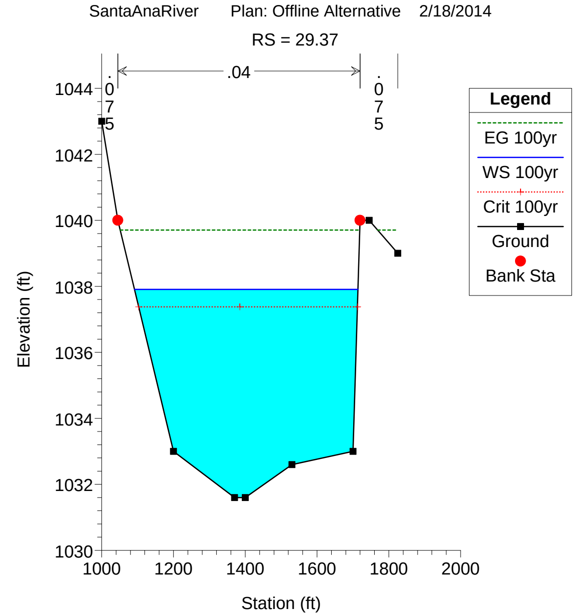
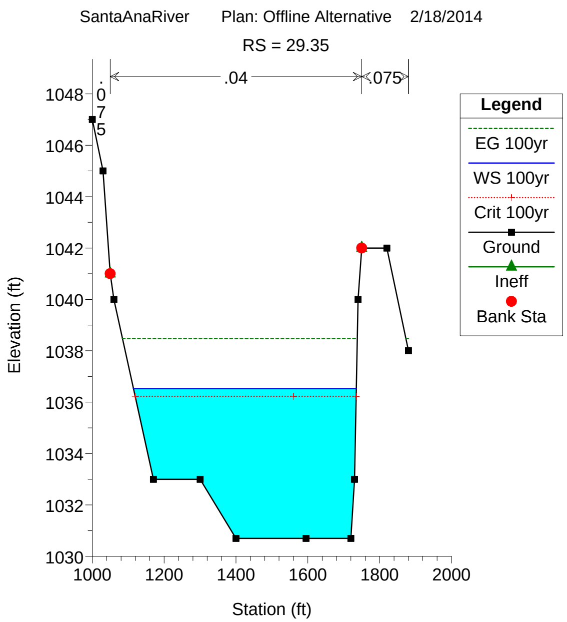
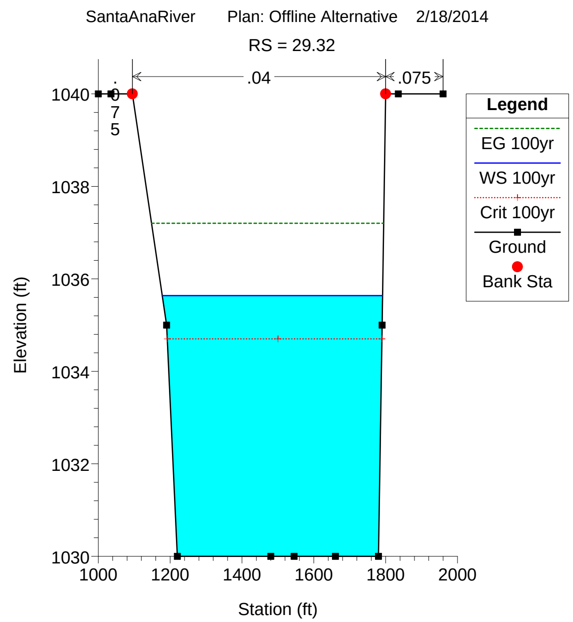
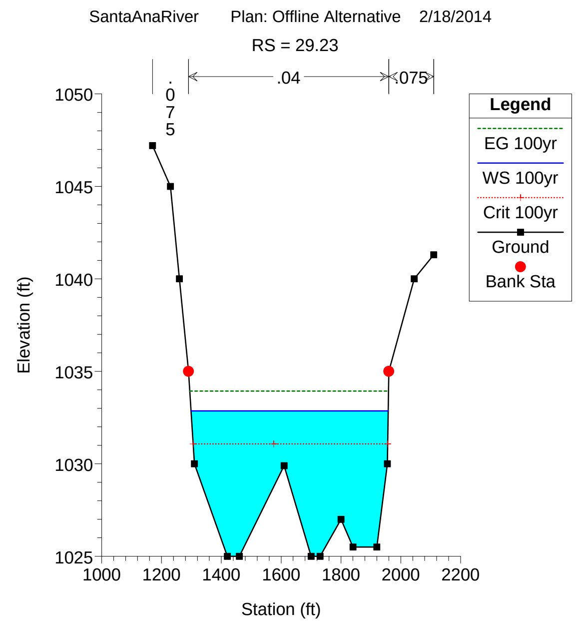
1400
1500
1600
1700


SantaAnaRiver Plan: Offline Alternative 2/18/2014
RS = 29.37
.075
.04
.075
Legend
EG 100yr
WS 100yr
Crit 100yr
Ground
Bank Sta
Elevation (ft)
Station (ft)
1030
1032
1034
1036
1038
1040
1042
1044
1000
1200
1400
1600
1800
2000


SantaAnaRiver Plan: Offline Alternative 2/18/2014
RS = 29.35
.075
.04
.075
Legend
EG 100yr
WS 100yr
Crit 100yr
Ground
Ineff
Bank Sta
Elevation (ft)
Station (ft)
1030
1032
1034
1036
1038
1040
1042
1044
1046
1048
1000
1200
1400
1600
1800
2000


SantaAnaRiver Plan: Offline Alternative 2/18/2014
RS = 29.32
.075
.04
.075
Legend
EG 100yr
WS 100yr
Crit 100yr
Ground
Bank Sta
Elevation (ft)
Station (ft)
1030
1032
1034
1036
1038
1040
1000
1200
1400
1600
1800
2000


SantaAnaRiver Plan: Offline Alternative 2/18/2014
RS = 29.23
.075
.04
.075
Legend
EG 100yr
WS 100yr
Crit 100yr
Ground
Bank Sta
Elevation (ft)
Station (ft)
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1040
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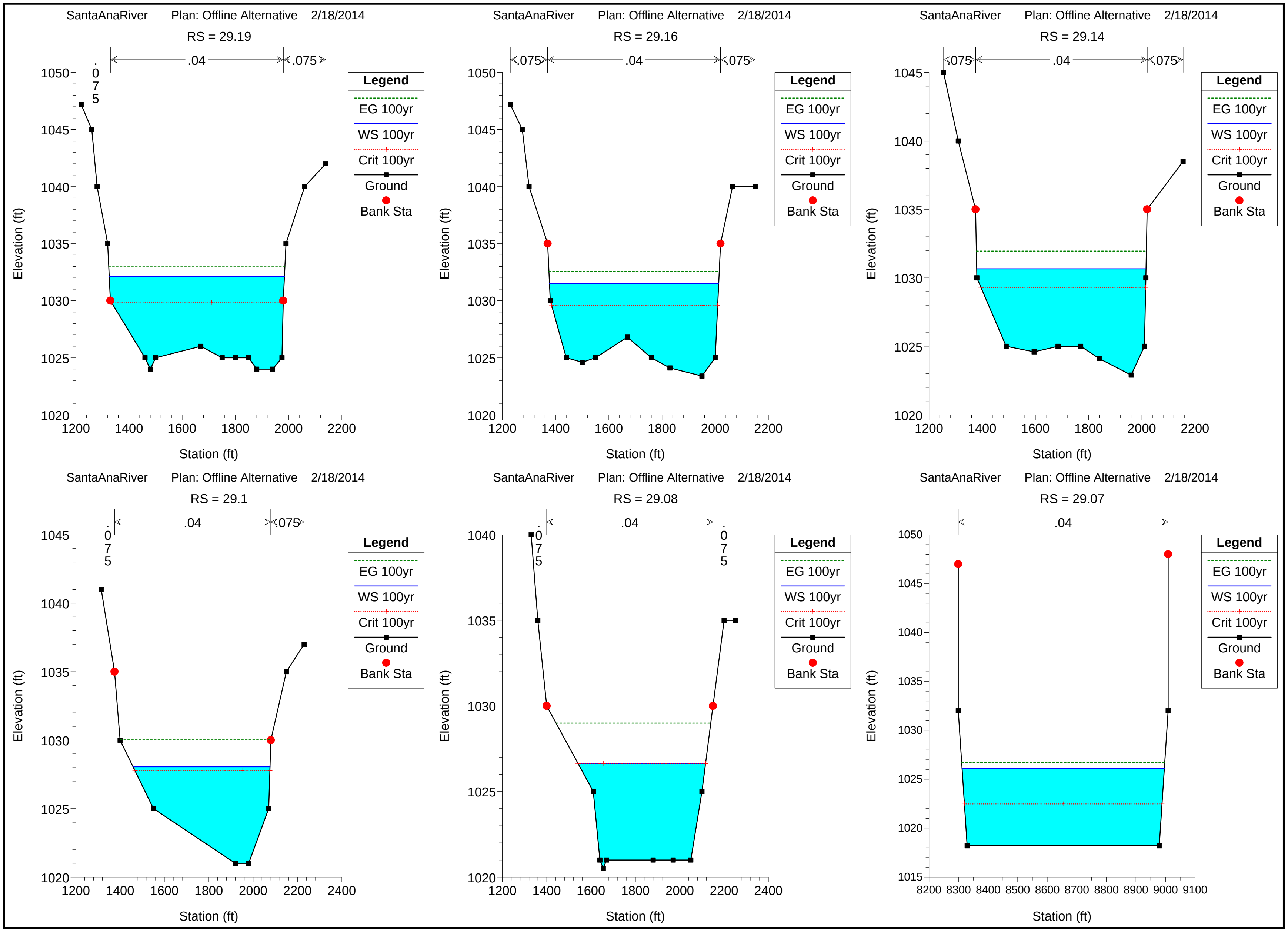
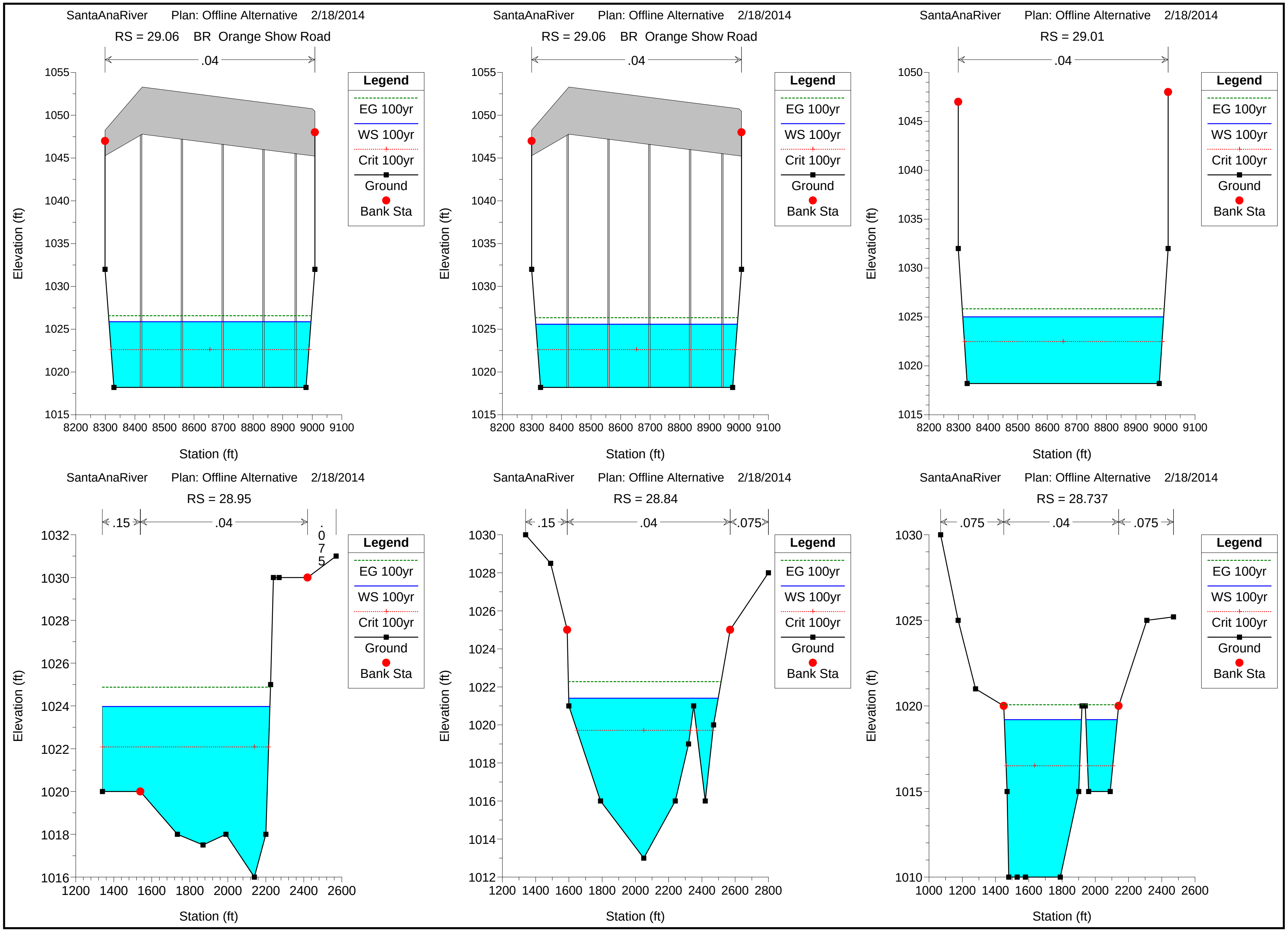
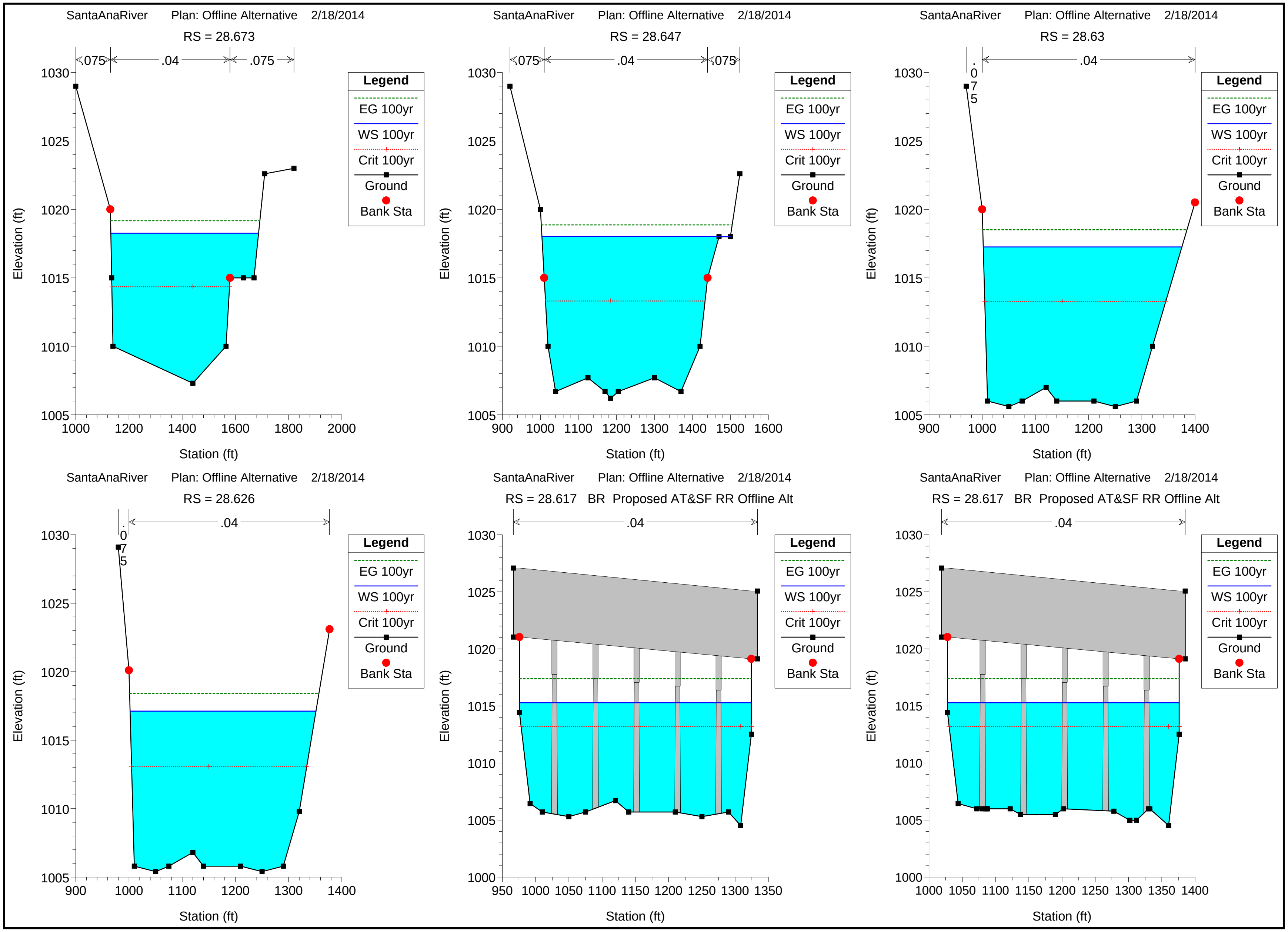
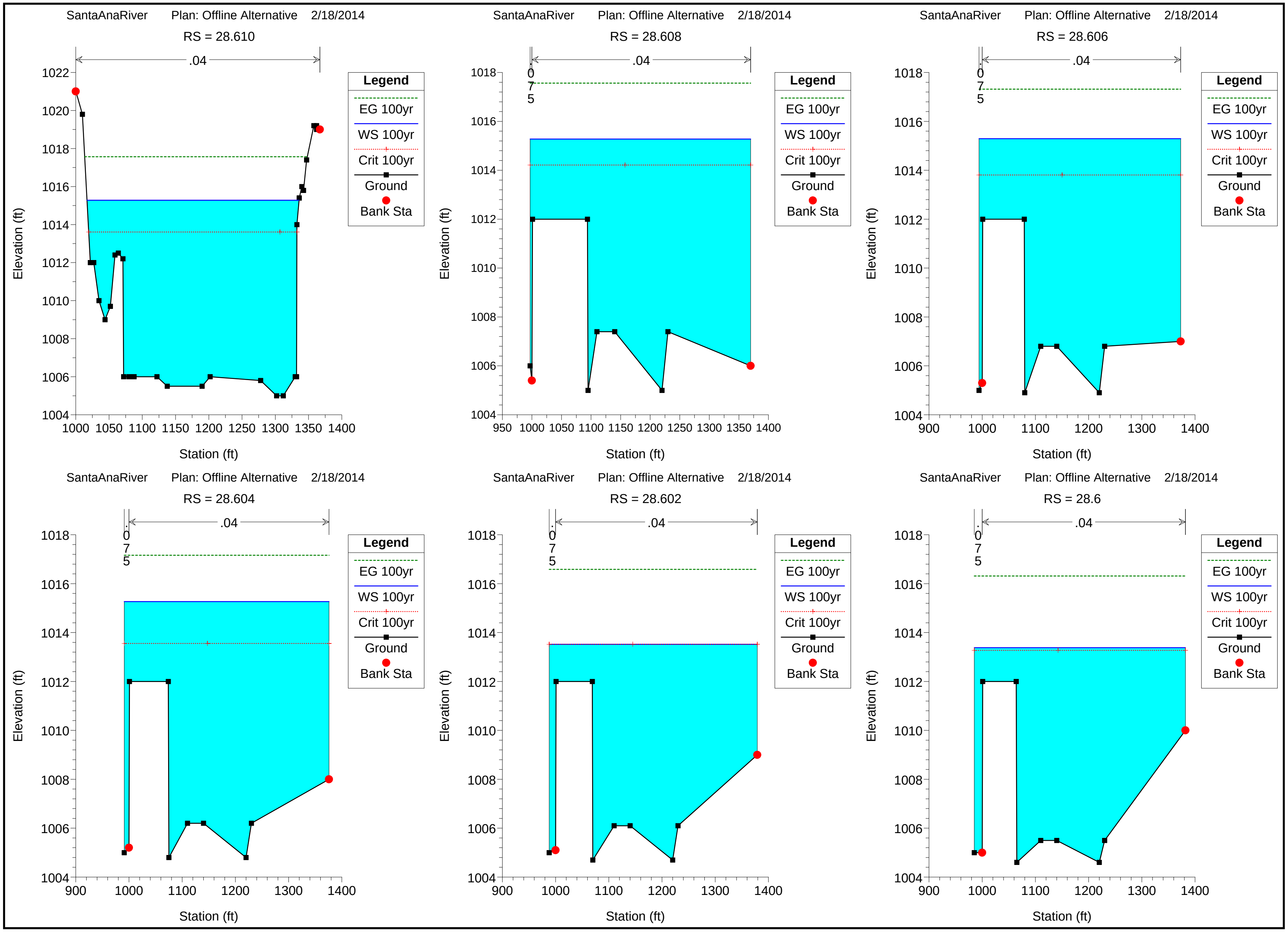
1000
1200
1400
1600
1800
2000
2200

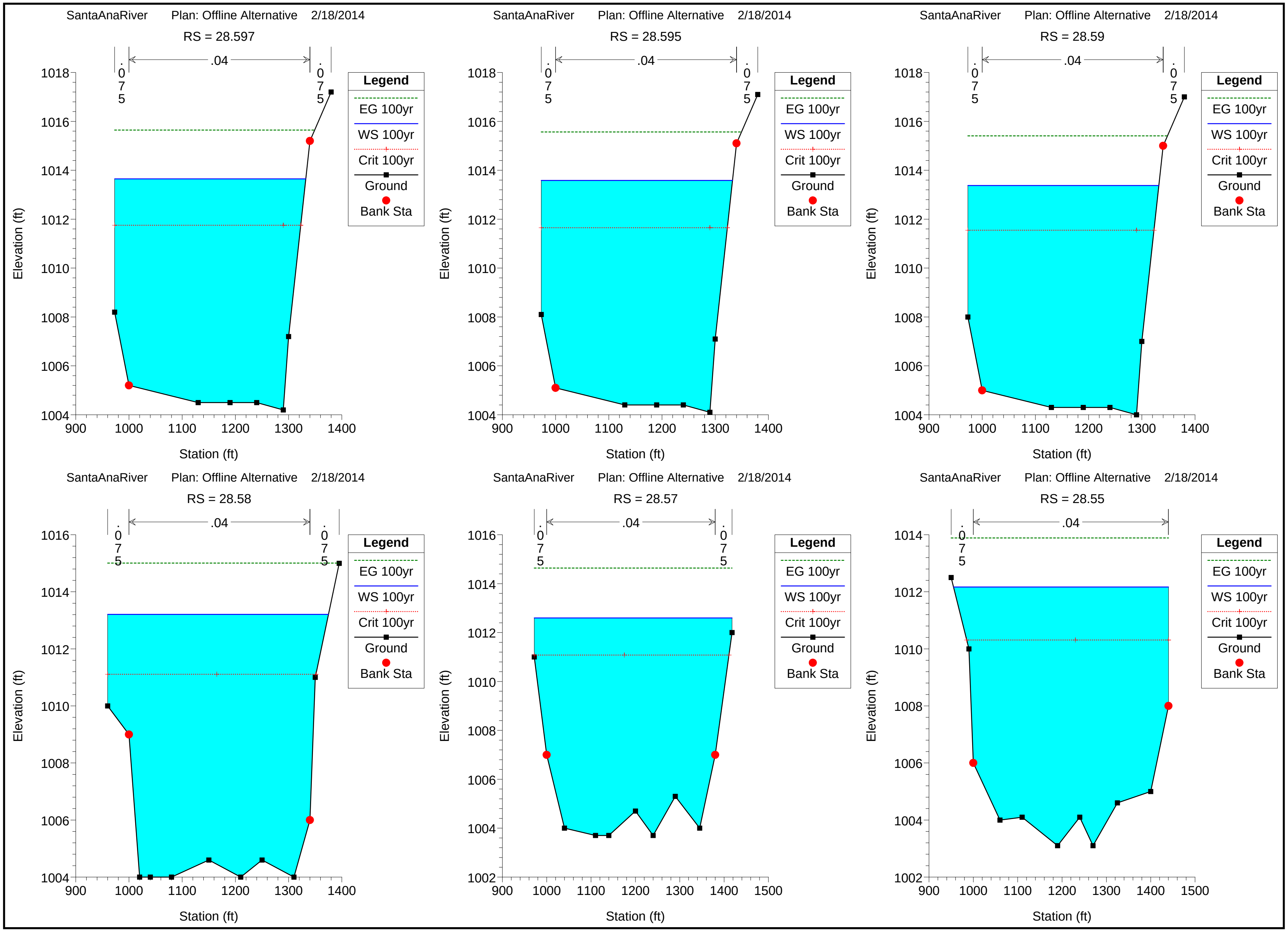

SantaAnaRiver Plan: Offline Alternative 2/18/2014
RS = 29.19
.04
.075
.075
Legend
EG 100yr
WS 100yr
Crit 100yr
Ground
Bank Sta
Elevation (ft)
Station (ft)
SantaAnaRiver Plan: Offline Alternative 2/18/2014
RS = 29.16
.075
.04
.075
Legend
EG 100yr
WS 100yr
Crit 100yr
Ground
Bank Sta
Elevation (ft)
Station (ft)
SantaAnaRiver Plan: Offline Alternative 2/18/2014
RS = 29.14
.075
.04
.075
Legend
EG 100yr
WS 100yr
Crit 100yr
Ground
Bank Sta
Elevation (ft)
Station (ft)
SantaAnaRiver Plan: Offline Alternative 2/18/2014
RS = 29.1
.075
.04
.075
Legend
EG 100yr
WS 100yr
Crit 100yr
Ground
Bank Sta
Elevation (ft)
Station (ft)
SantaAnaRiver Plan: Offline Alternative 2/18/2014
RS = 29.08
.075
.04
.075
Legend
EG 100yr
WS 100yr
Crit 100yr
Ground
Bank Sta
Elevation (ft)
Station (ft)
SantaAnaRiver Plan: Offline Alternative 2/18/2014
RS = 29.07
.04
Legend
EG 100yr
WS 100yr
Crit 100yr
Ground
Bank Sta
Elevation (ft)
Station (ft)

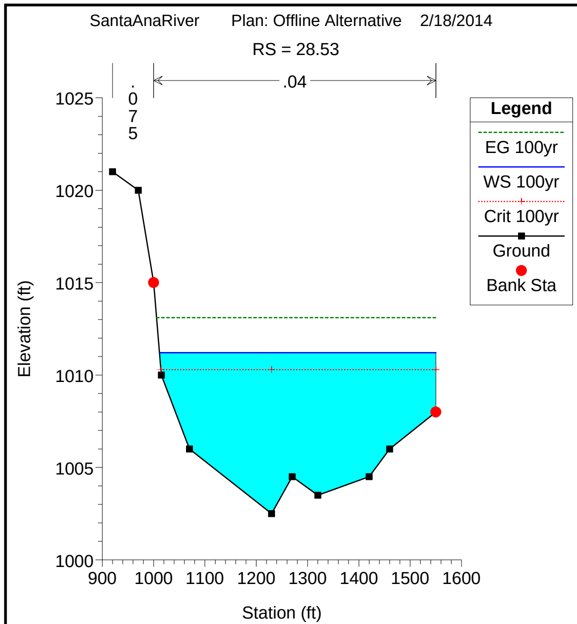
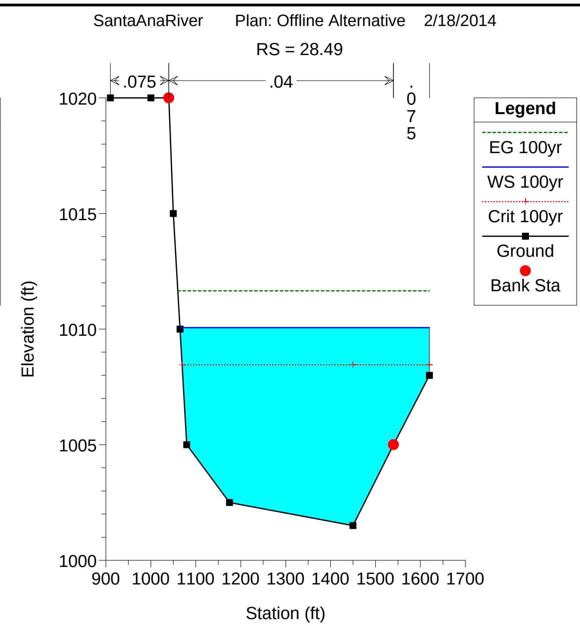
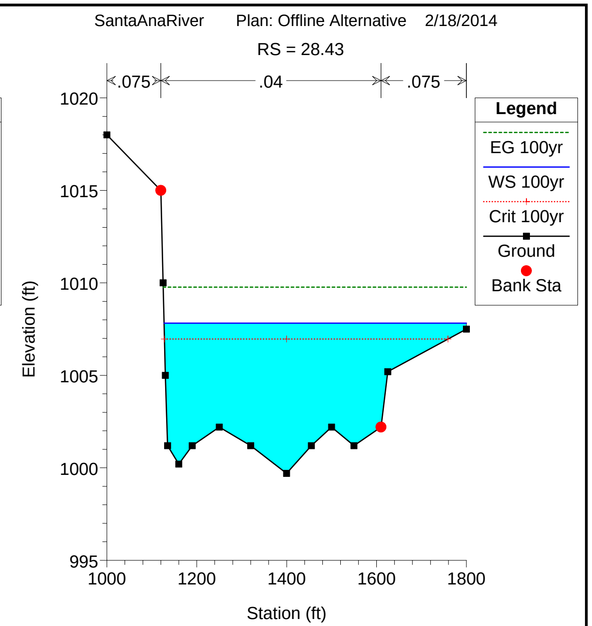
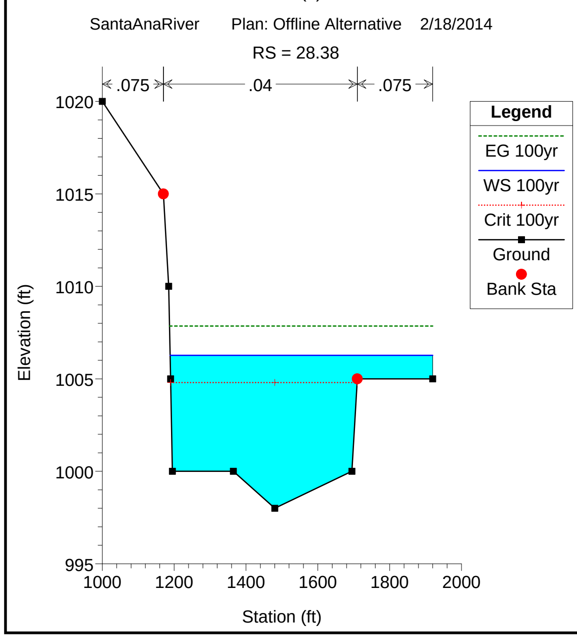
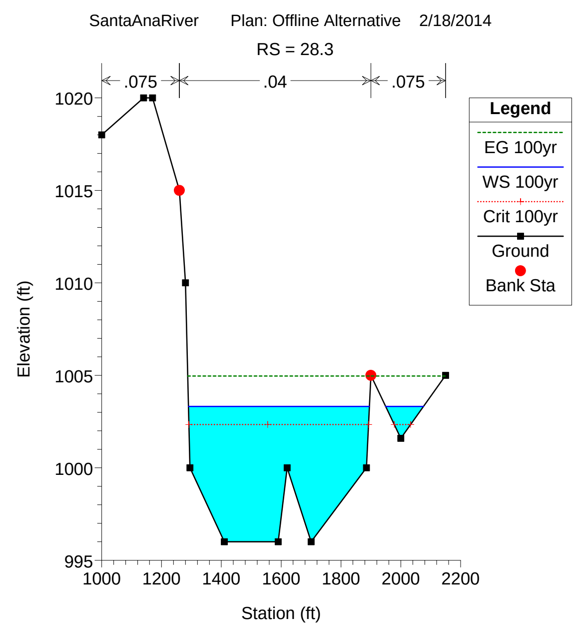


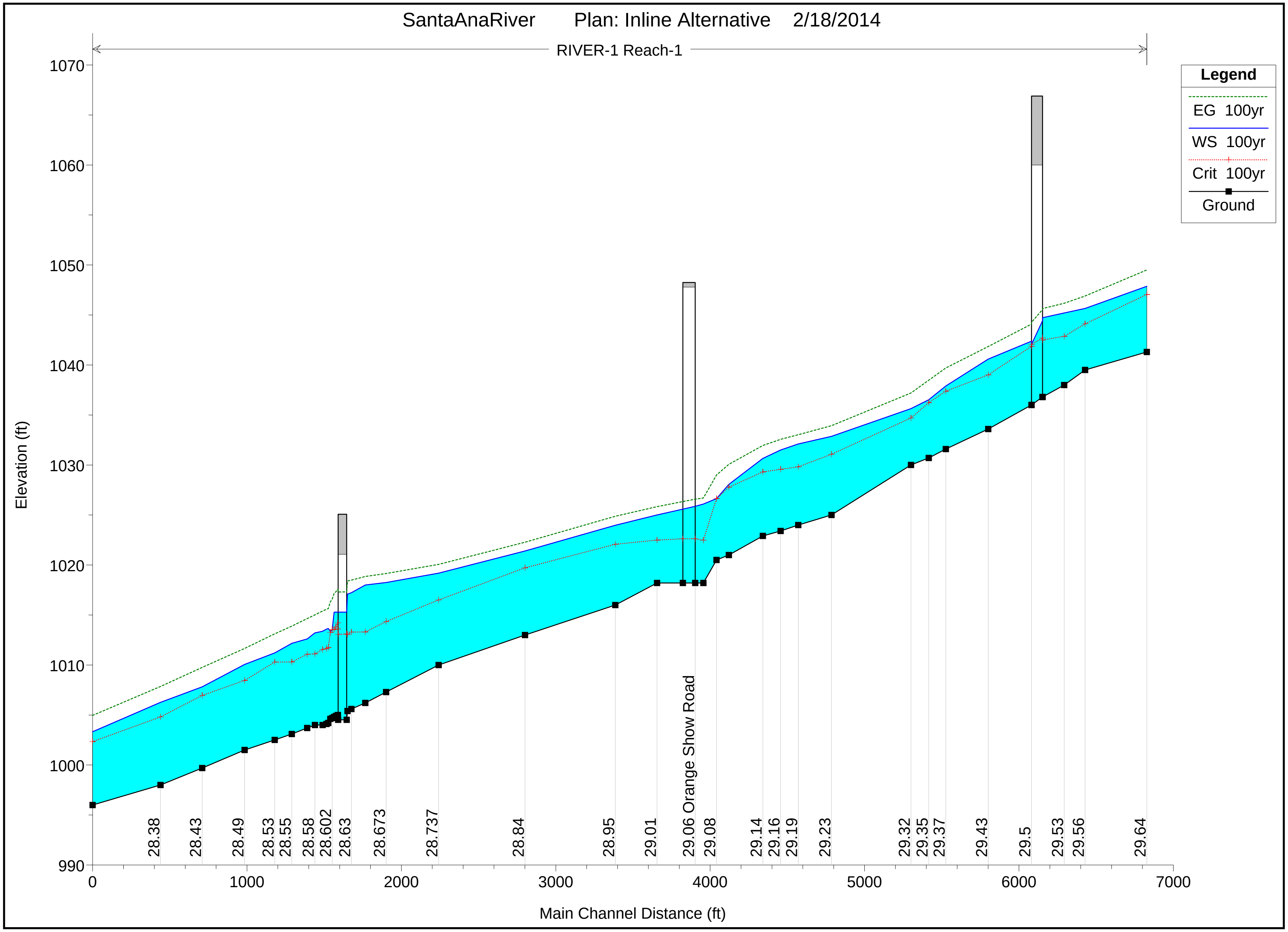
SantaAnaRiver Plan: Offline Alternative 2/18/2014
RS = 29.06 BR Orange Show Road
.04
Legend
EG 100yr
WS 100yr
Crit 100yr
Ground
Bank Sta
Elevation (ft)
Station (ft)
SantaAnaRiver Plan: Offline Alternative 2/18/2014
RS = 29.06 BR Orange Show Road
.04
Legend
EG 100yr
WS 100yr
Crit 100yr
Ground
Bank Sta
Elevation (ft)
Station (ft)
SantaAnaRiver Plan: Offline Alternative 2/18/2014
RS = 29.01
.04
Legend
EG 100yr
WS 100yr
Crit 100yr
Ground
Bank Sta
Elevation (ft)
Station (ft)
SantaAnaRiver Plan: Offline Alternative 2/18/2014
RS = 28.95
.15
.04
.075
Legend
EG 100yr
WS 100yr
Crit 100yr
Ground
Bank Sta
Elevation (ft)
Station (ft)
SantaAnaRiver Plan: Offline Alternative 2/18/2014
RS = 28.84
.15
.04
.075
Legend
EG 100yr
WS 100yr
Crit 100yr
Ground
Bank Sta
Elevation (ft)
Station (ft)
SantaAnaRiver Plan: Offline Alternative 2/18/2014
RS = 28.737
.075
.04
.075
Legend
EG 100yr
WS 100yr
Crit 100yr
Ground
Bank Sta
Elevation (ft)
Station (ft)


SantaAnaRiver Plan: Offline Alternative 2/18/2014
RS = 28.673
.075 .04 .075
SantaAnaRiver Plan: Offline Alternative 2/18/2014
RS = 28.647
.075 .04 .075
SantaAnaRiver Plan: Offline Alternative 2/18/2014
RS = 28.63
.075 .04
SantaAnaRiver Plan: Offline Alternative 2/18/2014
RS = 28.626
.075 .04
SantaAnaRiver Plan: Offline Alternative 2/18/2014
RS = 28.617 BR Proposed AT&SF RR Offline Alt
.04
SantaAnaRiver Plan: Offline Alternative 2/18/2014
RS = 28.617 BR Proposed AT&SF RR Offline Alt
.04
Legend
EG 100yr
WS 100yr
Crit 100yr
Ground
Bank Sta
Elevation (ft)
Station (ft)

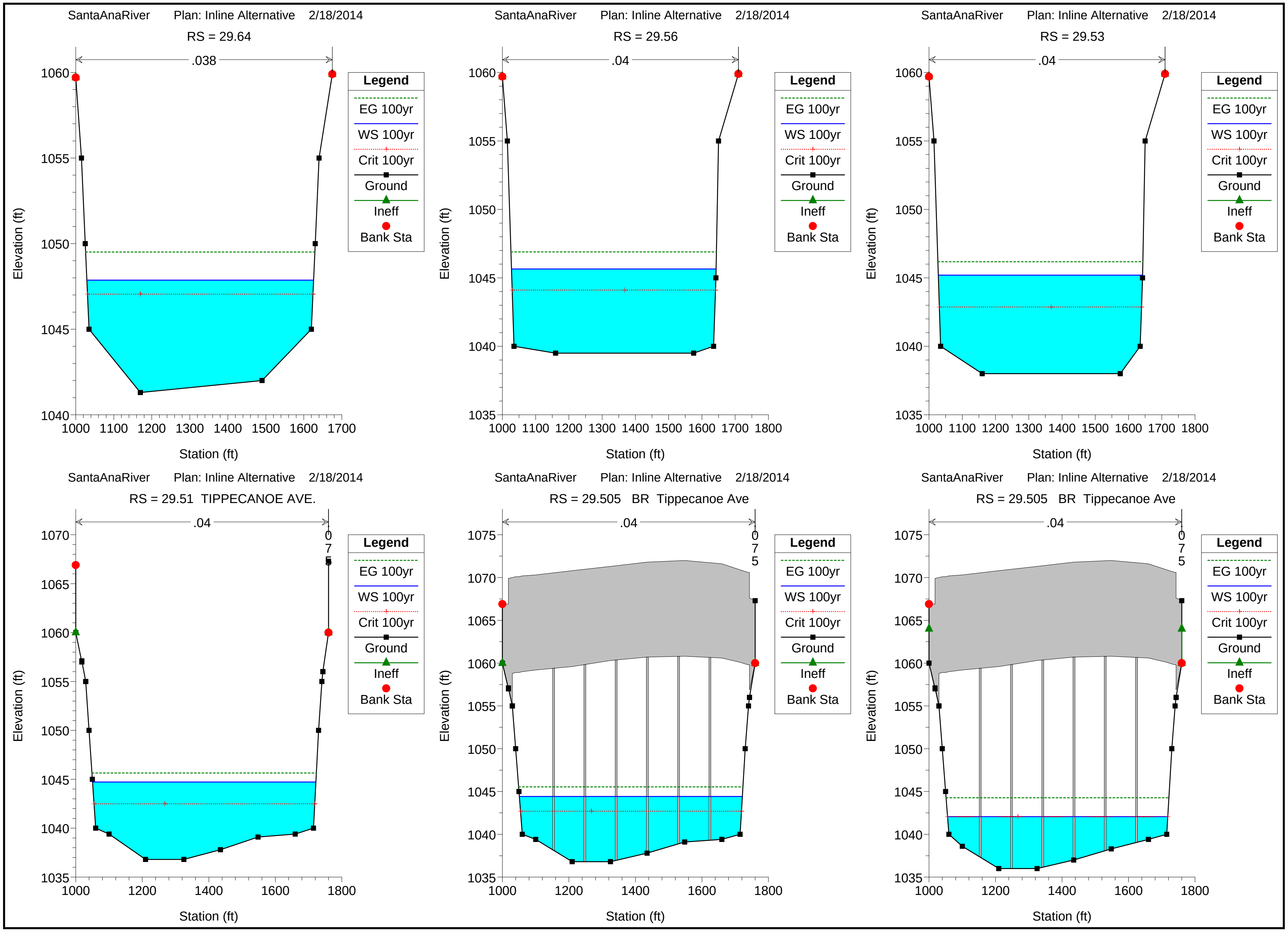

SantaAnaRiver Plan: Offline Alternative 2/18/2014
RS = 28.610
.04
Legend
EG 100yr
WS 100yr
Crit 100yr
Ground
Bank Sta
Elevation (ft)
Station (ft)
SantaAnaRiver Plan: Offline Alternative 2/18/2014
RS = 28.608
.04
Legend
EG 100yr
WS 100yr
Crit 100yr
Ground
Bank Sta
Elevation (ft)
Station (ft)
SantaAnaRiver Plan: Offline Alternative 2/18/2014
RS = 28.606
.04
Legend
EG 100yr
WS 100yr
Crit 100yr
Ground
Bank Sta
Elevation (ft)
Station (ft)
SantaAnaRiver Plan: Offline Alternative 2/18/2014
RS = 28.604
.04
Legend
EG 100yr
WS 100yr
Crit 100yr
Ground
Bank Sta
Elevation (ft)
Station (ft)
SantaAnaRiver Plan: Offline Alternative 2/18/2014
RS = 28.602
.04
Legend
EG 100yr
WS 100yr
Crit 100yr
Ground
Bank Sta
Elevation (ft)
Station (ft)
SantaAnaRiver Plan: Offline Alternative 2/18/2014
RS = 28.6
.04
Legend
EG 100yr
WS 100yr
Crit 100yr
Ground
Bank Sta
Elevation (ft)
Station (ft)

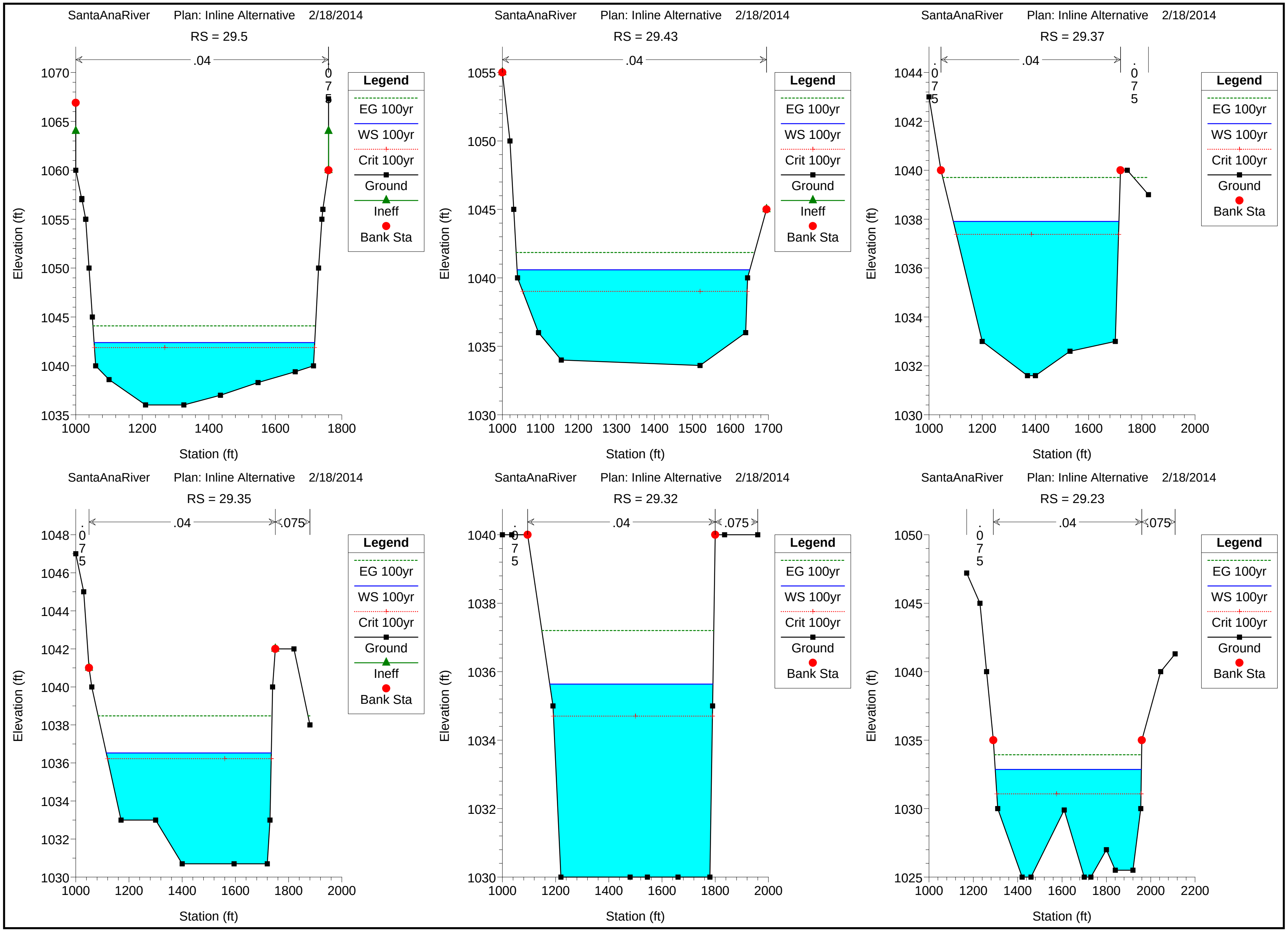

SantaAnaRiver Plan: Offline Alternative 2/18/2014
RS = 28.597
RS = 28.595
RS = 28.59
RS = 28.58
RS = 28.57
RS = 28.55
.04
.075
Legend
EG 100yr
WS 100yr
Crit 100yr
Ground
Bank Sta
Elevation (ft)
Station (ft)

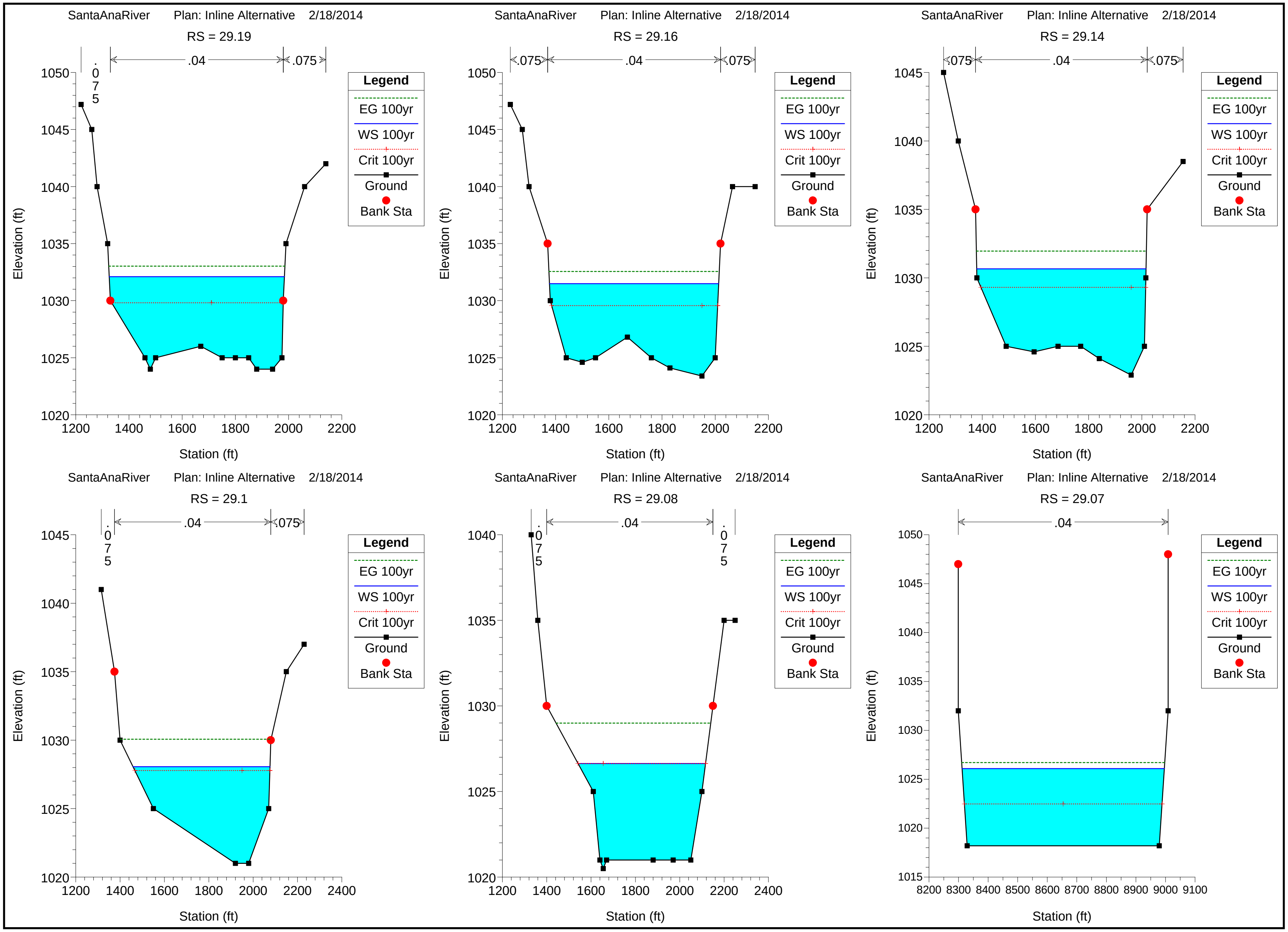

SantaAnaRiver Plan: Offline Alternative 2/18/2014
RS = 28.53
.075
.04
Legend
EG 100yr
WS 100yr
Crit 100yr
Ground
Bank Sta
Elevation (ft)
Station (ft)

SantaAnaRiver Plan: Offline Alternative 2/18/2014
RS = 28.49
.075
.04
.075
Legend
EG 100yr
WS 100yr
Crit 100yr
Ground
Bank Sta
Elevation (ft)
Station (ft)

SantaAnaRiver Plan: Offline Alternative 2/18/2014
RS = 28.43
.075
.04
.075
Legend
EG 100yr
WS 100yr
Crit 100yr
Ground
Bank Sta
Elevation (ft)
Station (ft)

SantaAnaRiver Plan: Offline Alternative 2/18/2014
RS = 28.38
.075
.04
.075
Legend
EG 100yr
WS 100yr
Crit 100yr
Ground
Bank Sta
Elevation (ft)
Station (ft)

SantaAnaRiver Plan: Offline Alternative 2/18/2014
RS = 28.3
.075
.04
.075
Legend
EG 100yr
WS 100yr
Crit 100yr
Ground
Bank Sta
Elevation (ft)
Station (ft)

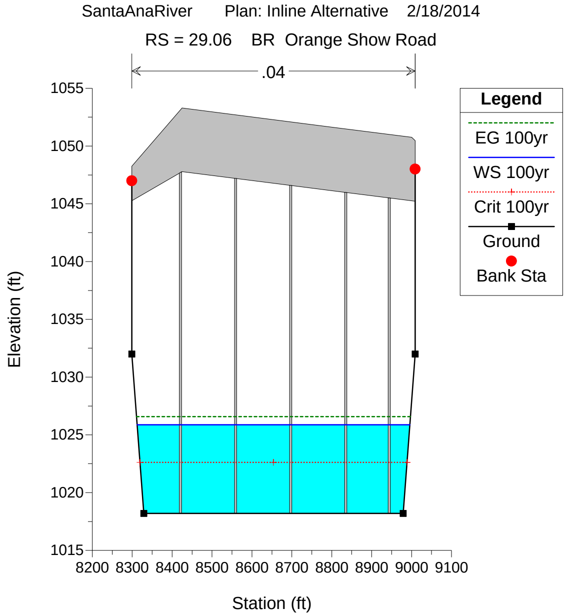


SantaAnaRiver Plan: Inline Alternative 2/18/2014
RIVER-1 Reach-1
Legend
EG 100yr
WS 100yr
Crit 100yr
Ground
Elevation (ft)
1070
1060
1050
1040
1030
1020
1010
1000
990
Orange Show Road
28.38
28.43
28.49
28.53
28.55
28.58
28.602
28.63
28.673
28.737
28.84
28.95
29.01
29.06
29.08
29.14
29.16
29.19
29.23
29.32
29.35
29.37
29.43
29.5
29.53
29.56
29.64
0
1000
2000
3000
4000
5000
6000
7000
Main Channel Distance (ft)

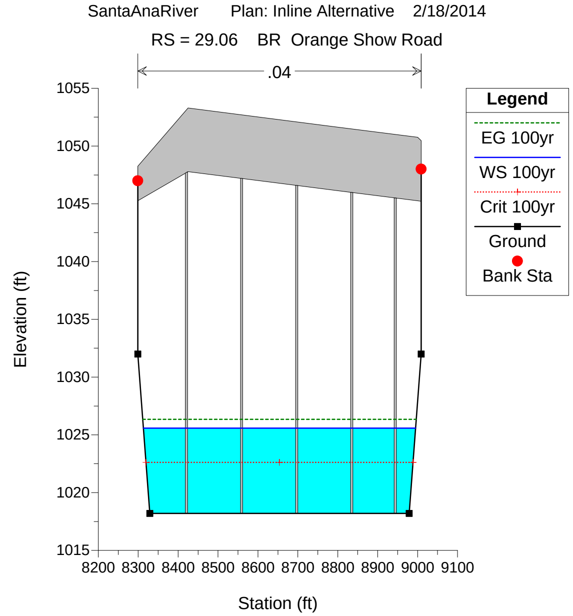

SantaAnaRiver Plan: Inline Alternative 2/18/2014
RS = 29.64
.038
Legend
EG 100yr
WS 100yr
Crit 100yr
Ground
Ineff
Bank Sta
Elevation (ft)
Station (ft)
SantaAnaRiver Plan: Inline Alternative 2/18/2014
RS = 29.56
.04
Legend
EG 100yr
WS 100yr
Crit 100yr
Ground
Ineff
Bank Sta
Elevation (ft)
Station (ft)
SantaAnaRiver Plan: Inline Alternative 2/18/2014
RS = 29.53
.04
Legend
EG 100yr
WS 100yr
Crit 100yr
Ground
Ineff
Bank Sta
Elevation (ft)
Station (ft)
SantaAnaRiver Plan: Inline Alternative 2/18/2014
RS = 29.51 TIPPECANOE AVE.
.04
Legend
EG 100yr
WS 100yr
Crit 100yr
Ground
Ineff
Bank Sta
Elevation (ft)
Station (ft)
SantaAnaRiver Plan: Inline Alternative 2/18/2014
RS = 29.505 BR Tippecanoe Ave
.04
Legend
EG 100yr
WS 100yr
Crit 100yr
Ground
Ineff
Bank Sta
Elevation (ft)
Station (ft)
SantaAnaRiver Plan: Inline Alternative 2/18/2014
RS = 29.505 BR Tippecanoe Ave
.04
Legend
EG 100yr
WS 100yr
Crit 100yr
Ground
Ineff
Bank Sta
Elevation (ft)
Station (ft)


SantaAnaRiver Plan: Inline Alternative 2/18/2014
RS = 29.5
.04
Elevation (ft)
1035
1040
1045
1050
1055
1060
1065
1070
Station (ft)
1000
1200
1400
1600
1800
Legend
EG 100yr
WS 100yr
Crit 100yr
Ground
Ineff
Bank Sta
SantaAnaRiver Plan: Inline Alternative 2/18/2014
RS = 29.43
.04
Elevation (ft)
1030
1035
1040
1045
1050
1055
Station (ft)
1000
1100
1200
1300
1400
1500
1600
1700
Legend
EG 100yr
WS 100yr
Crit 100yr
Ground
Ineff
Bank Sta
SantaAnaRiver Plan: Inline Alternative 2/18/2014
RS = 29.37
.04
Elevation (ft)
1030
1032
1034
1036
1038
1040
1042
1044
Station (ft)
1000
1200
1400
1600
1800
2000
Legend
EG 100yr
WS 100yr
Crit 100yr
Ground
Bank Sta
SantaAnaRiver Plan: Inline Alternative 2/18/2014
RS = 29.35
.04
.075
Elevation (ft)
1030
1032
1034
1036
1038
1040
1042
1044
1046
1048
Station (ft)
1000
1200
1400
1600
1800
2000
Legend
EG 100yr
WS 100yr
Crit 100yr
Ground
Ineff
Bank Sta
SantaAnaRiver Plan: Inline Alternative 2/18/2014
RS = 29.32
.04
.075
Elevation (ft)
1030
1032
1034
1036
1038
1040
Station (ft)
1000
1200
1400
1600
1800
2000
Legend
EG 100yr
WS 100yr
Crit 100yr
Ground
Bank Sta
SantaAnaRiver Plan: Inline Alternative 2/18/2014
RS = 29.23
.04
.075
Elevation (ft)
1025
1030
1035
1040
1045
1050
Station (ft)
1000
1200
1400
1600
1800
2000
2200
Legend
EG 100yr
WS 100yr
Crit 100yr
Ground
Bank Sta

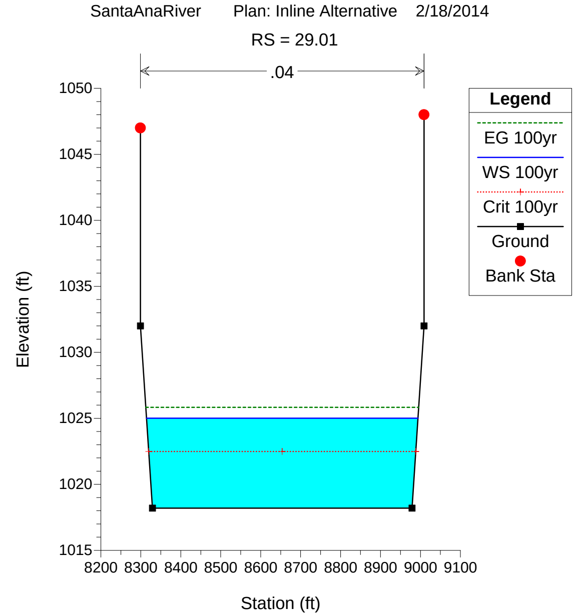

SantaAnaRiver Plan: Inline Alternative 2/18/2014
RS = 29.19
.075
.04
.075
Legend
EG 100yr
WS 100yr
Crit 100yr
Ground
Bank Sta
Elevation (ft)
1020
1025
1030
1035
1040
1045
1050
1200
1400
1600
1800
2000
2200
Station (ft)
SantaAnaRiver Plan: Inline Alternative 2/18/2014
RS = 29.16
.075
.04
.075
Legend
EG 100yr
WS 100yr
Crit 100yr
Ground
Bank Sta
Elevation (ft)
1020
1025
1030
1035
1040
1045
1050
1200
1400
1600
1800
2000
2200
Station (ft)
SantaAnaRiver Plan: Inline Alternative 2/18/2014
RS = 29.14
.075
.04
.075
Legend
EG 100yr
WS 100yr
Crit 100yr
Ground
Bank Sta
Elevation (ft)
1020
1025
1030
1035
1040
1045
1200
1400
1600
1800
2000
2200
Station (ft)
SantaAnaRiver Plan: Inline Alternative 2/18/2014
RS = 29.1
.075
.04
.075
Legend
EG 100yr
WS 100yr
Crit 100yr
Ground
Bank Sta
Elevation (ft)
1020
1025
1030
1035
1040
1045
1200
1400
1600
1800
2000
2200
2400
Station (ft)
SantaAnaRiver Plan: Inline Alternative 2/18/2014
RS = 29.08
.075
.04
.075
Legend
EG 100yr
WS 100yr
Crit 100yr
Ground
Bank Sta
Elevation (ft)
1020
1025
1030
1035
1040
1200
1400
1600
1800
2000
2200
2400
Station (ft)
SantaAnaRiver Plan: Inline Alternative 2/18/2014
RS = 29.07
.04
Legend
EG 100yr
WS 100yr
Crit 100yr
Ground
Bank Sta
Elevation (ft)
1015
1020
1025
1030
1035
1040
1045
1050
8200
8300
8400
8500
8600
8700
8800
8900
9000
9100
Station (ft)



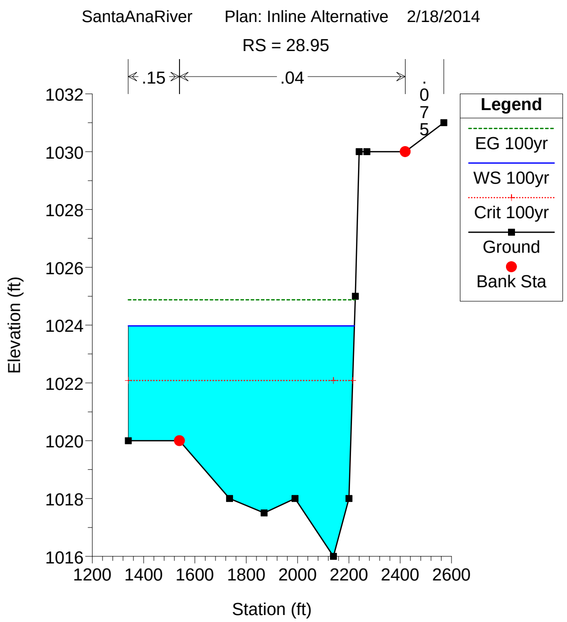
SantaAnaRiver Plan: Inline Alternative 2/18/2014
RS = 29.06 BR Orange Show Road
.04
Legend
EG 100yr
WS 100yr
Crit 100yr
Ground
Bank Sta
Elevation (ft)
Station (ft)

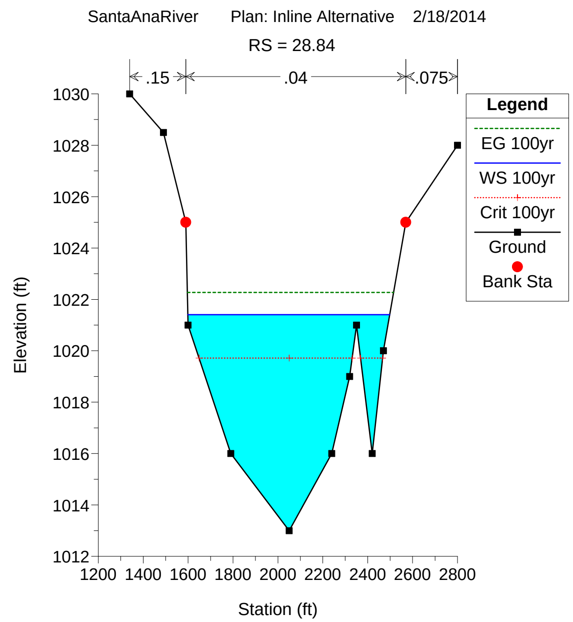
SantaAnaRiver Plan: Inline Alternative 2/18/2014
RS = 29.06 BR Orange Show Road
.04
Legend
EG 100yr
WS 100yr
Crit 100yr
Ground
Bank Sta
Elevation (ft)
Station (ft)

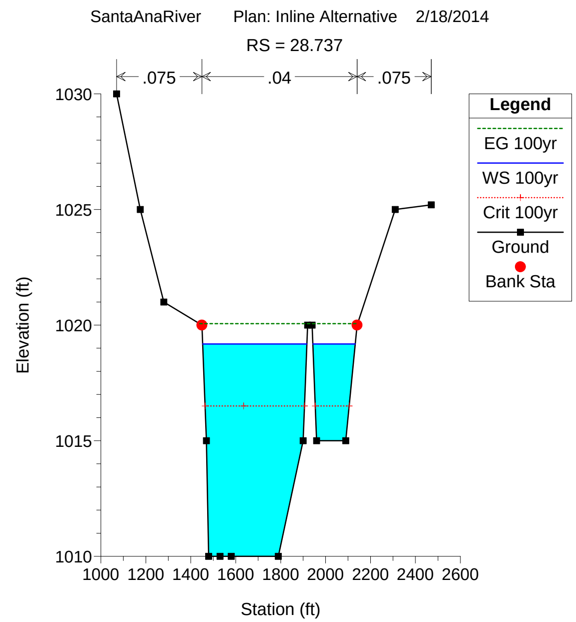
SantaAnaRiver Plan: Inline Alternative 2/18/2014
RS = 29.01
.04
Legend
EG 100yr
WS 100yr
Crit 100yr
Ground
Bank Sta
Elevation (ft)
Station (ft)

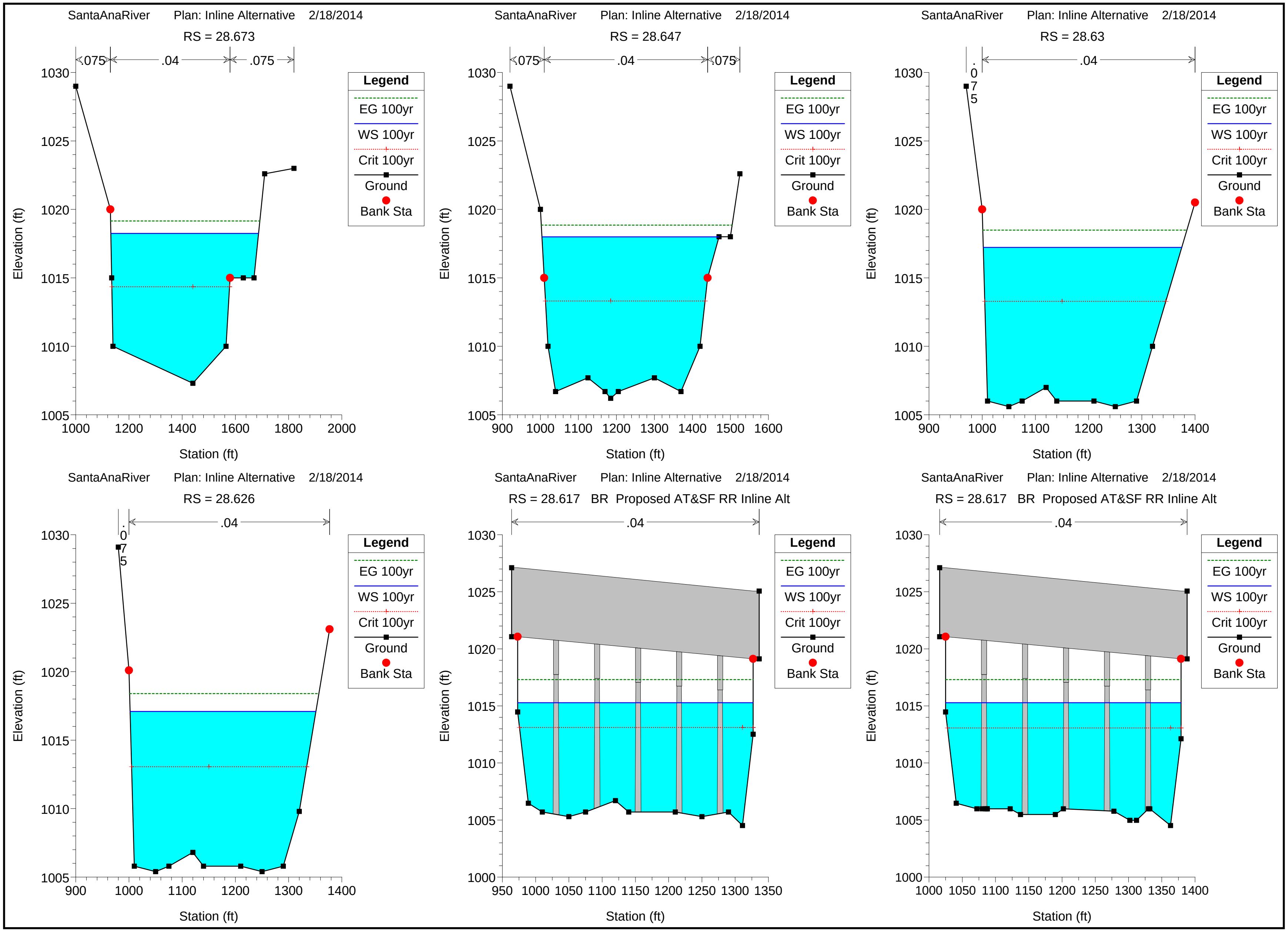
SantaAnaRiver Plan: Inline Alternative 2/18/2014
RS = 28.95
.15
.04
.075
Legend
EG 100yr
WS 100yr
Crit 100yr
Ground
Bank Sta
Elevation (ft)
Station (ft)

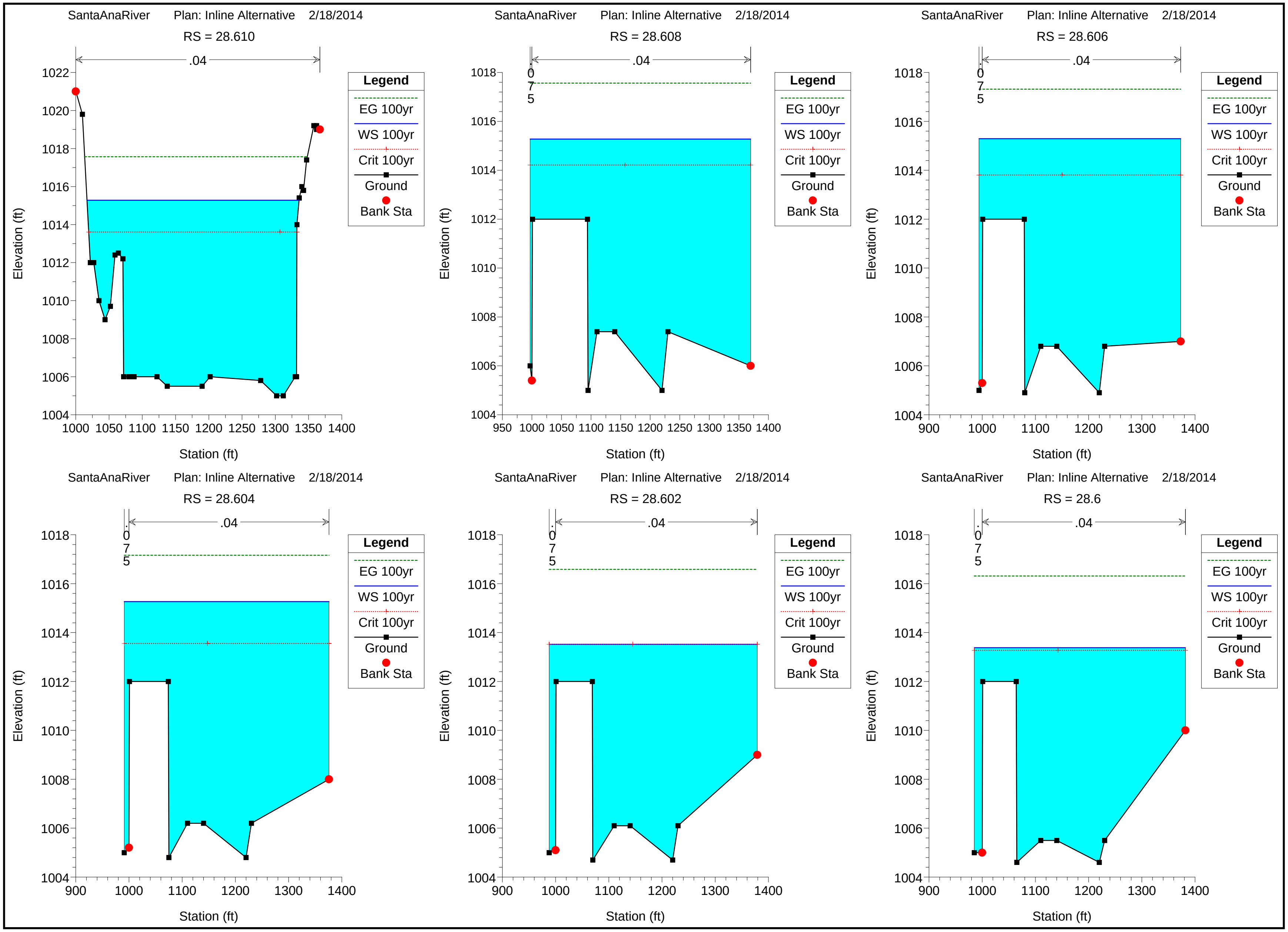



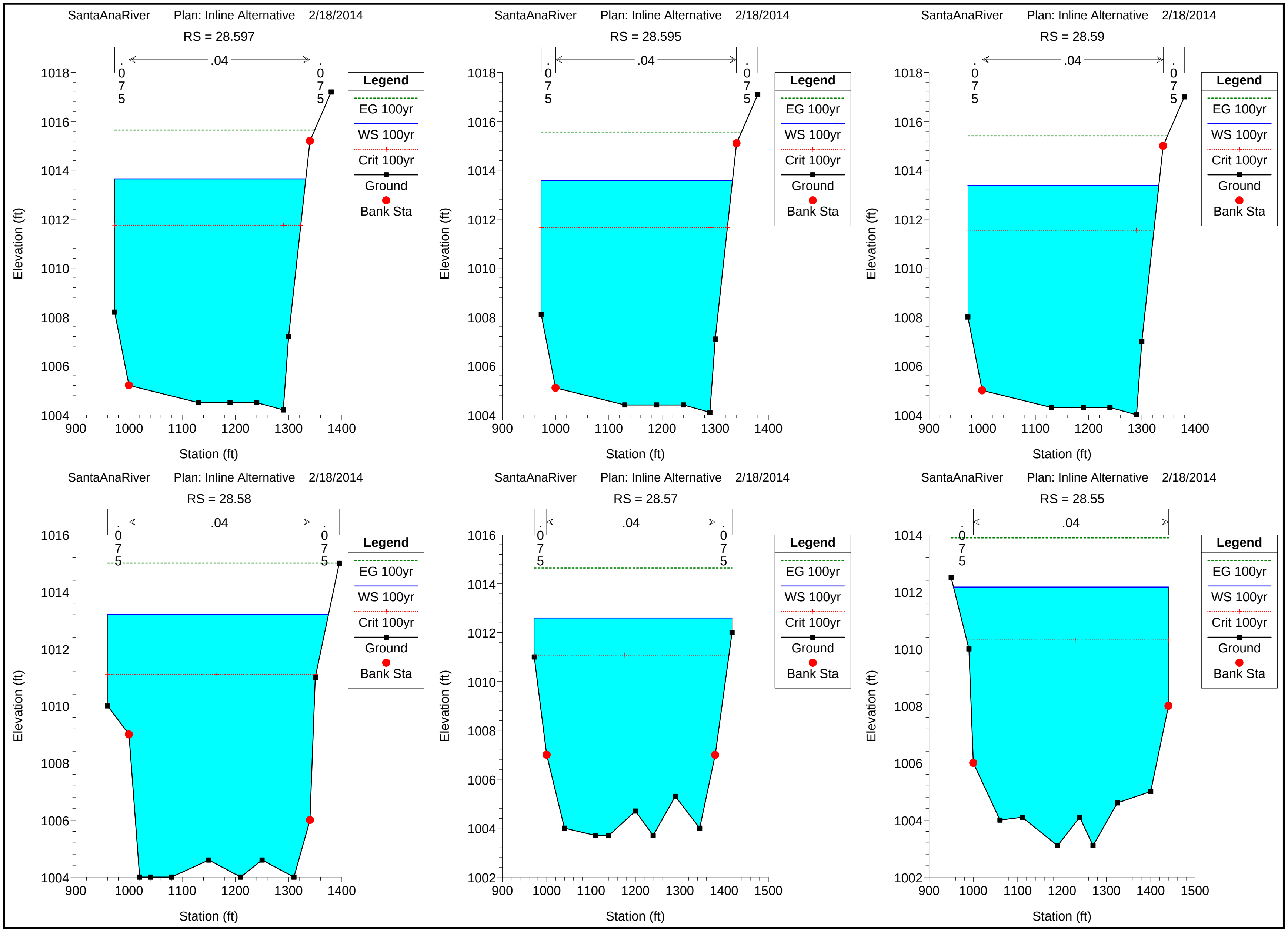
SantaAnaRiver Plan: Inline Alternative 2/18/2014
RS = 28.84
.15
.04
.075
Legend
EG 100yr
WS 100yr
Crit 100yr
Ground
Bank Sta
Elevation (ft)
Station (ft)

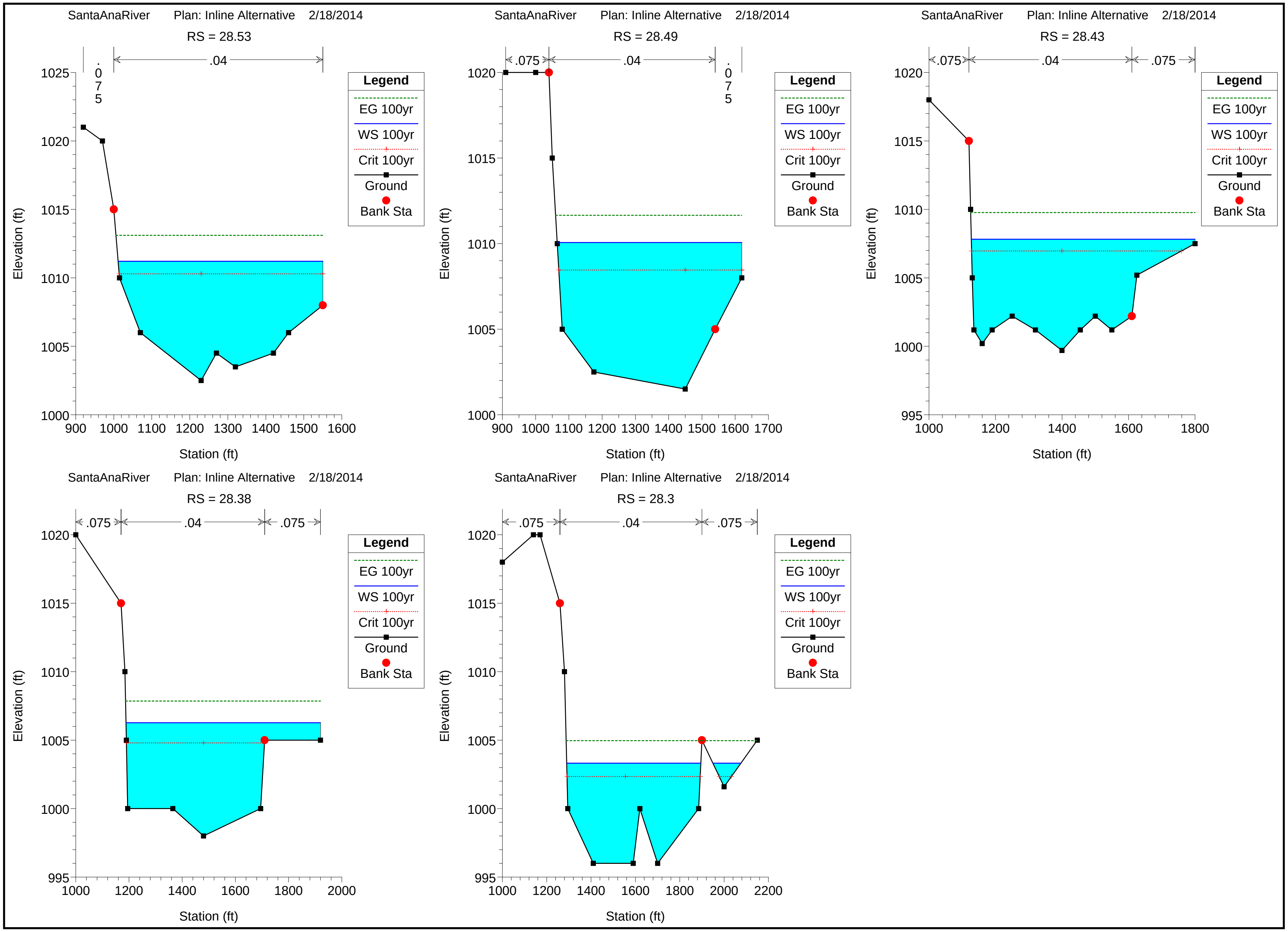
SantaAnaRiver Plan: Inline Alternative 2/18/2014
RS = 28.737
.075
.04
.075
Legend
EG 100yr
WS 100yr
Crit 100yr
Ground
Bank Sta
Elevation (ft)
Station (ft)


SantaAnaRiver Plan: Inline Alternative 2/18/2014
RS = 28.673
.075 .04 .075
Legend
EG 100yr
WS 100yr
Crit 100yr
Ground
Bank Sta
Elevation (ft)
Station (ft)
SantaAnaRiver Plan: Inline Alternative 2/18/2014
RS = 28.647
.075 .04 .075
Legend
EG 100yr
WS 100yr
Crit 100yr
Ground
Bank Sta
Elevation (ft)
Station (ft)
SantaAnaRiver Plan: Inline Alternative 2/18/2014
RS = 28.63
.075 .04
Legend
EG 100yr
WS 100yr
Crit 100yr
Ground
Bank Sta
Elevation (ft)
Station (ft)
SantaAnaRiver Plan: Inline Alternative 2/18/2014
RS = 28.626
.075 .04
Legend
EG 100yr
WS 100yr
Crit 100yr
Ground
Bank Sta
Elevation (ft)
Station (ft)
SantaAnaRiver Plan: Inline Alternative 2/18/2014
RS = 28.617 BR Proposed AT&SF RR Inline Alt
.04
Legend
EG 100yr
WS 100yr
Crit 100yr
Ground
Bank Sta
Elevation (ft)
Station (ft)
SantaAnaRiver Plan: Inline Alternative 2/18/2014
RS = 28.617 BR Proposed AT&SF RR Inline Alt
.04
Legend
EG 100yr
WS 100yr
Crit 100yr
Ground
Bank Sta
Elevation (ft)
Station (ft)


SantaAnaRiver Plan: Inline Alternative 2/18/2014
RS = 28.610
.04
Legend
EG 100yr
WS 100yr
Crit 100yr
Ground
Bank Sta
Elevation (ft)
Station (ft)
SantaAnaRiver Plan: Inline Alternative 2/18/2014
RS = 28.608
.04
Legend
EG 100yr
WS 100yr
Crit 100yr
Ground
Bank Sta
Elevation (ft)
Station (ft)
SantaAnaRiver Plan: Inline Alternative 2/18/2014
RS = 28.606
.04
Legend
EG 100yr
WS 100yr
Crit 100yr
Ground
Bank Sta
Elevation (ft)
Station (ft)
SantaAnaRiver Plan: Inline Alternative 2/18/2014
RS = 28.604
.04
Legend
EG 100yr
WS 100yr
Crit 100yr
Ground
Bank Sta
Elevation (ft)
Station (ft)
SantaAnaRiver Plan: Inline Alternative 2/18/2014
RS = 28.602
.04
Legend
EG 100yr
WS 100yr
Crit 100yr
Ground
Bank Sta
Elevation (ft)
Station (ft)
SantaAnaRiver Plan: Inline Alternative 2/18/2014
RS = 28.6
.04
Legend
EG 100yr
WS 100yr
Crit 100yr
Ground
Bank Sta
Elevation (ft)
Station (ft)



SantaAnaRiver Plan: Inline Alternative 2/18/2014
RS = 28.597
RS = 28.595
RS = 28.59
RS = 28.58
RS = 28.57
RS = 28.55
.04
.075
Legend
EG 100yr
WS 100yr
Crit 100yr
Ground
Bank Sta
Elevation (ft)
Station (ft)


SantaAnaRiver Plan: Inline Alternative 2/18/2014
RS = 28.53
.075
.04
Legend
EG 100yr
WS 100yr
Crit 100yr
Ground
Bank Sta
Elevation (ft)
Station (ft)
1000
1005
1010
1015
1020
1025
900 1000 1100 1200 1300 1400 1500 1600
SantaAnaRiver Plan: Inline Alternative 2/18/2014
RS = 28.49
.075
.04
.075
Legend
EG 100yr
WS 100yr
Crit 100yr
Ground
Bank Sta
Elevation (ft)
Station (ft)
1000
1005
1010
1015
1020
900 1000 1100 1200 1300 1400 1500 1600 1700
SantaAnaRiver Plan: Inline Alternative 2/18/2014
RS = 28.43
.075
.04
.075
Legend
EG 100yr
WS 100yr
Crit 100yr
Ground
Bank Sta
Elevation (ft)
Station (ft)
995
1000
1005
1010
1015
1020
1000 1200 1400 1600 1800
SantaAnaRiver Plan: Inline Alternative 2/18/2014
RS = 28.38
.075
.04
.075
Legend
EG 100yr
WS 100yr
Crit 100yr
Ground
Bank Sta
Elevation (ft)
Station (ft)
995
1000
1005
1010
1015
1020
1000 1200 1400 1600 1800 2000
SantaAnaRiver Plan: Inline Alternative 2/18/2014
RS = 28.3
.075
.04
.075
Legend
EG 100yr
WS 100yr
Crit 100yr
Ground
Bank Sta
Elevation (ft)
Station (ft)
995
1000
1005
1010
1015
1020
1000 1200 1400 1600 1800 2000 2200

# Attachment 2 – Hydraulic Analysis Results

HEC-RAS Plan: Dup Eff River: RIVER-1 Reach: Reach-1 Profile: PF 1

| Reach | River Sta | Profile | Q Total | Min Ch El | W.S. Elev | Crit W.S. | E.G. Elev | E.G. Slope | Vel Chnl | Flow Area | Top Width | Froude # Chl |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | (cfs) | (ft) | (ft) | (ft) | (ft) | (ft/ft) | (ft/s) | (sq ft) | (ft) | |
| Reach-1 | 29.64 | PF 1 | 33000.00 | 1041.30 | 1047.96 | 1047.05 | 1049.55 | 0.007688 | 10.10 | 3267.22 | 596.85 | 0.76 |
| Reach-1 | 29.56 | PF 1 | 33000.00 | 1039.50 | 1045.65 | 1044.11 | 1046.89 | 0.005387 | 8.96 | 3684.41 | 615.04 | 0.64 |
| Reach-1 | 29.53 | PF 1 | 33000.00 | 1038.00 | 1045.20 | 1042.87 | 1046.17 | 0.003554 | 7.91 | 4170.56 | 614.09 | 0.54 |
| Reach-1 | 29.51 | PF 1 | 33000.00 | 1036.80 | 1044.72 | 1042.49 | 1045.64 | 0.003625 | 7.69 | 4294.00 | 671.53 | 0.54 |
| Reach-1 | 29.505 | | Bridge | | | | | | | | | |
| Reach-1 | 29.5 | PF 1 | 33000.00 | 1036.00 | 1042.38 | 1041.88 | 1044.09 | 0.009995 | 10.48 | 3149.66 | 663.33 | 0.85 |
| Reach-1 | 29.43 | PF 1 | 33000.00 | 1033.60 | 1040.59 | 1039.01 | 1041.85 | 0.005416 | 9.00 | 3666.62 | 612.09 | 0.65 |
| Reach-1 | 29.37 | PF 1 | 33000.00 | 1031.60 | 1037.90 | 1037.38 | 1039.71 | 0.010053 | 10.77 | 3064.88 | 622.61 | 0.86 |
| Reach-1 | 29.35 | PF 1 | 33000.00 | 1030.70 | 1036.52 | 1036.23 | 1038.48 | 0.011476 | 11.22 | 2942.43 | 620.41 | 0.91 |
| Reach-1 | 29.32 | PF 1 | 33000.00 | 1030.00 | 1035.64 | 1034.70 | 1037.20 | 0.007810 | 10.04 | 3288.16 | 613.44 | 0.76 |
| Reach-1 | 29.23 | PF 1 | 33000.00 | 1025.00 | 1032.85 | 1031.07 | 1033.93 | 0.004612 | 8.32 | 3964.53 | 659.25 | 0.60 |
| Reach-1 | 29.19 | PF 1 | 33000.00 | 1024.00 | 1032.08 | 1029.82 | 1033.01 | 0.003585 | 7.76 | 4259.50 | 658.31 | 0.53 |
| Reach-1 | 29.16 | PF 1 | 33000.00 | 1023.40 | 1031.46 | 1029.57 | 1032.54 | 0.004434 | 8.35 | 3954.00 | 635.84 | 0.59 |
| Reach-1 | 29.14 | PF 1 | 33000.00 | 1022.90 | 1030.57 | 1029.30 | 1031.91 | 0.006344 | 9.29 | 3552.98 | 636.14 | 0.69 |
| Reach-1 | 29.1 | PF 1 | 33000.00 | 1021.00 | 1028.32 | 1027.78 | 1030.12 | 0.010139 | 10.77 | 3064.25 | 626.32 | 0.86 |
| Reach-1 | 29.08 | PF 1 | 33000.00 | 1020.50 | 1027.93 | 1026.64 | 1029.34 | 0.006933 | 9.51 | 3469.11 | 642.58 | 0.72 |
| Reach-1 | 29.07 | PF 1 | 33000.00 | 1019.80 | 1027.38 | 1025.98 | 1028.74 | 0.006960 | 9.36 | 3526.50 | 670.55 | 0.72 |
| Reach-1 | 29.01 | PF 1 | 33000.00 | 1018.00 | 1025.14 | 1024.26 | 1026.50 | 0.007981 | 9.36 | 3524.35 | 750.55 | 0.76 |
| Reach-1 | 28.95 | PF 1 | 33000.00 | 1016.00 | 1023.97 | 1022.08 | 1024.88 | 0.004036 | 7.78 | 4877.05 | 881.32 | 0.56 |
| Reach-1 | 28.84 | PF 1 | 33000.00 | 1013.00 | 1021.56 | 1019.72 | 1022.38 | 0.004427 | 7.26 | 4546.32 | 902.58 | 0.57 |
| Reach-1 | 28.737 | PF 1 | 33000.00 | 1010.00 | 1019.79 | 1016.50 | 1020.53 | 0.002501 | 6.90 | 4784.20 | 665.36 | 0.45 |
| Reach-1 | 28.673 | PF 1 | 33000.00 | 1007.30 | 1019.09 | 1014.35 | 1019.84 | 0.001647 | 7.04 | 4988.58 | 560.61 | 0.39 |
| Reach-1 | 28.647 | PF 1 | 33000.00 | 1006.20 | 1018.90 | 1013.31 | 1019.62 | 0.001356 | 6.83 | 4934.14 | 502.69 | 0.36 |
| Reach-1 | 28.63 | PF 1 | 33000.00 | 1005.60 | 1018.34 | 1013.27 | 1019.35 | 0.002067 | 8.09 | 4080.76 | 382.35 | 0.44 |
| Reach-1 | 28.624 | PF 1 | 33000.00 | 1005.30 | 1018.23 | 1012.97 | 1019.27 | 0.001959 | 8.18 | 4032.21 | 355.33 | 0.43 |
| Reach-1 | 28.622 | PF 1 | 33000.00 | 1005.20 | 1018.19 | 1012.87 | 1019.24 | 0.001927 | 8.23 | 4009.70 | 345.43 | 0.43 |
| Reach-1 | 28.62 | PF 1 | 33000.00 | 1005.00 | 1017.53 | 1013.96 | 1019.03 | 0.003353 | 9.83 | 3358.28 | 334.34 | 0.55 |
| Reach-1 | 28.615 | | Bridge | | | | | | | | | |
| Reach-1 | 28.61 | PF 1 | 33000.00 | 1005.00 | 1015.58 | 1013.62 | 1017.71 | 0.005847 | 11.72 | 2815.08 | 320.75 | 0.70 |
| Reach-1 | 28.608 | PF 1 | 33000.00 | 1005.00 | 1015.28 | 1014.21 | 1017.56 | 0.008124 | 12.15 | 2736.49 | 373.00 | 0.79 |
| Reach-1 | 28.606 | PF 1 | 33000.00 | 1004.90 | 1015.29 | 1013.81 | 1017.32 | 0.006773 | 11.46 | 2918.43 | 379.00 | 0.73 |
| Reach-1 | 28.604 | PF 1 | 33000.00 | 1004.80 | 1015.27 | 1013.55 | 1017.16 | 0.006161 | 11.10 | 3028.83 | 385.00 | 0.70 |
| Reach-1 | 28.602 | PF 1 | 33000.00 | 1004.70 | 1013.52 | 1013.52 | 1016.58 | 0.014065 | 14.16 | 2383.33 | 391.00 | 1.02 |
| Reach-1 | 28.6 | PF 1 | 33000.00 | 1004.60 | 1013.38 | 1013.27 | 1016.31 | 0.013356 | 13.88 | 2439.63 | 397.00 | 0.99 |
| Reach-1 | 28.597 | PF 1 | 33000.00 | 1004.20 | 1013.65 | 1011.75 | 1015.65 | 0.005596 | 11.48 | 2985.06 | 359.23 | 0.70 |
| Reach-1 | 28.595 | PF 1 | 33000.00 | 1004.10 | 1013.59 | 1011.65 | 1015.57 | 0.005512 | 11.42 | 2999.61 | 359.43 | 0.69 |
| Reach-1 | 28.59 | PF 1 | 33000.00 | 1004.00 | 1013.37 | 1011.55 | 1015.41 | 0.005751 | 11.58 | 2959.14 | 358.87 | 0.71 |
| Reach-1 | 28.58 | PF 1 | 33000.00 | 1004.00 | 1013.21 | 1011.11 | 1015.01 | 0.004741 | 10.86 | 3203.69 | 414.82 | 0.65 |
| Reach-1 | 28.57 | PF 1 | 36500.00 | 1003.70 | 1012.60 | 1011.08 | 1014.64 | 0.005922 | 11.56 | 3312.65 | 446.00 | 0.71 |
| Reach-1 | 28.55 | PF 1 | 36500.00 | 1003.10 | 1012.17 | 1010.31 | 1013.89 | 0.005260 | 10.55 | 3523.15 | 484.69 | 0.66 |
| Reach-1 | 28.53 | PF 1 | 36500.00 | 1002.50 | 1011.21 | 1010.29 | 1013.11 | 0.007997 | 11.07 | 3297.88 | 538.62 | 0.79 |
| Reach-1 | 28.49 | PF 1 | 36500.00 | 1001.50 | 1010.06 | 1008.46 | 1011.65 | 0.005397 | 10.25 | 3752.02 | 555.18 | 0.67 |
| Reach-1 | 28.43 | PF 1 | 36500.00 | 999.70 | 1007.82 | 1006.96 | 1009.77 | 0.007629 | 11.31 | 3477.74 | 672.82 | 0.78 |
| Reach-1 | 28.38 | PF 1 | 36500.00 | 998.00 | 1006.28 | 1004.80 | 1007.86 | 0.005863 | 10.16 | 3812.25 | 731.28 | 0.69 |
| Reach-1 | 28.3 | PF 1 | 36500.00 | 996.00 | 1003.30 | 1002.34 | 1004.96 | 0.007470 | 10.35 | 3617.75 | 729.85 | 0.76 |

HEC-RAS Plan: Corr Eff River: RIVER-1 Reach: Reach-1 Profile: 100yr

| Reach | River Sta | Profile | Q Total | Min Ch El | W.S. Elev | Crit W.S. | E.G. Elev | E.G. Slope | Vel Chnl | Flow Area | Top Width | Froude # Chl |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | (cfs) | (ft) | (ft) | (ft) | (ft) | (ft/ft) | (ft/s) | (sq ft) | (ft) | |
| Reach-1 | 29.64 | 100yr | 33000.00 | 1041.30 | 1047.87 | 1047.05 | 1049.51 | 0.007337 | 10.27 | 3212.01 | 596.48 | 0.78 |
| Reach-1 | 29.56 | 100yr | 33000.00 | 1039.50 | 1045.65 | 1044.11 | 1046.89 | 0.005383 | 8.95 | 3685.31 | 615.05 | 0.64 |
| Reach-1 | 29.53 | 100yr | 33000.00 | 1038.00 | 1045.20 | 1042.87 | 1046.17 | 0.003551 | 7.91 | 4171.84 | 614.09 | 0.53 |
| Reach-1 | 29.51 | 100yr | 33000.00 | 1036.80 | 1044.73 | 1042.49 | 1045.64 | 0.003619 | 7.68 | 4295.97 | 671.54 | 0.54 |
| Reach-1 | 29.505 | | Bridge | | | | | | | | | |
| Reach-1 | 29.5 | 100yr | 33000.00 | 1036.00 | 1042.38 | 1041.88 | 1044.09 | 0.009995 | 10.48 | 3149.66 | 663.33 | 0.85 |
| Reach-1 | 29.43 | 100yr | 33000.00 | 1033.60 | 1040.59 | 1039.01 | 1041.85 | 0.005416 | 9.00 | 3666.62 | 612.09 | 0.65 |
| Reach-1 | 29.37 | 100yr | 33000.00 | 1031.60 | 1037.91 | 1037.38 | 1039.71 | 0.010051 | 10.77 | 3065.04 | 622.62 | 0.86 |
| Reach-1 | 29.35 | 100yr | 33000.00 | 1030.70 | 1036.52 | 1036.23 | 1038.48 | 0.011479 | 11.22 | 2942.21 | 620.41 | 0.91 |
| Reach-1 | 29.32 | 100yr | 33000.00 | 1030.00 | 1035.64 | 1034.70 | 1037.20 | 0.007815 | 10.04 | 3287.56 | 613.41 | 0.76 |
| Reach-1 | 29.23 | 100yr | 33000.00 | 1025.00 | 1032.86 | 1031.07 | 1033.93 | 0.004581 | 8.31 | 3972.50 | 659.31 | 0.60 |
| Reach-1 | 29.19 | 100yr | 33000.00 | 1024.00 | 1032.10 | 1029.82 | 1033.03 | 0.003548 | 7.74 | 4273.08 | 658.40 | 0.53 |
| Reach-1 | 29.16 | 100yr | 33000.00 | 1023.40 | 1031.49 | 1029.57 | 1032.56 | 0.004358 | 8.30 | 3974.96 | 635.97 | 0.59 |
| Reach-1 | 29.14 | 100yr | 33000.00 | 1022.90 | 1030.66 | 1029.30 | 1031.96 | 0.006036 | 9.15 | 3606.95 | 636.31 | 0.68 |
| Reach-1 | 29.1 | 100yr | 33000.00 | 1021.00 | 1028.06 | 1027.78 | 1030.07 | 0.011944 | 11.37 | 2901.58 | 617.95 | 0.92 |
| Reach-1 | 29.08 | 100yr | 33000.00 | 1020.50 | 1026.64 | 1026.64 | 1028.99 | 0.014144 | 12.32 | 2679.49 | 575.14 | 1.01 |
| Reach-1 | 29.07 | 100yr | 33000.00 | 1018.20 | 1026.11 | 1022.48 | 1026.72 | 0.001873 | 6.25 | 5277.17 | 684.39 | 0.40 |
| Reach-1 | 29.06 | | Bridge | | | | | | | | | |
| Reach-1 | 29.01 | 100yr | 33000.00 | 1018.20 | 1025.01 | 1022.49 | 1025.83 | 0.003092 | 7.29 | 4526.32 | 679.60 | 0.50 |
| Reach-1 | 28.95 | 100yr | 33000.00 | 1016.00 | 1023.97 | 1022.08 | 1024.88 | 0.004038 | 7.78 | 4876.41 | 881.32 | 0.56 |
| Reach-1 | 28.84 | 100yr | 33000.00 | 1013.00 | 1021.55 | 1019.72 | 1022.37 | 0.004459 | 7.28 | 4535.80 | 902.32 | 0.57 |
| Reach-1 | 28.737 | 100yr | 33000.00 | 1010.00 | 1019.75 | 1016.50 | 1020.50 | 0.002538 | 6.93 | 4760.54 | 664.58 | 0.46 |
| Reach-1 | 28.673 | 100yr | 33000.00 | 1007.30 | 1019.04 | 1014.35 | 1019.80 | 0.001673 | 7.07 | 4962.66 | 560.32 | 0.39 |
| Reach-1 | 28.647 | 100yr | 33000.00 | 1006.20 | 1018.85 | 1013.31 | 1019.58 | 0.001376 | 6.86 | 4909.51 | 502.33 | 0.36 |
| Reach-1 | 28.63 | 100yr | 33000.00 | 1005.60 | 1018.28 | 1013.27 | 1019.31 | 0.002101 | 8.13 | 4058.79 | 381.87 | 0.44 |
| Reach-1 | 28.624 | 100yr | 33000.00 | 1005.30 | 1018.17 | 1012.97 | 1019.22 | 0.001991 | 8.23 | 4011.46 | 355.04 | 0.43 |
| Reach-1 | 28.622 | 100yr | 33000.00 | 1005.20 | 1018.13 | 1012.87 | 1019.20 | 0.001958 | 8.27 | 3989.42 | 345.20 | 0.43 |
| Reach-1 | 28.62 | 100yr | 33000.00 | 1005.00 | 1017.46 | 1013.96 | 1018.98 | 0.003432 | 9.90 | 3332.63 | 333.75 | 0.55 |
| Reach-1 | 28.615 | | Bridge | | | | | | | | | |
| Reach-1 | 28.61 | 100yr | 33000.00 | 1005.00 | 1015.58 | 1013.62 | 1017.71 | 0.005847 | 11.72 | 2815.08 | 320.75 | 0.70 |
| Reach-1 | 28.608 | 100yr | 33000.00 | 1005.00 | 1015.28 | 1014.21 | 1017.56 | 0.008124 | 12.15 | 2736.49 | 373.00 | 0.79 |
| Reach-1 | 28.606 | 100yr | 33000.00 | 1004.90 | 1015.29 | 1013.81 | 1017.32 | 0.006773 | 11.46 | 2918.43 | 379.00 | 0.73 |
| Reach-1 | 28.604 | 100yr | 33000.00 | 1004.80 | 1015.27 | 1013.55 | 1017.16 | 0.006161 | 11.10 | 3028.83 | 385.00 | 0.70 |
| Reach-1 | 28.602 | 100yr | 33000.00 | 1004.70 | 1013.52 | 1013.52 | 1016.58 | 0.014065 | 14.16 | 2383.33 | 391.00 | 1.02 |
| Reach-1 | 28.6 | 100yr | 33000.00 | 1004.60 | 1013.38 | 1013.27 | 1016.31 | 0.013357 | 13.88 | 2439.56 | 397.00 | 0.99 |
| Reach-1 | 28.597 | 100yr | 33000.00 | 1004.20 | 1013.65 | 1011.75 | 1015.65 | 0.005597 | 11.48 | 2985.02 | 359.23 | 0.70 |
| Reach-1 | 28.595 | 100yr | 33000.00 | 1004.10 | 1013.59 | 1011.65 | 1015.57 | 0.005512 | 11.42 | 2999.57 | 359.43 | 0.69 |
| Reach-1 | 28.59 | 100yr | 33000.00 | 1004.00 | 1013.37 | 1011.55 | 1015.41 | 0.005752 | 11.58 | 2959.12 | 358.87 | 0.71 |
| Reach-1 | 28.58 | 100yr | 33000.00 | 1004.00 | 1013.21 | 1011.11 | 1015.01 | 0.004741 | 10.86 | 3203.66 | 414.82 | 0.65 |
| Reach-1 | 28.57 | 100yr | 36500.00 | 1003.70 | 1012.60 | 1011.08 | 1014.64 | 0.005922 | 11.56 | 3312.57 | 446.00 | 0.71 |
| Reach-1 | 28.55 | 100yr | 36500.00 | 1003.10 | 1012.17 | 1010.31 | 1013.89 | 0.005260 | 10.55 | 3523.03 | 484.69 | 0.66 |
| Reach-1 | 28.53 | 100yr | 36500.00 | 1002.50 | 1011.21 | 1010.29 | 1013.11 | 0.007996 | 11.07 | 3298.01 | 538.62 | 0.79 |
| Reach-1 | 28.49 | 100yr | 36500.00 | 1001.50 | 1010.06 | 1008.46 | 1011.66 | 0.005396 | 10.25 | 3752.26 | 555.18 | 0.67 |
| Reach-1 | 28.43 | 100yr | 36500.00 | 999.70 | 1007.82 | 1006.96 | 1009.77 | 0.007633 | 11.31 | 3477.09 | 672.82 | 0.78 |
| Reach-1 | 28.38 | 100yr | 36500.00 | 998.00 | 1006.27 | 1004.80 | 1007.86 | 0.005885 | 10.18 | 3806.98 | 731.27 | 0.69 |
| Reach-1 | 28.3 | 100yr | 36500.00 | 996.00 | 1003.32 | 1002.34 | 1004.96 | 0.007384 | 10.31 | 3632.37 | 731.41 | 0.75 |

HEC-RAS Plan: Existing Model River: RIVER-1 Reach: Reach-1 Profile: 100yr

| Reach | River Sta | Profile | Q Total | Min Ch El | W.S. Elev | Crit W.S. | E.G. Elev | E.G. Slope | Vel Chnl | Flow Area | Top Width | Froude # Chl |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | (cfs) | (ft) | (ft) | (ft) | (ft) | (ft/ft) | (ft/s) | (sq ft) | (ft) | |
| Reach-1 | 29.64 | 100yr | 33000.00 | 1041.30 | 1047.87 | 1047.05 | 1049.51 | 0.007337 | 10.27 | 3212.01 | 596.48 | 0.78 |
| Reach-1 | 29.56 | 100yr | 33000.00 | 1039.50 | 1045.65 | 1044.11 | 1046.89 | 0.005383 | 8.95 | 3685.31 | 615.05 | 0.64 |
| Reach-1 | 29.53 | 100yr | 33000.00 | 1038.00 | 1045.20 | 1042.87 | 1046.17 | 0.003551 | 7.91 | 4171.84 | 614.09 | 0.53 |
| Reach-1 | 29.51 | 100yr | 33000.00 | 1036.80 | 1044.73 | 1042.49 | 1045.64 | 0.003619 | 7.68 | 4295.97 | 671.54 | 0.54 |
| Reach-1 | 29.505 | | Bridge | | | | | | | | | |
| Reach-1 | 29.5 | 100yr | 33000.00 | 1036.00 | 1042.38 | 1041.88 | 1044.09 | 0.009995 | 10.48 | 3149.66 | 663.33 | 0.85 |
| Reach-1 | 29.43 | 100yr | 33000.00 | 1033.60 | 1040.59 | 1039.01 | 1041.85 | 0.005416 | 9.00 | 3666.62 | 612.09 | 0.65 |
| Reach-1 | 29.37 | 100yr | 33000.00 | 1031.60 | 1037.91 | 1037.38 | 1039.71 | 0.010051 | 10.77 | 3065.04 | 622.62 | 0.86 |
| Reach-1 | 29.35 | 100yr | 33000.00 | 1030.70 | 1036.52 | 1036.23 | 1038.48 | 0.011479 | 11.22 | 2942.21 | 620.41 | 0.91 |
| Reach-1 | 29.32 | 100yr | 33000.00 | 1030.00 | 1035.64 | 1034.70 | 1037.20 | 0.007815 | 10.04 | 3287.56 | 613.41 | 0.76 |
| Reach-1 | 29.23 | 100yr | 33000.00 | 1025.00 | 1032.86 | 1031.07 | 1033.93 | 0.004581 | 8.31 | 3972.50 | 659.31 | 0.60 |
| Reach-1 | 29.19 | 100yr | 33000.00 | 1024.00 | 1032.10 | 1029.82 | 1033.03 | 0.003548 | 7.74 | 4273.08 | 658.40 | 0.53 |
| Reach-1 | 29.16 | 100yr | 33000.00 | 1023.40 | 1031.49 | 1029.57 | 1032.56 | 0.004358 | 8.30 | 3974.96 | 635.97 | 0.59 |
| Reach-1 | 29.14 | 100yr | 33000.00 | 1022.90 | 1030.66 | 1029.30 | 1031.96 | 0.006036 | 9.15 | 3606.95 | 636.31 | 0.68 |
| Reach-1 | 29.1 | 100yr | 33000.00 | 1021.00 | 1028.06 | 1027.78 | 1030.07 | 0.011944 | 11.37 | 2901.58 | 617.95 | 0.92 |
| Reach-1 | 29.08 | 100yr | 33000.00 | 1020.50 | 1026.64 | 1026.64 | 1028.99 | 0.014144 | 12.32 | 2679.49 | 575.14 | 1.01 |
| Reach-1 | 29.07 | 100yr | 33000.00 | 1018.20 | 1026.11 | 1022.48 | 1026.72 | 0.001873 | 6.25 | 5276.67 | 684.39 | 0.40 |
| Reach-1 | 29.06 | | Bridge | | | | | | | | | |
| Reach-1 | 29.01 | 100yr | 33000.00 | 1018.20 | 1025.01 | 1022.49 | 1025.83 | 0.003094 | 7.29 | 4525.33 | 679.60 | 0.50 |
| Reach-1 | 28.95 | 100yr | 33000.00 | 1016.00 | 1023.97 | 1022.08 | 1024.87 | 0.004045 | 7.79 | 4873.40 | 881.31 | 0.56 |
| Reach-1 | 28.84 | 100yr | 33000.00 | 1013.00 | 1021.51 | 1019.72 | 1022.35 | 0.004556 | 7.32 | 4505.19 | 901.56 | 0.58 |
| Reach-1 | 28.737 | 100yr | 33000.00 | 1010.00 | 1019.65 | 1016.50 | 1020.41 | 0.002658 | 7.04 | 4688.23 | 662.18 | 0.47 |
| Reach-1 | 28.673 | 100yr | 33000.00 | 1007.30 | 1018.90 | 1014.35 | 1019.68 | 0.001756 | 7.18 | 4882.28 | 559.42 | 0.40 |
| Reach-1 | 28.647 | 100yr | 33000.00 | 1006.20 | 1018.70 | 1013.31 | 1019.45 | 0.001442 | 6.95 | 4833.01 | 501.19 | 0.37 |
| Reach-1 | 28.63 | 100yr | 33000.00 | 1005.60 | 1018.10 | 1013.27 | 1019.16 | 0.002212 | 8.27 | 3989.93 | 380.36 | 0.45 |
| Reach-1 | 28.626 | 100yr | 33000.00 | 1005.40 | 1017.98 | 1013.07 | 1019.09 | 0.002158 | 8.44 | 3908.80 | 353.59 | 0.45 |
| Reach-1 | 28.624 | 100yr | 33000.00 | 1005.30 | 1017.97 | 1012.97 | 1019.06 | 0.002105 | 8.38 | 3940.23 | 354.04 | 0.44 |
| Reach-1 | 28.622 | 100yr | 33000.00 | 1005.20 | 1017.93 | 1012.87 | 1019.03 | 0.002069 | 8.42 | 3919.80 | 344.44 | 0.44 |
| Reach-1 | 28.62 | 100yr | 33000.00 | 1005.00 | 1017.19 | 1013.96 | 1018.79 | 0.003740 | 10.18 | 3241.99 | 332.37 | 0.57 |
| Reach-1 | 28.615 | | Bridge | | | | | | | | | |
| Reach-1 | 28.61 | 100yr | 33000.00 | 1005.00 | 1015.58 | 1013.62 | 1017.71 | 0.005847 | 11.72 | 2815.08 | 320.75 | 0.70 |
| Reach-1 | 28.608 | 100yr | 33000.00 | 1005.00 | 1015.28 | 1014.21 | 1017.56 | 0.008124 | 12.15 | 2736.49 | 373.00 | 0.79 |
| Reach-1 | 28.606 | 100yr | 33000.00 | 1004.90 | 1015.29 | 1013.81 | 1017.32 | 0.006773 | 11.46 | 2918.43 | 379.00 | 0.73 |
| Reach-1 | 28.604 | 100yr | 33000.00 | 1004.80 | 1015.27 | 1013.55 | 1017.16 | 0.006161 | 11.10 | 3028.83 | 385.00 | 0.70 |
| Reach-1 | 28.602 | 100yr | 33000.00 | 1004.70 | 1013.52 | 1013.52 | 1016.58 | 0.014065 | 14.16 | 2383.33 | 391.00 | 1.02 |
| Reach-1 | 28.6 | 100yr | 33000.00 | 1004.60 | 1013.38 | 1013.27 | 1016.31 | 0.013357 | 13.88 | 2439.56 | 397.00 | 0.99 |
| Reach-1 | 28.597 | 100yr | 33000.00 | 1004.20 | 1013.65 | 1011.75 | 1015.65 | 0.005597 | 11.48 | 2985.02 | 359.23 | 0.70 |
| Reach-1 | 28.595 | 100yr | 33000.00 | 1004.10 | 1013.59 | 1011.65 | 1015.57 | 0.005512 | 11.42 | 2999.57 | 359.43 | 0.69 |
| Reach-1 | 28.59 | 100yr | 33000.00 | 1004.00 | 1013.37 | 1011.55 | 1015.41 | 0.005752 | 11.58 | 2959.12 | 358.87 | 0.71 |
| Reach-1 | 28.58 | 100yr | 33000.00 | 1004.00 | 1013.21 | 1011.11 | 1015.01 | 0.004741 | 10.86 | 3203.66 | 414.82 | 0.65 |
| Reach-1 | 28.57 | 100yr | 36500.00 | 1003.70 | 1012.60 | 1011.08 | 1014.64 | 0.005922 | 11.56 | 3312.57 | 446.00 | 0.71 |
| Reach-1 | 28.55 | 100yr | 36500.00 | 1003.10 | 1012.17 | 1010.31 | 1013.89 | 0.005260 | 10.55 | 3523.03 | 484.69 | 0.66 |
| Reach-1 | 28.53 | 100yr | 36500.00 | 1002.50 | 1011.21 | 1010.29 | 1013.11 | 0.007996 | 11.07 | 3298.01 | 538.62 | 0.79 |
| Reach-1 | 28.49 | 100yr | 36500.00 | 1001.50 | 1010.06 | 1008.46 | 1011.66 | 0.005396 | 10.25 | 3752.26 | 555.18 | 0.67 |
| Reach-1 | 28.43 | 100yr | 36500.00 | 999.70 | 1007.82 | 1006.96 | 1009.77 | 0.007633 | 11.31 | 3477.09 | 672.82 | 0.78 |
| Reach-1 | 28.38 | 100yr | 36500.00 | 998.00 | 1006.27 | 1004.80 | 1007.86 | 0.005885 | 10.18 | 3806.98 | 731.27 | 0.69 |
| Reach-1 | 28.3 | 100yr | 36500.00 | 996.00 | 1003.32 | 1002.34 | 1004.96 | 0.007384 | 10.31 | 3632.37 | 731.41 | 0.75 |

HEC-RAS Plan: Offline Alt River: RIVER-1 Reach: Reach-1 Profile: 100yr

| Reach | River Sta | Profile | Q Total | Min Ch El | W.S. Elev | Crit W.S. | E.G. Elev | E.G. Slope | Vel Chnl | Flow Area | Top Width | Froude # Chl |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | (cfs) | (ft) | (ft) | (ft) | (ft) | (ft/ft) | (ft/s) | (sq ft) | (ft) | |
| Reach-1 | 29.64 | 100yr | 33000.00 | 1041.30 | 1047.87 | 1047.05 | 1049.51 | 0.007337 | 10.27 | 3212.01 | 596.48 | 0.78 |
| Reach-1 | 29.56 | 100yr | 33000.00 | 1039.50 | 1045.65 | 1044.11 | 1046.89 | 0.005383 | 8.95 | 3685.31 | 615.05 | 0.64 |
| Reach-1 | 29.53 | 100yr | 33000.00 | 1038.00 | 1045.20 | 1042.87 | 1046.17 | 0.003551 | 7.91 | 4171.84 | 614.09 | 0.53 |
| Reach-1 | 29.51 | 100yr | 33000.00 | 1036.80 | 1044.73 | 1042.49 | 1045.64 | 0.003619 | 7.68 | 4295.97 | 671.54 | 0.54 |
| Reach-1 | 29.505 | | Bridge | | | | | | | | | |
| Reach-1 | 29.5 | 100yr | 33000.00 | 1036.00 | 1042.38 | 1041.88 | 1044.09 | 0.009995 | 10.48 | 3149.66 | 663.33 | 0.85 |
| Reach-1 | 29.43 | 100yr | 33000.00 | 1033.60 | 1040.59 | 1039.01 | 1041.85 | 0.005416 | 9.00 | 3666.62 | 612.09 | 0.65 |
| Reach-1 | 29.37 | 100yr | 33000.00 | 1031.60 | 1037.91 | 1037.38 | 1039.71 | 0.010051 | 10.77 | 3065.04 | 622.62 | 0.86 |
| Reach-1 | 29.35 | 100yr | 33000.00 | 1030.70 | 1036.52 | 1036.23 | 1038.48 | 0.011479 | 11.22 | 2942.21 | 620.41 | 0.91 |
| Reach-1 | 29.32 | 100yr | 33000.00 | 1030.00 | 1035.64 | 1034.70 | 1037.20 | 0.007815 | 10.04 | 3287.56 | 613.41 | 0.76 |
| Reach-1 | 29.23 | 100yr | 33000.00 | 1025.00 | 1032.86 | 1031.07 | 1033.93 | 0.004581 | 8.31 | 3972.50 | 659.31 | 0.60 |
| Reach-1 | 29.19 | 100yr | 33000.00 | 1024.00 | 1032.10 | 1029.82 | 1033.03 | 0.003548 | 7.74 | 4273.08 | 658.40 | 0.53 |
| Reach-1 | 29.16 | 100yr | 33000.00 | 1023.40 | 1031.49 | 1029.57 | 1032.56 | 0.004358 | 8.30 | 3974.96 | 635.97 | 0.59 |
| Reach-1 | 29.14 | 100yr | 33000.00 | 1022.90 | 1030.66 | 1029.30 | 1031.96 | 0.006036 | 9.15 | 3606.95 | 636.31 | 0.68 |
| Reach-1 | 29.1 | 100yr | 33000.00 | 1021.00 | 1028.06 | 1027.78 | 1030.07 | 0.011944 | 11.37 | 2901.58 | 617.95 | 0.92 |
| Reach-1 | 29.08 | 100yr | 33000.00 | 1020.50 | 1026.64 | 1026.64 | 1028.99 | 0.014144 | 12.32 | 2679.49 | 575.14 | 1.01 |
| Reach-1 | 29.07 | 100yr | 33000.00 | 1018.20 | 1026.09 | 1022.48 | 1026.70 | 0.001888 | 6.27 | 5264.47 | 684.31 | 0.40 |
| Reach-1 | 29.06 | | Bridge | | | | | | | | | |
| Reach-1 | 29.01 | 100yr | 33000.00 | 1018.20 | 1025.01 | 1022.49 | 1025.83 | 0.003091 | 7.29 | 4526.74 | 679.61 | 0.50 |
| Reach-1 | 28.95 | 100yr | 33000.00 | 1016.00 | 1023.97 | 1022.08 | 1024.88 | 0.004034 | 7.78 | 4877.65 | 881.33 | 0.56 |
| Reach-1 | 28.84 | 100yr | 33000.00 | 1013.00 | 1021.40 | 1019.72 | 1022.28 | 0.004886 | 7.49 | 4406.61 | 899.10 | 0.60 |
| Reach-1 | 28.737 | 100yr | 33000.00 | 1010.00 | 1019.20 | 1016.50 | 1020.07 | 0.003236 | 7.51 | 4392.74 | 652.29 | 0.51 |
| Reach-1 | 28.673 | 100yr | 33000.00 | 1007.30 | 1018.26 | 1014.35 | 1019.17 | 0.002198 | 7.70 | 4527.80 | 555.44 | 0.44 |
| Reach-1 | 28.647 | 100yr | 33000.00 | 1006.20 | 1018.02 | 1013.31 | 1018.87 | 0.001792 | 7.43 | 4492.25 | 496.11 | 0.41 |
| Reach-1 | 28.63 | 100yr | 33000.00 | 1005.60 | 1017.26 | 1013.29 | 1018.51 | 0.002843 | 8.99 | 3671.72 | 373.32 | 0.51 |
| Reach-1 | 28.626 | 100yr | 33000.00 | 1005.40 | 1017.12 | 1013.06 | 1018.42 | 0.002774 | 9.15 | 3605.64 | 349.29 | 0.50 |
| Reach-1 | 28.617 | | Bridge | | | | | | | | | |
| Reach-1 | 28.610 | 100yr | 33000.00 | 1005.00 | 1015.28 | 1013.61 | 1017.57 | 0.006491 | 12.13 | 2721.36 | 318.76 | 0.73 |
| Reach-1 | 28.608 | 100yr | 33000.00 | 1005.00 | 1015.28 | 1014.21 | 1017.56 | 0.008124 | 12.15 | 2736.49 | 373.00 | 0.79 |
| Reach-1 | 28.606 | 100yr | 33000.00 | 1004.90 | 1015.29 | 1013.81 | 1017.32 | 0.006773 | 11.46 | 2918.43 | 379.00 | 0.73 |
| Reach-1 | 28.604 | 100yr | 33000.00 | 1004.80 | 1015.27 | 1013.55 | 1017.16 | 0.006161 | 11.10 | 3028.83 | 385.00 | 0.70 |
| Reach-1 | 28.602 | 100yr | 33000.00 | 1004.70 | 1013.52 | 1013.52 | 1016.58 | 0.014065 | 14.16 | 2383.33 | 391.00 | 1.02 |
| Reach-1 | 28.6 | 100yr | 33000.00 | 1004.60 | 1013.38 | 1013.27 | 1016.31 | 0.013357 | 13.88 | 2439.56 | 397.00 | 0.99 |
| Reach-1 | 28.597 | 100yr | 33000.00 | 1004.20 | 1013.65 | 1011.75 | 1015.65 | 0.005597 | 11.48 | 2985.02 | 359.23 | 0.70 |
| Reach-1 | 28.595 | 100yr | 33000.00 | 1004.10 | 1013.59 | 1011.65 | 1015.57 | 0.005512 | 11.42 | 2999.57 | 359.43 | 0.69 |
| Reach-1 | 28.59 | 100yr | 33000.00 | 1004.00 | 1013.37 | 1011.55 | 1015.41 | 0.005752 | 11.58 | 2959.12 | 358.87 | 0.71 |
| Reach-1 | 28.58 | 100yr | 33000.00 | 1004.00 | 1013.21 | 1011.11 | 1015.01 | 0.004741 | 10.86 | 3203.66 | 414.82 | 0.65 |
| Reach-1 | 28.57 | 100yr | 36500.00 | 1003.70 | 1012.60 | 1011.08 | 1014.64 | 0.005922 | 11.56 | 3312.57 | 446.00 | 0.71 |
| Reach-1 | 28.55 | 100yr | 36500.00 | 1003.10 | 1012.17 | 1010.31 | 1013.89 | 0.005260 | 10.55 | 3523.03 | 484.69 | 0.66 |
| Reach-1 | 28.53 | 100yr | 36500.00 | 1002.50 | 1011.21 | 1010.29 | 1013.11 | 0.007996 | 11.07 | 3298.01 | 538.62 | 0.79 |
| Reach-1 | 28.49 | 100yr | 36500.00 | 1001.50 | 1010.06 | 1008.46 | 1011.66 | 0.005396 | 10.25 | 3752.26 | 555.18 | 0.67 |
| Reach-1 | 28.43 | 100yr | 36500.00 | 999.70 | 1007.82 | 1006.96 | 1009.77 | 0.007633 | 11.31 | 3477.09 | 672.82 | 0.78 |
| Reach-1 | 28.38 | 100yr | 36500.00 | 998.00 | 1006.27 | 1004.80 | 1007.86 | 0.005885 | 10.18 | 3806.98 | 731.27 | 0.69 |
| Reach-1 | 28.3 | 100yr | 36500.00 | 996.00 | 1003.32 | 1002.34 | 1004.96 | 0.007384 | 10.31 | 3632.37 | 731.41 | 0.75 |

HEC-RAS Plan: Inline Alt River: RIVER-1 Reach: Reach-1 Profile: 100yr

| Reach | River Sta | Profile | Q Total | Min Ch El | W.S. Elev | Crit W.S. | E.G. Elev | E.G. Slope | Vel Chnl | Flow Area | Top Width | Froude # Chl |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | (cfs) | (ft) | (ft) | (ft) | (ft) | (ft/ft) | (ft/s) | (sq ft) | (ft) | |
| Reach-1 | 29.64 | 100yr | 33000.00 | 1041.30 | 1047.87 | 1047.05 | 1049.51 | 0.007337 | 10.27 | 3212.01 | 596.48 | 0.78 |
| Reach-1 | 29.56 | 100yr | 33000.00 | 1039.50 | 1045.65 | 1044.11 | 1046.89 | 0.005383 | 8.95 | 3685.31 | 615.05 | 0.64 |
| Reach-1 | 29.53 | 100yr | 33000.00 | 1038.00 | 1045.20 | 1042.87 | 1046.17 | 0.003551 | 7.91 | 4171.84 | 614.09 | 0.53 |
| Reach-1 | 29.51 | 100yr | 33000.00 | 1036.80 | 1044.73 | 1042.49 | 1045.64 | 0.003619 | 7.68 | 4295.97 | 671.54 | 0.54 |
| Reach-1 | 29.505 | | Bridge | | | | | | | | | |
| Reach-1 | 29.5 | 100yr | 33000.00 | 1036.00 | 1042.38 | 1041.88 | 1044.09 | 0.009995 | 10.48 | 3149.66 | 663.33 | 0.85 |
| Reach-1 | 29.43 | 100yr | 33000.00 | 1033.60 | 1040.59 | 1039.01 | 1041.85 | 0.005416 | 9.00 | 3666.62 | 612.09 | 0.65 |
| Reach-1 | 29.37 | 100yr | 33000.00 | 1031.60 | 1037.91 | 1037.38 | 1039.71 | 0.010051 | 10.77 | 3065.04 | 622.62 | 0.86 |
| Reach-1 | 29.35 | 100yr | 33000.00 | 1030.70 | 1036.52 | 1036.23 | 1038.48 | 0.011479 | 11.22 | 2942.21 | 620.41 | 0.91 |
| Reach-1 | 29.32 | 100yr | 33000.00 | 1030.00 | 1035.64 | 1034.70 | 1037.20 | 0.007815 | 10.04 | 3287.56 | 613.41 | 0.76 |
| Reach-1 | 29.23 | 100yr | 33000.00 | 1025.00 | 1032.86 | 1031.07 | 1033.93 | 0.004581 | 8.31 | 3972.50 | 659.31 | 0.60 |
| Reach-1 | 29.19 | 100yr | 33000.00 | 1024.00 | 1032.10 | 1029.82 | 1033.03 | 0.003548 | 7.74 | 4273.08 | 658.40 | 0.53 |
| Reach-1 | 29.16 | 100yr | 33000.00 | 1023.40 | 1031.49 | 1029.57 | 1032.56 | 0.004358 | 8.30 | 3974.96 | 635.97 | 0.59 |
| Reach-1 | 29.14 | 100yr | 33000.00 | 1022.90 | 1030.66 | 1029.30 | 1031.96 | 0.006036 | 9.15 | 3606.95 | 636.31 | 0.68 |
| Reach-1 | 29.1 | 100yr | 33000.00 | 1021.00 | 1028.06 | 1027.78 | 1030.07 | 0.011944 | 11.37 | 2901.58 | 617.95 | 0.92 |
| Reach-1 | 29.08 | 100yr | 33000.00 | 1020.50 | 1026.64 | 1026.64 | 1028.99 | 0.014144 | 12.32 | 2679.49 | 575.14 | 1.01 |
| Reach-1 | 29.07 | 100yr | 33000.00 | 1018.20 | 1026.09 | 1022.48 | 1026.70 | 0.001888 | 6.27 | 5264.47 | 684.31 | 0.40 |
| Reach-1 | 29.06 | | Bridge | | | | | | | | | |
| Reach-1 | 29.01 | 100yr | 33000.00 | 1018.20 | 1025.01 | 1022.49 | 1025.83 | 0.003091 | 7.29 | 4526.74 | 679.61 | 0.50 |
| Reach-1 | 28.95 | 100yr | 33000.00 | 1016.00 | 1023.97 | 1022.08 | 1024.88 | 0.004034 | 7.78 | 4877.65 | 881.33 | 0.56 |
| Reach-1 | 28.84 | 100yr | 33000.00 | 1013.00 | 1021.40 | 1019.72 | 1022.27 | 0.004892 | 7.49 | 4404.96 | 899.05 | 0.60 |
| Reach-1 | 28.737 | 100yr | 33000.00 | 1010.00 | 1019.18 | 1016.50 | 1020.06 | 0.003256 | 7.53 | 4383.75 | 651.99 | 0.51 |
| Reach-1 | 28.673 | 100yr | 33000.00 | 1007.30 | 1018.24 | 1014.35 | 1019.15 | 0.002214 | 7.72 | 4516.11 | 555.30 | 0.44 |
| Reach-1 | 28.647 | 100yr | 33000.00 | 1006.20 | 1017.99 | 1013.31 | 1018.85 | 0.001803 | 7.44 | 4481.56 | 465.92 | 0.41 |
| Reach-1 | 28.63 | 100yr | 33000.00 | 1005.60 | 1017.23 | 1013.29 | 1018.49 | 0.002871 | 9.02 | 3660.15 | 373.07 | 0.51 |
| Reach-1 | 28.626 | 100yr | 33000.00 | 1005.40 | 1017.09 | 1013.06 | 1018.40 | 0.002800 | 9.18 | 3594.54 | 349.13 | 0.50 |
| Reach-1 | 28.617 | | Bridge | | | | | | | | | |
| Reach-1 | 28.610 | 100yr | 33000.00 | 1005.00 | 1015.28 | 1013.61 | 1017.57 | 0.006493 | 12.13 | 2721.11 | 318.75 | 0.73 |
| Reach-1 | 28.608 | 100yr | 33000.00 | 1005.00 | 1015.28 | 1014.21 | 1017.56 | 0.008124 | 12.15 | 2736.49 | 373.00 | 0.79 |
| Reach-1 | 28.606 | 100yr | 33000.00 | 1004.90 | 1015.29 | 1013.81 | 1017.32 | 0.006773 | 11.46 | 2918.43 | 379.00 | 0.73 |
| Reach-1 | 28.604 | 100yr | 33000.00 | 1004.80 | 1015.27 | 1013.55 | 1017.16 | 0.006161 | 11.10 | 3028.83 | 385.00 | 0.70 |
| Reach-1 | 28.602 | 100yr | 33000.00 | 1004.70 | 1013.52 | 1013.52 | 1016.58 | 0.014065 | 14.16 | 2383.33 | 391.00 | 1.02 |
| Reach-1 | 28.6 | 100yr | 33000.00 | 1004.60 | 1013.38 | 1013.27 | 1016.31 | 0.013357 | 13.88 | 2439.56 | 397.00 | 0.99 |
| Reach-1 | 28.597 | 100yr | 33000.00 | 1004.20 | 1013.65 | 1011.75 | 1015.65 | 0.005597 | 11.48 | 2985.02 | 359.23 | 0.70 |
| Reach-1 | 28.595 | 100yr | 33000.00 | 1004.10 | 1013.59 | 1011.65 | 1015.57 | 0.005512 | 11.42 | 2999.57 | 359.43 | 0.69 |
| Reach-1 | 28.59 | 100yr | 33000.00 | 1004.00 | 1013.37 | 1011.55 | 1015.41 | 0.005752 | 11.58 | 2959.12 | 358.87 | 0.71 |
| Reach-1 | 28.58 | 100yr | 33000.00 | 1004.00 | 1013.21 | 1011.11 | 1015.01 | 0.004741 | 10.86 | 3203.66 | 414.82 | 0.65 |
| Reach-1 | 28.57 | 100yr | 36500.00 | 1003.70 | 1012.60 | 1011.08 | 1014.64 | 0.005922 | 11.56 | 3312.57 | 446.00 | 0.71 |
| Reach-1 | 28.55 | 100yr | 36500.00 | 1003.10 | 1012.17 | 1010.31 | 1013.89 | 0.005260 | 10.55 | 3523.03 | 484.69 | 0.66 |
| Reach-1 | 28.53 | 100yr | 36500.00 | 1002.50 | 1011.21 | 1010.29 | 1013.11 | 0.007996 | 11.07 | 3298.01 | 538.62 | 0.79 |
| Reach-1 | 28.49 | 100yr | 36500.00 | 1001.50 | 1010.06 | 1008.46 | 1011.66 | 0.005396 | 10.25 | 3752.26 | 555.18 | 0.67 |
| Reach-1 | 28.43 | 100yr | 36500.00 | 999.70 | 1007.82 | 1006.96 | 1009.77 | 0.007633 | 11.31 | 3477.09 | 672.82 | 0.78 |
| Reach-1 | 28.38 | 100yr | 36500.00 | 998.00 | 1006.27 | 1004.80 | 1007.86 | 0.005885 | 10.18 | 3806.98 | 731.27 | 0.69 |
| Reach-1 | 28.3 | 100yr | 36500.00 | 996.00 | 1003.32 | 1002.34 | 1004.96 | 0.007384 | 10.31 | 3632.37 | 731.41 | 0.75 |

# Attachment 3 – Engineering "No Rise" Certificate

NATIONAL FLOOD INSURANCE PROGRAM
ENGINEERING "NO-RISE" CERTIFICATE

## SITE INFORMATION

| | | | |
|---|---|---|---|
| Community | San Bernardino Associated Governments (SANBAG) | County | San Bernardino County |
| Applicant | SANBAG | Date | 08/30/12 |
| Address | 1170 W. 3rd St, San Bernardino, CA 92410 | Engineer | Mark Seits, P.E., HDR Engineering, Inc. |
| | | Address | 8690 Balboa Ave, Suite 200, San Diego, CA 92123 |
| Telephone | 909-884-8276 | Telephone | 858-712-8312 |
| Site Address/ Location | Santa Ana River Bridge 3.4<br>N34.07515 and W117.2721, California Coordinate System 1983 (ft), Zone 5 | Township | |
| | | Section | |

## PROJECT INFORMATION

Description of Development: New bridge development with ties, subgrade and rails.

Type of Development: Filling ___ Grading _X_ Excavation _X__ Minor Improv ___
Substantial Improv _X_ New Construction ___ Other ___

## FLOOD INSURANCE RATE MAP (FIRM) INFORMATION

NFIP map(s) and panel(s) affected: FIRM Map Number- 06071C8684H
Effective date of map: August 28, 2008
Base Flood Elevation (feet): Existing 1017.19; Proposed 1017.12
Name of flooding source: Santa Ana River

## CERTIFICATION

This is to certify that I am a duly qualified Professional Engineer licensed to practice in the State of California. I further certify that the attached engineering data supports the fact the proposed development in the floodway described above will not create any increase in the base flood elevations (100-year flood), floodway elevations and the floodway widths on Santa Ana River at published cross sections listed in the Flood Insurance Study for the above community dated August 28, 2008 and will not create any increase to the base flood elevations (100-year flood), floodway elevations and the floodway widths at unpublished cross-section in the vicinity of the proposed development.

Mark Seits, P.E.
CERTIFIER'S NAME
HDR Engineering, Inc.
COMPANY NAME

SIGNATURE

CA 41103
LICENSE NUMBER

August 30, 2012
DATE

REGISTERED PROFESSIONAL ENGINEER
MARK H. SEITS
41103
EXP. 3-31-13
CIVIL
STATE OF CALIFORNIA

# Attachment 4 – Digital Information (CD)

## SANBAG Redlands Passenger Rail Project

Job Name: Hydraulic Impact Analysis – Mission Zanja Creek and Mill Creek Zanja
Job Number: 170063
Client: SANBAG
Consultant: HDR Engineering, Inc.

This report and the analysis and design calculations contained herein have been prepared under the supervision of the following Registered Civil Engineer:

_______________________________________ August 2012

Mark Seits, P.E.
CA 41103 Date

# Table of Contents



# List of Attachments

# List of Tables



# List of Figures



# List of Exhibits

# 1. Purpose

The rail from historic Warm Creek (that portion of Warm Creek that was not combined with East Twin Creek and Warm Creek Improvements) to Mill Creek Zanja is proposed to be improved as part of the Redlands Passenger Rail Project (RPRP) (see Exhibit 1). This report covers the hydraulic impact analysis for the railroad from Mission Zanja Creek. Mill Creek Zanja is not evaluated in this report due to the limited impacts of the proposed project. The improvements are proposed to reconstruct the rail from its existing freight-only operation to current standards as required for regular passenger rail operations. As part of this project, recommendations are being provided to assist in this process including hydraulic analysis.

The purpose of the hydraulic modeling is to: (1) analyze the existing hydraulic condition of the Mission Zanja Creek, considering updated site conditions; and (2) evaluate the hydraulic impact on the railroad.

# 2. Background

The RPRP will design a double-track alignment for passenger and freight service from the proposed San Bernardino Transit Center east to the University of Redlands. The Redlands Corridor Strategic Plan (RCSP) was developed by San Bernardino Associated Governments (SANBAG) to address the transportation needs of the Redlands Corridor, assess the capability of transit service and multimodal improvements to meet mobility needs, and describe a course of action to implement transit service in the Redlands Corridor in a cost-effective manner. The first phase of the RCSP calls for the development of a passenger rail service operating between the San Bernardino Transit Center and the University of Redlands, a distance of approximately nine miles. Exhibit 1 shows the overall project.

Mission Zanja Creek, also known as Mill Creek Zanja, Mission Storm Drain, and The Zanja, is one drainage course with different names in different locations and drains an approximately 27-square-mile (17,510-acre) watershed. The area served by this system can be generally described as a drainage basin starting at Zanja Peak in the Crafton Hills area and extending westward for approximately 12 miles to Tippecanoe Avenue near the Santa Ana River. In the north-south direction, the basin generally lies between State Highway 38 and the San Bernardino/Riverside County line. The basin slopes westward, varying from steep mountainous slopes in the southeast to mild alluvial slopes in the northwest portion. Mission Zanja, as a drainage channel, was built in 1819 to transport irrigation water from Mill Creek to the San Bernardino Asistencia and surrounding orchards. The channel has essentially maintained its historical alignment, but its use has evolved from a water supply ditch to a main storm water drainage facility (Mission Zanja Creek Area Drainage Plan 1991).

Due to urbanization and limited improvements along the Mission Zanja Creek, runoff from even small storms (i.e., less than 5-year events) has the potential to exceed existing channel capacity, resulting in overflow and flooding of the surrounding areas. Mission Zanja Channel at the Gage Canal, Tippecanoe, and Bryn Mawr crossings are the areas that have experienced the most problems. The channel has experienced significant flooding and scour issues. Flooding from Mission Zanja Channel has resulted in the past from either debris obstruction in the channel or stream discharges that have exceeded channel or culvert capacity. The San Bernardino County Flood Control District and

City of Redlands have been working on addressing the flooding issues. The flooding could significantly impact the operation of the railroad tracks which are adjacent to the channel. The Gage Canal crossing hydraulic impact was evaluated in a separate report.

Mission Zanja Channel and Mill Creek Zanja are shown in FEMA Flood insurance Rate Map (FIRM) 06071C8684H, 8703H, 8704H, 8711H, 8712H and 8716H. FEMA has used the name "The Zanja" for the channel upstream of the confluence with Morey Wash, "The Mission Zanja Channel" downstream of the confluence with Morey Wash, and "Zanja Creek" downstream of Richardson Street in the City of Loma Linda. Although the FEMA map panels designate the Zanja, the Mission Zanja Channel, and Zanja Creek as Zone A, 1% Annual Chance Flood Discharge Contained in Channel, this is apparently a misstatement as there is ample discussion in the FIS that the channel is subject to overflow and breakout discharges because of lack of capacity for the 1% annual event in the channel and particular bridge crossings. The AT&SF Railroad crosses the creek at a number of locations, runs alongside the creek in other areas, or is sometimes separated some distance from the creek but either within or outside the overflow flood areas. The overflow flood areas are shown on the FEMA map panels as shallow flood hazard Zone AO areas with flood depth ranging from 1 to 3 feet. Zone AO is the area with a 1% or greater chance of shallow flooding. Average flood depths derived from detailed analyses are shown within the zone. See Exhibit 5 for FEMA FIRMs.

For the purpose of this report, the Mission Zanja Channel and Mill Creek Zanja are divided into three reaches. The reach limits are shown in Table 1. Exhibit 1 shows the limits for each reach graphically.

**Table 1: Reach Limits**

| Reach Name | Limits |
|---|---|
| Lower Mission Zanja Channel | Santa Ana River confluence to 2000' east of Bryn Mawr |
| Upper Mission Zanja Channel | 2000' east of Bryn Mawr to I-10 Crossing (East of Church Street) |
| Mill Creek Zanja | I-10 crossing (East of Church Street) to Ford Street (Judson Street) |

**Lower Mission Zanja Channel**: The railroad is parallel to the Mission Zanja Channel from the Santa Ana River to approximately 1,600 feet east of Bryn Mawr. The channel is labeled Zone A (with no overbank flooding shown) on the FEMA map panels from the Santa Ana confluence to I-10 (approximately 500 feet west of Bryn Mawr). There is an overbank flooding area Zone AO with a 1-foot depth upstream of that. A detailed study is not available. A hydraulic model was developed for this reach; detailed analyses can be found in Section 5 of this report.

**Upper Mission Zanja Channel**: The reach flows from east to west from the Interstate 10 (I-10) (east of Church St) crossing to New Jersey Street, then flows northwest from New Jersey Street to California Street. The channel does not hydraulically impact the railroad for most portions of the reach, except at the east end. The railroad track is not in the floodplain from approximately 2,000 feet east of Bryn Mawr to New York Street. The railroad track is in Zone AO with 1 to 2 feet depth from New York Street to I-10 crossing.

**Mill Creek Zanja**: The railroad track is in Zone AO with 1 to 3 feet depth in this reach.

Due to the limited impacts on the Upper Mission Zanja Channel and Mill Creek Zanja, only the impacts within the Lower Mission Zanja Channel are included in this study.

## 3. Flood History

Floods inundate portions of the City of Redlands almost every year. From a 1984 USACE report discussion in the FEMA FIS: Records show that 23 medium-to-large floods have occurred since construction of Mission Zanja in 1819. Most recently (before 1984), floods have occurred in January and February 1969, in September 1976, and in 1978. On September 24, 1976, an intense local thunderstorm dropped 3.5 inches of rain in a 20- to 30-minute period. This heavy rain produced an extremely high rate of runoff that quickly exceeded the capacity of local drainage systems. Major overflows occurred on the eastern edge of the downtown business district, flooding the area, and depositing mud up to 3 feet deep. Damages to houses, businesses, roads, and flood-control facilities reached $2 million (FEMA FIS).

## 4. Hydrology – Lower Mission Zanja Channel

Available literature has been reviewed to determine the hydrology for lower Mission Zanja Channel. The literature shows the following flowrate discrepancies.

- Per email dated January 24, 2012 from Roy King at Caltrans, the 100-year flowrate at I-10 bridge (west of Bryn Mawr) is 7,200 cubic feet per second (cfs).
- Per I-10 HOV Concept Drainage Report, the 100-year flowrate at I-10 bridge (west of Bryn Mawr) is 7,608 cfs.
- Per Mission Zanja Creek Channel Improvement Study (1987), the existing channel capacity is 4,000 cfs at I-10 bridge (west of Bryn Mawr). Table 2 shows the capacities in Mission Zanja Channel from the study.
- Table 3 shows the flowrates of the Zanja from the FEMA FIS. It shows approximately 6,100 cfs at the I-10 bridge (west of Bryn Mawr). The FEMA FIS also tabulates flow rates for Mission Zanja Creek and shows 5,100 cfs upstream of Interstate Highway 10. It is not clear why there are two discharge listings for the creek in this area.
- Comprehensive Storm Drain Plans (CSDP) 4 flowrates at crossings are shown in Table 4. It shows the flowrate of 7,607 cfs at the I-10 bridge (west of Bryn Mawr).

**Table 2: Existing Mission Zanja Channel Capacity**

| From | To | Channel Length (ft) | Size (WxH), ft | Capacity (cfs) |
|---|---|---|---|---|
| Santa Ana River | Tippecanoe | 3,880 | 40x5 | 3,000 |
| Tippecanoe | Richardson | 2,156 | 30x10 | 3,500 |
| Richardson | Mountain View | 2,838 | 30x10 | 4,000 |
| Mountain View | I-10 Freeway | 2,323 | 30x10 | 4,000 |
| I-10 Freeway | Bryn Mawr | 698 | 30x10 | 4,000 |

**Table 3: FEMA FIS Flowrates**

| The Zanja | Drainage Area (sq. miles) | Peak Discharge (cfs) 10 Percent | 2 Percent | 1 Percent | 0.2 Percent |
|---|---|---|---|---|---|
| At confluence with Santa Ana River | 25.23 | 1,450 | 3,500 | 4,050 | 5,900 |
| Downstream of Bryn Mawr | 21.4 | 1,400 | 4,100 | 6,100* | 14,500 |
| *- Overland flow | | | | | |

**Table 4: CSDP 4 Flowrates**

| Crossing | 100-year Flowrate (cfs) |
|---|---|
| Bryn Mawr | 7555 |
| I-10 | 7607 |
| Mountain View | 7952 |
| Richardson | 7952 |
| Tippecanoe | 7952 |
| Santa Ana River | 7952 |

According to the FIS, the I-10 bridge downstream of Bryn Mawr limits the flow in the Mission Zanja Channel (The Zanja) to 3,000 cfs. The remaining 3,100 cfs for the 1 percent annual chance flood are diverted from Mission Zanja Channel to the west along the south side of I-10. This breakout is in the City of Lorna Linda. Bryn Mawr Avenue has a 25-foot-wide culvert that has restricted discharge capacity of the channel to a 2 percent annual chance frequency flood. Shallow flooding less than 1-foot deep occurs along this reach. This overflow joins the San Timoteo Creek overflow downstream of the corporate limits (FEMA 2008).

Taking into consideration the discrepancies reported in 100-year discharge, a range of flowrates were analyzed in this study to determine the existing channel capacity.

# 5. Hydraulic Modeling – Lower Mission Zanja Channel

## 5.1 Modeling Overview

Hydraulic modeling was conducted using the USACE HEC-RAS (v.4.1) program. Existing FEMA effective modeling was not available for Mission Zanja Creek. Therefore, channel geometry was generated based on the topographic map by using HEC-GeoRAS program (v.4.1.1), an extension for support of HEC-RAS using ArcGIS. The model is based on the current topographic map which was flown in 2011 for RPRP. The horizontal control is based on North American Datum (NAD) 1983 and the vertical control is based on North American Vertical Datum (NAVD )1988.

Mission Zanja Channel is an excavated trapezoidal earthen channel with soft bottom and grouted riprap on the slope. The Lower Mission Zanja Channel was modeled from Santa Ana River confluence to approximately 700 feet west of California St. The model is based on the topographic data provided by Project Design Consultants (PDC). In addition, PDC surveyed bridge crossings in the Lower Mission Zanja Channel. Bridge geometries in the model were based on the survey data.

The 1-foot topographic data were used to create a TIN surface within GIS program, with cross section geometry subsequently cut using the GeoRas Program. An approximate centerline was laid out along the channel. Cross sections were cut perpendicular to the channel centerline. The cross section interval is approximately 100 feet to 200 feet. Additional cross sections were added at bridge locations. There are limitations in accuracy cutting channel cross sections from topographic map compared with survey or as-built source. It can not capture the actual trapezoidal channel from the topographic data without points at the breaklines in slope. Exhibit 2 shows the modeling limits and cross section locations.

There are five bridges in this reach: Tippecanoe Avenue, Richardson Street, Mountain View Avenue, I-10 bridge, and Bryn Mawr. The bridges are modeled in the HEC-RAS model.

## 5.2 Flowrate

A range of flows (1000 to 6000 cfs) has been analyzed to evaluate the existing channel capacity and evaluate potential solutions to the identified problems. One additional flow of 7,600 cfs was also included.

## 5.3 Model Inputs

The HEC-RAS model was developed based on the available topographic data. This model is used to address the impact of the existing channel capacity and hydraulic impact on the railroad.

- Manning's *n* values were based on the aerial imagery, site photos, and site investigations.
- Ineffective flow areas were added to cross sections, as needed, to reflect restrictions in conveyance.
- Bridges were modeled using the Highest Energy Answer from Energy, Momentum and Yarnell equation for low flow and the pressure/weir option for high flow.
- Normal depth was used for the downstream boundary condition.
- The model was run under subcritical flow conditions.
- The bridge structure information was obtained based on survey (PDC 2012). The photos of the structures are available in the photo log.
- After reviewing the initial model, the channel capacity was determined to be below the 100-year flow. Two lateral weirs were used in the model where the capacity is well below the modeled flow rate to allow the flow to spill outside of the channel. One is from upstream end of the model to the I-10 bridge and the other is from Tippecanoe to Santa Ana River.

## 5.4 Model Results

The existing channel capacity, velocity and depth over the existing top of rail were evaluated based on a range of flows. The locations of flow restriction were identified. Figure 1 shows the lower Mission Zanja Channel profile. Attachment 1 shows the model profile and cross sections. Attachment 2 shows the model results from 1000 to 6000 cfs.

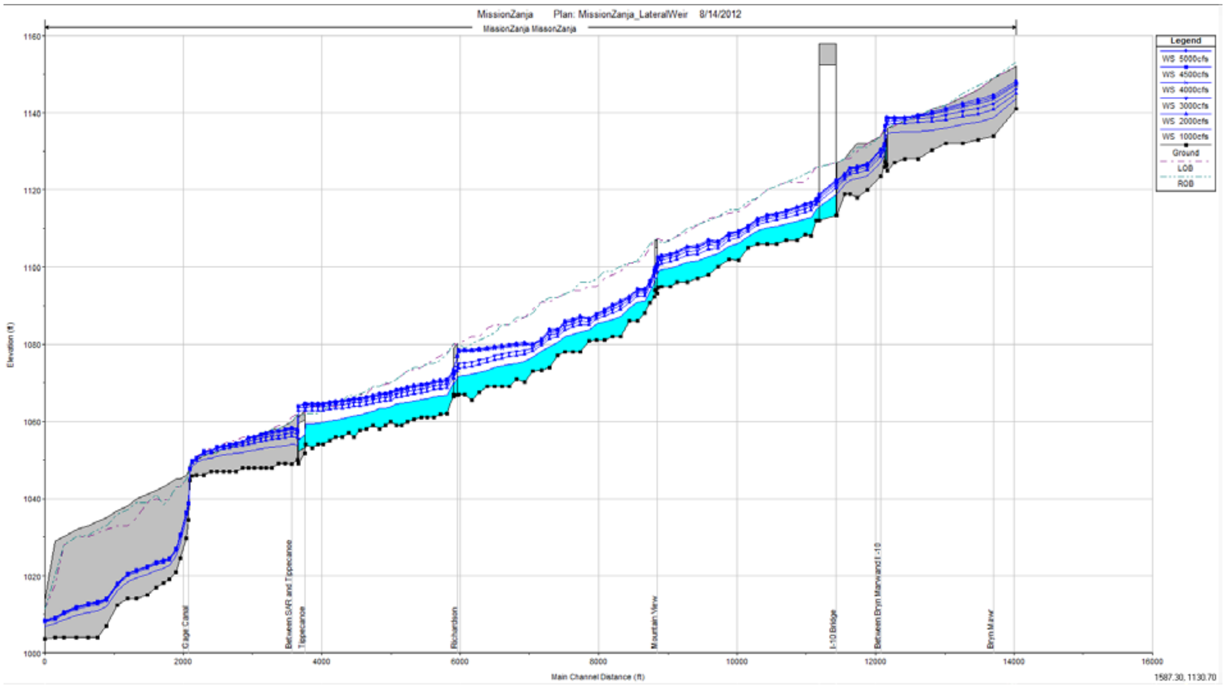



**Figure 1: Lower Mission Zanja Channel Profile**

### 5.4.1 Channel Capacity

Both the channel and bridge structure capacities were analyzed. Table 5 and Exhibit 3 show the channel capacity and corresponding return period and Table 6 shows the bridge structure capacity. Channel and structure capacities were calculated based on HEC-RAS model iterations with various flowrates until the channel/structure capacity is reached or no longer exceeded (i.e. flow up to but within the channel banks).

**Table 5: Channel Capacity**

| Channel | Flowrates (cfs) | Estimated Return Period |
|---|---|---|
| Downstream of California Street to Bryn Mawr | 1450 | <2 year |
| Bryn Mawr to I-10 | 7600 | 100 year |
| I-10 to Mountain View | 6000 | 25 year |
| Mountain View to Richardson | >4000 | <5 year |
| Richardson to Tippecanoe | 1780 | <2 year |
| Tippecanoe to Gage Canal | 1450 | <2 year |
| Gage Canal to Santa Ana River | >5000 | 8 year |

**Table 6: Structure Capacity**

| Crossing | Flowrates (cfs) |
|---|---|
| Bryn Mawr Bridge | 1450 |
| I-10 Bridge | 7600 |
| Mountain View Bridge | 6000 |
| Richardson Bridge | 4000 |
| Tippecanoe Culvert | 1780 |
| Gage Canal | 1450 |

There is no stream gage data available to help determine flood-frequency information. The return period for discharges was estimated based on rainfall data, assuming the precipitation frequency is linear with discharge frequency. CSDP 4 flowrates were assumed to be the 100-year flowrates. The computed channel capacity was divided by the CSDP 4 flowrate to obtain a ratio. This ratio times the 100-year 1-hour rainfall was used to get the corresponding rainfall for the capacity flowrate. The "Rainfall depth vs. Return Period" chart in San Bernardino County Hydrology Manual (1986) was interpolated to obtain the return period.

The results indicate that the channel capacity is well below the assumed 100-year flow rate except for the portion between Bryn Mawr and I-10. The majority of the existing channel does not have enough capacity to convey the 100-year discharge. Bryn Mawr, Tippecanoe and Gage Canal crossings are the major restrictions to the flow. Water backed up at the upstream face of these crossings. The flow that exceeds the channel capacity will generally flow overland in the same direction as the creek. According to the FIS, overland flows, however, do not necessarily reenter the channels immediately as the channel capacity increases and, in some cases, may leave the system, such as in the reach between California Street and I-10 on The Zanja (east of Church Street).

### 5.4.2 Velocity

Table 7 and Exhibit 4 show the channel velocities for the range of flows. The flow velocities are high enough to cause scour. Table 8 shows the maximum water depth over the existing top of rail (TOR). The model used lateral weirs which has split flow condition. The model assumes the cross sections extend vertically if the flow is no not contained in the cross section. The hydraulic impact on the rails are localized due to the restriction at the structures. To minimize the depth over the existing TOR, the structures need to be improved.

**Table 7: Channel Velocity**

| Channel | Velocity (ft/s) | | | |
|---|---|---|---|---|
| | 2000 cfs | 3000 cfs | 4000 cfs | 5000 cfs |
| Downstream of California St to Bryn Mawr | 5-9 | 7-10 | 8-12 | 8-13 |
| Bryn Mawr to I-10 | 8-11 | 9-12 | 10-12 | 10-13 |
| I-10 to Mountain View | 8-10 | 9-11 | 9-12 | 10-12 |
| Mountain View to Richardson | 7-11 | 7-12 | 7-12 | 7-13 |
| Richardson to Tippecanoe | 5-8 | 6-9 | 6-10 | 7-10 |
| Tippecanoe to Gage Canal | 6-11 | 7-11 | 8-11 | 8-12 |
| Gage Canal to Santa Ana River | 7-11 | 8-11 | 8-12 | 8-12 |

**Table 8: Maximum Depth over Existing Top of Rail (TOR)**

| Channel | Maximum Depth over Existing TOR* (ft) | | | |
|---|---|---|---|---|
| | 2000 cfs | 3000 cfs | 4000 cfs | 5000 cfs |
| California St to Bryn Mawr | 3 | 3 | 4 | 4 |
| Bryn Mawr to I-10 | 0 | 0 | 0 | 0 |
| I-10 to Mountain View | 0 | 0 | 0 | 0 |
| Mountain View to Richardson | 0 | 0 | 0 | 0 |
| Richardson to Tippecanoe | 1 | 2 | 3 | 3 |
| Tippecanoe to Gage Canal | 3 | 3 | 4 | 4 |
| Gage Canal to Santa Ana River | 1 | 1 | 1 | 1 |
| *Existing Top of Rail is measured from the 1' contour. | | | | |

## 6. Conclusions

Using the data and resources available, the hydraulic conditions were modeled for existing lower Mission Zanja Channel. The results of the modeling indicate that the Mission Zanja Channel only has limited capacity. It does not have the capacity to convey the approximate 100-year flowrate of 7,600 cfs. The flooding at the bridge/culvert are localized due to the crossing restriction. The model results match the historical flooding issues. In the HOV report, it states " The City of Redlands is currently preparing a hydrology report and preliminary plans to improve the Zanja Channel. The improvements will include installing a detention basin upstream of the HOV project, upsizing the channel and adding storm drains in downstream Redlands." This could improve the flooding situation in the future.

## 7. Recommendations

Upstream detention basins have been proposed to alleviate downstream flooding problems. We understand that Opal Basin preliminary engineering analysis has been considered recently. It is recommended to coordinate with the City of Redlands regarding the upstream detention basin design and construction. The Mission Zanja Channel and Mill Creek Zanja need to be evaluated after the detention basin is in place.

Scour protection should be considered for the Lower Mission Zanja Channel. The rail needs to be closely monitored and maintained after each rainfall event. It is recommended to work with the San Bernardino County Flood Control District and City of Redlands to improve the under-capacity structures. The improvement will alleviate the local hydraulic impact on the rail before the upstream detention basin is constructed. Railroad may not need to be designed for the full 100-year flow since the 100-year flow can not be conveyed to this reach due to upstream channel constrictions.

## 8. References

City of Redlands, City of Loma Linda, and San Bernardino County. 1991.Mission Zanja Creek Area Drainage Plan.

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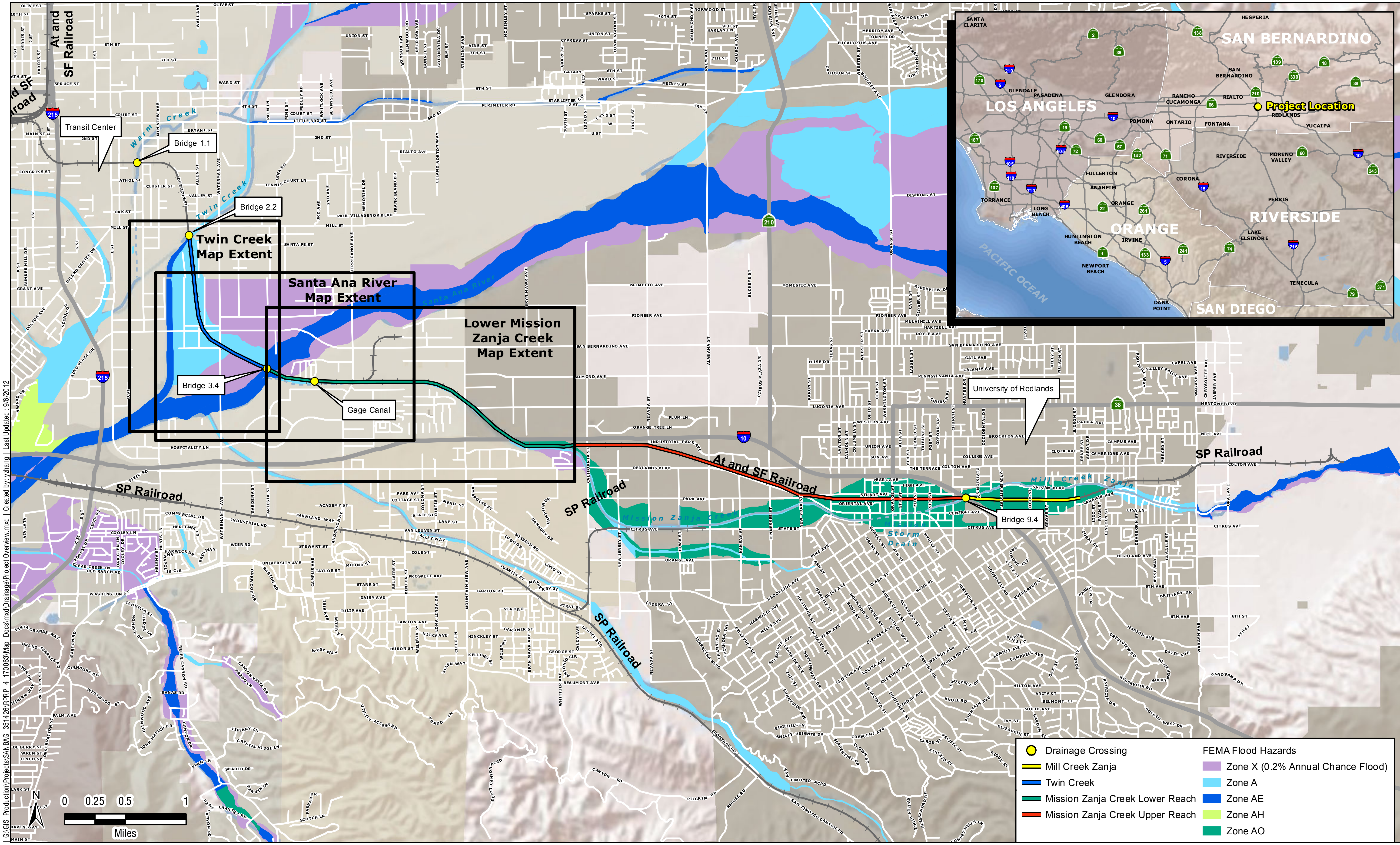


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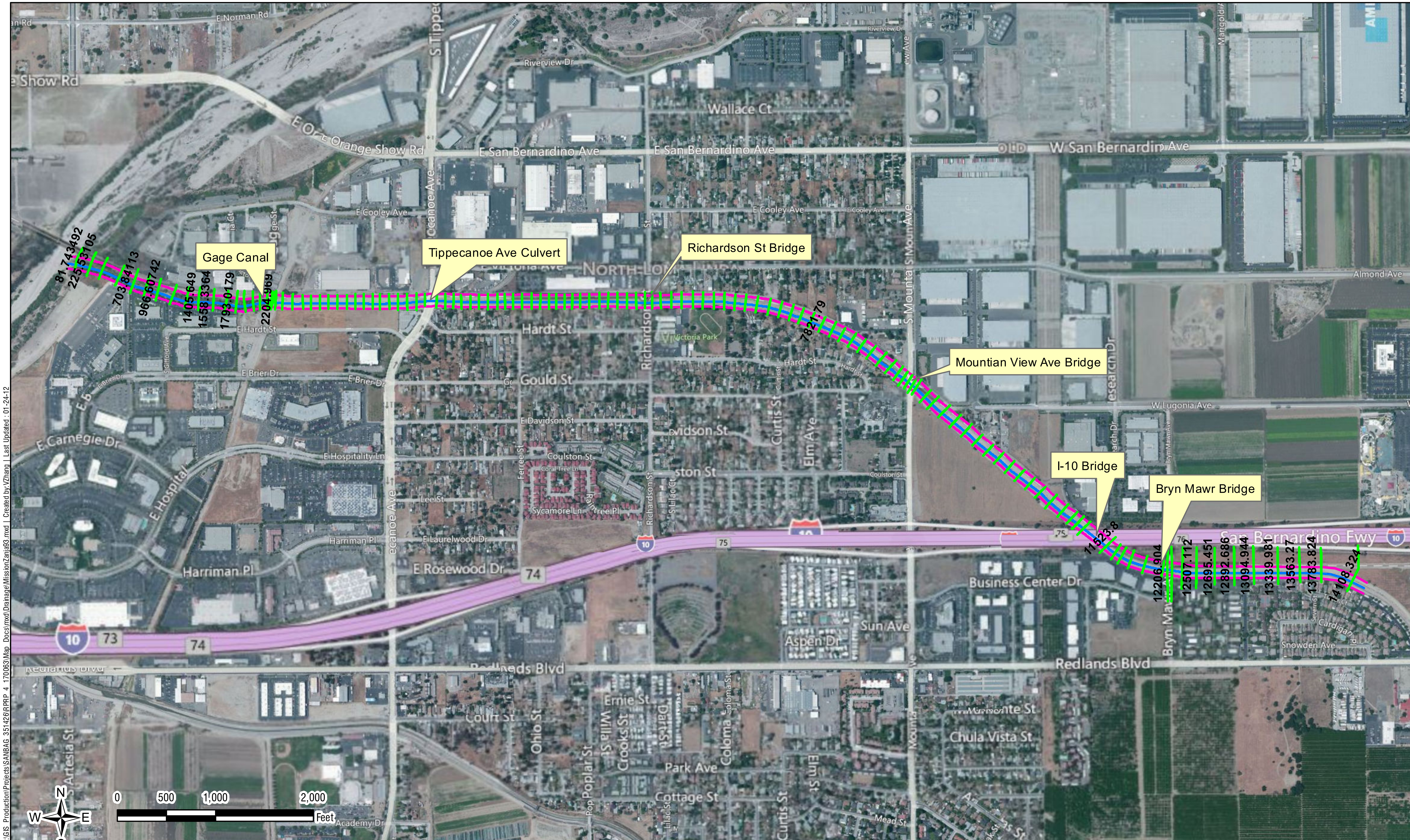
# Project Overview

**EXHIBIT 1**

SANBAG | Redlands Passenger Rail Project | Hydraulic Impact Report

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# Lower Mission Zanja Creek

**EXHIBIT 2**

SANBAG | Redlands Passenger Rail Project | Hydraulic Impact Report


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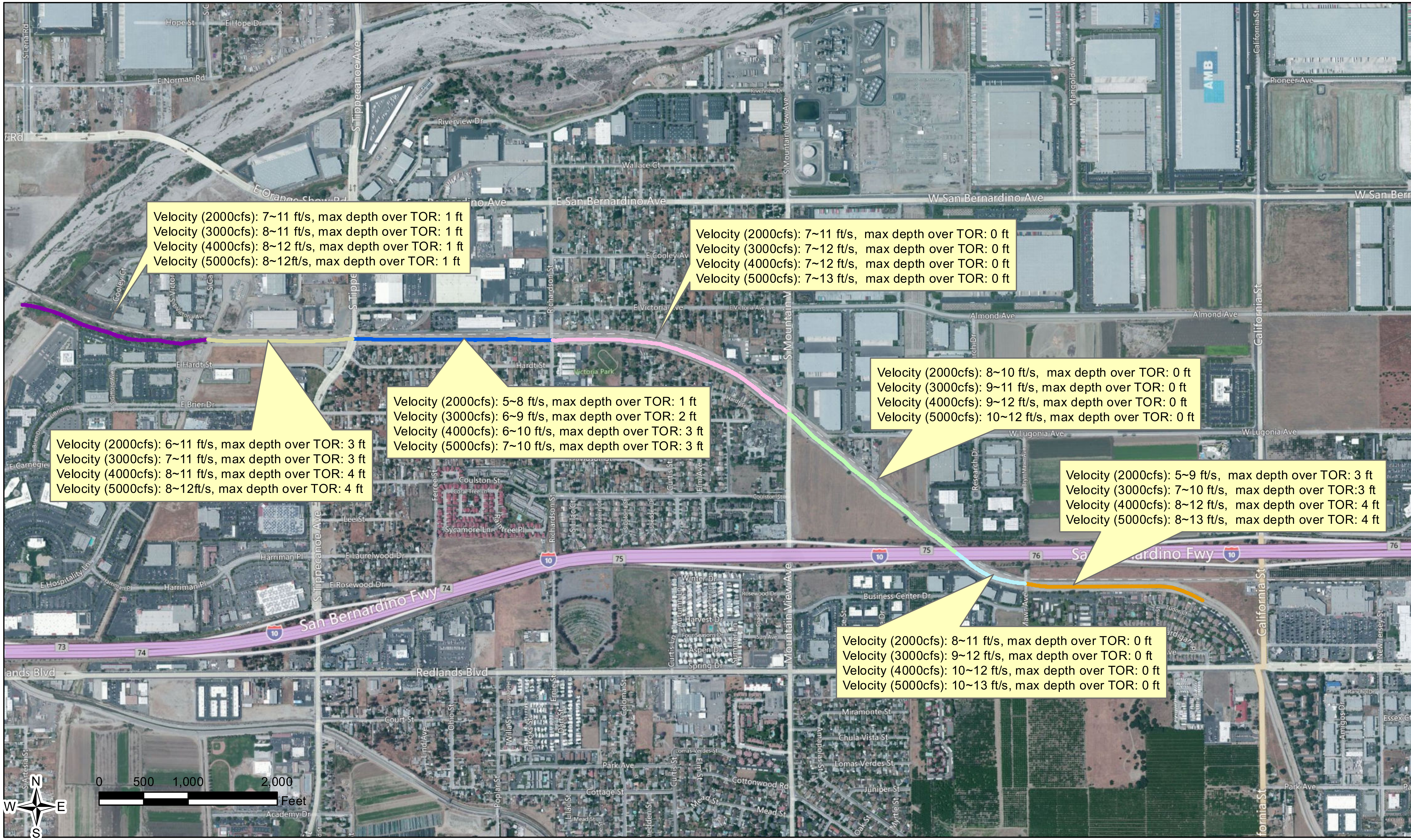
# Lower Mission Zanja Channel Capacity

**EXHIBIT 3**

SANBAG | Redlands Passenger Rail Project | Mission Zanja Channel Report

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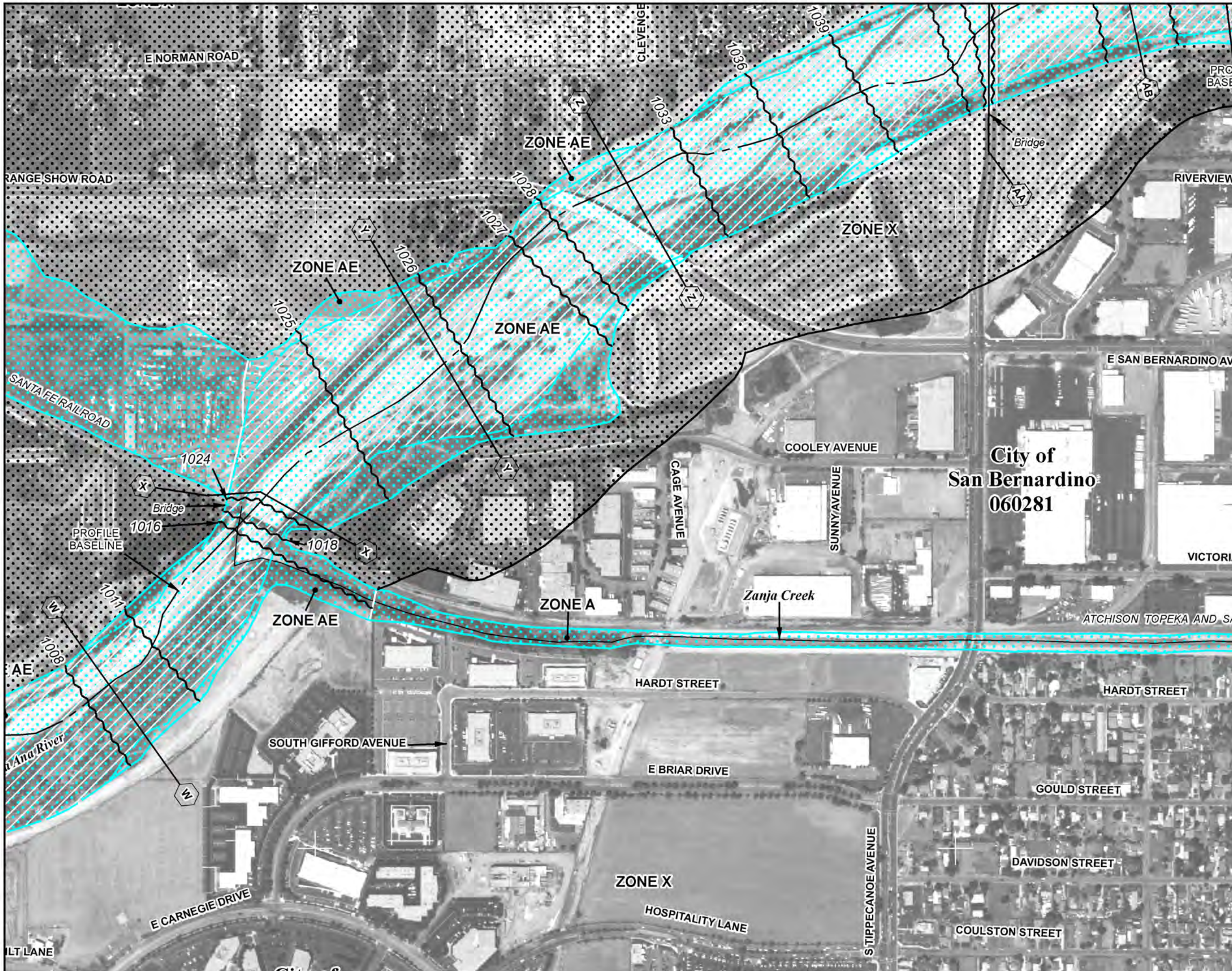
# Lower Mission Zanja Channel Velocity

**EXHIBIT 4**

SANBAG | Redlands Passenger Rail Project | Mission Zanja Channel Report

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MAP SCALE 1" = 500'

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METERS

PANEL 8684H

NATIONAL FLOOD INSURANCE PROGRAM

NFIP

# FIRM
## FLOOD INSURANCE RATE MAP

**SAN BERNARDINO COUNTY, CALIFORNIA**
AND INCORPORATED AREAS

**PANEL 8684 OF 9400**

(SEE MAP INDEX FOR FIRM PANEL LAYOUT)

CONTAINS:

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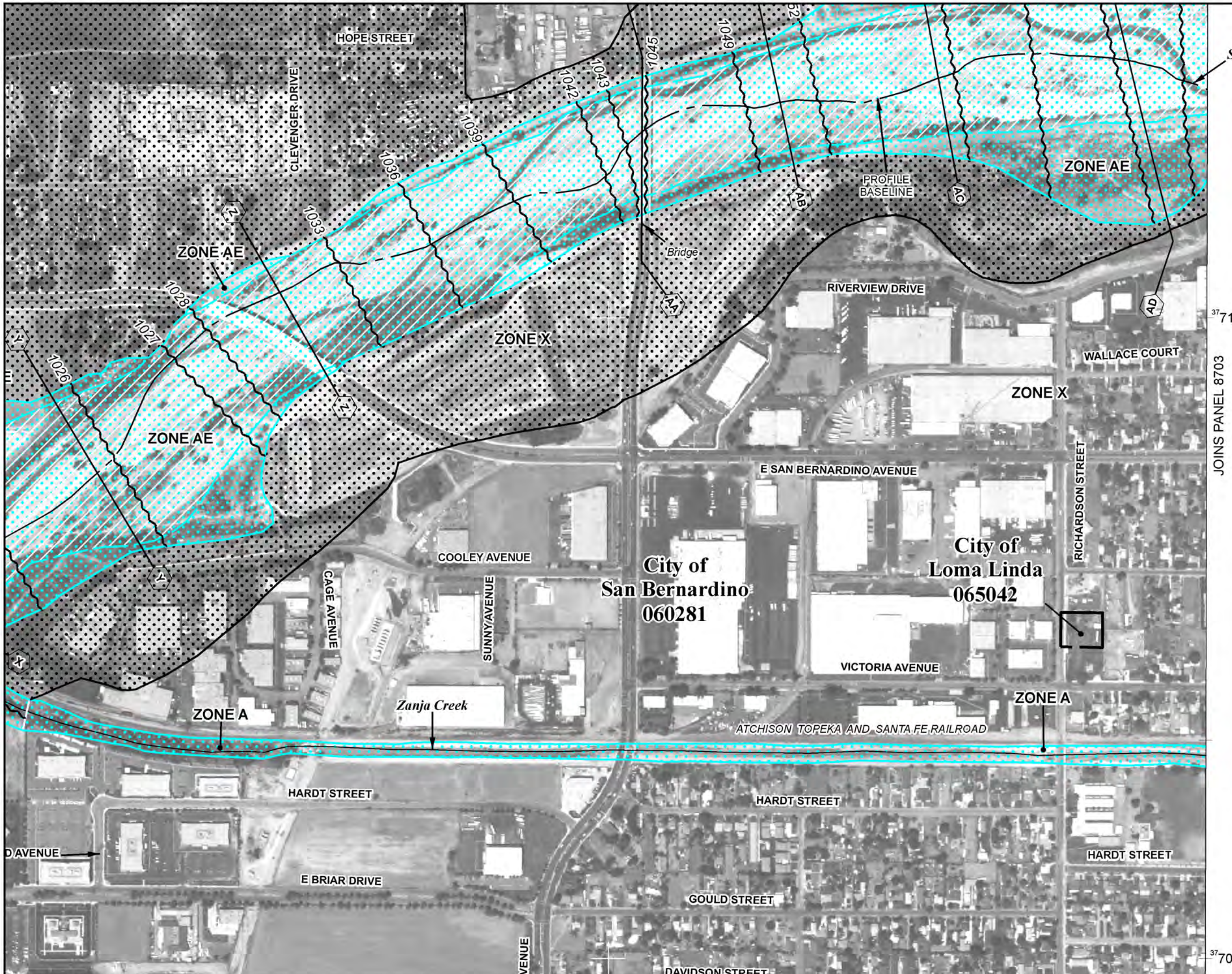


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PANEL 8684H

# FIRM

## FLOOD INSURANCE RATE MAP

**SAN BERNARDINO COUNTY, CALIFORNIA**
**AND INCORPORATED AREAS**

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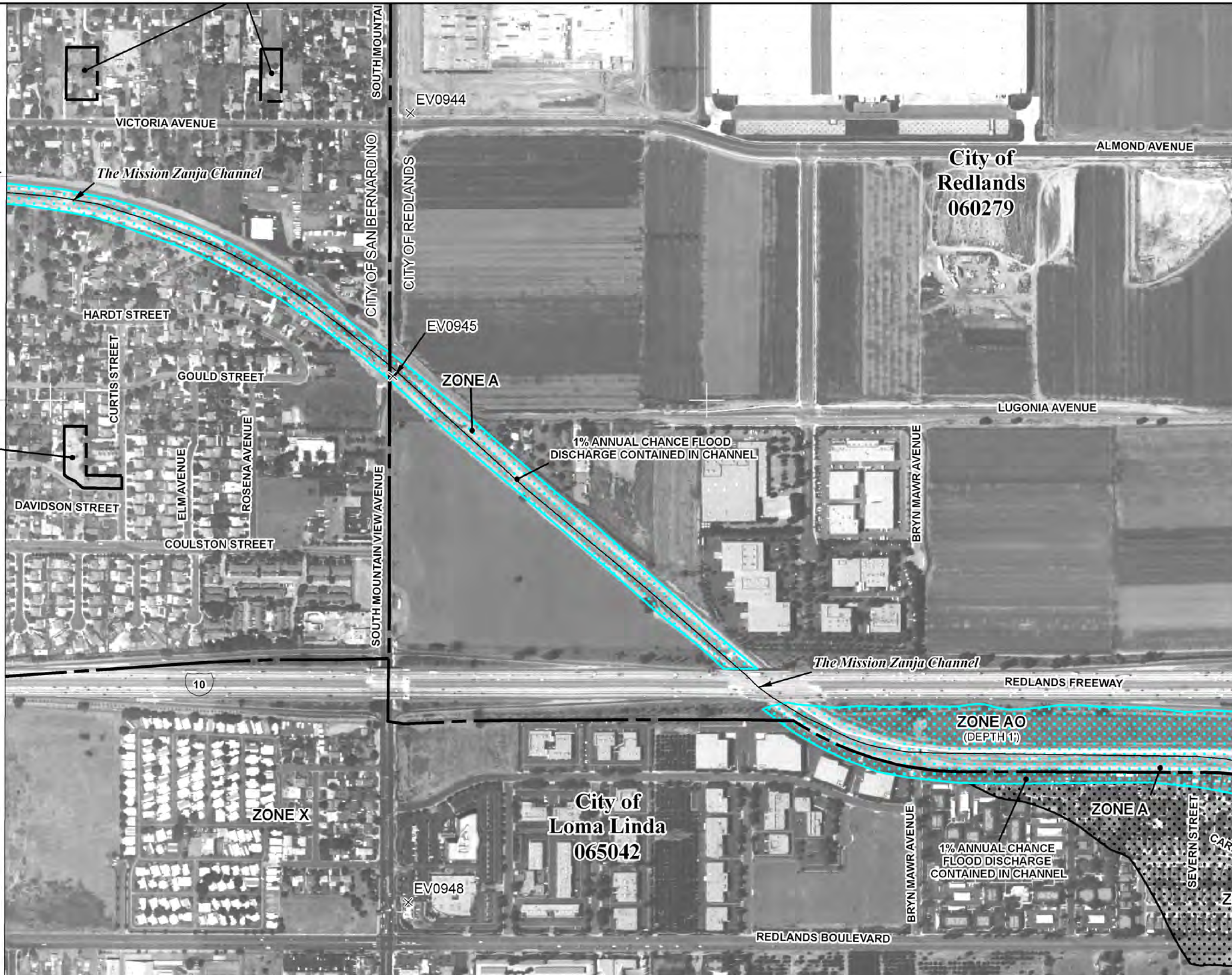


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NATIONAL FLOOD INSURANCE PROGRAM

PANEL 8703H

# FIRM
## FLOOD INSURANCE RATE MAP

SAN BERNARDINO COUNTY, CALIFORNIA
AND INCORPORATED AREAS

PANEL 8703 OF 9400

(SEE MAP INDEX FOR FIRM PANEL LAYOUT)

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| REDLANDS, CITY OF | 060279 | 8703 | H |
| SAN BERNARDINO COUNTY | 060270 | 8703 | H |
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MAP SCALE 1" = 500'

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NATIONAL FLOOD INSURANCE PROGRAM

PANEL 8703H

# FIRM
## FLOOD INSURANCE RATE MAP

SAN BERNARDINO COUNTY, CALIFORNIA
AND INCORPORATED AREAS

PANEL 8703 OF 9400

(SEE MAP INDEX FOR FIRM PANEL LAYOUT)

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| SAN BERNARDINO, CITY OF | 060281 | 8703 | H |

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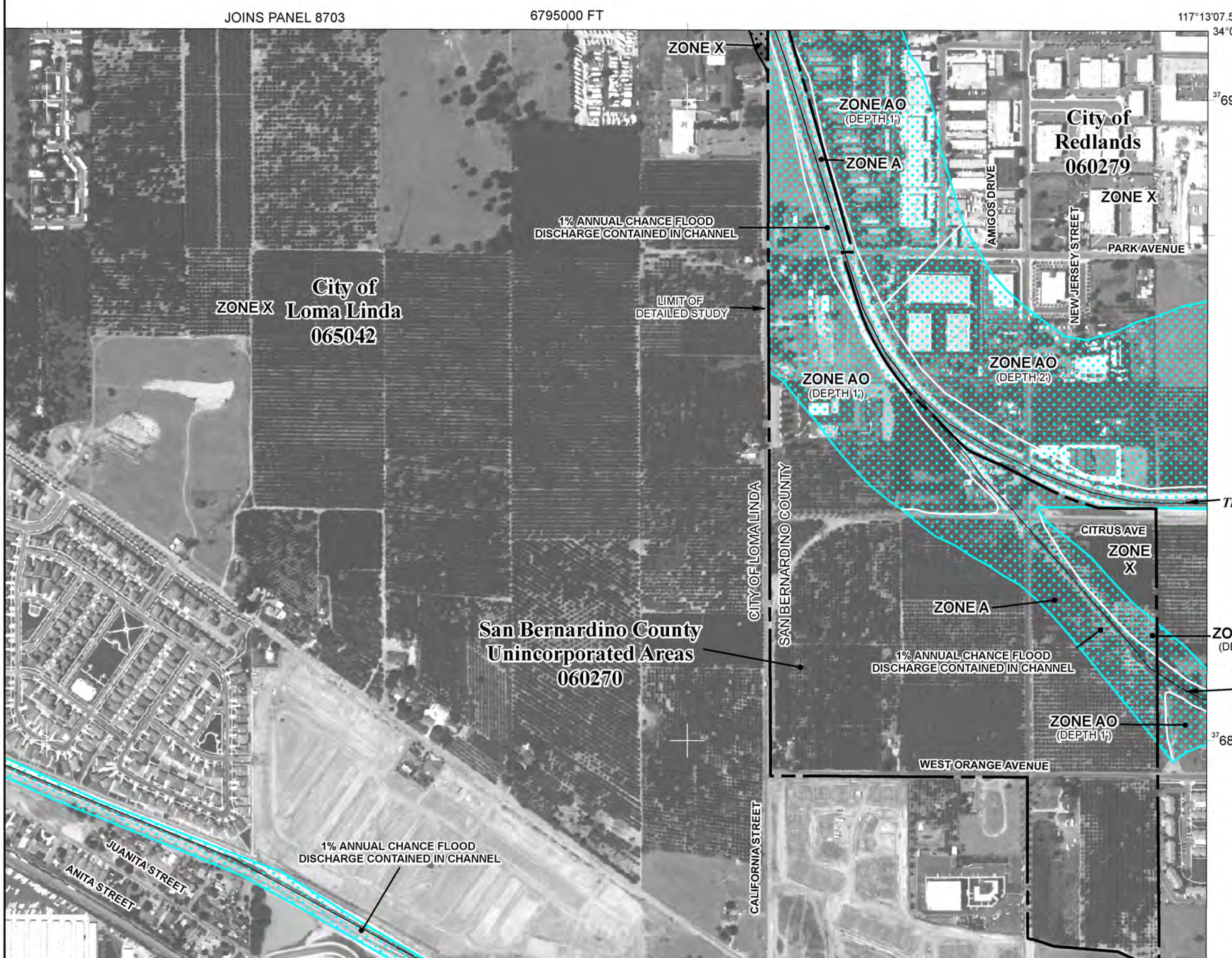


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NATIONAL FLOOD INSURANCE PROGRAM

PANEL 8711H

# FIRM
## FLOOD INSURANCE RATE MAP

SAN BERNARDINO COUNTY, CALIFORNIA
AND INCORPORATED AREAS

PANEL 8711 OF 9400

(SEE MAP INDEX FOR FIRM PANEL LAYOUT)

CONTAINS:

| COMMUNITY | NUMBER | PANEL | SUFFIX |
|---|---|---|---|
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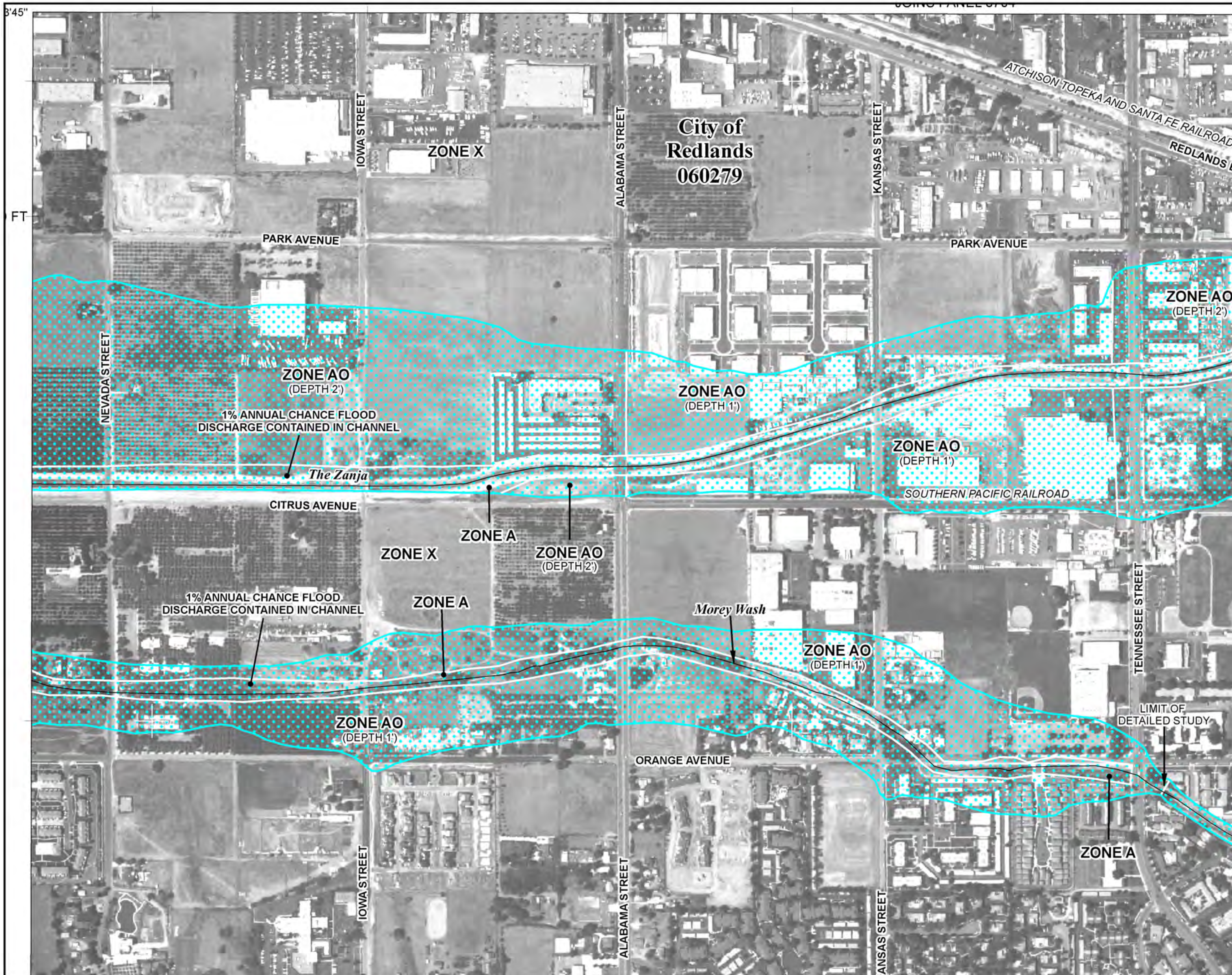


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PANEL 8712H

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NATIONAL FLOOD INSURANCE PROGRAM

# FIRM

## FLOOD INSURANCE RATE MAP

**SAN BERNARDINO COUNTY, CALIFORNIA**

**AND INCORPORATED AREAS**

**PANEL 8712 OF 9400**

(SEE MAP INDEX FOR FIRM PANEL LAYOUT)

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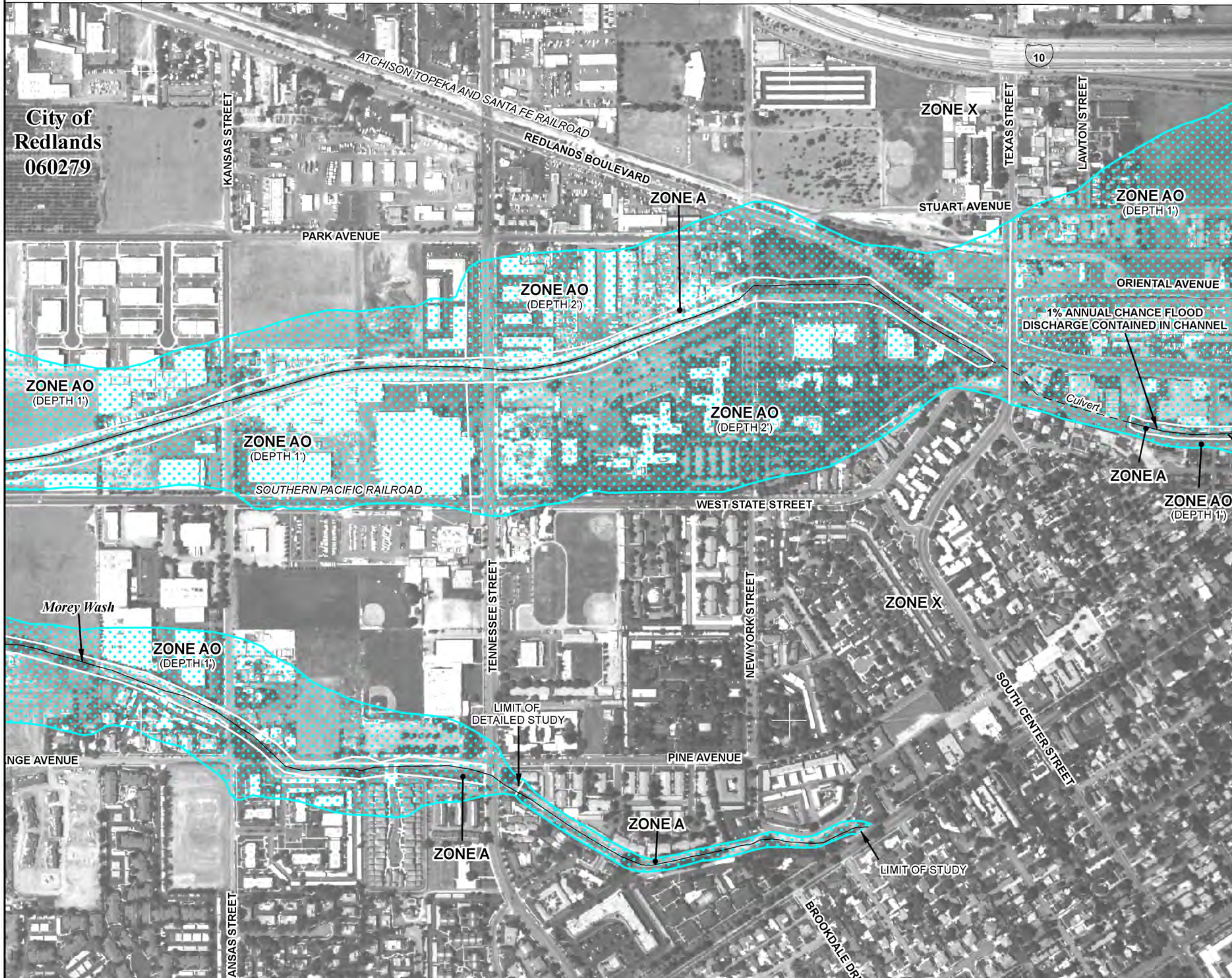


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NATIONAL FLOOD INSURANCE PROGRAM

PANEL 8712H

# FIRM

FLOOD INSURANCE RATE MAP

**SAN BERNARDINO COUNTY, CALIFORNIA**
**AND INCORPORATED AREAS**

**PANEL 8712 OF 9400**

(SEE MAP INDEX FOR FIRM PANEL LAYOUT)

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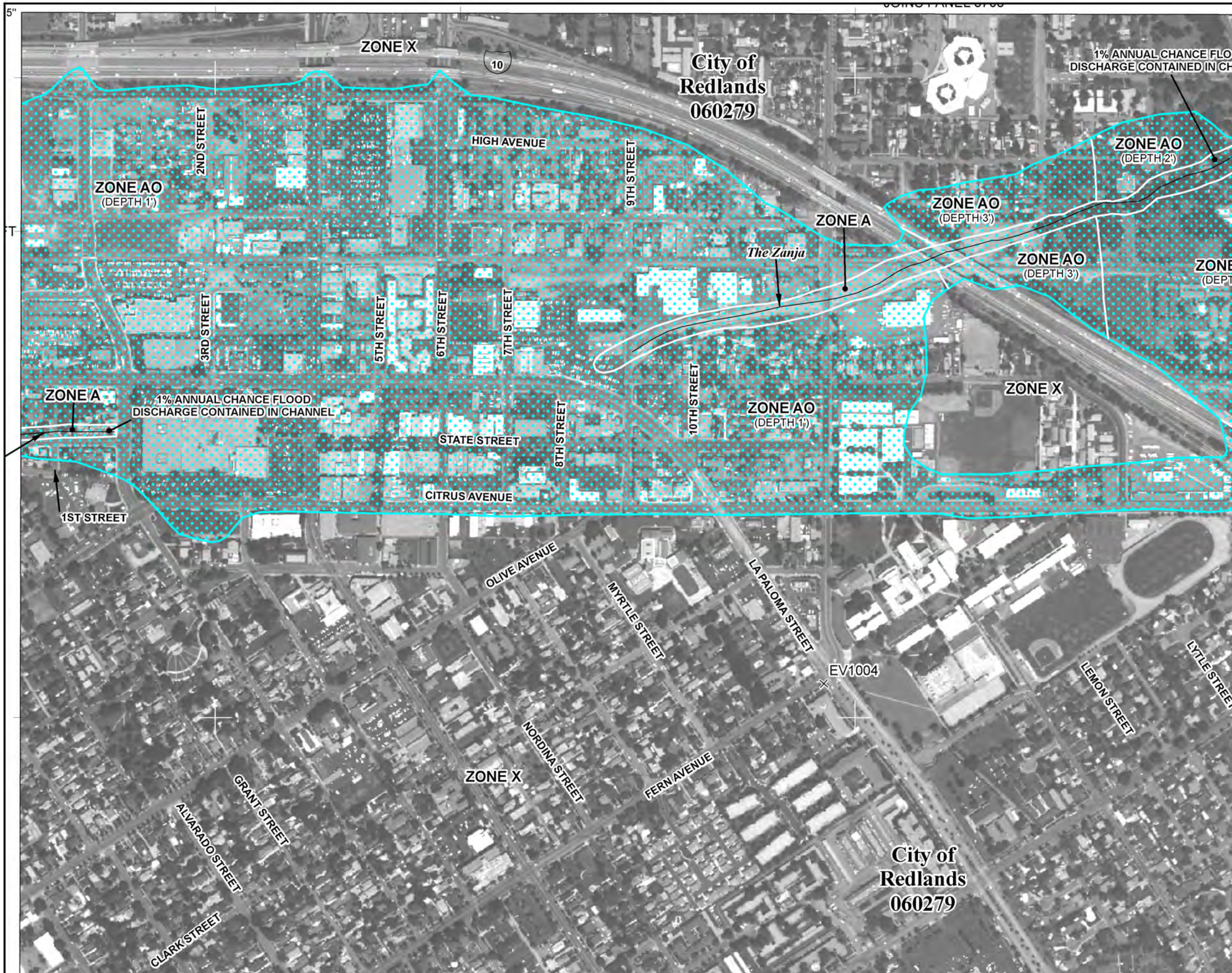


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MAP SCALE 1" = 500'

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METERS

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NATIONAL FLOOD INSURANCE PROGRAM

PANEL 8716H

# FIRM

## FLOOD INSURANCE RATE MAP

**SAN BERNARDINO COUNTY, CALIFORNIA**
**AND INCORPORATED AREAS**

**PANEL 8716 OF 9400**

(SEE MAP INDEX FOR FIRM PANEL LAYOUT)

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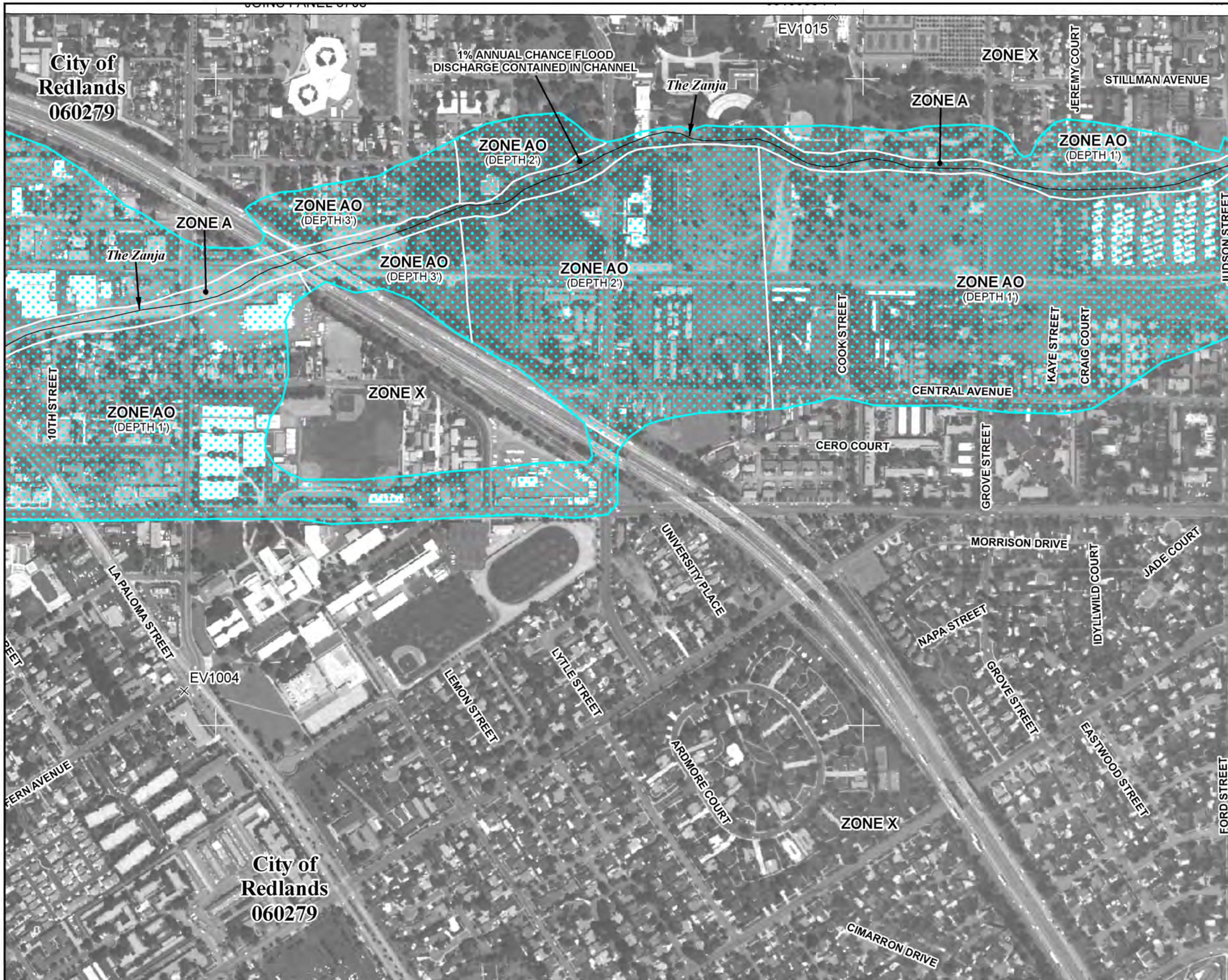


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NFIP

NATIONAL FLOOD INSURANCE PROGRAM

PANEL 8716H

# FIRM

FLOOD INSURANCE RATE MAP

SAN BERNARDINO COUNTY, CALIFORNIA

AND INCORPORATED AREAS

PANEL 8716 OF 9400

(SEE MAP INDEX FOR FIRM PANEL LAYOUT)

CONTAINS:

| COMMUNITY | NUMBER | PANEL | SUFFIX |
|---|---|---|---|
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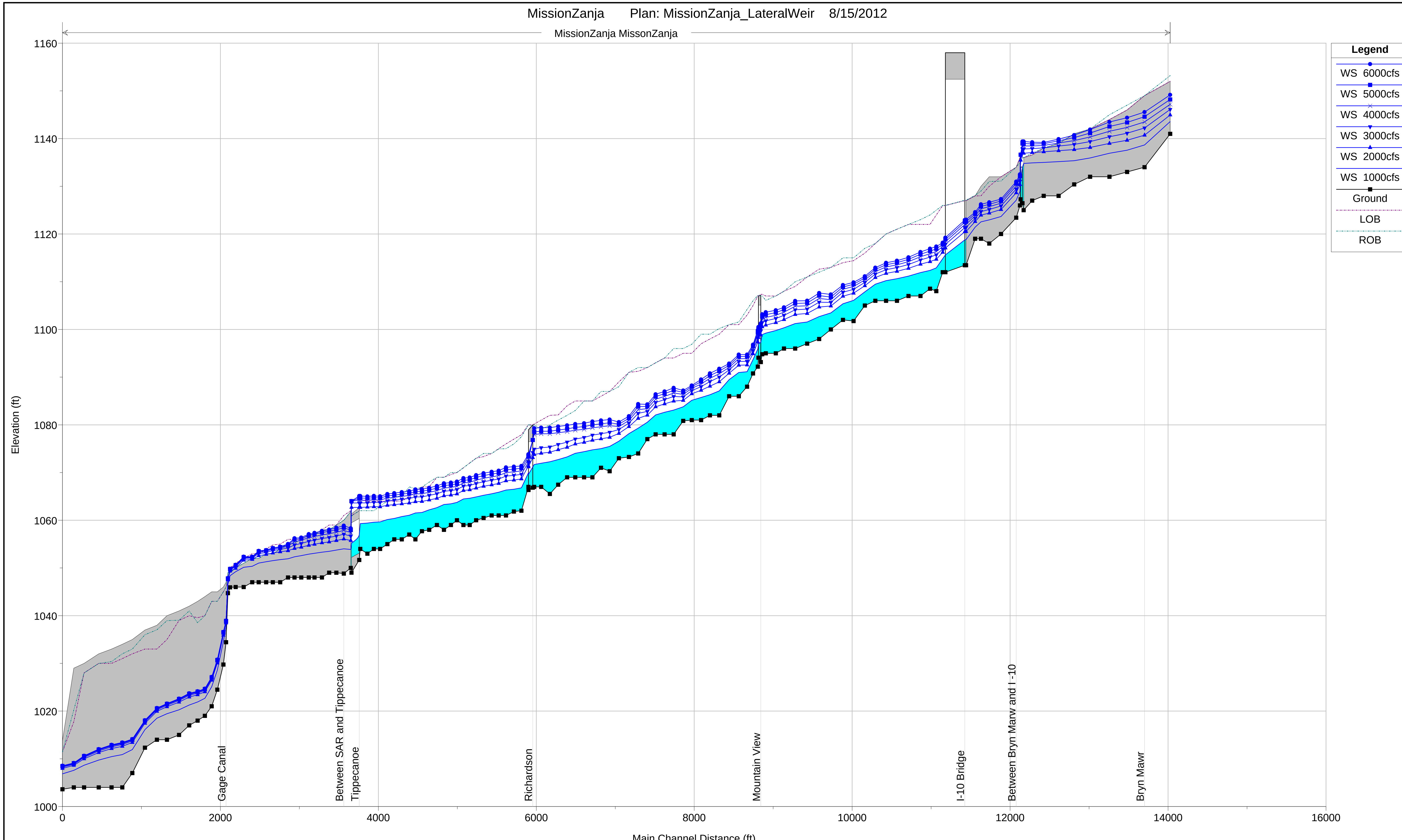
# Attachment 1 - HEC-RAS Modeling Exhibits



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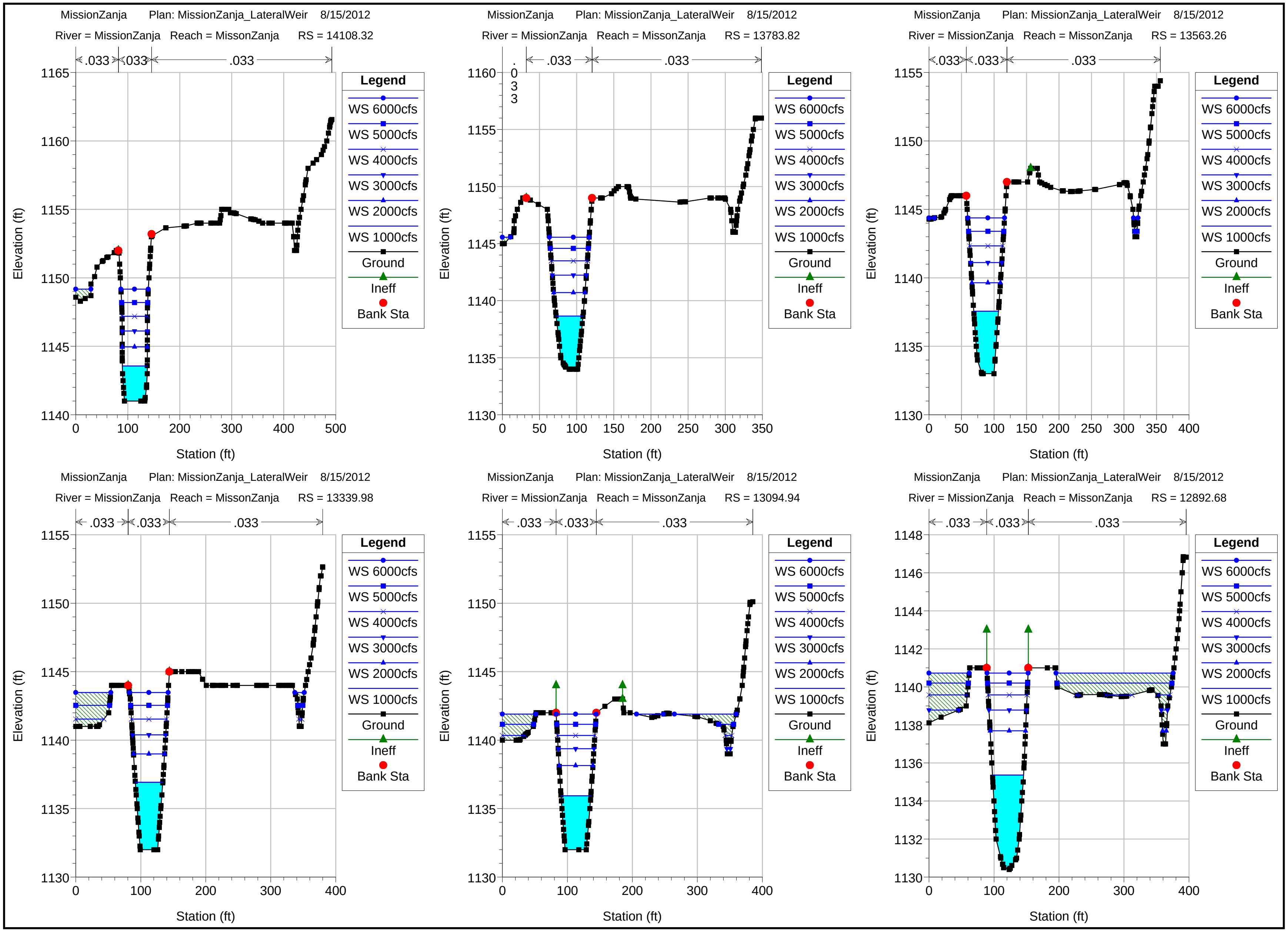
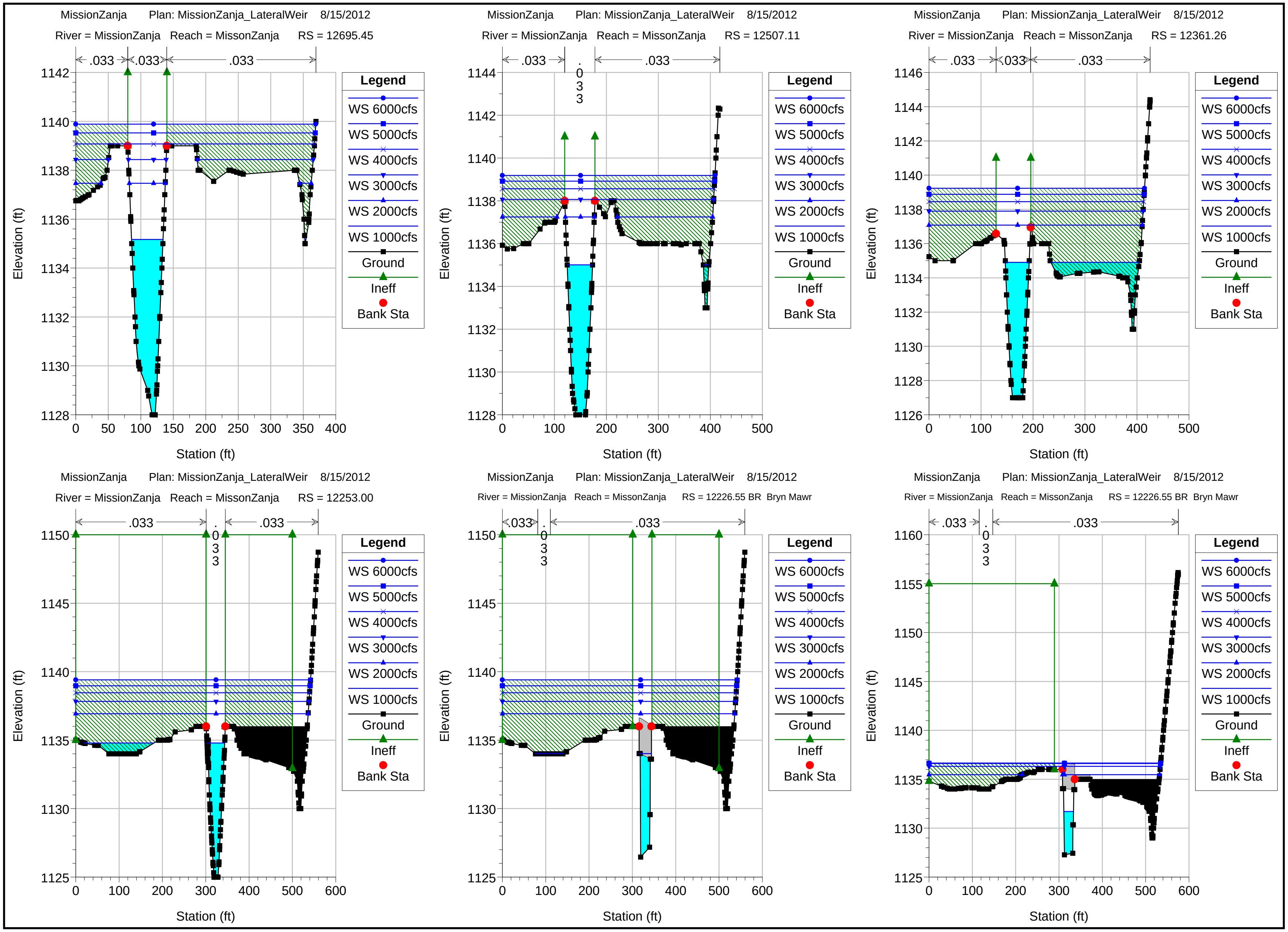
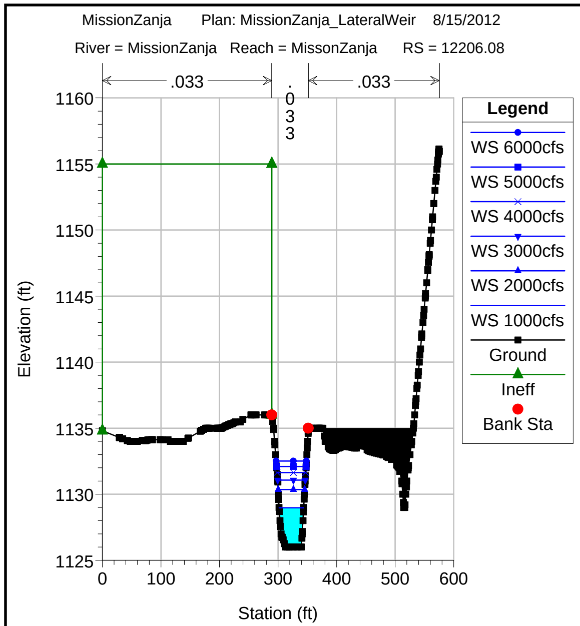
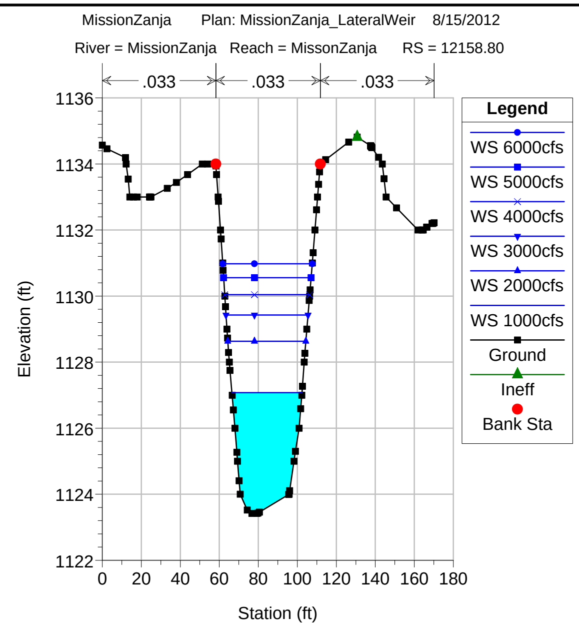
Legend
WS 6000cfs
WS 5000cfs
WS 4000cfs
WS 3000cfs
WS 2000cfs
WS 1000cfs
Ground
LOB
ROB
Elevation (ft)
Main Channel Distance (ft)
1000
1020
1040
1060
1080
1100
1120
1140
1160
0
2000
4000
6000
8000
10000
12000
14000
16000
Gage Canal
Between SAR and Tippecanoe
Tippecanoe
Richardson
Mountain View
I-10 Bridge
Between Bryn Mawr and I-10
Bryn Mawr

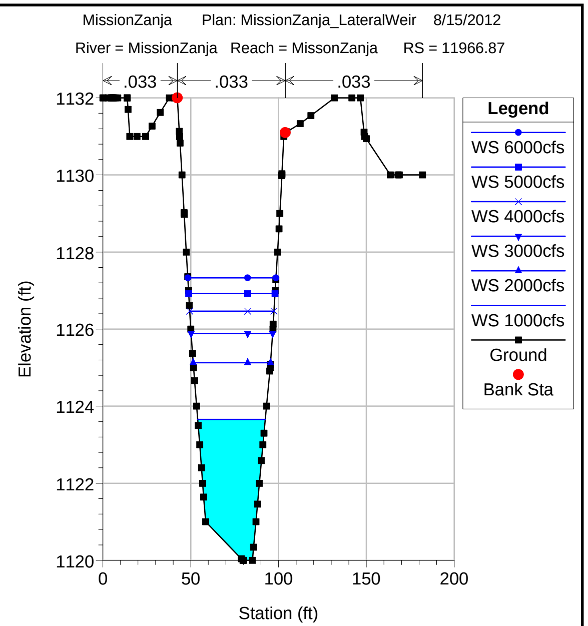


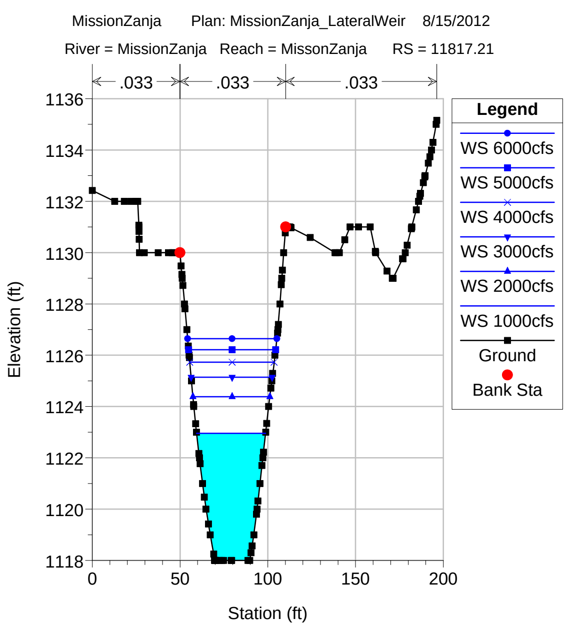
MissionZanja Plan: MissionZanja_LateralWeir 8/15/2012
River = MissionZanja Reach = MissonZanja RS = 14108.32
.033 .033 .033
Elevation (ft)
Station (ft)
Legend
WS 6000cfs
WS 5000cfs
WS 4000cfs
WS 3000cfs
WS 2000cfs
WS 1000cfs
Ground
Ineff
Bank Sta
MissionZanja Plan: MissionZanja_LateralWeir 8/15/2012
River = MissionZanja Reach = MissonZanja RS = 13783.82
.033 .033 .033
MissionZanja Plan: MissionZanja_LateralWeir 8/15/2012
River = MissionZanja Reach = MissonZanja RS = 13563.26
.033 .033 .033
MissionZanja Plan: MissionZanja_LateralWeir 8/15/2012
River = MissionZanja Reach = MissonZanja RS = 13339.98
.033 .033 .033
MissionZanja Plan: MissionZanja_LateralWeir 8/15/2012
River = MissionZanja Reach = MissonZanja RS = 13094.94
.033 .033 .033
MissionZanja Plan: MissionZanja_LateralWeir 8/15/2012
River = MissionZanja Reach = MissonZanja RS = 12892.68
.033 .033 .033

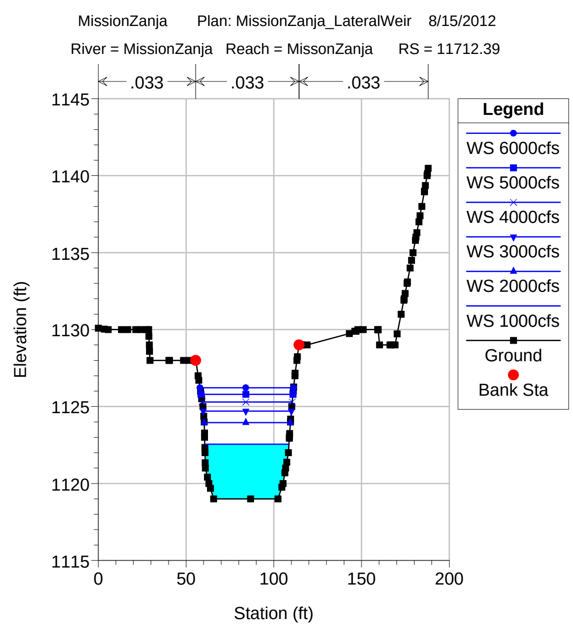

MissionZanja Plan: MissionZanja_LateralWeir 8/15/2012
River = MissionZanja Reach = MissonZanja RS = 12695.45
.033 .033 .033
Legend
WS 6000cfs
WS 5000cfs
WS 4000cfs
WS 3000cfs
WS 2000cfs
WS 1000cfs
Ground
Ineff
Bank Sta
Elevation (ft)
Station (ft)
MissionZanja Plan: MissionZanja_LateralWeir 8/15/2012
River = MissionZanja Reach = MissonZanja RS = 12507.11
.033 .033 .033
Legend
WS 6000cfs
WS 5000cfs
WS 4000cfs
WS 3000cfs
WS 2000cfs
WS 1000cfs
Ground
Ineff
Bank Sta
Elevation (ft)
Station (ft)
MissionZanja Plan: MissionZanja_LateralWeir 8/15/2012
River = MissionZanja Reach = MissonZanja RS = 12361.26
.033 .033 .033
Legend
WS 6000cfs
WS 5000cfs
WS 4000cfs
WS 3000cfs
WS 2000cfs
WS 1000cfs
Ground
Ineff
Bank Sta
Elevation (ft)
Station (ft)
MissionZanja Plan: MissionZanja_LateralWeir 8/15/2012
River = MissionZanja Reach = MissonZanja RS = 12253.00
.033 .033 .033
Legend
WS 6000cfs
WS 5000cfs
WS 4000cfs
WS 3000cfs
WS 2000cfs
WS 1000cfs
Ground
Ineff
Bank Sta
Elevation (ft)
Station (ft)
MissionZanja Plan: MissionZanja_LateralWeir 8/15/2012
River = MissionZanja Reach = MissonZanja RS = 12226.55 BR Bryn Mawr
.033 .033 .033
Legend
WS 6000cfs
WS 5000cfs
WS 4000cfs
WS 3000cfs
WS 2000cfs
WS 1000cfs
Ground
Ineff
Bank Sta
Elevation (ft)
Station (ft)
MissionZanja Plan: MissionZanja_LateralWeir 8/15/2012
River = MissionZanja Reach = MissonZanja RS = 12226.55 BR Bryn Mawr
.033 .033 .033
Legend
WS 6000cfs
WS 5000cfs
WS 4000cfs
WS 3000cfs
WS 2000cfs
WS 1000cfs
Ground
Ineff
Bank Sta
Elevation (ft)
Station (ft)

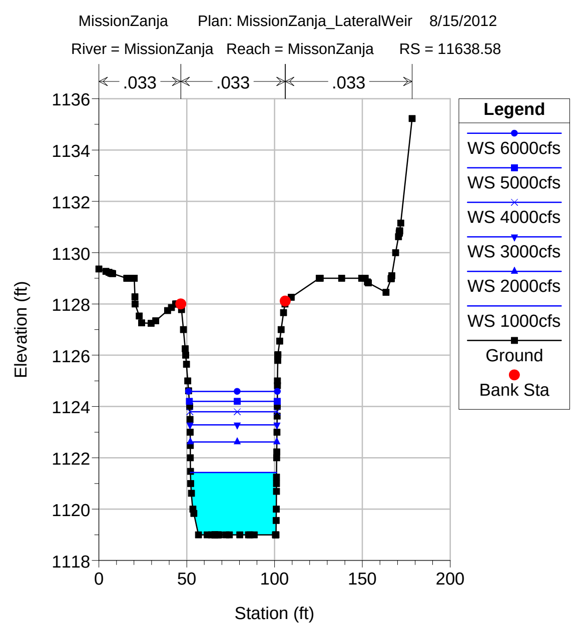

MissionZanja Plan: MissionZanja_LateralWeir 8/15/2012
River = MissionZanja Reach = MissonZanja RS = 12206.08
.033
.033
.033
Legend
WS 6000cfs
WS 5000cfs
WS 4000cfs
WS 3000cfs
WS 2000cfs
WS 1000cfs
Ground
Ineff
Bank Sta
Elevation (ft)
Station (ft)

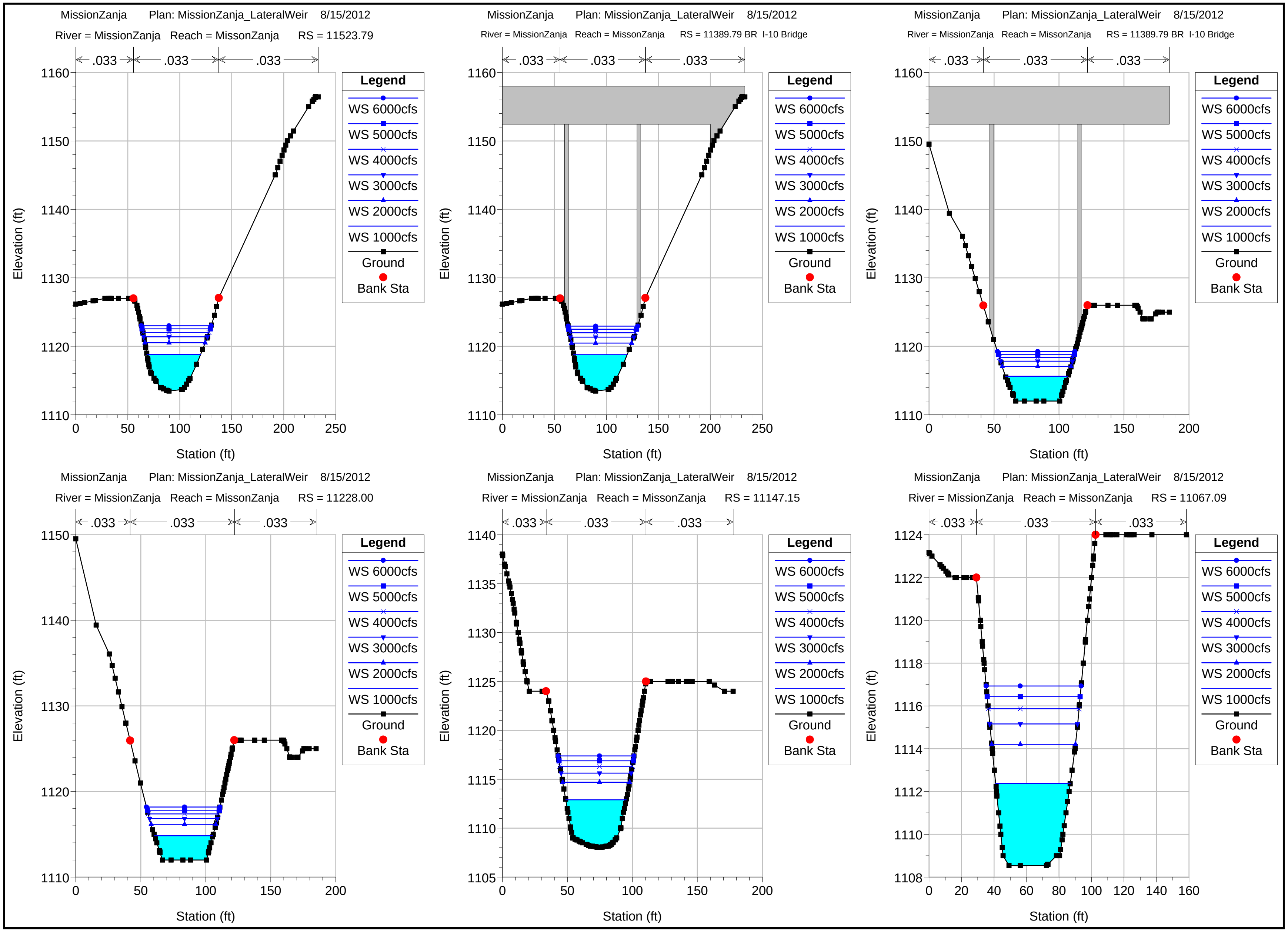

MissionZanja Plan: MissionZanja_LateralWeir 8/15/2012
River = MissionZanja Reach = MissonZanja RS = 12158.80
.033
.033
.033
Legend
WS 6000cfs
WS 5000cfs
WS 4000cfs
WS 3000cfs
WS 2000cfs
WS 1000cfs
Ground
Ineff
Bank Sta
Elevation (ft)
Station (ft)

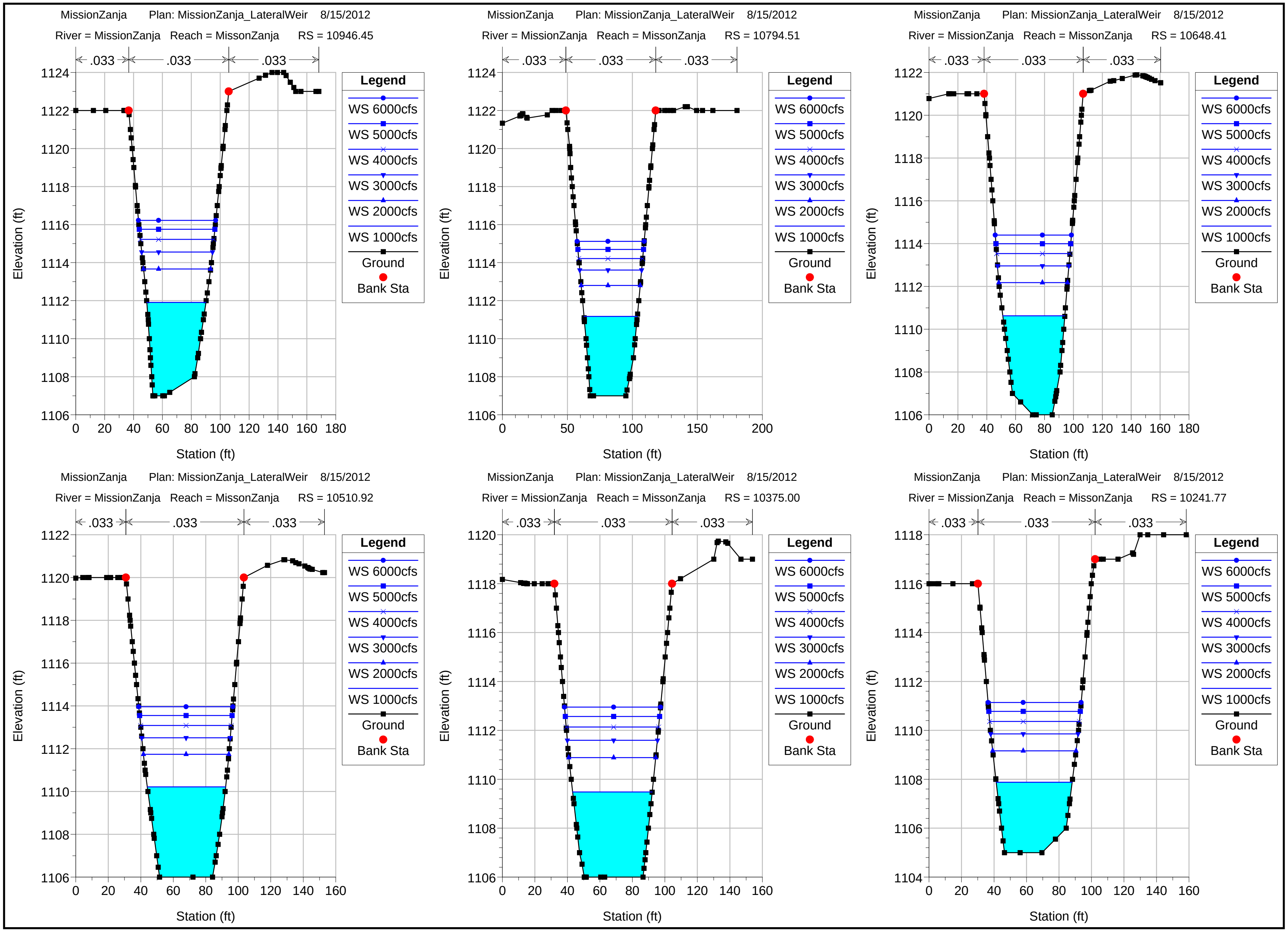

MissionZanja Plan: MissionZanja_LateralWeir 8/15/2012
River = MissionZanja Reach = MissonZanja RS = 11966.87
.033
.033
.033
Legend
WS 6000cfs
WS 5000cfs
WS 4000cfs
WS 3000cfs
WS 2000cfs
WS 1000cfs
Ground
Bank Sta
Elevation (ft)
Station (ft)

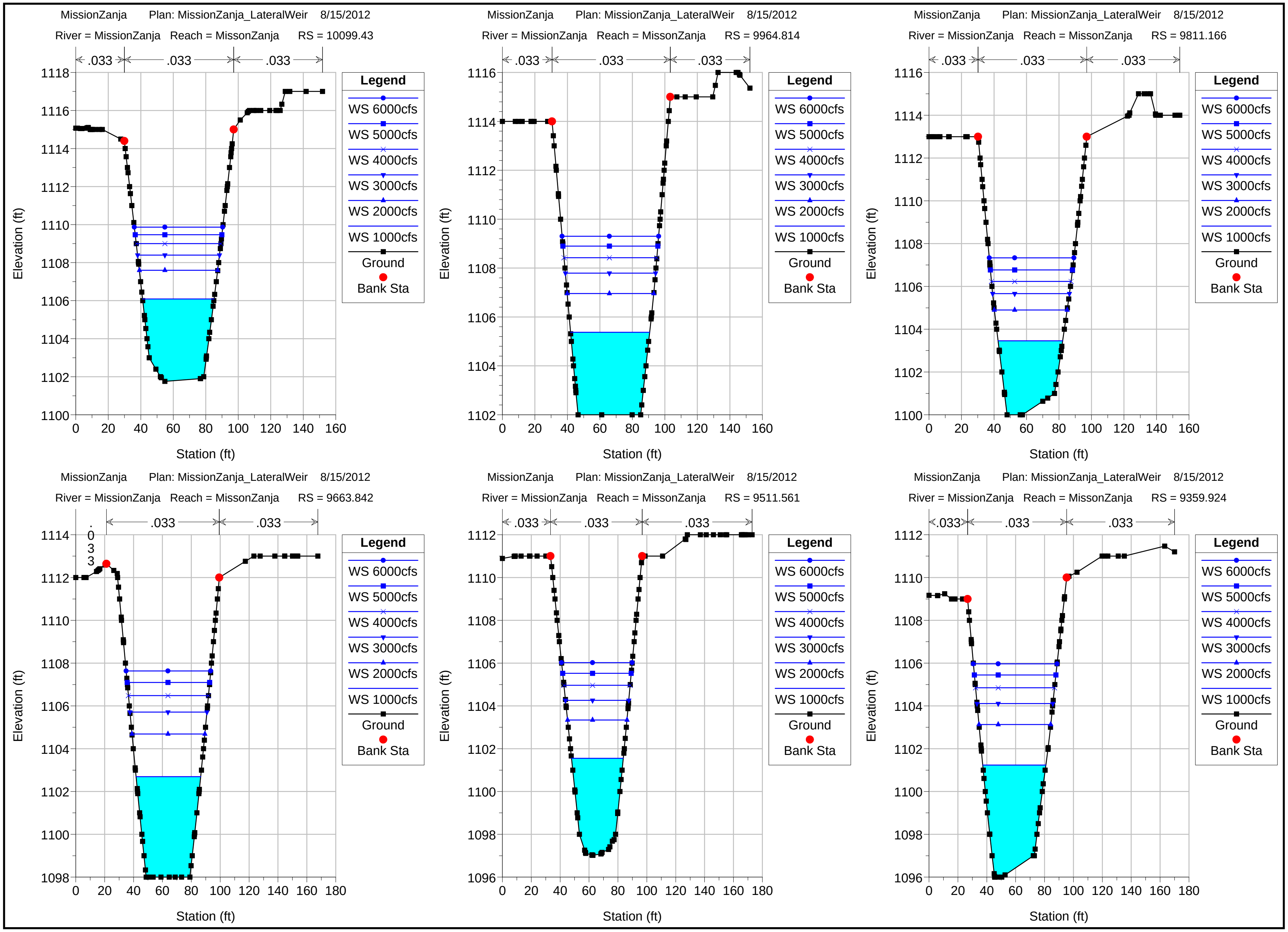

MissionZanja Plan: MissionZanja_LateralWeir 8/15/2012
River = MissionZanja Reach = MissonZanja RS = 11817.21
.033
.033
.033
Legend
WS 6000cfs
WS 5000cfs
WS 4000cfs
WS 3000cfs
WS 2000cfs
WS 1000cfs
Ground
Bank Sta
Elevation (ft)
Station (ft)

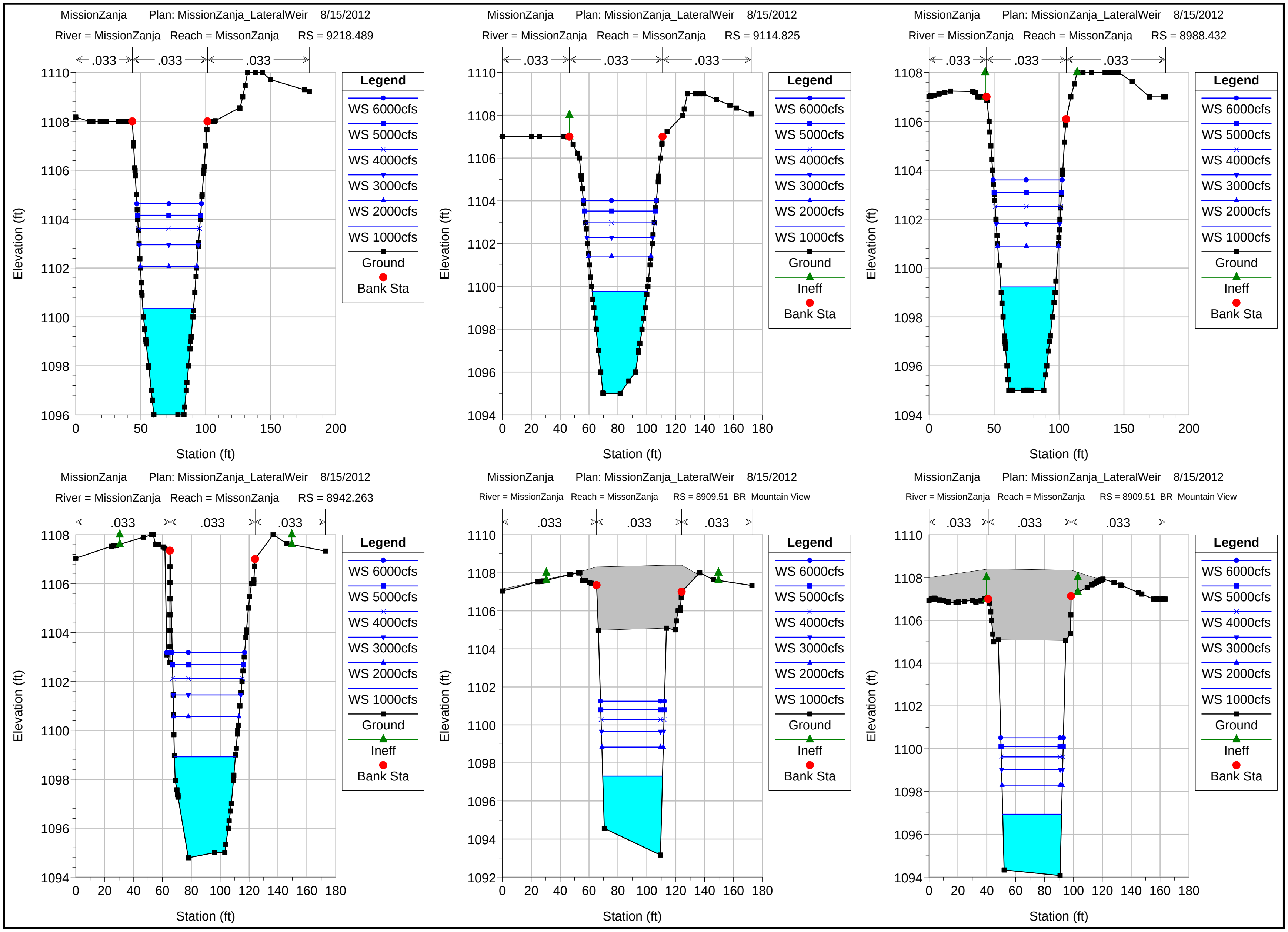

MissionZanja Plan: MissionZanja_LateralWeir 8/15/2012
River = MissionZanja Reach = MissonZanja RS = 11712.39
.033
.033
.033
Legend
WS 6000cfs
WS 5000cfs
WS 4000cfs
WS 3000cfs
WS 2000cfs
WS 1000cfs
Ground
Bank Sta
Elevation (ft)
Station (ft)


MissionZanja Plan: MissionZanja_LateralWeir 8/15/2012
River = MissionZanja Reach = MissonZanja RS = 11638.58
.033
.033
.033
Legend
WS 6000cfs
WS 5000cfs
WS 4000cfs
WS 3000cfs
WS 2000cfs
WS 1000cfs
Ground
Bank Sta
Elevation (ft)
Station (ft)

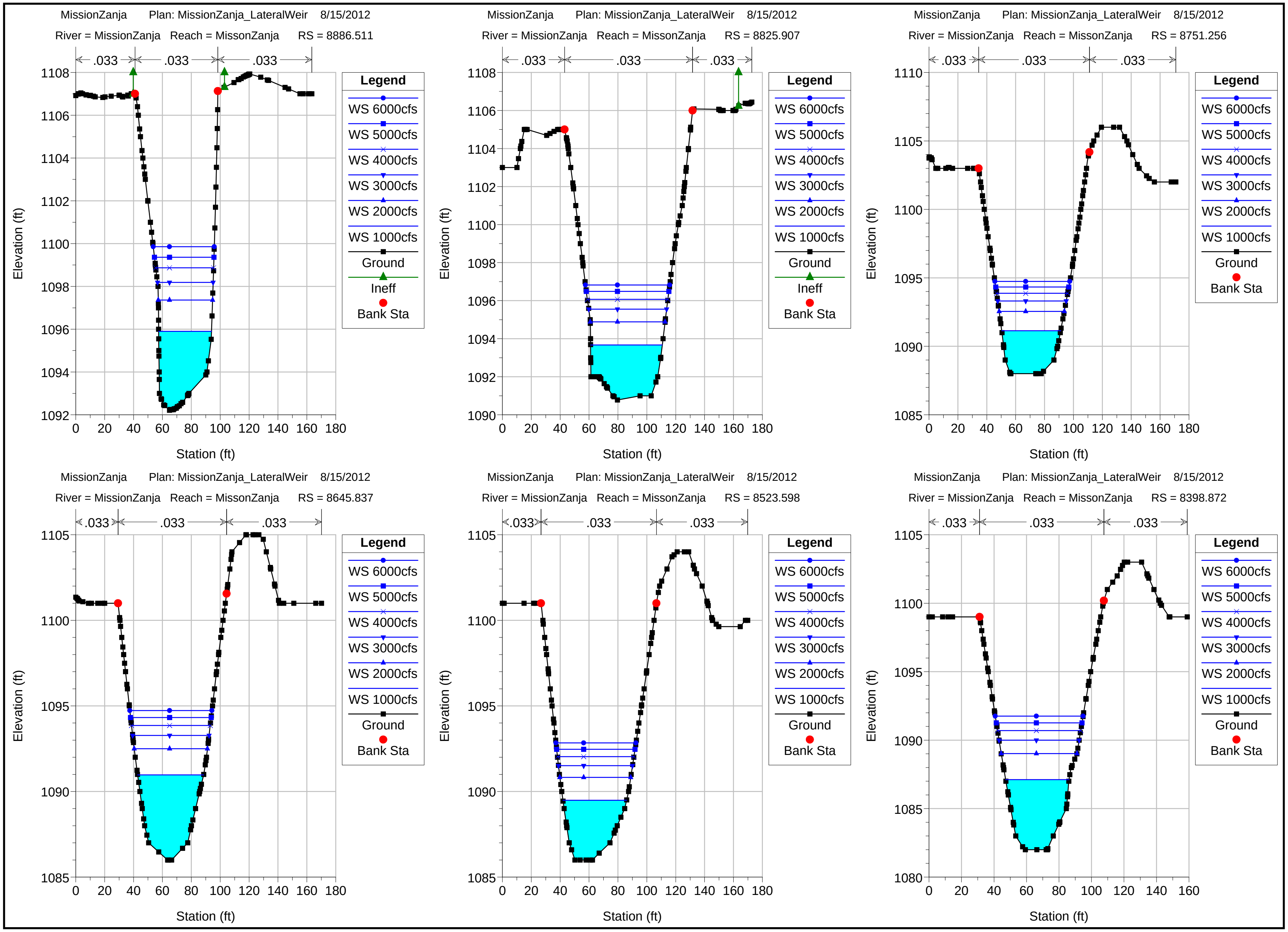

MissionZanja Plan: MissionZanja_LateralWeir 8/15/2012
River = MissionZanja Reach = MissonZanja RS = 11523.79
.033
.033
.033
Legend
WS 6000cfs
WS 5000cfs
WS 4000cfs
WS 3000cfs
WS 2000cfs
WS 1000cfs
Ground
Bank Sta
Elevation (ft)
Station (ft)
MissionZanja Plan: MissionZanja_LateralWeir 8/15/2012
River = MissionZanja Reach = MissonZanja RS = 11389.79 BR I-10 Bridge
Legend
WS 6000cfs
WS 5000cfs
WS 4000cfs
WS 3000cfs
WS 2000cfs
WS 1000cfs
Ground
Bank Sta
Elevation (ft)
Station (ft)
MissionZanja Plan: MissionZanja_LateralWeir 8/15/2012
River = MissionZanja Reach = MissonZanja RS = 11389.79 BR I-10 Bridge
Legend
WS 6000cfs
WS 5000cfs
WS 4000cfs
WS 3000cfs
WS 2000cfs
WS 1000cfs
Ground
Bank Sta
Elevation (ft)
Station (ft)
MissionZanja Plan: MissionZanja_LateralWeir 8/15/2012
River = MissionZanja Reach = MissonZanja RS = 11228.00
Legend
WS 6000cfs
WS 5000cfs
WS 4000cfs
WS 3000cfs
WS 2000cfs
WS 1000cfs
Ground
Bank Sta
Elevation (ft)
Station (ft)
MissionZanja Plan: MissionZanja_LateralWeir 8/15/2012
River = MissionZanja Reach = MissonZanja RS = 11147.15
Legend
WS 6000cfs
WS 5000cfs
WS 4000cfs
WS 3000cfs
WS 2000cfs
WS 1000cfs
Ground
Bank Sta
Elevation (ft)
Station (ft)
MissionZanja Plan: MissionZanja_LateralWeir 8/15/2012
River = MissionZanja Reach = MissonZanja RS = 11067.09
Legend
WS 6000cfs
WS 5000cfs
WS 4000cfs
WS 3000cfs
WS 2000cfs
WS 1000cfs
Ground
Bank Sta
Elevation (ft)
Station (ft)

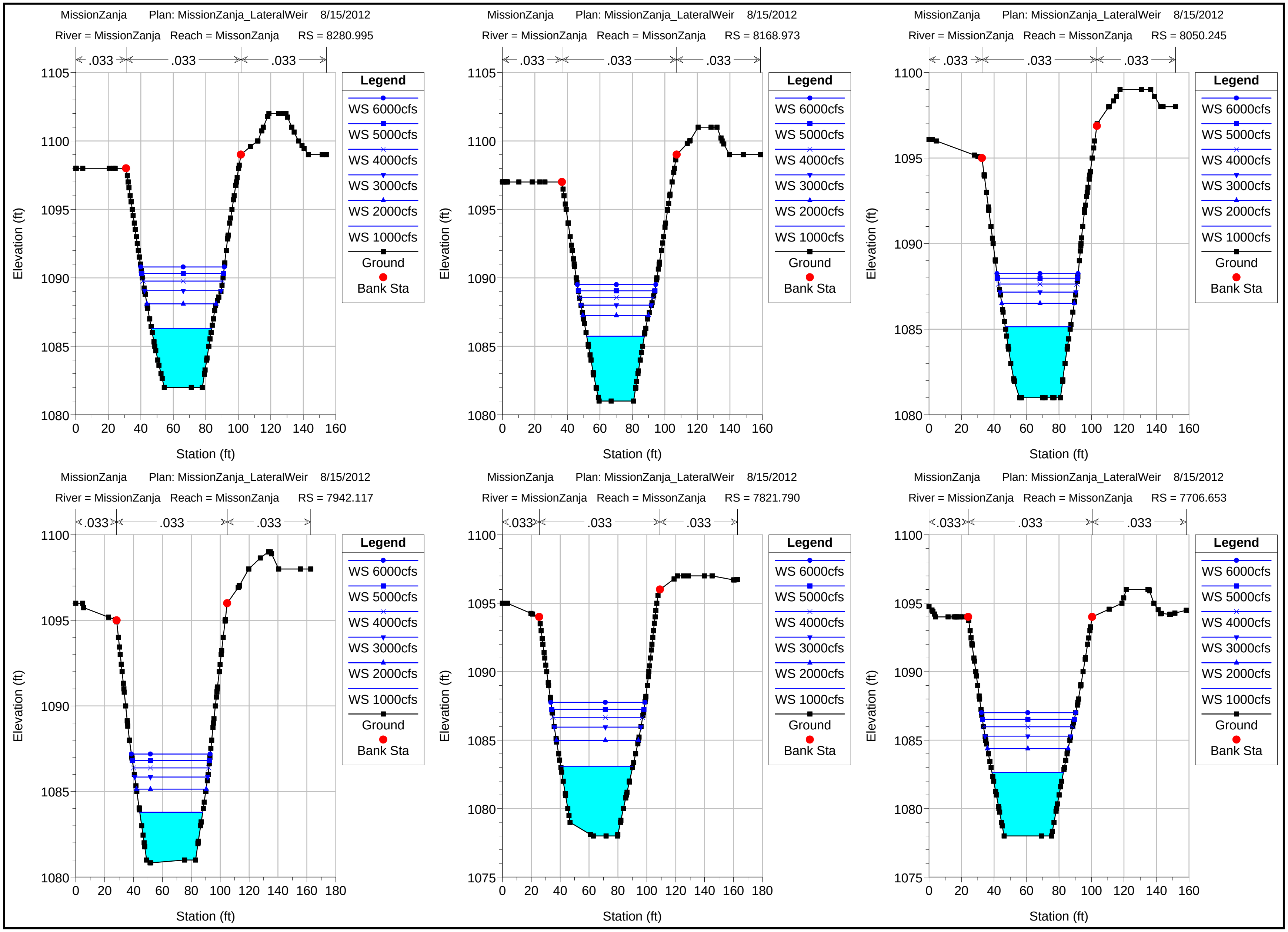

MissionZanja Plan: MissionZanja_LateralWeir 8/15/2012
River = MissionZanja Reach = MissonZanja RS = 10946.45
.033 .033 .033
Elevation (ft)
Station (ft)
Legend
WS 6000cfs
WS 5000cfs
WS 4000cfs
WS 3000cfs
WS 2000cfs
WS 1000cfs
Ground
Bank Sta
MissionZanja Plan: MissionZanja_LateralWeir 8/15/2012
River = MissionZanja Reach = MissonZanja RS = 10794.51
.033 .033 .033
Elevation (ft)
Station (ft)
Legend
WS 6000cfs
WS 5000cfs
WS 4000cfs
WS 3000cfs
WS 2000cfs
WS 1000cfs
Ground
Bank Sta
MissionZanja Plan: MissionZanja_LateralWeir 8/15/2012
River = MissionZanja Reach = MissonZanja RS = 10648.41
.033 .033 .033
Elevation (ft)
Station (ft)
Legend
WS 6000cfs
WS 5000cfs
WS 4000cfs
WS 3000cfs
WS 2000cfs
WS 1000cfs
Ground
Bank Sta
MissionZanja Plan: MissionZanja_LateralWeir 8/15/2012
River = MissionZanja Reach = MissonZanja RS = 10510.92
.033 .033 .033
Elevation (ft)
Station (ft)
Legend
WS 6000cfs
WS 5000cfs
WS 4000cfs
WS 3000cfs
WS 2000cfs
WS 1000cfs
Ground
Bank Sta
MissionZanja Plan: MissionZanja_LateralWeir 8/15/2012
River = MissionZanja Reach = MissonZanja RS = 10375.00
.033 .033 .033
Elevation (ft)
Station (ft)
Legend
WS 6000cfs
WS 5000cfs
WS 4000cfs
WS 3000cfs
WS 2000cfs
WS 1000cfs
Ground
Bank Sta
MissionZanja Plan: MissionZanja_LateralWeir 8/15/2012
River = MissionZanja Reach = MissonZanja RS = 10241.77
.033 .033 .033
Elevation (ft)
Station (ft)
Legend
WS 6000cfs
WS 5000cfs
WS 4000cfs
WS 3000cfs
WS 2000cfs
WS 1000cfs
Ground
Bank Sta

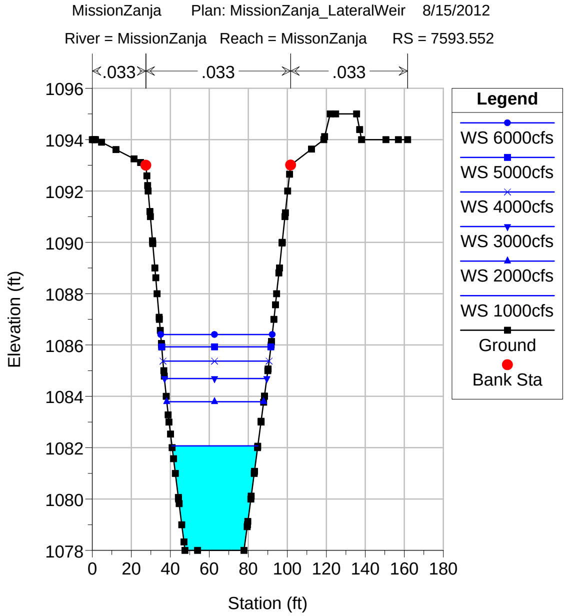

MissionZanja Plan: MissionZanja_LateralWeir 8/15/2012
River = MissionZanja Reach = MissonZanja RS = 10099.43
.033 .033 .033
Legend
WS 6000cfs
WS 5000cfs
WS 4000cfs
WS 3000cfs
WS 2000cfs
WS 1000cfs
Ground
Bank Sta
Elevation (ft)
Station (ft)
MissionZanja Plan: MissionZanja_LateralWeir 8/15/2012
River = MissionZanja Reach = MissonZanja RS = 9964.814
MissionZanja Plan: MissionZanja_LateralWeir 8/15/2012
River = MissionZanja Reach = MissonZanja RS = 9811.166
MissionZanja Plan: MissionZanja_LateralWeir 8/15/2012
River = MissionZanja Reach = MissonZanja RS = 9663.842
MissionZanja Plan: MissionZanja_LateralWeir 8/15/2012
River = MissionZanja Reach = MissonZanja RS = 9511.561
MissionZanja Plan: MissionZanja_LateralWeir 8/15/2012
River = MissionZanja Reach = MissonZanja RS = 9359.924

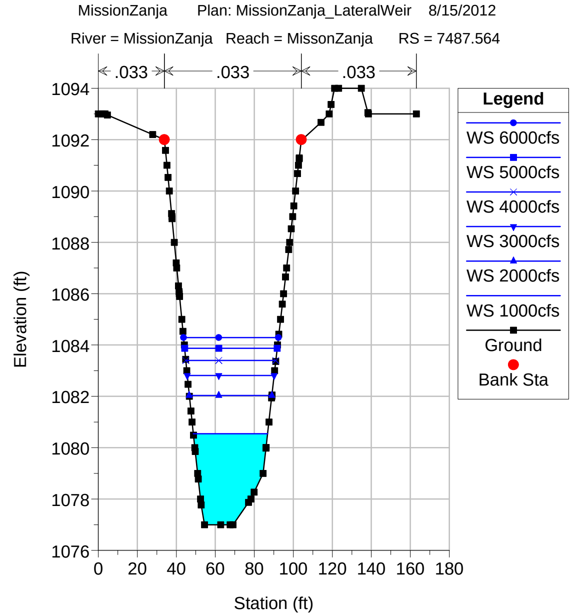


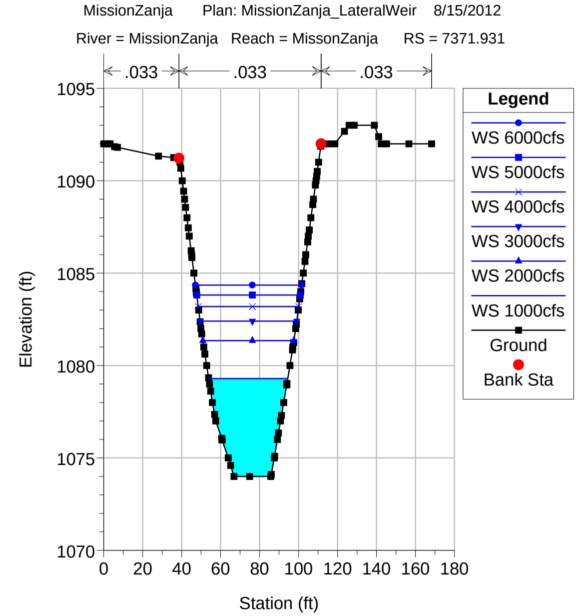
MissionZanja Plan: MissionZanja_LateralWeir 8/15/2012
River = MissionZanja Reach = MissonZanja RS = 9218.489
.033 .033 .033
Elevation (ft)
Station (ft)
Legend
WS 6000cfs
WS 5000cfs
WS 4000cfs
WS 3000cfs
WS 2000cfs
WS 1000cfs
Ground
Bank Sta
MissionZanja Plan: MissionZanja_LateralWeir 8/15/2012
River = MissionZanja Reach = MissonZanja RS = 9114.825
.033 .033 .033
Elevation (ft)
Station (ft)
Legend
WS 6000cfs
WS 5000cfs
WS 4000cfs
WS 3000cfs
WS 2000cfs
WS 1000cfs
Ground
Ineff
Bank Sta
MissionZanja Plan: MissionZanja_LateralWeir 8/15/2012
River = MissionZanja Reach = MissonZanja RS = 8988.432
.033 .033 .033
Elevation (ft)
Station (ft)
Legend
WS 6000cfs
WS 5000cfs
WS 4000cfs
WS 3000cfs
WS 2000cfs
WS 1000cfs
Ground
Ineff
Bank Sta
MissionZanja Plan: MissionZanja_LateralWeir 8/15/2012
River = MissionZanja Reach = MissonZanja RS = 8942.263
.033 .033 .033
Elevation (ft)
Station (ft)
Legend
WS 6000cfs
WS 5000cfs
WS 4000cfs
WS 3000cfs
WS 2000cfs
WS 1000cfs
Ground
Ineff
Bank Sta
MissionZanja Plan: MissionZanja_LateralWeir 8/15/2012
River = MissionZanja Reach = MissonZanja RS = 8909.51 BR Mountain View
.033 .033 .033
Elevation (ft)
Station (ft)
Legend
WS 6000cfs
WS 5000cfs
WS 4000cfs
WS 3000cfs
WS 2000cfs
WS 1000cfs
Ground
Ineff
Bank Sta
MissionZanja Plan: MissionZanja_LateralWeir 8/15/2012
River = MissionZanja Reach = MissonZanja RS = 8909.51 BR Mountain View
.033 .033 .033
Elevation (ft)
Station (ft)
Legend
WS 6000cfs
WS 5000cfs
WS 4000cfs
WS 3000cfs
WS 2000cfs
WS 1000cfs
Ground
Ineff
Bank Sta

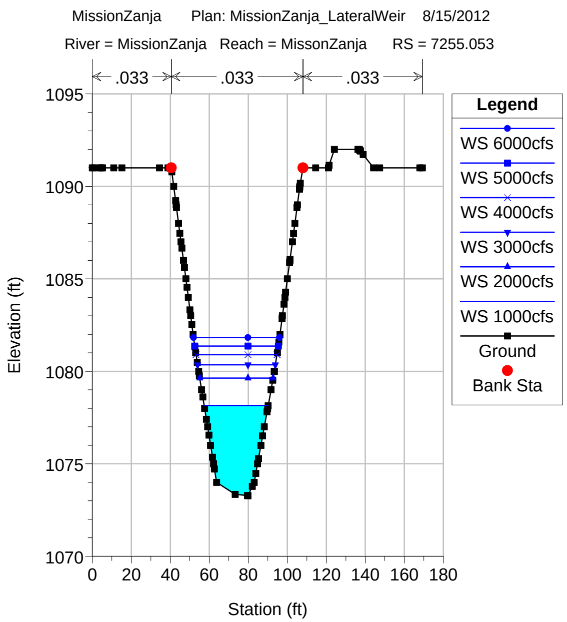

MissionZanja Plan: MissionZanja_LateralWeir 8/15/2012
River = MissionZanja Reach = MissonZanja RS = 8886.511
MissionZanja Plan: MissionZanja_LateralWeir 8/15/2012
River = MissionZanja Reach = MissonZanja RS = 8825.907
MissionZanja Plan: MissionZanja_LateralWeir 8/15/2012
River = MissionZanja Reach = MissonZanja RS = 8751.256
MissionZanja Plan: MissionZanja_LateralWeir 8/15/2012
River = MissionZanja Reach = MissonZanja RS = 8645.837
MissionZanja Plan: MissionZanja_LateralWeir 8/15/2012
River = MissionZanja Reach = MissonZanja RS = 8523.598
MissionZanja Plan: MissionZanja_LateralWeir 8/15/2012
River = MissionZanja Reach = MissonZanja RS = 8398.872
.033
Legend
WS 6000cfs
WS 5000cfs
WS 4000cfs
WS 3000cfs
WS 2000cfs
WS 1000cfs
Ground
Ineff
Bank Sta
Elevation (ft)
Station (ft)

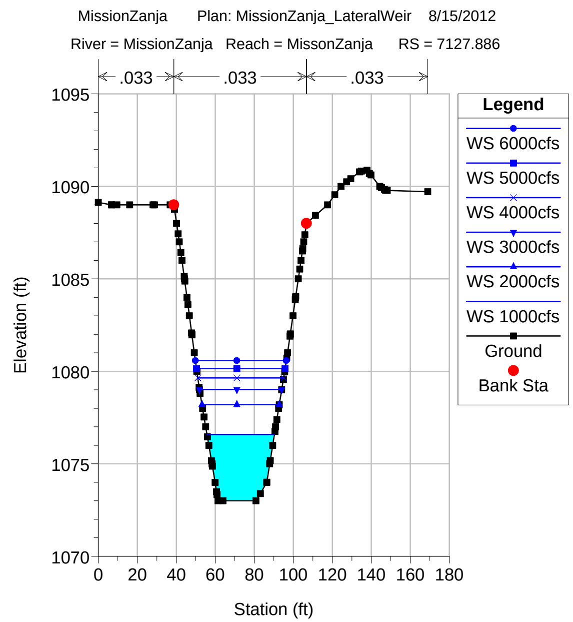

MissionZanja Plan: MissionZanja_LateralWeir 8/15/2012
River = MissionZanja Reach = MissonZanja RS = 8280.995
.033 .033 .033
Elevation (ft)
Station (ft)
Legend
WS 6000cfs
WS 5000cfs
WS 4000cfs
WS 3000cfs
WS 2000cfs
WS 1000cfs
Ground
Bank Sta
MissionZanja Plan: MissionZanja_LateralWeir 8/15/2012
River = MissionZanja Reach = MissonZanja RS = 8168.973
.033 .033 .033
Elevation (ft)
Station (ft)
Legend
WS 6000cfs
WS 5000cfs
WS 4000cfs
WS 3000cfs
WS 2000cfs
WS 1000cfs
Ground
Bank Sta
MissionZanja Plan: MissionZanja_LateralWeir 8/15/2012
River = MissionZanja Reach = MissonZanja RS = 8050.245
.033 .033 .033
Elevation (ft)
Station (ft)
Legend
WS 6000cfs
WS 5000cfs
WS 4000cfs
WS 3000cfs
WS 2000cfs
WS 1000cfs
Ground
Bank Sta
MissionZanja Plan: MissionZanja_LateralWeir 8/15/2012
River = MissionZanja Reach = MissonZanja RS = 7942.117
.033 .033 .033
Elevation (ft)
Station (ft)
Legend
WS 6000cfs
WS 5000cfs
WS 4000cfs
WS 3000cfs
WS 2000cfs
WS 1000cfs
Ground
Bank Sta
MissionZanja Plan: MissionZanja_LateralWeir 8/15/2012
River = MissionZanja Reach = MissonZanja RS = 7821.790
.033 .033 .033
Elevation (ft)
Station (ft)
Legend
WS 6000cfs
WS 5000cfs
WS 4000cfs
WS 3000cfs
WS 2000cfs
WS 1000cfs
Ground
Bank Sta
MissionZanja Plan: MissionZanja_LateralWeir 8/15/2012
River = MissionZanja Reach = MissonZanja RS = 7706.653
.033 .033 .033
Elevation (ft)
Station (ft)
Legend
WS 6000cfs
WS 5000cfs
WS 4000cfs
WS 3000cfs
WS 2000cfs
WS 1000cfs
Ground
Bank Sta

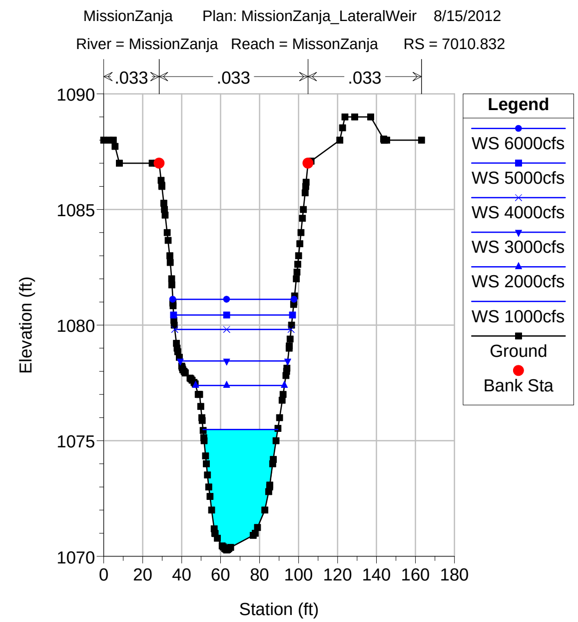

MissionZanja Plan: MissionZanja_LateralWeir 8/15/2012
River = MissionZanja Reach = MissonZanja RS = 7593.552
.033
.033
.033
Elevation (ft)
Station (ft)
Legend
WS 6000cfs
WS 5000cfs
WS 4000cfs
WS 3000cfs
WS 2000cfs
WS 1000cfs
Ground
Bank Sta


MissionZanja Plan: MissionZanja_LateralWeir 8/15/2012
River = MissionZanja Reach = MissonZanja RS = 7487.564
.033
.033
.033
Elevation (ft)
Station (ft)
Legend
WS 6000cfs
WS 5000cfs
WS 4000cfs
WS 3000cfs
WS 2000cfs
WS 1000cfs
Ground
Bank Sta


MissionZanja Plan: MissionZanja_LateralWeir 8/15/2012
River = MissionZanja Reach = MissonZanja RS = 7371.931
.033
.033
.033
Elevation (ft)
Station (ft)
Legend
WS 6000cfs
WS 5000cfs
WS 4000cfs
WS 3000cfs
WS 2000cfs
WS 1000cfs
Ground
Bank Sta


MissionZanja Plan: MissionZanja_LateralWeir 8/15/2012
River = MissionZanja Reach = MissonZanja RS = 7255.053
.033
.033
.033
Elevation (ft)
Station (ft)
Legend
WS 6000cfs
WS 5000cfs
WS 4000cfs
WS 3000cfs
WS 2000cfs
WS 1000cfs
Ground
Bank Sta


MissionZanja Plan: MissionZanja_LateralWeir 8/15/2012
River = MissionZanja Reach = MissonZanja RS = 7127.886
.033
.033
.033
Elevation (ft)
Station (ft)
Legend
WS 6000cfs
WS 5000cfs
WS 4000cfs
WS 3000cfs
WS 2000cfs
WS 1000cfs
Ground
Bank Sta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River = MissionZanja Reach = MissonZanja RS = 7010.832
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Elevation (ft)
Station (ft)
Legend
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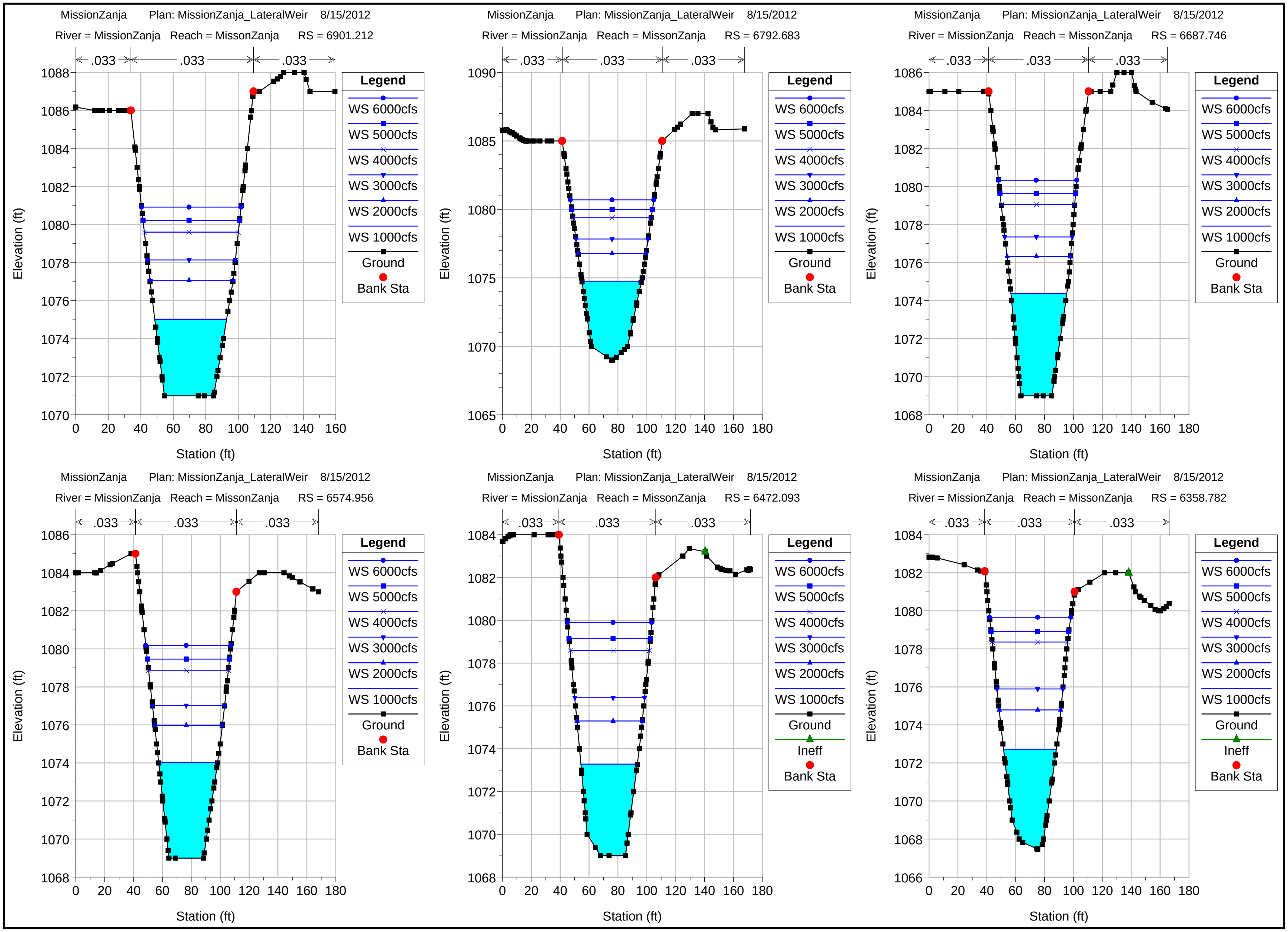
WS 1000cfs
Ground
Bank Sta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River = MissionZanja Reach = MissonZanja RS = 6901.212
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River = MissionZanja Reach = MissonZanja RS = 6792.683
MissionZanja Plan: MissionZanja_LateralWeir 8/15/2012
River = MissionZanja Reach = MissonZanja RS = 6687.746
MissionZanja Plan: MissionZanja_LateralWeir 8/15/2012
River = MissionZanja Reach = MissonZanja RS = 6574.956
MissionZanja Plan: MissionZanja_LateralWeir 8/15/2012
River = MissionZanja Reach = MissonZanja RS = 6472.093
MissionZanja Plan: MissionZanja_LateralWeir 8/15/2012
River = MissionZanja Reach = MissonZanja RS = 6358.782
.033 .033 .033
Elevation (ft)
Station (ft)
Legend
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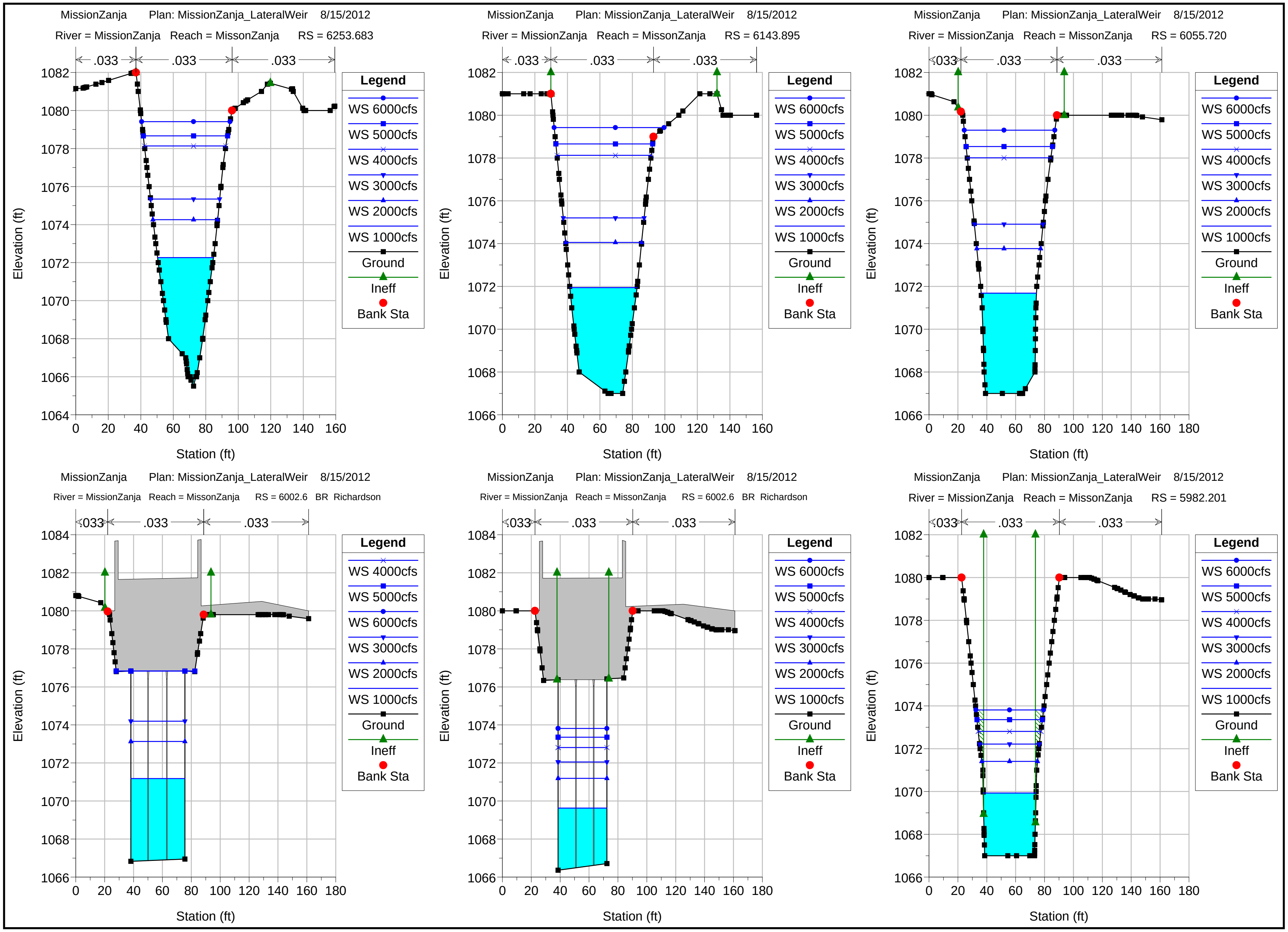
WS 1000cfs
Ground
Ineff
Bank Sta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River = MissionZanja Reach = MissonZanja RS = 6253.683
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Legend
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Ground
Ineff
Bank Sta
Elevation (ft)
Station (ft)
MissionZanja Plan: MissionZanja_LateralWeir 8/15/2012
River = MissionZanja Reach = MissonZanja RS = 6143.895
Legend
WS 6000cfs
WS 5000cfs
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WS 2000cfs
WS 1000cfs
Ground
Ineff
Bank Sta
Elevation (ft)
Station (ft)
MissionZanja Plan: MissionZanja_LateralWeir 8/15/2012
River = MissionZanja Reach = MissonZanja RS = 6055.720
Legend
WS 6000cfs
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WS 2000cfs
WS 1000cfs
Ground
Ineff
Bank Sta
Elevation (ft)
Station (ft)
MissionZanja Plan: MissionZanja_LateralWeir 8/15/2012
River = MissionZanja Reach = MissonZanja RS = 6002.6 BR Richardson
Legend
WS 4000cfs
WS 5000cfs
WS 6000cfs
WS 3000cfs
WS 2000cfs
WS 1000cfs
Ground
Ineff
Bank Sta
Elevation (ft)
Station (ft)
MissionZanja Plan: MissionZanja_LateralWeir 8/15/2012
River = MissionZanja Reach = MissonZanja RS = 6002.6 BR Richardson
Legend
WS 6000cfs
WS 5000cfs
WS 4000cfs
WS 3000cfs
WS 2000cfs
WS 1000cfs
Ground
Ineff
Bank Sta
Elevation (ft)
Station (ft)
MissionZanja Plan: MissionZanja_LateralWeir 8/15/2012
River = MissionZanja Reach = MissonZanja RS = 5982.201
Legend
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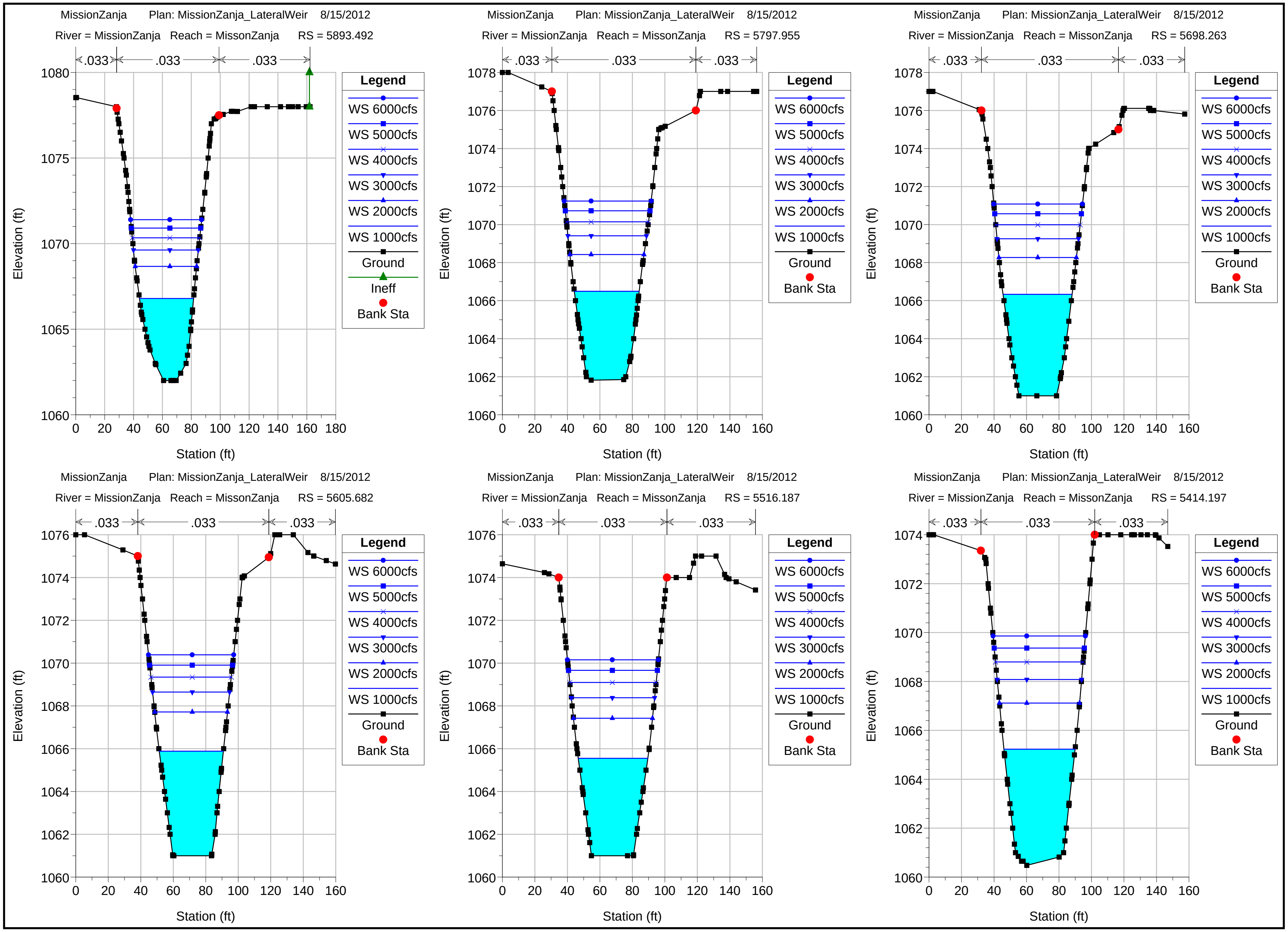
WS 1000cfs
Ground
Ineff
Bank Sta
Elevation (ft)
Station (ft)



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River = MissionZanja Reach = MissonZanja RS = 5893.492
.033 .033 .033
Legend
WS 6000cfs
WS 5000cfs
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WS 1000cfs
Ground
Ineff
Bank Sta
Elevation (ft)
Station (ft)
MissionZanja Plan: MissionZanja_LateralWeir 8/15/2012
River = MissionZanja Reach = MissonZanja RS = 5797.955
.033 .033 .033
Legend
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WS 1000cfs
Ground
Bank Sta
Elevation (ft)
Station (ft)
MissionZanja Plan: MissionZanja_LateralWeir 8/15/2012
River = MissionZanja Reach = MissonZanja RS = 5698.263
.033 .033 .033
Legend
WS 6000cfs
WS 5000cfs
WS 4000cfs
WS 3000cfs
WS 2000cfs
WS 1000cfs
Ground
Bank Sta
Elevation (ft)
Station (ft)
MissionZanja Plan: MissionZanja_LateralWeir 8/15/2012
River = MissionZanja Reach = MissonZanja RS = 5605.682
.033 .033 .033
Legend
WS 6000cfs
WS 5000cfs
WS 4000cfs
WS 3000cfs
WS 2000cfs
WS 1000cfs
Ground
Bank Sta
Elevation (ft)
Station (ft)
MissionZanja Plan: MissionZanja_LateralWeir 8/15/2012
River = MissionZanja Reach = MissonZanja RS = 5516.187
.033 .033 .033
Legend
WS 6000cfs
WS 5000cfs
WS 4000cfs
WS 3000cfs
WS 2000cfs
WS 1000cfs
Ground
Bank Sta
Elevation (ft)
Station (ft)
MissionZanja Plan: MissionZanja_LateralWeir 8/15/2012
River = MissionZanja Reach = MissonZanja RS = 5414.197
.033 .033 .033
Legend
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WS 4000cfs
WS 3000cfs
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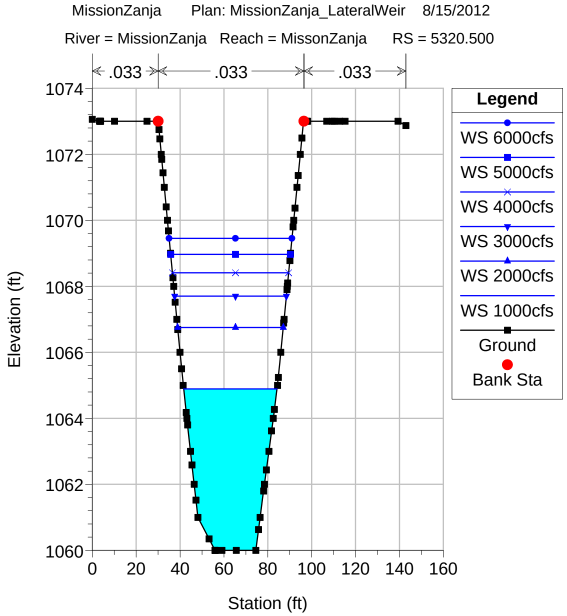
WS 1000cfs
Ground
Bank Sta
Elevation (ft)
Station (ft)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River = MissionZanja Reach = MissonZanja RS = 5320.500
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Elevation (ft)
Station (ft)
Legend
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WS 5000cfs
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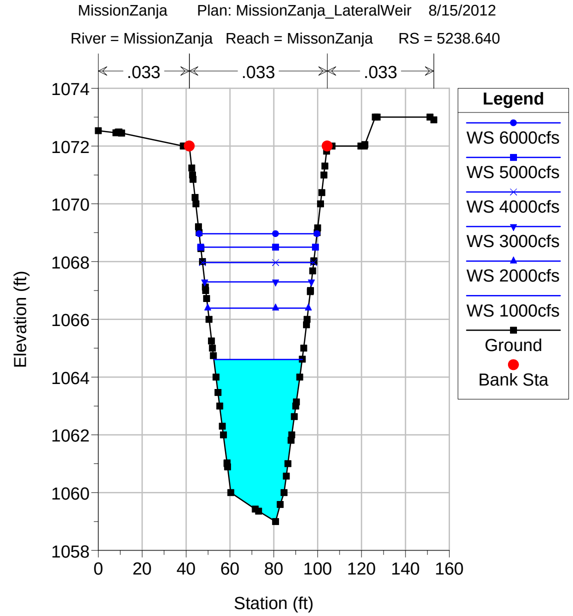
WS 1000cfs
Ground
Bank Sta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River = MissionZanja Reach = MissonZanja RS = 5238.640
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Elevation (ft)
Station (ft)
Legend
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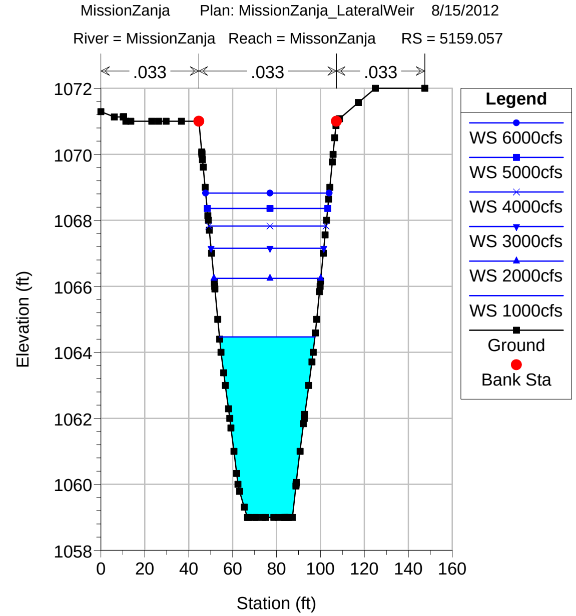
Ground
Bank Sta


MissionZanja Plan: MissionZanja_LateralWeir 8/15/2012
River = MissionZanja Reach = MissonZanja RS = 5159.057
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Elevation (ft)
Station (ft)
Legend
WS 6000cfs
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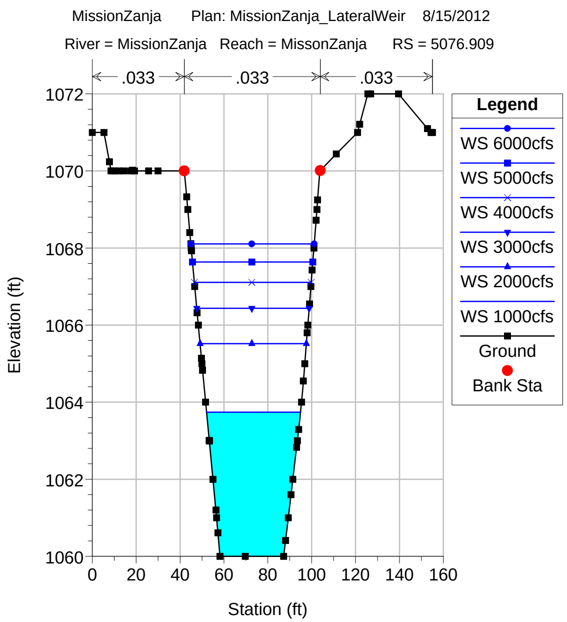
Ground
Bank Sta


MissionZanja Plan: MissionZanja_LateralWeir 8/15/2012
River = MissionZanja Reach = MissonZanja RS = 5076.909
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.033
.033
Elevation (ft)
Station (ft)
Legend
WS 6000cfs
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WS 4000cfs
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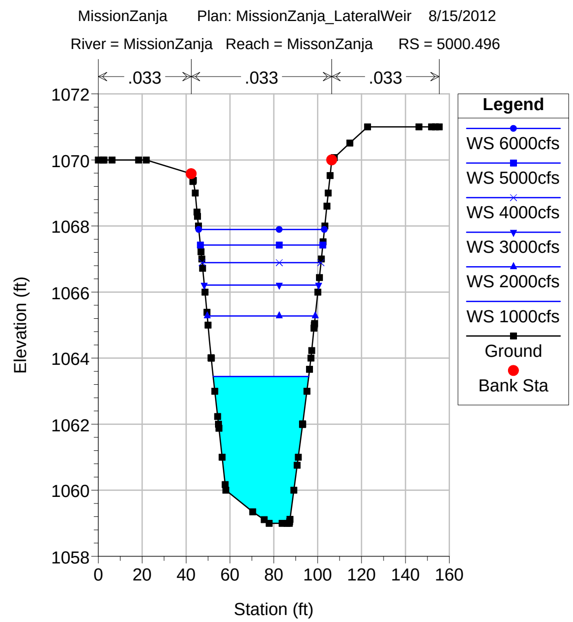
WS 2000cfs
WS 1000cfs
Ground
Bank Sta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River = MissionZanja Reach = MissonZanja RS = 5000.496
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.033
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Elevation (ft)
Station (ft)
Legend
WS 6000cfs
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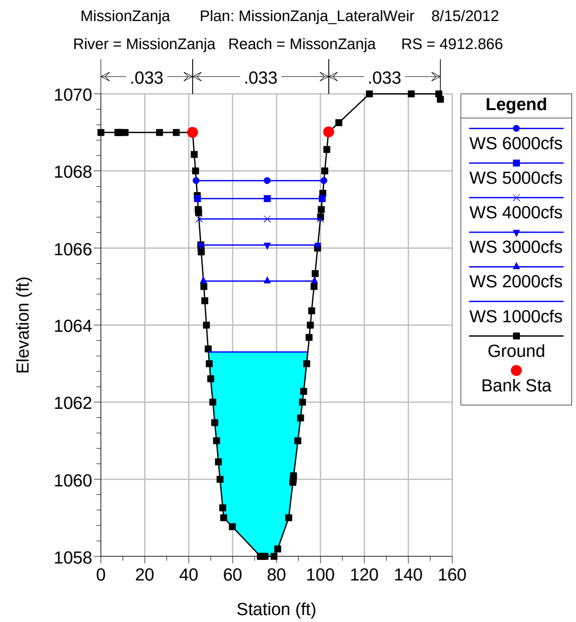
WS 1000cfs
Ground
Bank Sta


MissionZanja Plan: MissionZanja_LateralWeir 8/15/2012
River = MissionZanja Reach = MissonZanja RS = 4912.866
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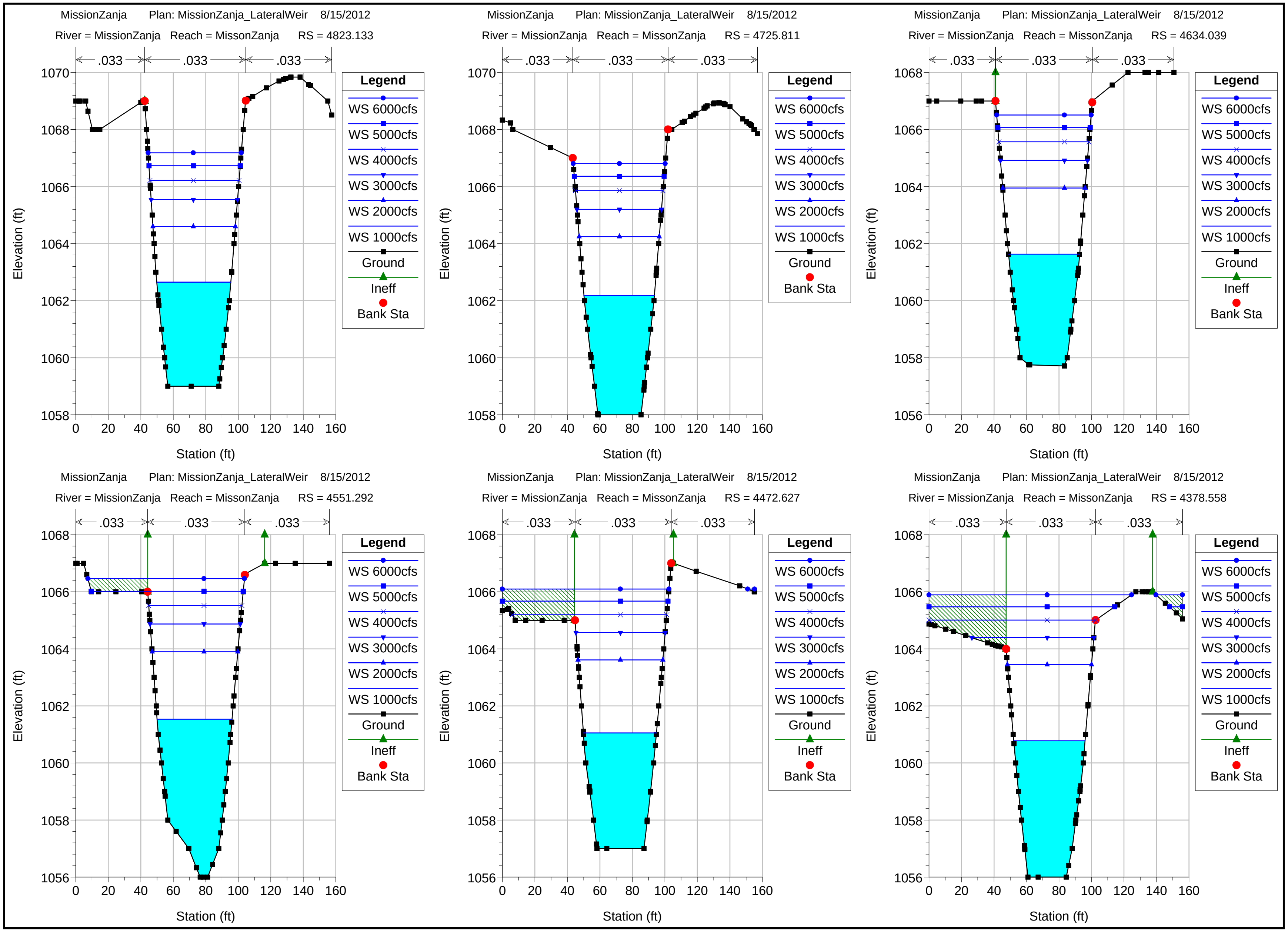
.033
.033
Elevation (ft)
Station (ft)
Legend
WS 6000cfs
WS 5000cfs
WS 4000cfs
WS 3000cfs
WS 2000cfs
WS 1000cfs
Ground
Bank Sta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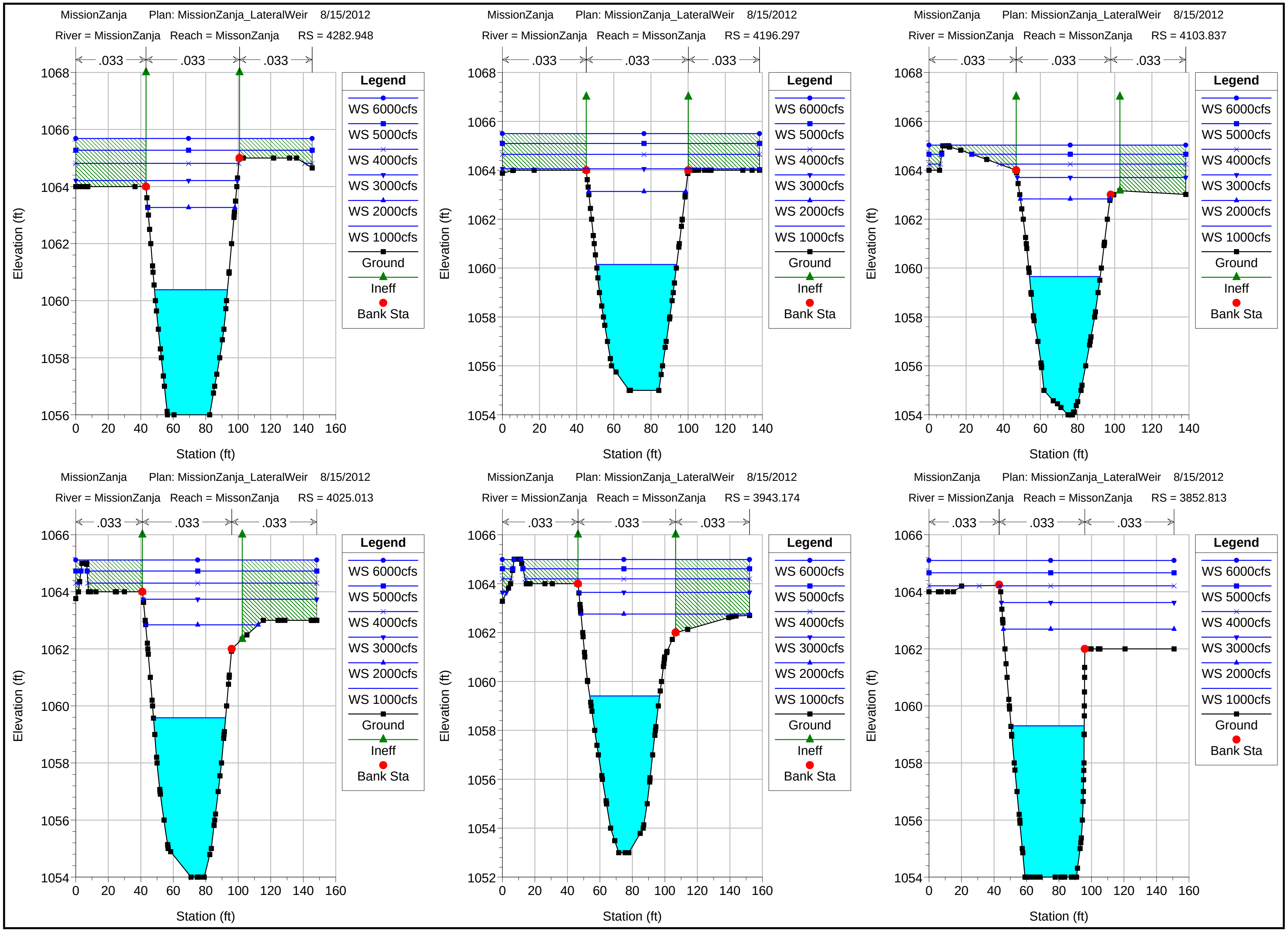
River = MissionZanja Reach = MissonZanja RS = 4823.133
MissionZanja Plan: MissionZanja_LateralWeir 8/15/2012
River = MissionZanja Reach = MissonZanja RS = 4725.811
MissionZanja Plan: MissionZanja_LateralWeir 8/15/2012
River = MissionZanja Reach = MissonZanja RS = 4634.039
MissionZanja Plan: MissionZanja_LateralWeir 8/15/2012
River = MissionZanja Reach = MissonZanja RS = 4551.292
MissionZanja Plan: MissionZanja_LateralWeir 8/15/2012
River = MissionZanja Reach = MissonZanja RS = 4472.627
MissionZanja Plan: MissionZanja_LateralWeir 8/15/2012
River = MissionZanja Reach = MissonZanja RS = 4378.558
.033
Elevation (ft)
Station (ft)
Legend
WS 6000cfs
WS 5000cfs
WS 4000cfs
WS 3000cfs
WS 2000cfs
WS 1000cfs
Ground
Ineff
Bank Sta



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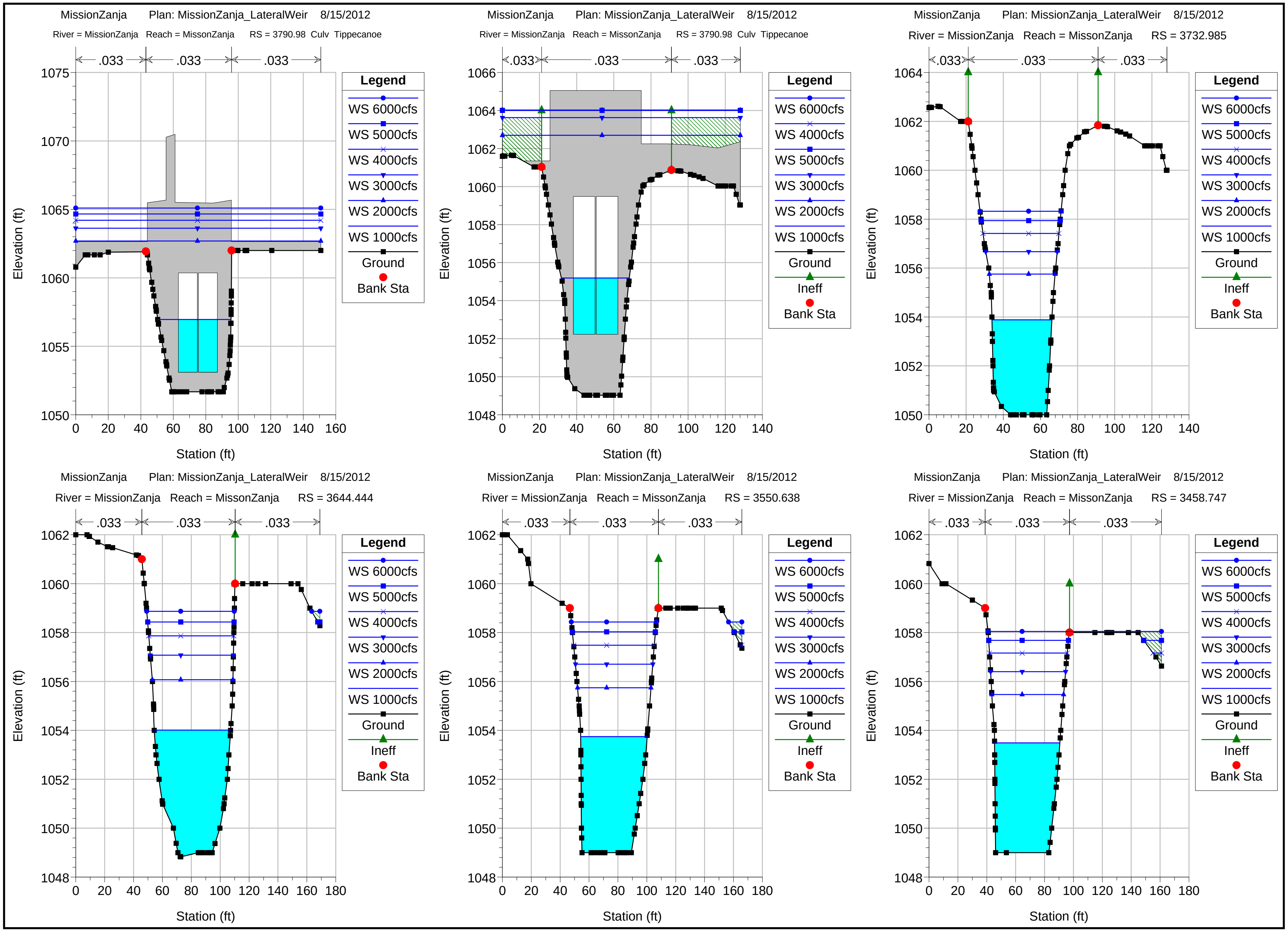
River = MissionZanja Reach = MissonZanja RS = 4282.948
.033 .033 .033
Elevation (ft)
Station (ft)
Legend
WS 6000cfs
WS 5000cfs
WS 4000cfs
WS 3000cfs
WS 2000cfs
WS 1000cfs
Ground
Ineff
Bank Sta
MissionZanja Plan: MissionZanja_LateralWeir 8/15/2012
River = MissionZanja Reach = MissonZanja RS = 4196.297
MissionZanja Plan: MissionZanja_LateralWeir 8/15/2012
River = MissionZanja Reach = MissonZanja RS = 4103.837
MissionZanja Plan: MissionZanja_LateralWeir 8/15/2012
River = MissionZanja Reach = MissonZanja RS = 4025.013
MissionZanja Plan: MissionZanja_LateralWeir 8/15/2012
River = MissionZanja Reach = MissonZanja RS = 3943.174
MissionZanja Plan: MissionZanja_LateralWeir 8/15/2012
River = MissionZanja Reach = MissonZanja RS = 3852.813


MissionZanja Plan: MissionZanja_LateralWeir 8/15/2012
River = MissionZanja Reach = MissonZanja RS = 3790.98 Culv Tippecanoe
.033
.033
.033
Elevation (ft)
Station (ft)
Legend
WS 6000cfs
WS 5000cfs
WS 4000cfs
WS 3000cfs
WS 2000cfs
WS 1000cfs
Ground
Bank Sta
MissionZanja Plan: MissionZanja_LateralWeir 8/15/2012
River = MissionZanja Reach = MissonZanja RS = 3790.98 Culv Tippecanoe
.033
.033
.033
Elevation (ft)
Station (ft)
Legend
WS 6000cfs
WS 4000cfs
WS 5000cfs
WS 3000cfs
WS 2000cfs
WS 1000cfs
Ground
Ineff
Bank Sta
MissionZanja Plan: MissionZanja_LateralWeir 8/15/2012
River = MissionZanja Reach = MissonZanja RS = 3732.985
.033
.033
.033
Elevation (ft)
Station (ft)
Legend
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WS 4000cfs
WS 3000cfs
WS 2000cfs
WS 1000cfs
Ground
Ineff
Bank Sta
MissionZanja Plan: MissionZanja_LateralWeir 8/15/2012
River = MissionZanja Reach = MissonZanja RS = 3644.444
.033
.033
.033
Elevation (ft)
Station (ft)
Legend
WS 6000cfs
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WS 2000cfs
WS 1000cfs
Ground
Ineff
Bank Sta
MissionZanja Plan: MissionZanja_LateralWeir 8/15/2012
River = MissionZanja Reach = MissonZanja RS = 3550.638
.033
.033
.033
Elevation (ft)
Station (ft)
Legend
WS 6000cfs
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WS 3000cfs
WS 2000cfs
WS 1000cfs
Ground
Ineff
Bank Sta
MissionZanja Plan: MissionZanja_LateralWeir 8/15/2012
River = MissionZanja Reach = MissonZanja RS = 3458.747
.033
.033
.033
Elevation (ft)
Station (ft)
Legend
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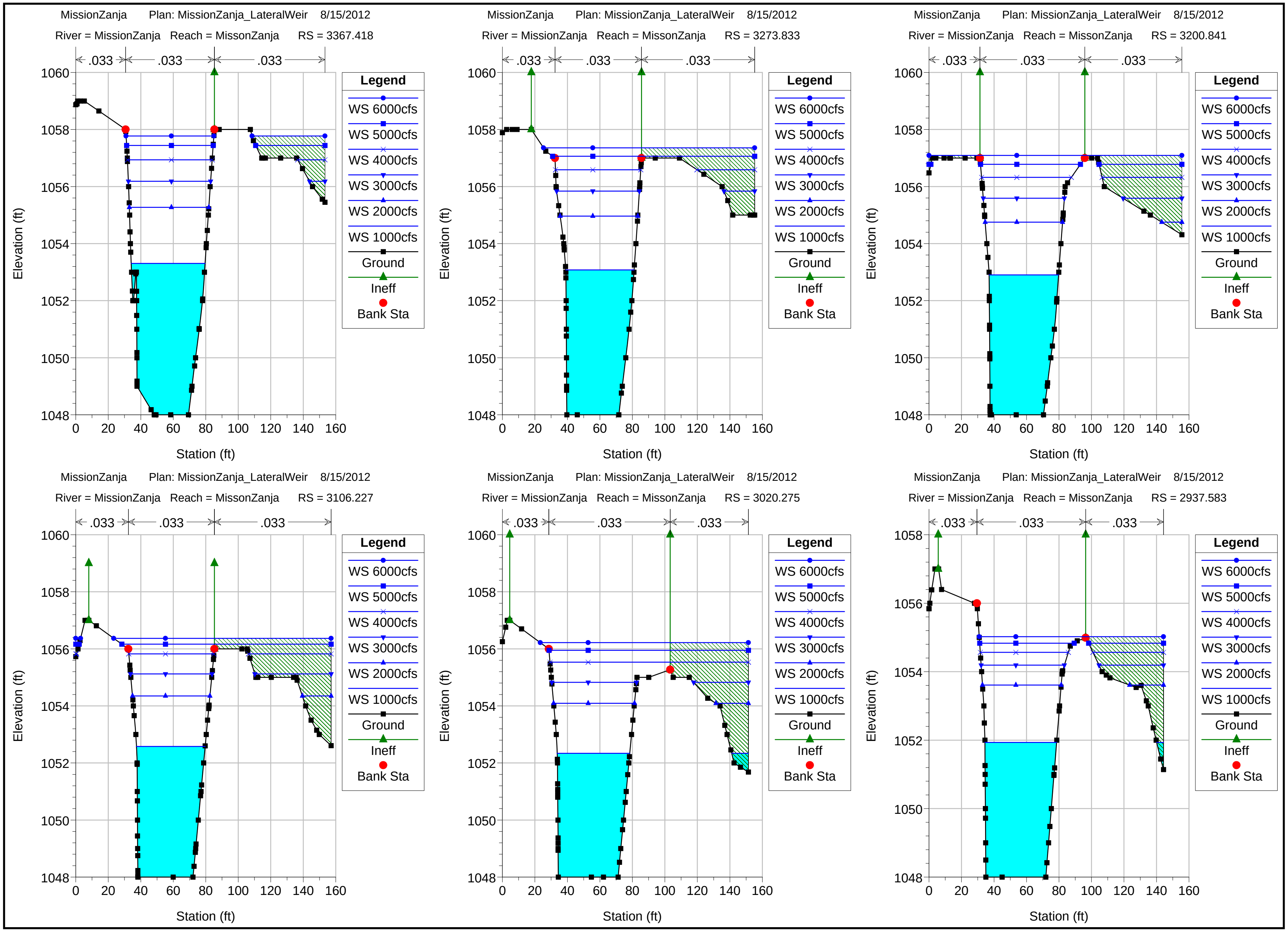
WS 2000cfs
WS 1000cfs
Ground
Ineff
Bank Sta



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River = MissionZanja Reach = MissonZanja RS = 3367.418
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.033
.033
Elevation (ft)
Station (ft)
Legend
WS 6000cfs
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WS 2000cfs
WS 1000cfs
Ground
Ineff
Bank Sta
MissionZanja Plan: MissionZanja_LateralWeir 8/15/2012
River = MissionZanja Reach = MissonZanja RS = 3273.833
.033
.033
.033
Elevation (ft)
Station (ft)
Legend
WS 6000cfs
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WS 4000cfs
WS 3000cfs
WS 2000cfs
WS 1000cfs
Ground
Ineff
Bank Sta
MissionZanja Plan: MissionZanja_LateralWeir 8/15/2012
River = MissionZanja Reach = MissonZanja RS = 3200.841
.033
.033
.033
Elevation (ft)
Station (ft)
Legend
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WS 3000cfs
WS 2000cfs
WS 1000cfs
Ground
Ineff
Bank Sta
MissionZanja Plan: MissionZanja_LateralWeir 8/15/2012
River = MissionZanja Reach = MissonZanja RS = 3106.227
.033
.033
.033
Elevation (ft)
Station (ft)
Legend
WS 6000cfs
WS 5000cfs
WS 4000cfs
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WS 2000cfs
WS 1000cfs
Ground
Ineff
Bank Sta
MissionZanja Plan: MissionZanja_LateralWeir 8/15/2012
River = MissionZanja Reach = MissonZanja RS = 3020.275
.033
.033
.033
Elevation (ft)
Station (ft)
Legend
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WS 2000cfs
WS 1000cfs
Ground
Ineff
Bank Sta
MissionZanja Plan: MissionZanja_LateralWeir 8/15/2012
River = MissionZanja Reach = MissonZanja RS = 2937.583
.033
.033
.033
Elevation (ft)
Station (ft)
Legend
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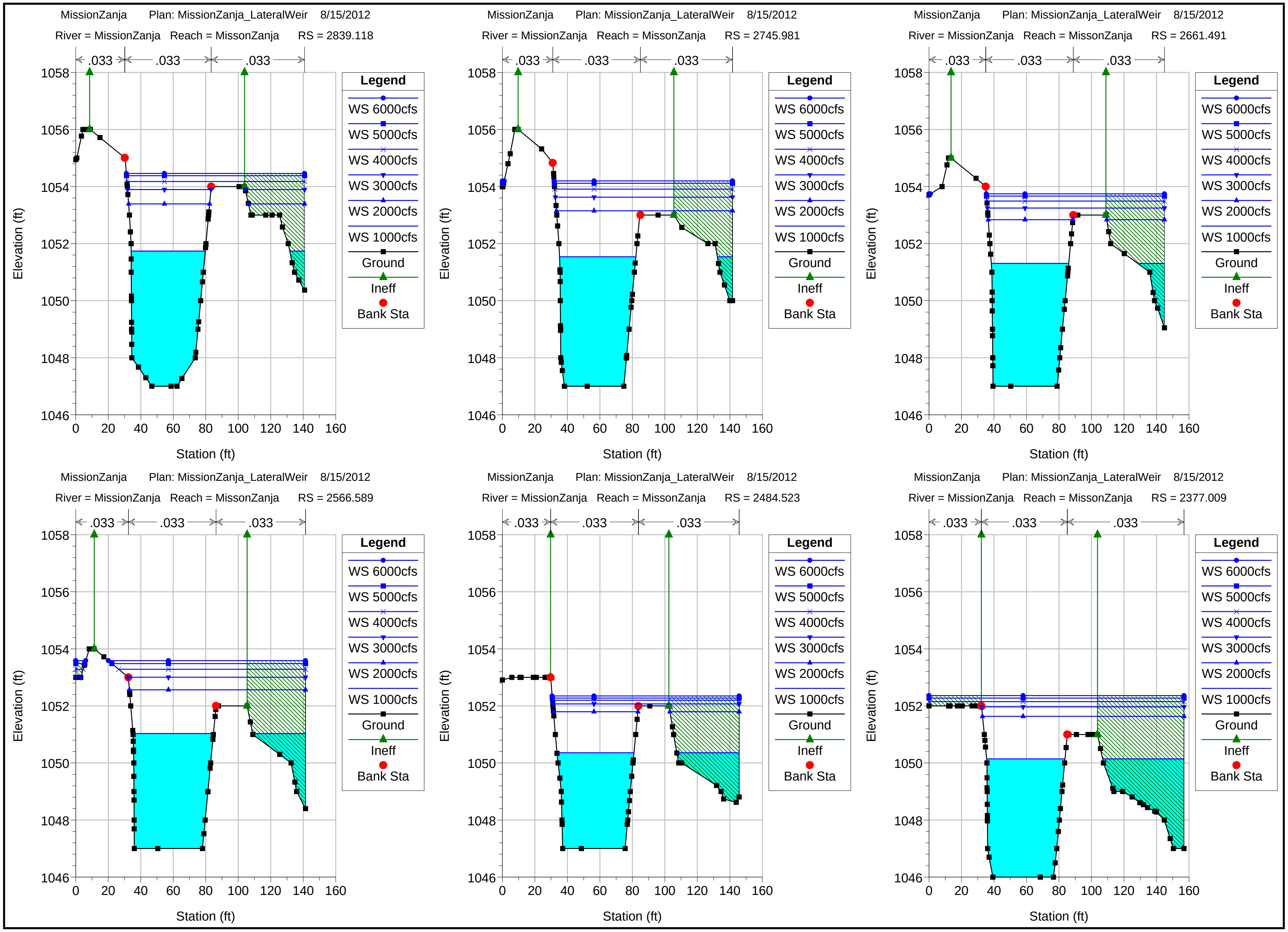
Ground
Ineff
Bank Sta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River = MissionZanja Reach = MissonZanja RS = 2839.118
MissionZanja Plan: MissionZanja_LateralWeir 8/15/2012
River = MissionZanja Reach = MissonZanja RS = 2745.981
MissionZanja Plan: MissionZanja_LateralWeir 8/15/2012
River = MissionZanja Reach = MissonZanja RS = 2661.491
MissionZanja Plan: MissionZanja_LateralWeir 8/15/2012
River = MissionZanja Reach = MissonZanja RS = 2566.589
MissionZanja Plan: MissionZanja_LateralWeir 8/15/2012
River = MissionZanja Reach = MissonZanja RS = 2484.523
MissionZanja Plan: MissionZanja_LateralWeir 8/15/2012
River = MissionZanja Reach = MissonZanja RS = 2377.009
.033
.033
.033
Legend
WS 6000cfs
WS 5000cfs
WS 4000cfs
WS 3000cfs
WS 2000cfs
WS 1000cfs
Ground
Ineff
Bank Sta
Elevation (ft)
Station (ft)
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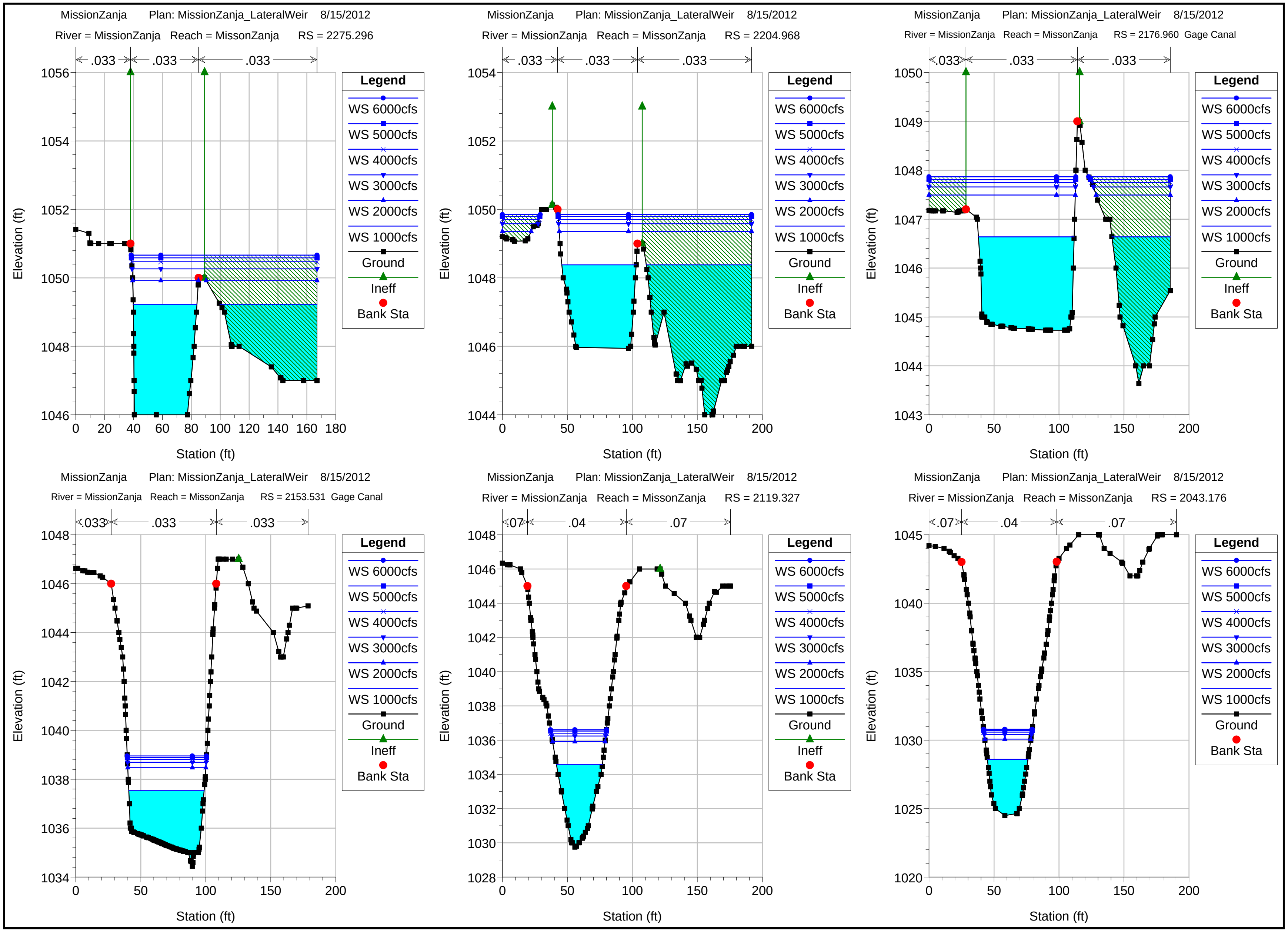
120
140
160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River = MissionZanja Reach = MissonZanja RS = 2275.296
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Legend
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WS 5000cfs
WS 4000cfs
WS 3000cfs
WS 2000cfs
WS 1000cfs
Ground
Ineff
Bank Sta
Elevation (ft)
Station (ft)
MissionZanja Plan: MissionZanja_LateralWeir 8/15/2012
River = MissionZanja Reach = MissonZanja RS = 2204.968
.033 .033 .033
Legend
WS 6000cfs
WS 5000cfs
WS 4000cfs
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WS 2000cfs
WS 1000cfs
Ground
Ineff
Bank Sta
Elevation (ft)
Station (ft)
MissionZanja Plan: MissionZanja_LateralWeir 8/15/2012
River = MissionZanja Reach = MissonZanja RS = 2176.960 Gage Canal
.033 .033 .033
Legend
WS 6000cfs
WS 5000cfs
WS 4000cfs
WS 3000cfs
WS 2000cfs
WS 1000cfs
Ground
Ineff
Bank Sta
Elevation (ft)
Station (ft)
MissionZanja Plan: MissionZanja_LateralWeir 8/15/2012
River = MissionZanja Reach = MissonZanja RS = 2153.531 Gage Canal
.033 .033 .033
Legend
WS 6000cfs
WS 5000cfs
WS 4000cfs
WS 3000cfs
WS 2000cfs
WS 1000cfs
Ground
Ineff
Bank Sta
Elevation (ft)
Station (ft)
MissionZanja Plan: MissionZanja_LateralWeir 8/15/2012
River = MissionZanja Reach = MissonZanja RS = 2119.327
.07 .04 .07
Legend
WS 6000cfs
WS 5000cfs
WS 4000cfs
WS 3000cfs
WS 2000cfs
WS 1000cfs
Ground
Ineff
Bank Sta
Elevation (ft)
Station (ft)
MissionZanja Plan: MissionZanja_LateralWeir 8/15/2012
River = MissionZanja Reach = MissonZanja RS = 2043.176
.07 .04 .07
Legend
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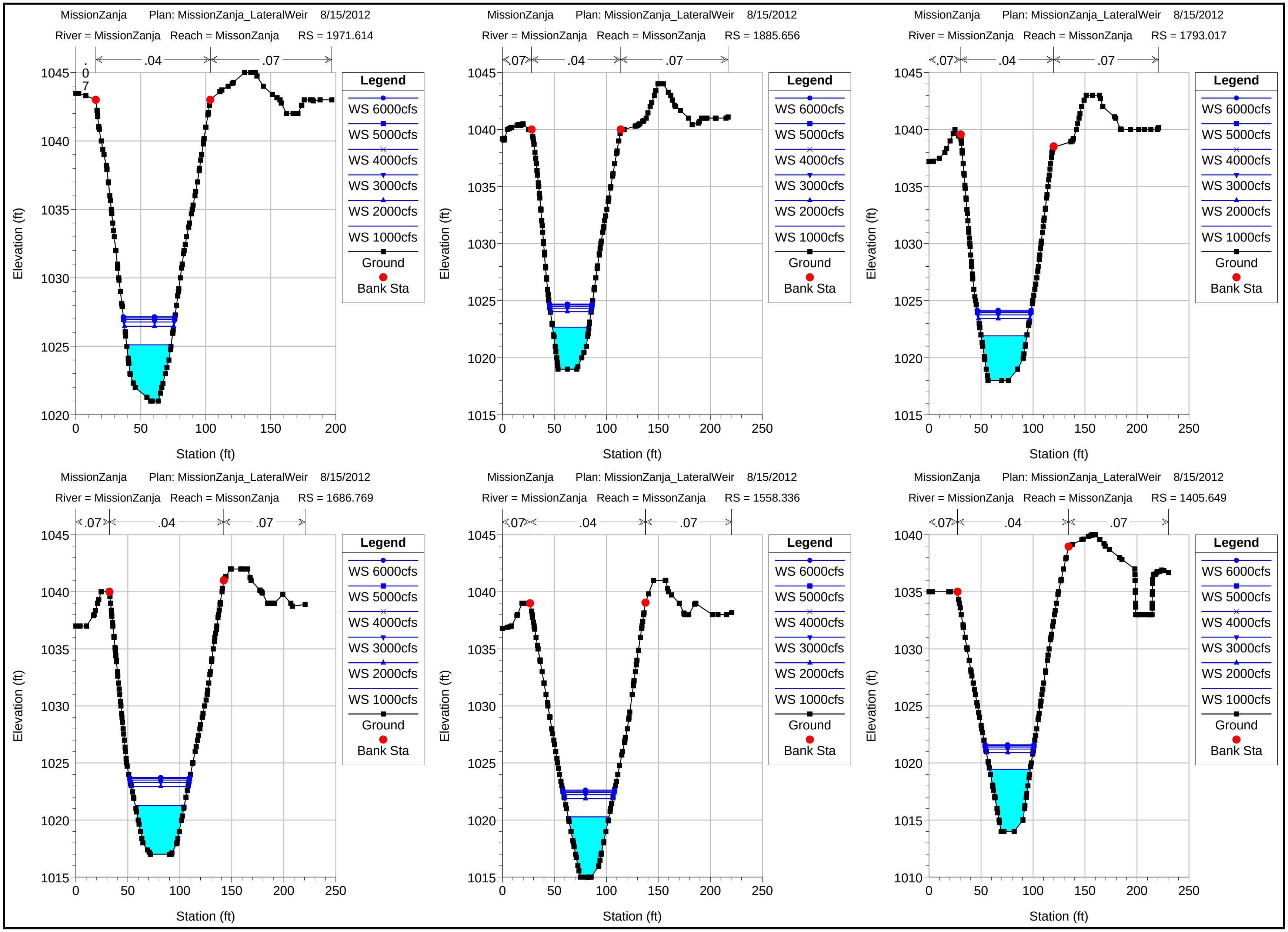
WS 1000cfs
Ground
Bank Sta
Elevation (ft)
Station (ft)


MissionZanja Plan: MissionZanja_LateralWeir 8/15/2012
River = MissionZanja Reach = MissonZanja RS = 1971.614
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River = MissionZanja Reach = MissonZanja RS = 1885.656
MissionZanja Plan: MissionZanja_LateralWeir 8/15/2012
River = MissionZanja Reach = MissonZanja RS = 1793.017
MissionZanja Plan: MissionZanja_LateralWeir 8/15/2012
River = MissionZanja Reach = MissonZanja RS = 1686.769
MissionZanja Plan: MissionZanja_LateralWeir 8/15/2012
River = MissionZanja Reach = MissonZanja RS = 1558.336
MissionZanja Plan: MissionZanja_LateralWeir 8/15/2012
River = MissionZanja Reach = MissonZanja RS = 1405.649
.07
.04
.07
Legend
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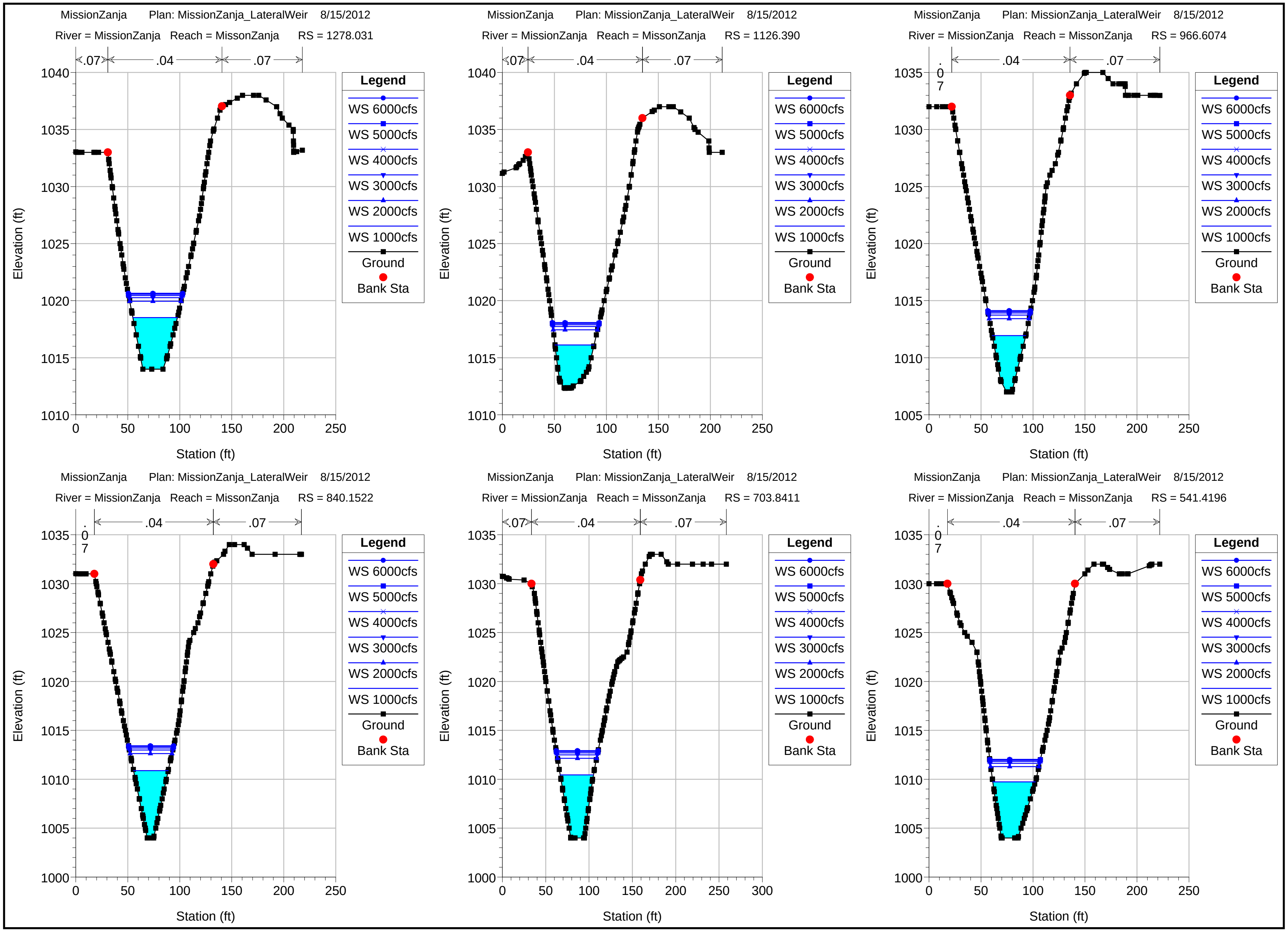
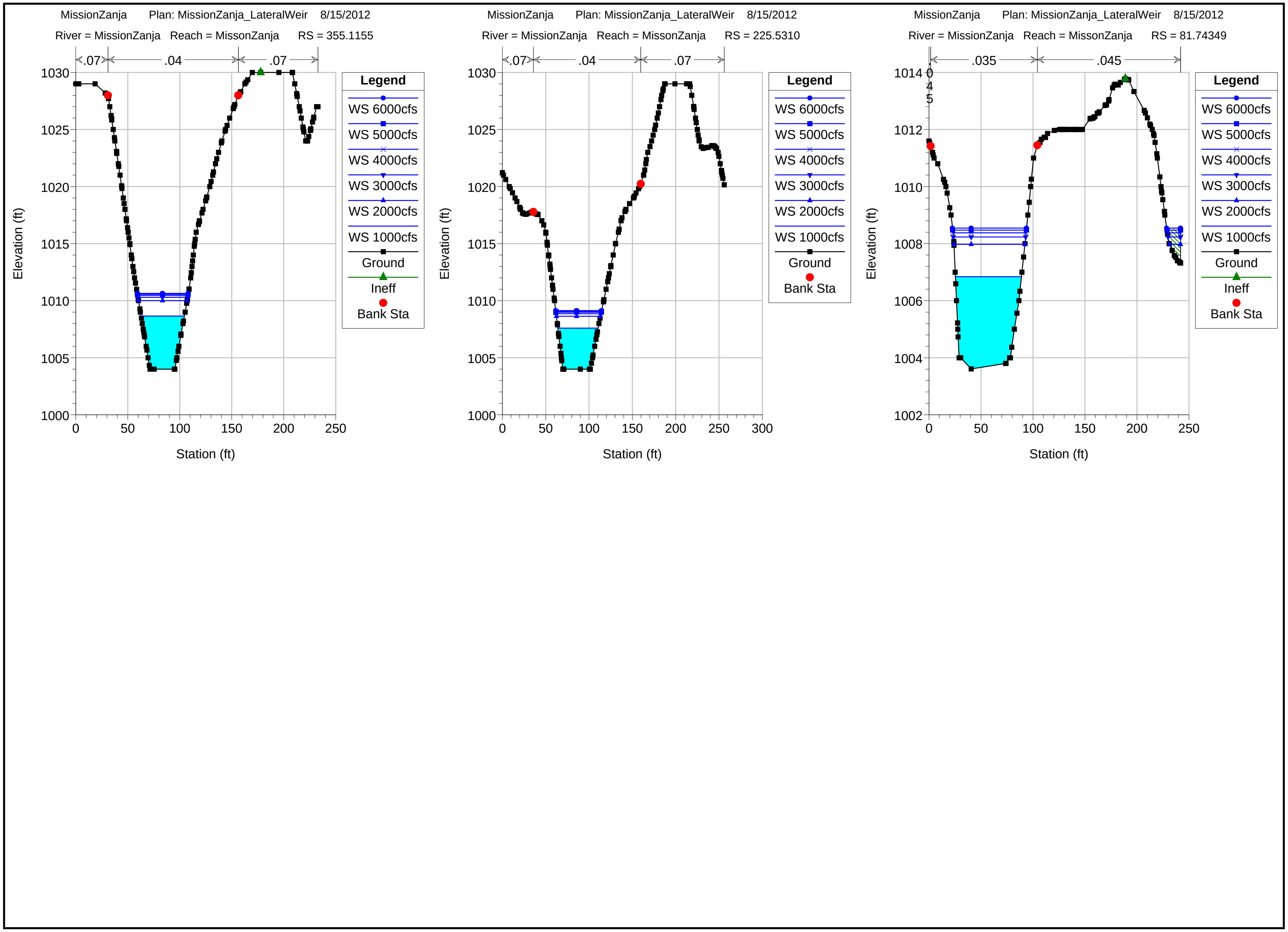
WS 2000cfs
WS 1000cfs
Ground
Bank Sta
Elevation (ft)
Station (ft)


MissionZanja Plan: MissionZanja_LateralWeir 8/15/2012
River = MissionZanja Reach = MissonZanja RS = 1278.031
Legend
WS 6000cfs
WS 5000cfs
WS 4000cfs
WS 3000cfs
WS 2000cfs
WS 1000cfs
Ground
Bank Sta
Elevation (ft)
Station (ft)
MissionZanja Plan: MissionZanja_LateralWeir 8/15/2012
River = MissionZanja Reach = MissonZanja RS = 1126.390
MissionZanja Plan: MissionZanja_LateralWeir 8/15/2012
River = MissionZanja Reach = MissonZanja RS = 966.6074
MissionZanja Plan: MissionZanja_LateralWeir 8/15/2012
River = MissionZanja Reach = MissonZanja RS = 840.1522
MissionZanja Plan: MissionZanja_LateralWeir 8/15/2012
River = MissionZanja Reach = MissonZanja RS = 703.8411
MissionZanja Plan: MissionZanja_LateralWeir 8/15/2012
River = MissionZanja Reach = MissonZanja RS = 541.4196



MissionZanja Plan: MissionZanja_LateralWeir 8/15/2012
River = MissionZanja Reach = MissonZanja RS = 355.1155
.07
.04
.07
Elevation (ft)
Station (ft)
Legend
WS 6000cfs
WS 5000cfs
WS 4000cfs
WS 3000cfs
WS 2000cfs
WS 1000cfs
Ground
Ineff
Bank Sta
MissionZanja Plan: MissionZanja_LateralWeir 8/15/2012
River = MissionZanja Reach = MissonZanja RS = 225.5310
.07
.04
.07
Elevation (ft)
Station (ft)
Legend
WS 6000cfs
WS 5000cfs
WS 4000cfs
WS 3000cfs
WS 2000cfs
WS 1000cfs
Ground
Bank Sta
MissionZanja Plan: MissionZanja_LateralWeir 8/15/2012
River = MissionZanja Reach = MissonZanja RS = 81.74349
.035
.045
Elevation (ft)
Station (ft)
Legend
WS 6000cfs
WS 5000cfs
WS 4000cfs
WS 3000cfs
WS 2000cfs
WS 1000cfs
Ground
Ineff
Bank Sta

# Attachment 2 – Hydraulic Analysis Results

HEC-RAS Plan: LW River: MissionZanja Reach: MissonZanja

| Reach | River Sta | Profile | Q Total | Min Ch El | W.S. Elev | Crit W.S. | E.G. Elev | E.G. Slope | Vel Chnl | Flow Area | Top Width | Froude # Chl |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | (cfs) | (ft) | (ft) | (ft) | (ft) | (ft/ft) | (ft/s) | (sq ft) | (ft) | |
| MissonZanja | 14108.32 | 1000cfs | 1000.00 | 1141.00 | 1143.57 | 1143.57 | 1144.75 | 0.012379 | 8.74 | 114.42 | 47.85 | 1.00 |
| MissonZanja | 14108.32 | 2000cfs | 2000.00 | 1141.00 | 1144.96 | 1144.96 | 1146.84 | 0.011473 | 11.02 | 181.45 | 48.32 | 1.00 |
| MissonZanja | 14108.32 | 3000cfs | 3000.00 | 1141.00 | 1146.12 | 1146.12 | 1148.59 | 0.011083 | 12.61 | 237.95 | 48.55 | 1.00 |
| MissonZanja | 14108.32 | 4000cfs | 4000.00 | 1141.00 | 1147.19 | 1147.19 | 1150.15 | 0.010751 | 13.80 | 289.86 | 48.89 | 1.00 |
| MissonZanja | 14108.32 | 5000cfs | 5000.00 | 1141.00 | 1148.20 | 1148.20 | 1151.57 | 0.010474 | 14.72 | 339.59 | 49.99 | 1.00 |
| MissonZanja | 14108.32 | 6000cfs | 6000.00 | 1141.00 | 1149.17 | 1149.17 | 1152.86 | 0.010242 | 15.40 | 389.59 | 81.73 | 1.00 |
| | | | | | | | | | | | | |
| MissonZanja | 14108 | | Lat Struct | | | | | | | | | |
| | | | | | | | | | | | | |
| MissonZanja | 13783.82 | 1000cfs | 1000.00 | 1134.00 | 1138.66 | 1137.85 | 1139.58 | 0.005788 | 7.69 | 130.00 | 36.21 | 0.72 |
| MissonZanja | 13783.82 | 2000cfs | 2000.00 | 1134.00 | 1140.71 | 1139.72 | 1142.11 | 0.005804 | 9.47 | 211.16 | 42.33 | 0.75 |
| MissonZanja | 13783.82 | 3000cfs | 3000.00 | 1134.00 | 1142.23 | 1141.16 | 1144.04 | 0.005922 | 10.78 | 278.21 | 45.85 | 0.77 |
| MissonZanja | 13783.82 | 4000cfs | 4000.00 | 1134.00 | 1143.49 | 1142.38 | 1145.67 | 0.006083 | 11.85 | 337.65 | 48.73 | 0.79 |
| MissonZanja | 13783.82 | 5000cfs | 5000.00 | 1134.00 | 1144.58 | 1143.46 | 1147.11 | 0.006243 | 12.75 | 392.18 | 51.22 | 0.81 |
| MissonZanja | 13783.82 | 6000cfs | 6000.00 | 1134.00 | 1145.56 | 1144.44 | 1148.41 | 0.006377 | 13.53 | 443.58 | 64.09 | 0.83 |
| | | | | | | | | | | | | |
| MissonZanja | 13563.26 | 1000cfs | 1000.00 | 1133.00 | 1137.57 | 1136.57 | 1138.37 | 0.004895 | 7.17 | 139.38 | 38.07 | 0.66 |
| MissonZanja | 13563.26 | 2000cfs | 2000.00 | 1133.00 | 1139.65 | 1138.38 | 1140.88 | 0.004954 | 8.90 | 224.69 | 43.94 | 0.69 |
| MissonZanja | 13563.26 | 3000cfs | 3000.00 | 1133.00 | 1141.12 | 1139.81 | 1142.75 | 0.005290 | 10.26 | 292.34 | 47.93 | 0.73 |
| MissonZanja | 13563.26 | 4000cfs | 4000.00 | 1133.00 | 1142.33 | 1141.02 | 1144.33 | 0.005564 | 11.34 | 352.59 | 51.23 | 0.76 |
| MissonZanja | 13563.26 | 5000cfs | 5000.00 | 1133.00 | 1143.40 | 1142.07 | 1145.72 | 0.005771 | 12.24 | 408.55 | 57.94 | 0.78 |
| MissonZanja | 13563.26 | 6000cfs | 6000.00 | 1133.00 | 1144.38 | 1143.07 | 1146.99 | 0.005879 | 12.96 | 463.47 | 71.87 | 0.80 |
| | | | | | | | | | | | | |
| MissonZanja | 13339.98 | 1000cfs | 1000.00 | 1132.00 | 1136.92 | 1135.28 | 1137.46 | 0.002913 | 5.88 | 170.09 | 42.35 | 0.52 |
| MissonZanja | 13339.98 | 2000cfs | 2000.00 | 1132.00 | 1138.99 | 1137.04 | 1139.89 | 0.003271 | 7.59 | 263.44 | 47.80 | 0.57 |
| MissonZanja | 13339.98 | 3000cfs | 3000.00 | 1132.00 | 1140.39 | 1138.39 | 1141.65 | 0.003771 | 9.02 | 332.70 | 51.26 | 0.62 |
| MissonZanja | 13339.98 | 4000cfs | 4000.00 | 1132.00 | 1141.54 | 1139.55 | 1143.14 | 0.004177 | 10.17 | 393.17 | 101.81 | 0.67 |
| MissonZanja | 13339.98 | 5000cfs | 5000.00 | 1132.00 | 1142.54 | 1140.59 | 1144.47 | 0.004496 | 11.14 | 448.82 | 116.22 | 0.70 |
| MissonZanja | 13339.98 | 6000cfs | 6000.00 | 1132.00 | 1143.48 | 1141.54 | 1145.69 | 0.004782 | 11.93 | 502.95 | 128.22 | 0.72 |
| | | | | | | | | | | | | |
| MissonZanja | 13094.94 | 1000cfs | 1000.00 | 1132.00 | 1135.94 | 1134.92 | 1136.59 | 0.004326 | 6.46 | 154.78 | 45.88 | 0.62 |
| MissonZanja | 13094.94 | 2000cfs | 2000.00 | 1132.00 | 1138.15 | 1136.48 | 1139.05 | 0.003593 | 7.61 | 262.69 | 51.83 | 0.60 |
| MissonZanja | 13094.94 | 3000cfs | 3000.00 | 1132.00 | 1139.38 | 1137.75 | 1140.67 | 0.004217 | 9.13 | 328.56 | 60.70 | 0.66 |
| MissonZanja | 13094.94 | 4000cfs | 4000.00 | 1132.00 | 1140.34 | 1138.83 | 1142.04 | 0.004827 | 10.45 | 382.87 | 102.05 | 0.71 |
| MissonZanja | 13094.94 | 5000cfs | 5000.00 | 1132.00 | 1141.16 | 1139.82 | 1143.25 | 0.005384 | 11.60 | 430.85 | 130.80 | 0.76 |
| MissonZanja | 13094.94 | 6000cfs | 6000.00 | 1132.00 | 1141.90 | 1140.71 | 1144.37 | 0.005849 | 12.61 | 475.90 | 249.77 | 0.80 |
| | | | | | | | | | | | | |
| MissonZanja | 12892.68 | 1000cfs | 1000.00 | 1130.40 | 1135.37 | 1133.81 | 1135.85 | 0.002763 | 5.57 | 179.55 | 47.75 | 0.51 |
| MissonZanja | 12892.68 | 2000cfs | 2000.00 | 1130.40 | 1137.69 | 1135.39 | 1138.39 | 0.002486 | 6.69 | 298.75 | 60.38 | 0.50 |
| MissonZanja | 12892.68 | 3000cfs | 3000.00 | 1130.40 | 1138.78 | 1136.65 | 1139.86 | 0.003269 | 8.33 | 360.02 | 112.88 | 0.59 |
| MissonZanja | 12892.68 | 4000cfs | 4000.00 | 1130.40 | 1139.58 | 1137.74 | 1141.08 | 0.004094 | 9.83 | 407.03 | 185.07 | 0.66 |
| MissonZanja | 12892.68 | 5000cfs | 5000.00 | 1130.40 | 1140.21 | 1138.68 | 1142.17 | 0.004966 | 11.24 | 444.99 | 299.31 | 0.74 |
| MissonZanja | 12892.68 | 6000cfs | 6000.00 | 1130.40 | 1140.73 | 1139.53 | 1143.18 | 0.005850 | 12.56 | 477.76 | 305.44 | 0.81 |
| | | | | | | | | | | | | |
| MissonZanja | 12695.45 | 1000cfs | 1000.00 | 1128.00 | 1135.17 | 1132.20 | 1135.45 | 0.001157 | 4.22 | 236.83 | 50.05 | 0.34 |
| MissonZanja | 12695.45 | 2000cfs | 2000.00 | 1128.00 | 1137.47 | 1133.89 | 1137.96 | 0.001454 | 5.62 | 355.79 | 111.97 | 0.39 |
| MissonZanja | 12695.45 | 3000cfs | 3000.00 | 1128.00 | 1138.44 | 1135.20 | 1139.26 | 0.002186 | 7.30 | 410.74 | 286.70 | 0.48 |
| MissonZanja | 12695.45 | 4000cfs | 3999.81 | 1128.00 | 1139.08 | 1136.36 | 1140.31 | 0.003019 | 8.91 | 448.81 | 367.31 | 0.57 |
| MissonZanja | 12695.45 | 5000cfs | 4975.98 | 1128.00 | 1139.53 | 1137.35 | 1141.23 | 0.003845 | 10.46 | 475.98 | 368.38 | 0.65 |
| MissonZanja | 12695.45 | 6000cfs | 5898.91 | 1128.00 | 1139.89 | 1138.17 | 1142.07 | 0.004662 | 11.86 | 497.61 | 369.25 | 0.73 |
| | | | | | | | | | | | | |
| MissonZanja | 12507.11 | 1000cfs | 1000.00 | 1128.00 | 1135.01 | 1131.50 | 1135.25 | 0.000896 | 3.90 | 256.64 | 59.25 | 0.30 |
| MissonZanja | 12507.11 | 2000cfs | 2000.00 | 1128.00 | 1137.24 | 1133.22 | 1137.69 | 0.001251 | 5.36 | 373.31 | 344.21 | 0.36 |
| MissonZanja | 12507.11 | 3000cfs | 2999.72 | 1128.00 | 1138.07 | 1134.60 | 1138.86 | 0.002023 | 7.14 | 420.11 | 406.37 | 0.47 |
| MissonZanja | 12507.11 | 4000cfs | 3924.86 | 1128.00 | 1138.57 | 1135.69 | 1139.75 | 0.002767 | 8.73 | 449.36 | 407.47 | 0.55 |
| MissonZanja | 12507.11 | 5000cfs | 4741.37 | 1128.00 | 1138.92 | 1136.54 | 1140.50 | 0.003478 | 10.09 | 469.96 | 408.25 | 0.63 |
| MissonZanja | 12507.11 | 6000cfs | 5497.60 | 1128.00 | 1139.19 | 1137.26 | 1141.18 | 0.004196 | 11.32 | 485.46 | 408.84 | 0.69 |
| | | | | | | | | | | | | |
| MissonZanja | 12361.26 | 1000cfs | 1000.00 | 1127.00 | 1134.91 | 1130.69 | 1135.12 | 0.000726 | 3.71 | 269.34 | 215.80 | 0.27 |
| MissonZanja | 12361.26 | 2000cfs | 1983.53 | 1127.00 | 1137.08 | 1132.55 | 1137.49 | 0.001388 | 5.13 | 386.33 | 410.21 | 0.38 |
| MissonZanja | 12361.26 | 3000cfs | 2810.95 | 1127.00 | 1137.90 | 1133.78 | 1138.53 | 0.001792 | 6.37 | 441.13 | 411.88 | 0.44 |
| MissonZanja | 12361.26 | 4000cfs | 3512.66 | 1127.00 | 1138.45 | 1134.68 | 1139.29 | 0.002142 | 7.35 | 478.02 | 413.00 | 0.48 |
| MissonZanja | 12361.26 | 5000cfs | 4125.69 | 1127.00 | 1138.88 | 1135.42 | 1139.91 | 0.002436 | 8.15 | 506.51 | 413.87 | 0.52 |
| MissonZanja | 12361.26 | 6000cfs | 4696.89 | 1127.00 | 1139.23 | 1136.20 | 1140.45 | 0.002714 | 8.86 | 530.07 | 414.58 | 0.55 |
| | | | | | | | | | | | | |
| MissonZanja | 12253.00 | 1000cfs | 1000.00 | 1125.00 | 1134.79 | 1130.10 | 1135.03 | 0.000868 | 3.98 | 251.50 | 201.23 | 0.28 |
| MissonZanja | 12253.00 | 2000cfs | 1853.99 | 1125.00 | 1136.93 | 1132.02 | 1137.35 | 0.001129 | 5.25 | 377.10 | 536.29 | 0.33 |
| MissonZanja | 12253.00 | 3000cfs | 2391.09 | 1125.00 | 1137.83 | 1132.95 | 1138.33 | 0.001207 | 5.84 | 450.24 | 538.26 | 0.35 |
| MissonZanja | 12253.00 | 4000cfs | 2837.13 | 1125.00 | 1138.46 | 1133.70 | 1139.03 | 0.001271 | 6.28 | 502.71 | 539.65 | 0.36 |
| MissonZanja | 12253.00 | 5000cfs | 3221.07 | 1125.00 | 1138.97 | 1134.33 | 1139.59 | 0.001311 | 6.61 | 545.67 | 540.78 | 0.37 |
| MissonZanja | 12253.00 | 6000cfs | 3578.83 | 1125.00 | 1139.41 | 1134.84 | 1140.08 | 0.001348 | 6.90 | 583.02 | 541.74 | 0.38 |
| | | | | | | | | | | | | |
| MissonZanja | 12226.55 | | Bridge | | | | | | | | | |
| | | | | | | | | | | | | |
| MissonZanja | 12206.08 | 1000cfs | 1000.00 | 1126.00 | 1128.97 | 1128.97 | 1130.28 | 0.012297 | 9.19 | 108.78 | 41.96 | 1.01 |
| MissonZanja | 12206.08 | 2000cfs | 1853.99 | 1126.00 | 1130.35 | 1130.35 | 1132.22 | 0.011029 | 10.97 | 168.97 | 45.20 | 1.00 |
| MissonZanja | 12206.08 | 3000cfs | 2391.09 | 1126.00 | 1131.07 | 1131.07 | 1133.25 | 0.010761 | 11.83 | 202.09 | 47.01 | 1.01 |
| MissonZanja | 12206.08 | 4000cfs | 2837.13 | 1126.00 | 1131.64 | 1131.64 | 1134.02 | 0.010489 | 12.36 | 229.46 | 48.83 | 1.01 |
| MissonZanja | 12206.08 | 5000cfs | 3221.07 | 1126.00 | 1132.11 | 1132.11 | 1134.64 | 0.010298 | 12.77 | 252.33 | 50.34 | 1.00 |
| MissonZanja | 12206.08 | 6000cfs | 3578.83 | 1126.00 | 1132.51 | 1132.51 | 1135.18 | 0.010158 | 13.11 | 272.94 | 51.64 | 1.01 |
| | | | | | | | | | | | | |

HEC-RAS Plan: LW River: MissionZanja Reach: MissonZanja (Continued)

| Reach | River Sta | Profile | Q Total | Min Ch El | W.S. Elev | Crit W.S. | E.G. Elev | E.G. Slope | Vel Chnl | Flow Area | Top Width | Froude # Chl |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | (cfs) | (ft) | (ft) | (ft) | (ft) | (ft/ft) | (ft/s) | (sq ft) | (ft) | |
| MissonZanja | 12206 | | Lat Struct | | | | | | | | | |
| | | | | | | | | | | | | |
| MissonZanja | 12158.80 | 1000cfs | 1000.00 | 1123.42 | 1127.08 | 1127.08 | 1128.53 | 0.011980 | 9.66 | 103.48 | 35.90 | 1.00 |
| MissonZanja | 12158.80 | 2000cfs | 1853.99 | 1123.42 | 1128.63 | 1128.63 | 1130.65 | 0.010838 | 11.40 | 162.63 | 40.05 | 1.00 |
| MissonZanja | 12158.80 | 3000cfs | 2391.09 | 1123.42 | 1129.43 | 1129.43 | 1131.76 | 0.010604 | 12.25 | 195.17 | 42.06 | 1.00 |
| MissonZanja | 12158.80 | 4000cfs | 2837.13 | 1123.42 | 1130.04 | 1130.04 | 1132.59 | 0.010346 | 12.80 | 221.61 | 43.60 | 1.00 |
| MissonZanja | 12158.80 | 5000cfs | 3221.07 | 1123.42 | 1130.56 | 1130.56 | 1133.26 | 0.010095 | 13.19 | 244.22 | 44.88 | 1.00 |
| MissonZanja | 12158.80 | 6000cfs | 3578.83 | 1123.42 | 1130.98 | 1130.98 | 1133.84 | 0.010048 | 13.59 | 263.38 | 45.94 | 1.00 |
| | | | | | | | | | | | | |
| MissonZanja | 11966.87 | 1000cfs | 1000.00 | 1120.00 | 1123.66 | 1123.66 | 1125.04 | 0.011940 | 9.42 | 106.17 | 38.46 | 1.00 |
| MissonZanja | 11966.87 | 2000cfs | 1853.99 | 1120.00 | 1125.13 | 1125.13 | 1127.05 | 0.011064 | 11.12 | 166.74 | 44.00 | 1.01 |
| MissonZanja | 11966.87 | 3000cfs | 2391.09 | 1120.00 | 1125.89 | 1125.89 | 1128.08 | 0.010674 | 11.89 | 201.05 | 46.39 | 1.01 |
| MissonZanja | 11966.87 | 4000cfs | 2837.13 | 1120.00 | 1126.46 | 1126.46 | 1128.86 | 0.010347 | 12.42 | 228.35 | 47.93 | 1.00 |
| MissonZanja | 11966.87 | 5000cfs | 3221.07 | 1120.00 | 1126.92 | 1126.92 | 1129.49 | 0.010165 | 12.85 | 250.59 | 49.10 | 1.00 |
| MissonZanja | 11966.87 | 6000cfs | 3578.83 | 1120.00 | 1127.33 | 1127.33 | 1130.04 | 0.010025 | 13.22 | 270.74 | 50.15 | 1.00 |
| | | | | | | | | | | | | |
| MissonZanja | 11817.21 | 1000cfs | 1000.00 | 1118.00 | 1122.96 | 1121.66 | 1123.64 | 0.003923 | 6.64 | 150.68 | 39.28 | 0.60 |
| MissonZanja | 11817.21 | 2000cfs | 1853.99 | 1118.00 | 1124.38 | 1123.24 | 1125.59 | 0.005232 | 8.82 | 210.09 | 43.82 | 0.71 |
| MissonZanja | 11817.21 | 3000cfs | 2391.09 | 1118.00 | 1125.14 | 1124.05 | 1126.63 | 0.005693 | 9.79 | 244.23 | 46.19 | 0.75 |
| MissonZanja | 11817.21 | 4000cfs | 2837.13 | 1118.00 | 1125.73 | 1124.68 | 1127.42 | 0.005931 | 10.43 | 271.93 | 48.03 | 0.77 |
| MissonZanja | 11817.21 | 5000cfs | 3221.07 | 1118.00 | 1126.22 | 1125.18 | 1128.06 | 0.006053 | 10.89 | 295.65 | 49.53 | 0.79 |
| MissonZanja | 11817.21 | 6000cfs | 3578.83 | 1118.00 | 1126.65 | 1125.62 | 1128.62 | 0.006139 | 11.28 | 317.26 | 50.86 | 0.80 |
| | | | | | | | | | | | | |
| MissonZanja | 11712.39 | 1000cfs | 1000.00 | 1119.00 | 1122.55 | 1121.64 | 1123.19 | 0.004497 | 6.40 | 156.34 | 47.95 | 0.62 |
| MissonZanja | 11712.39 | 2000cfs | 1853.99 | 1119.00 | 1123.95 | 1122.87 | 1125.01 | 0.005014 | 8.26 | 224.33 | 49.04 | 0.68 |
| MissonZanja | 11712.39 | 3000cfs | 2391.09 | 1119.00 | 1124.71 | 1123.56 | 1126.00 | 0.005227 | 9.14 | 261.71 | 50.20 | 0.71 |
| MissonZanja | 11712.39 | 4000cfs | 2837.13 | 1119.00 | 1125.30 | 1124.08 | 1126.77 | 0.005330 | 9.73 | 291.66 | 51.32 | 0.72 |
| MissonZanja | 11712.39 | 5000cfs | 3221.07 | 1119.00 | 1125.79 | 1124.52 | 1127.39 | 0.005371 | 10.15 | 317.20 | 52.39 | 0.73 |
| MissonZanja | 11712.39 | 6000cfs | 3578.83 | 1119.00 | 1126.22 | 1124.91 | 1127.94 | 0.005407 | 10.52 | 340.19 | 53.35 | 0.73 |
| | | | | | | | | | | | | |
| MissonZanja | 11638.58 | 1000cfs | 1000.00 | 1119.00 | 1121.43 | 1121.43 | 1122.60 | 0.012996 | 8.71 | 114.85 | 49.00 | 1.00 |
| MissonZanja | 11638.58 | 2000cfs | 1853.99 | 1119.00 | 1122.62 | 1122.62 | 1124.39 | 0.012027 | 10.69 | 173.35 | 49.29 | 1.00 |
| MissonZanja | 11638.58 | 3000cfs | 2391.09 | 1119.00 | 1123.29 | 1123.29 | 1125.37 | 0.011561 | 11.59 | 206.38 | 49.52 | 1.00 |
| MissonZanja | 11638.58 | 4000cfs | 2837.13 | 1119.00 | 1123.79 | 1123.79 | 1126.13 | 0.011362 | 12.25 | 231.59 | 49.74 | 1.00 |
| MissonZanja | 11638.58 | 5000cfs | 3221.07 | 1119.00 | 1124.20 | 1124.20 | 1126.74 | 0.011299 | 12.78 | 251.96 | 50.09 | 1.00 |
| MissonZanja | 11638.58 | 6000cfs | 3578.83 | 1119.00 | 1124.59 | 1124.59 | 1127.29 | 0.011147 | 13.19 | 271.26 | 50.57 | 1.00 |
| | | | | | | | | | | | | |
| MissonZanja | 11523.79 | 1000cfs | 1000.00 | 1113.46 | 1118.82 | 1116.95 | 1119.20 | 0.002093 | 4.98 | 200.98 | 51.60 | 0.44 |
| MissonZanja | 11523.79 | 2000cfs | 1853.99 | 1113.46 | 1120.53 | 1118.27 | 1121.14 | 0.002388 | 6.29 | 294.66 | 58.05 | 0.49 |
| MissonZanja | 11523.79 | 3000cfs | 2391.09 | 1113.46 | 1121.40 | 1118.97 | 1122.14 | 0.002506 | 6.90 | 346.55 | 61.36 | 0.51 |
| MissonZanja | 11523.79 | 4000cfs | 2837.13 | 1113.46 | 1122.04 | 1119.51 | 1122.88 | 0.002580 | 7.33 | 386.90 | 63.69 | 0.52 |
| MissonZanja | 11523.79 | 5000cfs | 3221.07 | 1113.46 | 1122.56 | 1119.93 | 1123.47 | 0.002632 | 7.66 | 420.25 | 65.56 | 0.53 |
| MissonZanja | 11523.79 | 6000cfs | 3578.83 | 1113.46 | 1123.01 | 1120.31 | 1123.99 | 0.002679 | 7.95 | 450.03 | 67.17 | 0.54 |
| | | | | | | | | | | | | |
| MissonZanja | 11389.79 | | Bridge | | | | | | | | | |
| | | | | | | | | | | | | |
| MissonZanja | 11228.00 | 1000cfs | 1000.00 | 1112.00 | 1114.83 | 1114.83 | 1116.08 | 0.012313 | 8.98 | 111.38 | 44.86 | 1.00 |
| MissonZanja | 11228.00 | 2000cfs | 1853.99 | 1112.00 | 1116.16 | 1116.16 | 1117.92 | 0.011056 | 10.63 | 174.43 | 49.81 | 1.00 |
| MissonZanja | 11228.00 | 3000cfs | 2391.09 | 1112.00 | 1116.85 | 1116.85 | 1118.87 | 0.010711 | 11.42 | 209.46 | 52.22 | 1.00 |
| MissonZanja | 11228.00 | 4000cfs | 2837.13 | 1112.00 | 1117.39 | 1117.39 | 1119.59 | 0.010347 | 11.92 | 238.03 | 53.98 | 1.00 |
| MissonZanja | 11228.00 | 5000cfs | 3221.07 | 1112.00 | 1117.81 | 1117.81 | 1120.17 | 0.010156 | 12.33 | 261.16 | 55.32 | 1.00 |
| MissonZanja | 11228.00 | 6000cfs | 3578.83 | 1112.00 | 1118.18 | 1118.18 | 1120.68 | 0.010002 | 12.69 | 282.11 | 56.47 | 1.00 |
| | | | | | | | | | | | | |
| MissonZanja | 11147.15 | 1000cfs | 1000.00 | 1108.03 | 1112.90 | 1111.27 | 1113.38 | 0.002660 | 5.54 | 180.46 | 46.54 | 0.50 |
| MissonZanja | 11147.15 | 2000cfs | 1853.99 | 1108.03 | 1114.70 | 1112.66 | 1115.44 | 0.002835 | 6.90 | 268.75 | 51.47 | 0.53 |
| MissonZanja | 11147.15 | 3000cfs | 2391.09 | 1108.03 | 1115.63 | 1113.40 | 1116.51 | 0.002896 | 7.52 | 317.89 | 53.90 | 0.55 |
| MissonZanja | 11147.15 | 4000cfs | 2837.13 | 1108.03 | 1116.33 | 1113.95 | 1117.32 | 0.002935 | 7.96 | 356.22 | 55.68 | 0.55 |
| MissonZanja | 11147.15 | 5000cfs | 3221.07 | 1108.03 | 1116.89 | 1114.40 | 1117.96 | 0.002963 | 8.31 | 387.82 | 57.07 | 0.56 |
| MissonZanja | 11147.15 | 6000cfs | 3578.83 | 1108.03 | 1117.39 | 1114.80 | 1118.53 | 0.002987 | 8.60 | 416.29 | 58.30 | 0.57 |
| | | | | | | | | | | | | |
| MissonZanja | 11067.09 | 1000cfs | 1000.00 | 1108.53 | 1112.38 | 1111.48 | 1113.07 | 0.004855 | 6.70 | 149.25 | 45.83 | 0.65 |
| MissonZanja | 11067.09 | 2000cfs | 1853.99 | 1108.53 | 1114.21 | 1112.84 | 1115.15 | 0.004172 | 7.77 | 238.62 | 51.57 | 0.64 |
| MissonZanja | 11067.09 | 3000cfs | 2391.09 | 1108.53 | 1115.16 | 1113.56 | 1116.22 | 0.003958 | 8.28 | 288.79 | 54.07 | 0.63 |
| MissonZanja | 11067.09 | 4000cfs | 2837.13 | 1108.53 | 1115.87 | 1114.10 | 1117.03 | 0.003844 | 8.66 | 327.77 | 55.81 | 0.63 |
| MissonZanja | 11067.09 | 5000cfs | 3221.07 | 1108.53 | 1116.43 | 1114.54 | 1117.68 | 0.003777 | 8.95 | 359.83 | 57.21 | 0.63 |
| MissonZanja | 11067.09 | 6000cfs | 3578.83 | 1108.53 | 1116.93 | 1114.92 | 1118.25 | 0.003728 | 9.21 | 388.67 | 58.43 | 0.63 |
| | | | | | | | | | | | | |
| MissonZanja | 10946.45 | 1000cfs | 1000.00 | 1107.00 | 1111.91 | 1110.56 | 1112.54 | 0.003707 | 6.38 | 156.73 | 40.95 | 0.57 |
| MissonZanja | 10946.45 | 2000cfs | 1853.99 | 1107.00 | 1113.67 | 1112.08 | 1114.64 | 0.004061 | 7.94 | 233.49 | 46.50 | 0.62 |
| MissonZanja | 10946.45 | 3000cfs | 2391.09 | 1107.00 | 1114.56 | 1112.88 | 1115.72 | 0.004183 | 8.66 | 276.08 | 49.04 | 0.64 |
| MissonZanja | 10946.45 | 4000cfs | 2837.13 | 1107.00 | 1115.22 | 1113.49 | 1116.53 | 0.004257 | 9.17 | 309.33 | 50.85 | 0.66 |
| MissonZanja | 10946.45 | 5000cfs | 3221.07 | 1107.00 | 1115.75 | 1113.97 | 1117.17 | 0.004311 | 9.56 | 336.77 | 52.29 | 0.66 |
| MissonZanja | 10946.45 | 6000cfs | 3578.83 | 1107.00 | 1116.22 | 1114.39 | 1117.74 | 0.004350 | 9.90 | 361.56 | 53.52 | 0.67 |
| | | | | | | | | | | | | |
| MissonZanja | 10794.51 | 1000cfs | 1000.00 | 1107.00 | 1111.17 | 1110.16 | 1111.90 | 0.004652 | 6.86 | 145.77 | 41.04 | 0.64 |
| MissonZanja | 10794.51 | 2000cfs | 1853.99 | 1107.00 | 1112.80 | 1111.63 | 1113.94 | 0.005042 | 8.58 | 216.02 | 45.43 | 0.69 |
| MissonZanja | 10794.51 | 3000cfs | 2391.09 | 1107.00 | 1113.61 | 1112.40 | 1114.99 | 0.005267 | 9.42 | 253.72 | 47.58 | 0.72 |
| MissonZanja | 10794.51 | 4000cfs | 2837.13 | 1107.00 | 1114.21 | 1112.99 | 1115.77 | 0.005424 | 10.03 | 282.94 | 49.18 | 0.74 |
| MissonZanja | 10794.51 | 5000cfs | 3221.07 | 1107.00 | 1114.69 | 1113.46 | 1116.40 | 0.005543 | 10.49 | 306.95 | 50.46 | 0.75 |
| MissonZanja | 10794.51 | 6000cfs | 3578.83 | 1107.00 | 1115.12 | 1113.88 | 1116.96 | 0.005636 | 10.89 | 328.62 | 51.59 | 0.76 |
| | | | | | | | | | | | | |

HEC-RAS Plan: LW River: MissionZanja Reach: MissonZanja (Continued)

| Reach | River Sta | Profile | Q Total | Min Ch El | W.S. Elev | Crit W.S. | E.G. Elev | E.G. Slope | Vel Chnl | Flow Area | Top Width | Froude # Chl |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | (cfs) | (ft) | (ft) | (ft) | (ft) | (ft/ft) | (ft/s) | (sq ft) | (ft) | |
| MissonZanja | 10648.41 | 1000cfs | 1000.00 | 1106.00 | 1110.63 | 1109.40 | 1111.26 | 0.003826 | 6.39 | 156.61 | 42.87 | 0.59 |
| MissonZanja | 10648.41 | 2000cfs | 1853.99 | 1106.00 | 1112.18 | 1110.85 | 1113.22 | 0.004470 | 8.17 | 226.92 | 47.54 | 0.66 |
| MissonZanja | 10648.41 | 3000cfs | 2391.09 | 1106.00 | 1112.96 | 1111.62 | 1114.23 | 0.004743 | 9.04 | 264.52 | 49.37 | 0.69 |
| MissonZanja | 10648.41 | 4000cfs | 2837.13 | 1106.00 | 1113.53 | 1112.19 | 1114.99 | 0.004938 | 9.67 | 293.42 | 50.71 | 0.71 |
| MissonZanja | 10648.41 | 5000cfs | 3221.07 | 1106.00 | 1113.99 | 1112.64 | 1115.60 | 0.005088 | 10.16 | 316.99 | 51.78 | 0.72 |
| MissonZanja | 10648.41 | 6000cfs | 3578.83 | 1106.00 | 1114.40 | 1113.05 | 1116.14 | 0.005211 | 10.58 | 338.22 | 52.73 | 0.74 |
| | | | | | | | | | | | | |
| MissonZanja | 10510.92 | 1000cfs | 1000.00 | 1106.00 | 1110.22 | 1108.88 | 1110.74 | 0.003259 | 5.82 | 171.68 | 48.18 | 0.54 |
| MissonZanja | 10510.92 | 2000cfs | 1853.99 | 1106.00 | 1111.74 | 1110.23 | 1112.61 | 0.003721 | 7.45 | 248.75 | 52.53 | 0.60 |
| MissonZanja | 10510.92 | 3000cfs | 2391.09 | 1106.00 | 1112.51 | 1110.95 | 1113.57 | 0.003934 | 8.25 | 289.92 | 54.41 | 0.63 |
| MissonZanja | 10510.92 | 4000cfs | 2837.13 | 1106.00 | 1113.09 | 1111.48 | 1114.30 | 0.004080 | 8.82 | 321.69 | 55.81 | 0.65 |
| MissonZanja | 10510.92 | 5000cfs | 3221.07 | 1106.00 | 1113.55 | 1111.91 | 1114.88 | 0.004191 | 9.27 | 347.65 | 56.93 | 0.66 |
| MissonZanja | 10510.92 | 6000cfs | 3578.83 | 1106.00 | 1113.96 | 1112.29 | 1115.40 | 0.004277 | 9.64 | 371.18 | 57.93 | 0.67 |
| | | | | | | | | | | | | |
| MissonZanja | 10375.00 | 1000cfs | 1000.00 | 1106.00 | 1109.48 | 1108.70 | 1110.17 | 0.005202 | 6.68 | 149.73 | 48.93 | 0.67 |
| MissonZanja | 10375.00 | 2000cfs | 1853.99 | 1106.00 | 1110.88 | 1109.99 | 1111.97 | 0.005535 | 8.37 | 221.60 | 53.52 | 0.72 |
| MissonZanja | 10375.00 | 3000cfs | 2391.09 | 1106.00 | 1111.60 | 1110.67 | 1112.91 | 0.005689 | 9.18 | 260.42 | 55.49 | 0.75 |
| MissonZanja | 10375.00 | 4000cfs | 2837.13 | 1106.00 | 1112.14 | 1111.19 | 1113.61 | 0.005776 | 9.76 | 290.73 | 56.93 | 0.76 |
| MissonZanja | 10375.00 | 5000cfs | 3221.07 | 1106.00 | 1112.57 | 1111.60 | 1114.19 | 0.005842 | 10.21 | 315.64 | 58.07 | 0.77 |
| MissonZanja | 10375.00 | 6000cfs | 3578.83 | 1106.00 | 1112.95 | 1111.97 | 1114.69 | 0.005893 | 10.59 | 338.09 | 59.08 | 0.78 |
| | | | | | | | | | | | | |
| MissonZanja | 10241.77 | 1000cfs | 1000.00 | 1105.00 | 1107.88 | 1107.88 | 1109.10 | 0.012444 | 8.88 | 112.67 | 46.72 | 1.01 |
| MissonZanja | 10241.77 | 2000cfs | 1853.99 | 1105.00 | 1109.16 | 1109.16 | 1110.89 | 0.011178 | 10.55 | 175.70 | 51.32 | 1.01 |
| MissonZanja | 10241.77 | 3000cfs | 2391.09 | 1105.00 | 1109.85 | 1109.85 | 1111.83 | 0.010626 | 11.28 | 212.06 | 53.71 | 1.00 |
| MissonZanja | 10241.77 | 4000cfs | 2837.13 | 1105.00 | 1110.36 | 1110.36 | 1112.54 | 0.010357 | 11.83 | 239.80 | 55.19 | 1.00 |
| MissonZanja | 10241.77 | 5000cfs | 3221.07 | 1105.00 | 1110.78 | 1110.78 | 1113.11 | 0.010162 | 12.26 | 262.76 | 56.33 | 1.00 |
| MissonZanja | 10241.77 | 6000cfs | 3578.83 | 1105.00 | 1111.14 | 1111.14 | 1113.62 | 0.010012 | 12.63 | 283.45 | 57.29 | 1.00 |
| | | | | | | | | | | | | |
| MissonZanja | 10099.43 | 1000cfs | 1000.00 | 1101.76 | 1106.09 | 1104.91 | 1106.72 | 0.003892 | 6.35 | 157.51 | 44.03 | 0.59 |
| MissonZanja | 10099.43 | 2000cfs | 1853.99 | 1101.76 | 1107.60 | 1106.32 | 1108.63 | 0.004552 | 8.16 | 227.08 | 48.25 | 0.66 |
| MissonZanja | 10099.43 | 3000cfs | 2391.09 | 1101.76 | 1108.40 | 1107.06 | 1109.65 | 0.004755 | 8.97 | 266.49 | 50.43 | 0.69 |
| MissonZanja | 10099.43 | 4000cfs | 2837.13 | 1101.76 | 1109.00 | 1107.63 | 1110.41 | 0.004870 | 9.54 | 297.51 | 52.06 | 0.70 |
| MissonZanja | 10099.43 | 5000cfs | 3221.07 | 1101.76 | 1109.47 | 1108.09 | 1111.02 | 0.005001 | 10.00 | 322.03 | 53.31 | 0.72 |
| MissonZanja | 10099.43 | 6000cfs | 3578.83 | 1101.76 | 1109.87 | 1108.49 | 1111.55 | 0.005128 | 10.41 | 343.63 | 54.41 | 0.73 |
| | | | | | | | | | | | | |
| MissonZanja | 9964.814 | 1000cfs | 1000.00 | 1102.00 | 1105.37 | 1104.65 | 1106.09 | 0.005496 | 6.79 | 147.24 | 48.69 | 0.69 |
| MissonZanja | 9964.814 | 2000cfs | 1853.99 | 1102.00 | 1106.96 | 1105.94 | 1107.99 | 0.005041 | 8.12 | 228.25 | 53.33 | 0.69 |
| MissonZanja | 9964.814 | 3000cfs | 2391.09 | 1102.00 | 1107.79 | 1106.62 | 1108.98 | 0.004891 | 8.74 | 273.44 | 55.49 | 0.69 |
| MissonZanja | 9964.814 | 4000cfs | 2837.13 | 1102.00 | 1108.43 | 1107.14 | 1109.73 | 0.004791 | 9.18 | 309.08 | 57.12 | 0.70 |
| MissonZanja | 9964.814 | 5000cfs | 3221.07 | 1102.00 | 1108.90 | 1107.56 | 1110.32 | 0.004808 | 9.57 | 336.56 | 58.36 | 0.70 |
| MissonZanja | 9964.814 | 6000cfs | 3578.83 | 1102.00 | 1109.30 | 1107.93 | 1110.84 | 0.004866 | 9.94 | 360.20 | 59.39 | 0.71 |
| | | | | | | | | | | | | |
| MissonZanja | 9811.166 | 1000cfs | 1000.00 | 1100.00 | 1103.46 | 1103.46 | 1104.82 | 0.012182 | 9.36 | 106.79 | 39.70 | 1.01 |
| MissonZanja | 9811.166 | 2000cfs | 1853.99 | 1100.00 | 1104.90 | 1104.90 | 1106.79 | 0.011072 | 11.04 | 167.89 | 44.83 | 1.01 |
| MissonZanja | 9811.166 | 3000cfs | 2391.09 | 1100.00 | 1105.66 | 1105.66 | 1107.82 | 0.010583 | 11.78 | 203.01 | 47.27 | 1.00 |
| MissonZanja | 9811.166 | 4000cfs | 2837.13 | 1100.00 | 1106.23 | 1106.23 | 1108.59 | 0.010322 | 12.32 | 230.33 | 48.98 | 1.00 |
| MissonZanja | 9811.166 | 5000cfs | 3221.07 | 1100.00 | 1106.77 | 1106.69 | 1109.21 | 0.009650 | 12.52 | 257.22 | 50.49 | 0.98 |
| MissonZanja | 9811.166 | 6000cfs | 3578.83 | 1100.00 | 1107.33 | 1107.09 | 1109.76 | 0.008754 | 12.51 | 286.11 | 52.05 | 0.94 |
| | | | | | | | | | | | | |
| MissonZanja | 9663.842 | 1000cfs | 1000.00 | 1098.00 | 1102.69 | 1101.05 | 1103.19 | 0.002781 | 5.68 | 176.04 | 44.82 | 0.51 |
| MissonZanja | 9663.842 | 2000cfs | 1853.99 | 1098.00 | 1104.69 | 1102.49 | 1105.41 | 0.002708 | 6.83 | 271.44 | 50.53 | 0.52 |
| MissonZanja | 9663.842 | 3000cfs | 2391.09 | 1098.00 | 1105.71 | 1103.26 | 1106.56 | 0.002692 | 7.36 | 324.66 | 53.33 | 0.53 |
| MissonZanja | 9663.842 | 4000cfs | 2837.13 | 1098.00 | 1106.48 | 1103.83 | 1107.41 | 0.002686 | 7.74 | 366.41 | 55.43 | 0.53 |
| MissonZanja | 9663.842 | 5000cfs | 3221.07 | 1098.00 | 1107.10 | 1104.29 | 1108.10 | 0.002682 | 8.03 | 400.93 | 57.10 | 0.53 |
| MissonZanja | 9663.842 | 6000cfs | 3578.83 | 1098.00 | 1107.63 | 1104.70 | 1108.70 | 0.002679 | 8.28 | 432.11 | 58.56 | 0.54 |
| | | | | | | | | | | | | |
| MissonZanja | 9511.561 | 1000cfs | 1000.00 | 1097.02 | 1101.55 | 1100.84 | 1102.53 | 0.006327 | 7.94 | 125.92 | 35.86 | 0.75 |
| MissonZanja | 9511.561 | 2000cfs | 1853.99 | 1097.02 | 1103.34 | 1102.47 | 1104.75 | 0.006244 | 9.52 | 194.85 | 41.19 | 0.77 |
| MissonZanja | 9511.561 | 3000cfs | 2391.09 | 1097.02 | 1104.26 | 1103.32 | 1105.88 | 0.006182 | 10.21 | 234.12 | 43.84 | 0.78 |
| MissonZanja | 9511.561 | 4000cfs | 2837.13 | 1097.02 | 1104.96 | 1103.95 | 1106.74 | 0.006121 | 10.69 | 265.45 | 45.85 | 0.78 |
| MissonZanja | 9511.561 | 5000cfs | 3221.07 | 1097.02 | 1105.52 | 1104.45 | 1107.42 | 0.006065 | 11.04 | 291.69 | 47.46 | 0.78 |
| MissonZanja | 9511.561 | 6000cfs | 3578.83 | 1097.02 | 1106.02 | 1104.90 | 1108.02 | 0.006010 | 11.34 | 315.68 | 48.88 | 0.79 |
| | | | | | | | | | | | | |
| MissonZanja | 9359.924 | 1000cfs | 1000.00 | 1096.00 | 1101.24 | 1099.64 | 1101.77 | 0.002933 | 5.84 | 171.34 | 43.66 | 0.52 |
| MissonZanja | 9359.924 | 2000cfs | 1853.99 | 1096.00 | 1103.13 | 1101.11 | 1103.92 | 0.003045 | 7.14 | 259.81 | 49.65 | 0.55 |
| MissonZanja | 9359.924 | 3000cfs | 2391.09 | 1096.00 | 1104.11 | 1101.89 | 1105.03 | 0.003061 | 7.72 | 309.87 | 52.49 | 0.56 |
| MissonZanja | 9359.924 | 4000cfs | 2837.13 | 1096.00 | 1104.85 | 1102.46 | 1105.87 | 0.003064 | 8.12 | 349.49 | 54.67 | 0.57 |
| MissonZanja | 9359.924 | 5000cfs | 3221.07 | 1096.00 | 1105.44 | 1102.93 | 1106.54 | 0.003064 | 8.42 | 382.50 | 56.42 | 0.57 |
| MissonZanja | 9359.924 | 6000cfs | 3578.83 | 1096.00 | 1105.97 | 1103.34 | 1107.14 | 0.003060 | 8.67 | 412.55 | 57.98 | 0.57 |
| | | | | | | | | | | | | |
| MissonZanja | 9218.489 | 1000cfs | 1000.00 | 1096.00 | 1100.34 | 1099.49 | 1101.18 | 0.005479 | 7.37 | 135.74 | 39.07 | 0.70 |
| MissonZanja | 9218.489 | 2000cfs | 1853.99 | 1096.00 | 1102.06 | 1101.02 | 1103.31 | 0.005459 | 8.96 | 207.03 | 43.44 | 0.72 |
| MissonZanja | 9218.489 | 3000cfs | 2391.09 | 1096.00 | 1102.95 | 1101.81 | 1104.41 | 0.005479 | 9.70 | 246.58 | 45.60 | 0.73 |
| MissonZanja | 9218.489 | 4000cfs | 2837.13 | 1096.00 | 1103.62 | 1102.41 | 1105.24 | 0.005492 | 10.22 | 277.61 | 47.23 | 0.74 |
| MissonZanja | 9218.489 | 5000cfs | 3221.07 | 1096.00 | 1104.16 | 1102.91 | 1105.91 | 0.005500 | 10.62 | 303.34 | 48.54 | 0.75 |
| MissonZanja | 9218.489 | 6000cfs | 3578.83 | 1096.00 | 1104.63 | 1103.34 | 1106.50 | 0.005503 | 10.95 | 326.69 | 49.70 | 0.75 |
| | | | | | | | | | | | | |
| MissonZanja | 9114.825 | 1000cfs | 1000.00 | 1095.00 | 1099.77 | 1098.88 | 1100.62 | 0.005352 | 7.38 | 135.56 | 38.20 | 0.69 |
| MissonZanja | 9114.825 | 2000cfs | 1853.99 | 1095.00 | 1101.42 | 1100.47 | 1102.72 | 0.005781 | 9.15 | 202.55 | 43.07 | 0.74 |
| MissonZanja | 9114.825 | 3000cfs | 2391.09 | 1095.00 | 1102.29 | 1101.29 | 1103.82 | 0.005838 | 9.91 | 241.36 | 45.58 | 0.76 |
| MissonZanja | 9114.825 | 4000cfs | 2837.13 | 1095.00 | 1102.97 | 1101.90 | 1104.65 | 0.005817 | 10.40 | 272.78 | 47.51 | 0.76 |

HEC-RAS Plan: LW River: MissionZanja Reach: MissonZanja (Continued)

| Reach | River Sta | Profile | Q Total | Min Ch El | W.S. Elev | Crit W.S. | E.G. Elev | E.G. Slope | Vel Chnl | Flow Area | Top Width | Froude # Chl |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | (cfs) | (ft) | (ft) | (ft) | (ft) | (ft/ft) | (ft/s) | (sq ft) | (ft) | |
| MissonZanja | 9114.825 | 5000cfs | 3221.07 | 1095.00 | 1103.52 | 1102.39 | 1105.32 | 0.005766 | 10.76 | 299.49 | 49.09 | 0.77 |
| MissonZanja | 9114.825 | 6000cfs | 3578.83 | 1095.00 | 1104.02 | 1102.80 | 1105.91 | 0.005703 | 11.04 | 324.15 | 50.50 | 0.77 |
| | | | | | | | | | | | | |
| MissonZanja | 8988.432 | 1000cfs | 1000.00 | 1095.00 | 1099.23 | 1098.24 | 1099.95 | 0.004671 | 6.82 | 146.53 | 42.13 | 0.64 |
| MissonZanja | 8988.432 | 2000cfs | 1853.99 | 1095.00 | 1100.90 | 1099.71 | 1101.99 | 0.004808 | 8.40 | 220.70 | 46.67 | 0.68 |
| MissonZanja | 8988.432 | 3000cfs | 2391.09 | 1095.00 | 1101.81 | 1100.47 | 1103.08 | 0.004721 | 9.05 | 264.26 | 48.83 | 0.69 |
| MissonZanja | 8988.432 | 4000cfs | 2837.13 | 1095.00 | 1102.51 | 1101.05 | 1103.91 | 0.004633 | 9.48 | 299.24 | 50.47 | 0.69 |
| MissonZanja | 8988.432 | 5000cfs | 3221.07 | 1095.00 | 1103.09 | 1101.50 | 1104.58 | 0.004556 | 9.80 | 328.72 | 51.82 | 0.69 |
| MissonZanja | 8988.432 | 6000cfs | 3578.83 | 1095.00 | 1103.60 | 1101.93 | 1105.18 | 0.004486 | 10.06 | 355.70 | 53.04 | 0.68 |
| | | | | | | | | | | | | |
| MissonZanja | 8942.263 | 1000cfs | 1000.00 | 1094.79 | 1098.92 | 1098.16 | 1099.71 | 0.005411 | 7.13 | 140.23 | 42.29 | 0.69 |
| MissonZanja | 8942.263 | 2000cfs | 1853.99 | 1094.79 | 1100.56 | 1099.55 | 1101.75 | 0.005349 | 8.74 | 212.08 | 45.23 | 0.71 |
| MissonZanja | 8942.263 | 3000cfs | 2391.09 | 1094.79 | 1101.45 | 1100.29 | 1102.84 | 0.005291 | 9.46 | 252.88 | 46.82 | 0.72 |
| MissonZanja | 8942.263 | 4000cfs | 2837.13 | 1094.79 | 1102.13 | 1100.86 | 1103.67 | 0.005239 | 9.95 | 285.26 | 48.10 | 0.72 |
| MissonZanja | 8942.263 | 5000cfs | 3221.07 | 1094.79 | 1102.69 | 1101.33 | 1104.34 | 0.005191 | 10.31 | 312.34 | 49.14 | 0.72 |
| MissonZanja | 8942.263 | 6000cfs | 3578.83 | 1094.79 | 1103.19 | 1101.75 | 1104.94 | 0.005141 | 10.62 | 337.61 | 52.25 | 0.72 |
| | | | | | | | | | | | | |
| MissonZanja | 8909.51 | | Bridge | | | | | | | | | |
| | | | | | | | | | | | | |
| MissonZanja | 8886.511 | 1000cfs | 1000.00 | 1092.21 | 1095.90 | 1095.90 | 1097.33 | 0.012613 | 9.61 | 104.06 | 36.60 | 1.00 |
| MissonZanja | 8886.511 | 2000cfs | 1853.99 | 1092.21 | 1097.37 | 1097.37 | 1099.49 | 0.011810 | 11.70 | 158.46 | 37.59 | 1.00 |
| MissonZanja | 8886.511 | 3000cfs | 2391.09 | 1092.21 | 1098.19 | 1098.19 | 1100.66 | 0.011455 | 12.61 | 189.68 | 38.55 | 1.00 |
| MissonZanja | 8886.511 | 4000cfs | 2837.13 | 1092.21 | 1098.87 | 1098.87 | 1101.54 | 0.011071 | 13.11 | 216.45 | 40.14 | 0.99 |
| MissonZanja | 8886.511 | 5000cfs | 3221.07 | 1092.21 | 1099.36 | 1099.36 | 1102.24 | 0.011077 | 13.62 | 236.51 | 41.21 | 1.00 |
| MissonZanja | 8886.511 | 6000cfs | 3578.83 | 1092.21 | 1099.85 | 1099.85 | 1102.86 | 0.010790 | 13.92 | 257.09 | 42.29 | 0.99 |
| | | | | | | | | | | | | |
| MissonZanja | 8825.907 | 1000cfs | 1000.00 | 1090.78 | 1093.67 | 1093.67 | 1094.83 | 0.012508 | 8.63 | 115.90 | 49.64 | 1.00 |
| MissonZanja | 8825.907 | 2000cfs | 1853.99 | 1090.78 | 1094.89 | 1094.89 | 1096.58 | 0.011321 | 10.44 | 177.60 | 51.83 | 0.99 |
| MissonZanja | 8825.907 | 3000cfs | 2391.09 | 1090.78 | 1095.55 | 1095.55 | 1097.52 | 0.010948 | 11.24 | 212.77 | 53.96 | 1.00 |
| MissonZanja | 8825.907 | 4000cfs | 2837.13 | 1090.78 | 1096.07 | 1096.07 | 1098.22 | 0.010666 | 11.77 | 241.01 | 55.77 | 1.00 |
| MissonZanja | 8825.907 | 5000cfs | 3221.07 | 1090.78 | 1096.49 | 1096.49 | 1098.79 | 0.010416 | 12.16 | 264.81 | 57.19 | 1.00 |
| MissonZanja | 8825.907 | 6000cfs | 3578.83 | 1090.78 | 1096.82 | 1096.82 | 1099.29 | 0.010471 | 12.60 | 283.97 | 58.28 | 1.01 |
| | | | | | | | | | | | | |
| MissonZanja | 8751.256 | 1000cfs | 1000.00 | 1088.00 | 1091.14 | 1091.14 | 1092.48 | 0.012230 | 9.28 | 107.70 | 40.82 | 1.01 |
| MissonZanja | 8751.256 | 2000cfs | 1853.99 | 1088.00 | 1092.55 | 1092.55 | 1094.44 | 0.011064 | 11.01 | 168.34 | 45.14 | 1.00 |
| MissonZanja | 8751.256 | 3000cfs | 2391.09 | 1088.00 | 1093.31 | 1093.31 | 1095.46 | 0.010589 | 11.76 | 203.26 | 47.45 | 1.00 |
| MissonZanja | 8751.256 | 4000cfs | 2837.13 | 1088.00 | 1093.88 | 1093.88 | 1096.22 | 0.010312 | 12.30 | 230.74 | 49.19 | 1.00 |
| MissonZanja | 8751.256 | 5000cfs | 3221.07 | 1088.00 | 1094.33 | 1094.33 | 1096.84 | 0.010128 | 12.70 | 253.53 | 50.60 | 1.00 |
| MissonZanja | 8751.256 | 6000cfs | 3578.83 | 1088.00 | 1094.74 | 1094.74 | 1097.38 | 0.009982 | 13.05 | 274.22 | 51.85 | 1.00 |
| | | | | | | | | | | | | |
| MissonZanja | 8645.837 | 1000cfs | 1000.00 | 1086.00 | 1090.97 | 1089.72 | 1091.57 | 0.003768 | 6.23 | 160.57 | 45.69 | 0.59 |
| MissonZanja | 8645.837 | 2000cfs | 1853.99 | 1086.00 | 1092.50 | 1091.18 | 1093.47 | 0.004280 | 7.91 | 234.52 | 50.69 | 0.65 |
| MissonZanja | 8645.837 | 3000cfs | 2391.09 | 1086.00 | 1093.28 | 1091.91 | 1094.45 | 0.004473 | 8.69 | 275.02 | 52.91 | 0.67 |
| MissonZanja | 8645.837 | 4000cfs | 2837.13 | 1086.00 | 1093.86 | 1092.46 | 1095.19 | 0.004608 | 9.26 | 306.27 | 54.52 | 0.69 |
| MissonZanja | 8645.837 | 5000cfs | 3221.07 | 1086.00 | 1094.32 | 1092.91 | 1095.79 | 0.004711 | 9.71 | 331.85 | 55.79 | 0.70 |
| MissonZanja | 8645.837 | 6000cfs | 3578.83 | 1086.00 | 1094.73 | 1093.30 | 1096.31 | 0.004796 | 10.09 | 354.85 | 56.90 | 0.71 |
| | | | | | | | | | | | | |
| MissonZanja | 8523.598 | 1000cfs | 1000.00 | 1086.00 | 1089.48 | 1089.48 | 1090.75 | 0.012068 | 9.01 | 111.00 | 44.05 | 1.00 |
| MissonZanja | 8523.598 | 2000cfs | 1853.99 | 1086.00 | 1090.82 | 1090.82 | 1092.60 | 0.010974 | 10.68 | 173.56 | 49.14 | 1.00 |
| MissonZanja | 8523.598 | 3000cfs | 2391.09 | 1086.00 | 1091.51 | 1091.51 | 1093.56 | 0.010671 | 11.50 | 207.95 | 51.31 | 1.01 |
| MissonZanja | 8523.598 | 4000cfs | 2837.13 | 1086.00 | 1092.04 | 1092.04 | 1094.29 | 0.010388 | 12.04 | 235.61 | 52.92 | 1.01 |
| MissonZanja | 8523.598 | 5000cfs | 3221.07 | 1086.00 | 1092.47 | 1092.47 | 1094.88 | 0.010198 | 12.46 | 258.53 | 54.22 | 1.01 |
| MissonZanja | 8523.598 | 6000cfs | 3578.83 | 1086.00 | 1092.84 | 1092.84 | 1095.39 | 0.010057 | 12.82 | 279.19 | 55.37 | 1.01 |
| | | | | | | | | | | | | |
| MissonZanja | 8398.872 | 1000cfs | 1000.00 | 1082.00 | 1087.11 | 1085.78 | 1087.78 | 0.003716 | 6.53 | 153.20 | 39.03 | 0.58 |
| MissonZanja | 8398.872 | 2000cfs | 1853.99 | 1082.00 | 1089.02 | 1087.33 | 1090.00 | 0.003990 | 7.92 | 234.16 | 46.66 | 0.62 |
| MissonZanja | 8398.872 | 3000cfs | 2391.09 | 1082.00 | 1090.00 | 1088.17 | 1091.12 | 0.003928 | 8.51 | 281.07 | 49.30 | 0.63 |
| MissonZanja | 8398.872 | 4000cfs | 2837.13 | 1082.00 | 1090.70 | 1088.83 | 1091.95 | 0.003951 | 8.97 | 316.33 | 51.22 | 0.64 |
| MissonZanja | 8398.872 | 5000cfs | 3221.07 | 1082.00 | 1091.26 | 1089.32 | 1092.61 | 0.003970 | 9.33 | 345.41 | 52.73 | 0.64 |
| MissonZanja | 8398.872 | 6000cfs | 3578.83 | 1082.00 | 1091.75 | 1089.74 | 1093.19 | 0.003989 | 9.63 | 371.59 | 54.07 | 0.65 |
| | | | | | | | | | | | | |
| MissonZanja | 8280.995 | 1000cfs | 1000.00 | 1082.00 | 1086.31 | 1085.50 | 1087.21 | 0.005771 | 7.61 | 131.44 | 37.09 | 0.71 |
| MissonZanja | 8280.995 | 2000cfs | 1853.99 | 1082.00 | 1088.10 | 1087.10 | 1089.40 | 0.005772 | 9.16 | 202.39 | 42.57 | 0.74 |
| MissonZanja | 8280.995 | 3000cfs | 2391.09 | 1082.00 | 1089.06 | 1087.92 | 1090.53 | 0.005776 | 9.74 | 245.59 | 47.12 | 0.75 |
| MissonZanja | 8280.995 | 4000cfs | 2837.13 | 1082.00 | 1089.76 | 1088.58 | 1091.36 | 0.005628 | 10.16 | 279.25 | 49.02 | 0.75 |
| MissonZanja | 8280.995 | 5000cfs | 3221.07 | 1082.00 | 1090.32 | 1089.10 | 1092.03 | 0.005534 | 10.50 | 306.79 | 50.37 | 0.75 |
| MissonZanja | 8280.995 | 6000cfs | 3578.83 | 1082.00 | 1090.79 | 1089.52 | 1092.61 | 0.005484 | 10.81 | 331.03 | 51.42 | 0.75 |
| | | | | | | | | | | | | |
| MissonZanja | 8168.973 | 1000cfs | 1000.00 | 1081.00 | 1085.74 | 1084.71 | 1086.59 | 0.005107 | 7.43 | 134.53 | 35.43 | 0.67 |
| MissonZanja | 8168.973 | 2000cfs | 1853.99 | 1081.00 | 1087.25 | 1086.38 | 1088.70 | 0.006491 | 9.66 | 191.88 | 40.40 | 0.78 |
| MissonZanja | 8168.973 | 3000cfs | 2391.09 | 1081.00 | 1088.00 | 1087.26 | 1089.78 | 0.007162 | 10.70 | 223.36 | 43.31 | 0.83 |
| MissonZanja | 8168.973 | 4000cfs | 2837.13 | 1081.00 | 1088.55 | 1087.92 | 1090.59 | 0.007600 | 11.45 | 247.76 | 45.32 | 0.86 |
| MissonZanja | 8168.973 | 5000cfs | 3221.07 | 1081.00 | 1089.05 | 1088.45 | 1091.25 | 0.007692 | 11.90 | 270.68 | 47.07 | 0.87 |
| MissonZanja | 8168.973 | 6000cfs | 3578.83 | 1081.00 | 1089.50 | 1088.90 | 1091.83 | 0.007646 | 12.25 | 292.25 | 48.31 | 0.88 |
| | | | | | | | | | | | | |
| MissonZanja | 8050.245 | 1000cfs | 1000.00 | 1081.00 | 1085.14 | 1084.29 | 1085.96 | 0.005370 | 7.24 | 138.06 | 40.20 | 0.69 |
| MissonZanja | 8050.245 | 2000cfs | 1853.99 | 1081.00 | 1086.51 | 1085.79 | 1087.90 | 0.006687 | 9.45 | 196.12 | 44.65 | 0.79 |
| MissonZanja | 8050.245 | 3000cfs | 2391.09 | 1081.00 | 1087.17 | 1086.58 | 1088.91 | 0.007410 | 10.58 | 226.10 | 46.77 | 0.85 |
| MissonZanja | 8050.245 | 4000cfs | 2837.13 | 1081.00 | 1087.64 | 1087.17 | 1089.66 | 0.007974 | 11.42 | 248.44 | 48.22 | 0.89 |
| MissonZanja | 8050.245 | 5000cfs | 3221.07 | 1081.00 | 1087.98 | 1087.64 | 1090.27 | 0.008564 | 12.16 | 264.89 | 49.25 | 0.92 |
| MissonZanja | 8050.245 | 6000cfs | 3578.83 | 1081.00 | 1088.25 | 1088.06 | 1090.81 | 0.009172 | 12.86 | 278.20 | 49.91 | 0.96 |

HEC-RAS Plan: LW River: MissionZanja Reach: MissonZanja (Continued)

| Reach | River Sta | Profile | Q Total | Min Ch El | W.S. Elev | Crit W.S. | E.G. Elev | E.G. Slope | Vel Chnl | Flow Area | Top Width | Froude # Chl |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | (cfs) | (ft) | (ft) | (ft) | (ft) | (ft/ft) | (ft/s) | (sq ft) | (ft) | |
| | | | | | | | | | | | | |
| MissonZanja | 7942.117 | 1000cfs | 1000.00 | 1080.83 | 1083.79 | 1083.79 | 1085.07 | 0.012339 | 9.08 | 110.16 | 43.56 | 1.01 |
| MissonZanja | 7942.117 | 2000cfs | 1853.99 | 1080.83 | 1085.14 | 1085.14 | 1086.94 | 0.011176 | 10.78 | 172.01 | 48.27 | 1.01 |
| MissonZanja | 7942.117 | 3000cfs | 2391.09 | 1080.83 | 1085.85 | 1085.85 | 1087.92 | 0.010738 | 11.55 | 207.06 | 50.57 | 1.01 |
| MissonZanja | 7942.117 | 4000cfs | 2837.13 | 1080.83 | 1086.38 | 1086.38 | 1088.65 | 0.010488 | 12.11 | 234.35 | 52.15 | 1.01 |
| MissonZanja | 7942.117 | 5000cfs | 3221.07 | 1080.83 | 1086.81 | 1086.81 | 1089.25 | 0.010294 | 12.53 | 257.12 | 53.40 | 1.01 |
| MissonZanja | 7942.117 | 6000cfs | 3578.83 | 1080.83 | 1087.19 | 1087.19 | 1089.77 | 0.010144 | 12.89 | 277.71 | 54.52 | 1.01 |
| | | | | | | | | | | | | |
| MissonZanja | 7821.790 | 1000cfs | 1000.00 | 1078.00 | 1083.09 | 1081.16 | 1083.48 | 0.002082 | 5.01 | 199.42 | 49.92 | 0.44 |
| MissonZanja | 7821.790 | 2000cfs | 1853.99 | 1078.00 | 1084.98 | 1082.52 | 1085.57 | 0.002209 | 6.18 | 300.10 | 56.82 | 0.47 |
| MissonZanja | 7821.790 | 3000cfs | 2391.09 | 1078.00 | 1085.95 | 1083.24 | 1086.64 | 0.002237 | 6.70 | 356.64 | 59.94 | 0.48 |
| MissonZanja | 7821.790 | 4000cfs | 2837.13 | 1078.00 | 1086.67 | 1083.79 | 1087.45 | 0.002248 | 7.08 | 400.85 | 62.06 | 0.49 |
| MissonZanja | 7821.790 | 5000cfs | 3221.07 | 1078.00 | 1087.25 | 1084.22 | 1088.09 | 0.002257 | 7.37 | 437.33 | 63.73 | 0.50 |
| MissonZanja | 7821.790 | 6000cfs | 3578.83 | 1078.00 | 1087.76 | 1084.61 | 1088.66 | 0.002264 | 7.61 | 470.17 | 65.16 | 0.50 |
| | | | | | | | | | | | | |
| MissonZanja | 7706.653 | 1000cfs | 1000.00 | 1078.00 | 1082.64 | 1081.12 | 1083.18 | 0.003094 | 5.92 | 169.06 | 43.92 | 0.53 |
| MissonZanja | 7706.653 | 2000cfs | 1853.99 | 1078.00 | 1084.39 | 1082.59 | 1085.23 | 0.003416 | 7.39 | 250.94 | 49.71 | 0.58 |
| MissonZanja | 7706.653 | 3000cfs | 2391.09 | 1078.00 | 1085.29 | 1083.36 | 1086.30 | 0.003516 | 8.04 | 297.38 | 52.76 | 0.60 |
| MissonZanja | 7706.653 | 4000cfs | 2837.13 | 1078.00 | 1085.97 | 1083.94 | 1087.09 | 0.003560 | 8.49 | 334.16 | 54.95 | 0.61 |
| MissonZanja | 7706.653 | 5000cfs | 3221.07 | 1078.00 | 1086.52 | 1084.41 | 1087.73 | 0.003579 | 8.83 | 364.75 | 56.56 | 0.61 |
| MissonZanja | 7706.653 | 6000cfs | 3578.83 | 1078.00 | 1087.01 | 1084.82 | 1088.30 | 0.003592 | 9.12 | 392.38 | 57.96 | 0.62 |
| | | | | | | | | | | | | |
| MissonZanja | 7593.552 | 1000cfs | 1000.00 | 1078.00 | 1082.07 | 1081.04 | 1082.75 | 0.004450 | 6.61 | 151.18 | 44.04 | 0.63 |
| MissonZanja | 7593.552 | 2000cfs | 1853.99 | 1078.00 | 1083.79 | 1082.46 | 1084.78 | 0.004397 | 8.00 | 231.86 | 49.72 | 0.65 |
| MissonZanja | 7593.552 | 3000cfs | 2391.09 | 1078.00 | 1084.69 | 1083.22 | 1085.84 | 0.004325 | 8.60 | 278.05 | 52.44 | 0.66 |
| MissonZanja | 7593.552 | 4000cfs | 2837.13 | 1078.00 | 1085.38 | 1083.78 | 1086.64 | 0.004267 | 9.02 | 314.56 | 54.39 | 0.66 |
| MissonZanja | 7593.552 | 5000cfs | 3221.07 | 1078.00 | 1085.93 | 1084.23 | 1087.28 | 0.004222 | 9.34 | 344.91 | 55.93 | 0.66 |
| MissonZanja | 7593.552 | 6000cfs | 3578.83 | 1078.00 | 1086.41 | 1084.63 | 1087.84 | 0.004184 | 9.61 | 372.27 | 57.20 | 0.66 |
| | | | | | | | | | | | | |
| MissonZanja | 7487.564 | 1000cfs | 1000.00 | 1077.00 | 1080.54 | 1080.54 | 1081.94 | 0.012139 | 9.50 | 105.27 | 38.11 | 1.01 |
| MissonZanja | 7487.564 | 2000cfs | 1853.99 | 1077.00 | 1082.03 | 1082.03 | 1083.99 | 0.010944 | 11.22 | 165.25 | 42.40 | 1.00 |
| MissonZanja | 7487.564 | 3000cfs | 2391.09 | 1077.00 | 1082.81 | 1082.81 | 1085.05 | 0.010569 | 12.01 | 199.05 | 44.56 | 1.00 |
| MissonZanja | 7487.564 | 4000cfs | 2837.13 | 1077.00 | 1083.40 | 1083.40 | 1085.85 | 0.010333 | 12.57 | 225.67 | 46.13 | 1.00 |
| MissonZanja | 7487.564 | 5000cfs | 3221.07 | 1077.00 | 1083.87 | 1083.87 | 1086.49 | 0.010174 | 13.00 | 247.81 | 47.42 | 1.00 |
| MissonZanja | 7487.564 | 6000cfs | 3578.83 | 1077.00 | 1084.29 | 1084.29 | 1087.06 | 0.010035 | 13.35 | 268.06 | 48.62 | 1.00 |
| | | | | | | | | | | | | |
| MissonZanja | 7371.931 | 1000cfs | 1000.00 | 1074.00 | 1079.30 | 1077.72 | 1079.88 | 0.003158 | 6.13 | 163.01 | 40.56 | 0.54 |
| MissonZanja | 7371.931 | 2000cfs | 1853.99 | 1074.00 | 1081.35 | 1079.28 | 1082.18 | 0.003118 | 7.34 | 252.49 | 46.73 | 0.56 |
| MissonZanja | 7371.931 | 3000cfs | 2391.09 | 1074.00 | 1082.40 | 1080.09 | 1083.37 | 0.003079 | 7.88 | 303.40 | 49.61 | 0.56 |
| MissonZanja | 7371.931 | 4000cfs | 2837.13 | 1074.00 | 1083.19 | 1080.70 | 1084.25 | 0.003051 | 8.26 | 343.33 | 51.58 | 0.56 |
| MissonZanja | 7371.931 | 5000cfs | 3221.07 | 1074.00 | 1083.82 | 1081.19 | 1084.96 | 0.003041 | 8.57 | 376.07 | 53.15 | 0.57 |
| MissonZanja | 7371.931 | 6000cfs | 3578.83 | 1074.00 | 1084.35 | 1081.62 | 1085.57 | 0.003049 | 8.84 | 404.92 | 54.49 | 0.57 |
| | | | | | | | | | | | | |
| MissonZanja | 7255.053 | 1000cfs | 1000.00 | 1073.27 | 1078.15 | 1077.58 | 1079.29 | 0.007293 | 8.55 | 116.93 | 32.79 | 0.80 |
| MissonZanja | 7255.053 | 2000cfs | 1853.99 | 1073.27 | 1079.64 | 1079.32 | 1081.50 | 0.008929 | 10.96 | 169.17 | 37.62 | 0.91 |
| MissonZanja | 7255.053 | 3000cfs | 2391.09 | 1073.27 | 1080.35 | 1080.19 | 1082.64 | 0.009771 | 12.15 | 196.72 | 39.88 | 0.96 |
| MissonZanja | 7255.053 | 4000cfs | 2837.13 | 1073.27 | 1080.90 | 1080.86 | 1083.50 | 0.010184 | 12.94 | 219.28 | 41.60 | 0.99 |
| MissonZanja | 7255.053 | 5000cfs | 3221.07 | 1073.27 | 1081.37 | 1081.37 | 1084.19 | 0.010333 | 13.49 | 238.81 | 42.86 | 1.01 |
| MissonZanja | 7255.053 | 6000cfs | 3578.83 | 1073.27 | 1081.82 | 1081.82 | 1084.79 | 0.010199 | 13.84 | 258.63 | 44.08 | 1.01 |
| | | | | | | | | | | | | |
| MissonZanja | 7127.886 | 1000cfs | 1000.00 | 1073.00 | 1076.59 | 1076.59 | 1078.08 | 0.012064 | 9.81 | 101.91 | 34.55 | 1.01 |
| MissonZanja | 7127.886 | 2000cfs | 1853.99 | 1073.00 | 1078.20 | 1078.20 | 1080.24 | 0.010913 | 11.47 | 161.68 | 39.63 | 1.00 |
| MissonZanja | 7127.886 | 3000cfs | 2391.09 | 1073.00 | 1079.02 | 1079.02 | 1081.35 | 0.010568 | 12.23 | 195.55 | 42.21 | 1.00 |
| MissonZanja | 7127.886 | 4000cfs | 2837.13 | 1073.00 | 1079.64 | 1079.64 | 1082.17 | 0.010332 | 12.76 | 222.28 | 44.01 | 1.00 |
| MissonZanja | 7127.886 | 5000cfs | 3221.07 | 1073.00 | 1080.14 | 1080.14 | 1082.84 | 0.010155 | 13.17 | 244.59 | 45.43 | 1.00 |
| MissonZanja | 7127.886 | 6000cfs | 3578.83 | 1073.00 | 1080.58 | 1080.58 | 1083.42 | 0.010023 | 13.52 | 264.73 | 46.66 | 1.00 |
| | | | | | | | | | | | | |
| MissonZanja | 7010.832 | 1000cfs | 1000.00 | 1070.28 | 1075.48 | 1074.24 | 1076.20 | 0.004093 | 6.78 | 147.54 | 38.34 | 0.61 |
| MissonZanja | 7010.832 | 2000cfs | 1853.99 | 1070.28 | 1077.39 | 1075.84 | 1078.43 | 0.004318 | 8.19 | 226.44 | 45.53 | 0.65 |
| MissonZanja | 7010.832 | 3000cfs | 2391.09 | 1070.28 | 1078.45 | 1076.65 | 1079.58 | 0.004498 | 8.52 | 280.56 | 55.11 | 0.67 |
| MissonZanja | 7010.832 | 4000cfs | 2837.13 | 1070.28 | 1079.81 | 1077.33 | 1080.78 | 0.003121 | 7.90 | 359.25 | 59.69 | 0.57 |
| MissonZanja | 7010.832 | 5000cfs | 3221.07 | 1070.28 | 1080.44 | 1078.00 | 1081.46 | 0.002997 | 8.12 | 396.86 | 61.03 | 0.56 |
| MissonZanja | 7010.832 | 6000cfs | 3578.83 | 1070.28 | 1081.11 | 1078.43 | 1082.15 | 0.002749 | 8.16 | 438.75 | 62.33 | 0.54 |
| | | | | | | | | | | | | |
| MissonZanja | 6901.212 | 1000cfs | 1000.00 | 1071.00 | 1075.02 | 1074.03 | 1075.71 | 0.004599 | 6.67 | 149.85 | 44.19 | 0.64 |
| MissonZanja | 6901.212 | 2000cfs | 1853.99 | 1071.00 | 1077.07 | 1075.45 | 1077.94 | 0.003673 | 7.49 | 247.68 | 51.20 | 0.60 |
| MissonZanja | 6901.212 | 3000cfs | 2391.09 | 1071.00 | 1078.14 | 1076.21 | 1079.10 | 0.003360 | 7.87 | 304.00 | 54.08 | 0.58 |
| MissonZanja | 6901.212 | 4000cfs | 2837.13 | 1071.00 | 1079.61 | 1076.77 | 1080.45 | 0.002371 | 7.35 | 385.95 | 57.84 | 0.50 |
| MissonZanja | 6901.212 | 5000cfs | 3221.07 | 1071.00 | 1080.23 | 1077.22 | 1081.13 | 0.002359 | 7.62 | 422.44 | 59.43 | 0.50 |
| MissonZanja | 6901.212 | 6000cfs | 3578.83 | 1071.00 | 1080.92 | 1077.61 | 1081.84 | 0.002226 | 7.71 | 464.19 | 61.21 | 0.49 |
| | | | | | | | | | | | | |
| MissonZanja | 6792.683 | 1000cfs | 1000.00 | 1069.00 | 1074.75 | 1072.96 | 1075.29 | 0.002766 | 5.85 | 170.83 | 41.21 | 0.51 |
| MissonZanja | 6792.683 | 2000cfs | 1853.99 | 1069.00 | 1076.78 | 1074.56 | 1077.57 | 0.002843 | 7.11 | 260.60 | 47.06 | 0.53 |
| MissonZanja | 6792.683 | 3000cfs | 2391.09 | 1069.00 | 1077.84 | 1075.37 | 1078.75 | 0.002841 | 7.66 | 312.01 | 49.98 | 0.54 |
| MissonZanja | 6792.683 | 4000cfs | 2837.13 | 1069.00 | 1079.38 | 1075.98 | 1080.20 | 0.002106 | 7.23 | 392.29 | 54.19 | 0.47 |
| MissonZanja | 6792.683 | 5000cfs | 3221.07 | 1069.00 | 1079.99 | 1076.46 | 1080.88 | 0.002159 | 7.56 | 425.93 | 55.85 | 0.48 |
| MissonZanja | 6792.683 | 6000cfs | 3578.83 | 1069.00 | 1080.69 | 1076.89 | 1081.61 | 0.002083 | 7.69 | 465.49 | 57.74 | 0.48 |
| | | | | | | | | | | | | |
| MissonZanja | 6687.746 | 1000cfs | 1000.00 | 1069.00 | 1074.38 | 1072.68 | 1074.97 | 0.003083 | 6.17 | 162.18 | 38.73 | 0.53 |
| MissonZanja | 6687.746 | 2000cfs | 1853.99 | 1069.00 | 1076.33 | 1074.33 | 1077.23 | 0.003349 | 7.63 | 242.84 | 43.97 | 0.57 |
| MissonZanja | 6687.746 | 3000cfs | 2391.09 | 1069.00 | 1077.35 | 1075.18 | 1078.41 | 0.003401 | 8.27 | 289.28 | 46.64 | 0.58 |

HEC-RAS Plan: LW River: MissionZanja Reach: MissonZanja (Continued)

| Reach | River Sta | Profile | Q Total | Min Ch El | W.S. Elev | Crit W.S. | E.G. Elev | E.G. Slope | Vel Chnl | Flow Area | Top Width | Froude # Chl |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | (cfs) | (ft) | (ft) | (ft) | (ft) | (ft/ft) | (ft/s) | (sq ft) | (ft) | |
| MissonZanja | 6687.746 | 4000cfs | 2837.13 | 1069.00 | 1079.05 | 1075.80 | 1079.95 | 0.002365 | 7.63 | 372.00 | 50.87 | 0.50 |
| MissonZanja | 6687.746 | 5000cfs | 3221.07 | 1069.00 | 1079.63 | 1076.31 | 1080.63 | 0.002453 | 8.01 | 402.22 | 52.33 | 0.51 |
| MissonZanja | 6687.746 | 6000cfs | 3578.83 | 1069.00 | 1080.34 | 1076.75 | 1081.36 | 0.002374 | 8.14 | 439.50 | 54.19 | 0.50 |
| | | | | | | | | | | | | |
| MissonZanja | 6574.956 | 1000cfs | 1000.00 | 1069.00 | 1074.03 | 1072.46 | 1074.62 | 0.003205 | 6.14 | 162.99 | 40.84 | 0.54 |
| MissonZanja | 6574.956 | 2000cfs | 1853.99 | 1069.00 | 1075.98 | 1074.03 | 1076.85 | 0.003301 | 7.46 | 248.68 | 46.87 | 0.57 |
| MissonZanja | 6574.956 | 3000cfs | 2391.09 | 1069.00 | 1077.03 | 1074.84 | 1078.02 | 0.003257 | 7.99 | 299.16 | 49.91 | 0.58 |
| MissonZanja | 6574.956 | 4000cfs | 2837.13 | 1069.00 | 1078.87 | 1075.46 | 1079.67 | 0.002083 | 7.16 | 396.39 | 55.21 | 0.47 |
| MissonZanja | 6574.956 | 5000cfs | 3221.07 | 1069.00 | 1079.46 | 1075.95 | 1080.34 | 0.002151 | 7.50 | 429.27 | 56.88 | 0.48 |
| MissonZanja | 6574.956 | 6000cfs | 3578.83 | 1069.00 | 1080.18 | 1076.37 | 1081.08 | 0.002056 | 7.60 | 470.84 | 58.93 | 0.47 |
| | | | | | | | | | | | | |
| MissonZanja | 6472.093 | 1000cfs | 1000.00 | 1069.00 | 1073.28 | 1072.53 | 1074.15 | 0.005816 | 7.50 | 133.28 | 39.07 | 0.72 |
| MissonZanja | 6472.093 | 2000cfs | 1853.99 | 1069.00 | 1075.30 | 1074.06 | 1076.41 | 0.004795 | 8.49 | 218.42 | 45.19 | 0.68 |
| MissonZanja | 6472.093 | 3000cfs | 2391.09 | 1069.00 | 1076.38 | 1074.83 | 1077.61 | 0.004388 | 8.88 | 269.23 | 48.28 | 0.66 |
| MissonZanja | 6472.093 | 4000cfs | 2837.13 | 1069.00 | 1078.59 | 1075.46 | 1079.44 | 0.002303 | 7.41 | 382.75 | 54.78 | 0.49 |
| MissonZanja | 6472.093 | 5000cfs | 3221.07 | 1069.00 | 1079.16 | 1075.94 | 1080.10 | 0.002375 | 7.77 | 414.68 | 56.43 | 0.50 |
| MissonZanja | 6472.093 | 6000cfs | 3578.83 | 1069.00 | 1079.90 | 1076.37 | 1080.85 | 0.002232 | 7.83 | 457.11 | 58.41 | 0.49 |
| | | | | | | | | | | | | |
| MissonZanja | 6358.782 | 1000cfs | 1000.00 | 1067.45 | 1072.72 | 1071.66 | 1073.54 | 0.004803 | 7.25 | 137.94 | 36.53 | 0.66 |
| MissonZanja | 6358.782 | 2000cfs | 1853.99 | 1067.45 | 1074.79 | 1073.33 | 1075.89 | 0.004401 | 8.43 | 219.90 | 42.69 | 0.65 |
| MissonZanja | 6358.782 | 3000cfs | 2391.09 | 1067.45 | 1075.89 | 1074.17 | 1077.12 | 0.004147 | 8.89 | 268.85 | 45.62 | 0.65 |
| MissonZanja | 6358.782 | 4000cfs | 2837.13 | 1067.45 | 1078.36 | 1074.81 | 1079.18 | 0.002084 | 7.29 | 389.29 | 52.25 | 0.47 |
| MissonZanja | 6358.782 | 5000cfs | 3221.07 | 1067.45 | 1078.91 | 1075.31 | 1079.83 | 0.002200 | 7.69 | 418.81 | 53.84 | 0.49 |
| MissonZanja | 6358.782 | 6000cfs | 3578.83 | 1067.45 | 1079.66 | 1075.76 | 1080.60 | 0.002115 | 7.78 | 459.93 | 56.30 | 0.48 |
| | | | | | | | | | | | | |
| MissonZanja | 6253.683 | 1000cfs | 1000.00 | 1065.51 | 1072.27 | 1070.94 | 1073.05 | 0.004319 | 7.10 | 140.79 | 34.36 | 0.62 |
| MissonZanja | 6253.683 | 2000cfs | 1853.99 | 1065.51 | 1074.26 | 1072.72 | 1075.41 | 0.004522 | 8.63 | 214.71 | 39.77 | 0.65 |
| MissonZanja | 6253.683 | 3000cfs | 2391.09 | 1065.51 | 1075.34 | 1073.60 | 1076.66 | 0.004429 | 9.22 | 259.43 | 42.52 | 0.66 |
| MissonZanja | 6253.683 | 4000cfs | 2837.13 | 1065.51 | 1078.13 | 1074.27 | 1078.96 | 0.002064 | 7.31 | 388.27 | 50.10 | 0.46 |
| MissonZanja | 6253.683 | 5000cfs | 3221.07 | 1065.51 | 1078.66 | 1074.81 | 1079.60 | 0.002231 | 7.76 | 415.24 | 51.89 | 0.48 |
| MissonZanja | 6253.683 | 6000cfs | 3578.83 | 1065.51 | 1079.41 | 1075.28 | 1080.37 | 0.002164 | 7.86 | 455.13 | 54.43 | 0.48 |
| | | | | | | | | | | | | |
| MissonZanja | 6143.895 | 1000cfs | 1000.00 | 1067.00 | 1071.94 | 1070.59 | 1072.57 | 0.003628 | 6.35 | 157.47 | 41.42 | 0.57 |
| MissonZanja | 6143.895 | 2000cfs | 1853.99 | 1067.00 | 1074.06 | 1072.11 | 1074.91 | 0.003212 | 7.40 | 250.63 | 46.78 | 0.56 |
| MissonZanja | 6143.895 | 3000cfs | 2391.09 | 1067.00 | 1075.20 | 1072.92 | 1076.15 | 0.003019 | 7.81 | 306.05 | 49.75 | 0.56 |
| MissonZanja | 6143.895 | 4000cfs | 2837.13 | 1067.00 | 1078.13 | 1073.49 | 1078.71 | 0.001339 | 6.12 | 463.24 | 57.98 | 0.38 |
| MissonZanja | 6143.895 | 5000cfs | 3221.07 | 1067.00 | 1078.66 | 1073.98 | 1079.32 | 0.001441 | 6.51 | 494.70 | 59.54 | 0.40 |
| MissonZanja | 6143.895 | 6000cfs | 3578.83 | 1067.00 | 1079.42 | 1074.34 | 1080.10 | 0.001372 | 6.62 | 542.10 | 67.62 | 0.39 |
| | | | | | | | | | | | | |
| MissonZanja | 6055.720 | 1000cfs | 1000.00 | 1067.00 | 1071.69 | 1070.07 | 1072.26 | 0.003101 | 6.07 | 164.87 | 38.33 | 0.52 |
| MissonZanja | 6055.720 | 2000cfs | 1853.99 | 1067.00 | 1073.77 | 1071.55 | 1074.62 | 0.003244 | 7.40 | 250.44 | 44.21 | 0.55 |
| MissonZanja | 6055.720 | 3000cfs | 2391.09 | 1067.00 | 1074.91 | 1072.39 | 1075.88 | 0.003180 | 7.90 | 302.73 | 47.63 | 0.55 |
| MissonZanja | 6055.720 | 4000cfs | 2837.13 | 1067.00 | 1078.01 | 1073.04 | 1078.59 | 0.001383 | 6.09 | 465.91 | 57.91 | 0.38 |
| MissonZanja | 6055.720 | 5000cfs | 3221.07 | 1067.00 | 1078.54 | 1073.58 | 1079.19 | 0.001502 | 6.48 | 496.81 | 59.81 | 0.40 |
| MissonZanja | 6055.720 | 6000cfs | 3578.83 | 1067.00 | 1079.30 | 1074.02 | 1079.98 | 0.001458 | 6.58 | 543.80 | 62.65 | 0.39 |
| | | | | | | | | | | | | |
| MissonZanja | 6002.6 | | Bridge | | | | | | | | | |
| | | | | | | | | | | | | |
| MissonZanja | 5982.201 | 1000cfs | 1000.00 | 1067.00 | 1069.93 | 1069.93 | 1071.37 | 0.012081 | 9.63 | 103.84 | 36.63 | 1.00 |
| MissonZanja | 5982.201 | 2000cfs | 1853.99 | 1067.00 | 1071.41 | 1071.41 | 1073.58 | 0.010536 | 11.83 | 156.69 | 38.60 | 1.00 |
| MissonZanja | 5982.201 | 3000cfs | 2391.09 | 1067.00 | 1072.22 | 1072.22 | 1074.79 | 0.009948 | 12.88 | 185.71 | 41.34 | 1.00 |
| MissonZanja | 5982.201 | 4000cfs | 2837.13 | 1067.00 | 1072.81 | 1072.81 | 1075.73 | 0.009745 | 13.70 | 207.06 | 43.44 | 1.00 |
| MissonZanja | 5982.201 | 5000cfs | 3221.07 | 1067.00 | 1073.36 | 1073.36 | 1076.49 | 0.009306 | 14.22 | 226.55 | 45.30 | 1.00 |
| MissonZanja | 5982.201 | 6000cfs | 3578.83 | 1067.00 | 1073.81 | 1073.81 | 1077.18 | 0.009099 | 14.73 | 242.96 | 46.81 | 1.00 |
| | | | | | | | | | | | | |
| MissonZanja | 5893.492 | 1000cfs | 1000.00 | 1062.00 | 1066.79 | 1066.01 | 1067.69 | 0.005719 | 7.59 | 131.78 | 37.45 | 0.71 |
| MissonZanja | 5893.492 | 2000cfs | 1853.99 | 1062.00 | 1068.67 | 1067.58 | 1069.92 | 0.005330 | 8.97 | 206.77 | 42.46 | 0.72 |
| MissonZanja | 5893.492 | 3000cfs | 2391.09 | 1062.00 | 1069.62 | 1068.38 | 1071.06 | 0.005235 | 9.62 | 248.55 | 44.88 | 0.72 |
| MissonZanja | 5893.492 | 4000cfs | 2837.13 | 1062.00 | 1070.34 | 1069.03 | 1071.92 | 0.005188 | 10.09 | 281.20 | 46.64 | 0.72 |
| MissonZanja | 5893.492 | 5000cfs | 3221.07 | 1062.00 | 1070.90 | 1069.50 | 1072.60 | 0.005166 | 10.46 | 307.98 | 47.99 | 0.73 |
| MissonZanja | 5893.492 | 6000cfs | 3578.83 | 1062.00 | 1071.40 | 1069.92 | 1073.20 | 0.005161 | 10.78 | 332.00 | 49.20 | 0.73 |
| | | | | | | | | | | | | |
| MissonZanja | 5797.955 | 1000cfs | 1000.00 | 1061.82 | 1066.49 | 1065.25 | 1067.17 | 0.003950 | 6.61 | 151.33 | 39.91 | 0.60 |
| MissonZanja | 5797.955 | 2000cfs | 1853.99 | 1061.82 | 1068.43 | 1066.77 | 1069.40 | 0.003880 | 7.92 | 234.00 | 45.58 | 0.62 |
| MissonZanja | 5797.955 | 3000cfs | 2391.09 | 1061.82 | 1069.41 | 1067.58 | 1070.54 | 0.003873 | 8.53 | 280.16 | 48.37 | 0.62 |
| MissonZanja | 5797.955 | 4000cfs | 2837.13 | 1061.82 | 1070.14 | 1068.19 | 1071.39 | 0.003874 | 8.97 | 316.42 | 50.49 | 0.63 |
| MissonZanja | 5797.955 | 5000cfs | 3221.07 | 1061.82 | 1070.73 | 1068.67 | 1072.07 | 0.003880 | 9.30 | 346.33 | 52.18 | 0.64 |
| MissonZanja | 5797.955 | 6000cfs | 3578.83 | 1061.82 | 1071.24 | 1069.10 | 1072.66 | 0.003880 | 9.59 | 373.28 | 53.56 | 0.64 |
| | | | | | | | | | | | | |
| MissonZanja | 5698.263 | 1000cfs | 1000.00 | 1061.00 | 1066.33 | 1064.41 | 1066.81 | 0.002413 | 5.55 | 180.13 | 42.47 | 0.48 |
| MissonZanja | 5698.263 | 2000cfs | 1853.99 | 1061.00 | 1068.27 | 1065.93 | 1069.02 | 0.002640 | 6.92 | 268.02 | 47.72 | 0.51 |
| MissonZanja | 5698.263 | 3000cfs | 2391.09 | 1061.00 | 1069.26 | 1066.73 | 1070.15 | 0.002736 | 7.56 | 316.22 | 50.15 | 0.53 |
| MissonZanja | 5698.263 | 4000cfs | 2837.13 | 1061.00 | 1069.99 | 1067.32 | 1070.99 | 0.002803 | 8.02 | 353.63 | 51.94 | 0.54 |
| MissonZanja | 5698.263 | 5000cfs | 3221.07 | 1061.00 | 1070.57 | 1067.80 | 1071.66 | 0.002858 | 8.38 | 384.22 | 53.35 | 0.55 |
| MissonZanja | 5698.263 | 6000cfs | 3578.83 | 1061.00 | 1071.08 | 1068.22 | 1072.25 | 0.002906 | 8.69 | 411.64 | 54.59 | 0.56 |
| | | | | | | | | | | | | |
| MissonZanja | 5605.682 | 1000cfs | 1000.00 | 1061.00 | 1065.88 | 1064.45 | 1066.52 | 0.003583 | 6.42 | 155.70 | 39.47 | 0.57 |
| MissonZanja | 5605.682 | 2000cfs | 1853.99 | 1061.00 | 1067.72 | 1066.05 | 1068.70 | 0.003880 | 7.96 | 233.05 | 44.79 | 0.61 |
| MissonZanja | 5605.682 | 3000cfs | 2391.09 | 1061.00 | 1068.65 | 1066.87 | 1069.81 | 0.003995 | 8.66 | 276.14 | 47.43 | 0.63 |
| MissonZanja | 5605.682 | 4000cfs | 2837.13 | 1061.00 | 1069.35 | 1067.48 | 1070.65 | 0.004066 | 9.15 | 310.01 | 49.44 | 0.64 |
| MissonZanja | 5605.682 | 5000cfs | 3221.07 | 1061.00 | 1069.90 | 1067.97 | 1071.32 | 0.004122 | 9.53 | 337.87 | 51.03 | 0.65 |

HEC-RAS Plan: LW River: MissionZanja Reach: MissonZanja (Continued)

| Reach | River Sta | Profile | Q Total | Min Ch El | W.S. Elev | Crit W.S. | E.G. Elev | E.G. Slope | Vel Chnl | Flow Area | Top Width | Froude # Chl |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | (cfs) | (ft) | (ft) | (ft) | (ft) | (ft/ft) | (ft/s) | (sq ft) | (ft) | |
| MissonZanja | 5605.682 | 6000cfs | 3578.83 | 1061.00 | 1070.39 | 1068.41 | 1071.90 | 0.004165 | 9.86 | 363.05 | 52.42 | 0.66 |
| | | | | | | | | | | | | |
| MissonZanja | 5516.187 | 1000cfs | 1000.00 | 1061.00 | 1065.55 | 1064.30 | 1066.19 | 0.003874 | 6.41 | 155.98 | 42.79 | 0.59 |
| MissonZanja | 5516.187 | 2000cfs | 1853.99 | 1061.00 | 1067.42 | 1065.80 | 1068.34 | 0.003735 | 7.67 | 241.86 | 48.62 | 0.61 |
| MissonZanja | 5516.187 | 3000cfs | 2391.09 | 1061.00 | 1068.38 | 1066.56 | 1069.44 | 0.003688 | 8.25 | 289.70 | 51.21 | 0.61 |
| MissonZanja | 5516.187 | 4000cfs | 2837.13 | 1061.00 | 1069.10 | 1067.13 | 1070.26 | 0.003670 | 8.68 | 327.00 | 53.15 | 0.62 |
| MissonZanja | 5516.187 | 5000cfs | 3221.07 | 1061.00 | 1069.66 | 1067.59 | 1070.92 | 0.003671 | 9.01 | 357.50 | 54.69 | 0.62 |
| MissonZanja | 5516.187 | 6000cfs | 3578.83 | 1061.00 | 1070.16 | 1068.00 | 1071.50 | 0.003674 | 9.30 | 384.98 | 56.04 | 0.63 |
| | | | | | | | | | | | | |
| MissonZanja | 5414.197 | 1000cfs | 1000.00 | 1060.48 | 1065.23 | 1063.82 | 1065.80 | 0.003338 | 6.07 | 164.65 | 43.78 | 0.55 |
| MissonZanja | 5414.197 | 2000cfs | 1853.99 | 1060.48 | 1067.12 | 1065.28 | 1067.95 | 0.003294 | 7.33 | 252.76 | 49.31 | 0.57 |
| MissonZanja | 5414.197 | 3000cfs | 2391.09 | 1060.48 | 1068.08 | 1066.04 | 1069.06 | 0.003296 | 7.93 | 301.55 | 51.94 | 0.58 |
| MissonZanja | 5414.197 | 4000cfs | 2837.13 | 1060.48 | 1068.80 | 1066.61 | 1069.88 | 0.003307 | 8.36 | 339.50 | 53.91 | 0.59 |
| MissonZanja | 5414.197 | 5000cfs | 3221.07 | 1060.48 | 1069.37 | 1067.06 | 1070.54 | 0.003327 | 8.70 | 370.44 | 55.46 | 0.59 |
| MissonZanja | 5414.197 | 6000cfs | 3578.83 | 1060.48 | 1069.86 | 1067.47 | 1071.12 | 0.003345 | 8.98 | 398.31 | 56.81 | 0.60 |
| | | | | | | | | | | | | |
| MissonZanja | 5320.500 | 1000cfs | 1000.00 | 1060.00 | 1064.89 | 1063.47 | 1065.48 | 0.003425 | 6.19 | 161.59 | 42.60 | 0.56 |
| MissonZanja | 5320.500 | 2000cfs | 1853.99 | 1060.00 | 1066.75 | 1064.98 | 1067.63 | 0.003481 | 7.53 | 246.23 | 48.17 | 0.59 |
| MissonZanja | 5320.500 | 3000cfs | 2391.09 | 1060.00 | 1067.70 | 1065.75 | 1068.73 | 0.003514 | 8.15 | 293.30 | 50.92 | 0.60 |
| MissonZanja | 5320.500 | 4000cfs | 2837.13 | 1060.00 | 1068.41 | 1066.35 | 1069.56 | 0.003541 | 8.60 | 330.05 | 52.97 | 0.61 |
| MissonZanja | 5320.500 | 5000cfs | 3221.07 | 1060.00 | 1068.97 | 1066.82 | 1070.21 | 0.003574 | 8.95 | 359.96 | 54.57 | 0.61 |
| MissonZanja | 5320.500 | 6000cfs | 3578.83 | 1060.00 | 1069.46 | 1067.24 | 1070.78 | 0.003600 | 9.25 | 387.00 | 55.99 | 0.62 |
| | | | | | | | | | | | | |
| MissonZanja | 5238.640 | 1000cfs | 1000.00 | 1059.00 | 1064.61 | 1063.05 | 1065.21 | 0.003274 | 6.22 | 160.87 | 40.32 | 0.55 |
| MissonZanja | 5238.640 | 2000cfs | 1853.99 | 1059.00 | 1066.39 | 1064.64 | 1067.33 | 0.003713 | 7.80 | 237.60 | 45.90 | 0.60 |
| MissonZanja | 5238.640 | 3000cfs | 2391.09 | 1059.00 | 1067.30 | 1065.46 | 1068.42 | 0.003866 | 8.52 | 280.58 | 48.63 | 0.63 |
| MissonZanja | 5238.640 | 4000cfs | 2837.13 | 1059.00 | 1067.97 | 1066.06 | 1069.24 | 0.003977 | 9.04 | 313.88 | 50.67 | 0.64 |
| MissonZanja | 5238.640 | 5000cfs | 3221.07 | 1059.00 | 1068.50 | 1066.56 | 1069.88 | 0.004063 | 9.44 | 341.18 | 52.27 | 0.65 |
| MissonZanja | 5238.640 | 6000cfs | 3578.83 | 1059.00 | 1068.96 | 1067.00 | 1070.45 | 0.004128 | 9.78 | 365.92 | 53.67 | 0.66 |
| | | | | | | | | | | | | |
| MissonZanja | 5159.057 | 1000cfs | 1000.00 | 1059.00 | 1064.47 | 1062.56 | 1064.95 | 0.002484 | 5.56 | 179.74 | 43.43 | 0.48 |
| MissonZanja | 5159.057 | 2000cfs | 1853.99 | 1059.00 | 1066.24 | 1064.12 | 1067.02 | 0.002907 | 7.09 | 261.50 | 48.70 | 0.54 |
| MissonZanja | 5159.057 | 3000cfs | 2391.09 | 1059.00 | 1067.15 | 1064.90 | 1068.09 | 0.003064 | 7.79 | 307.13 | 51.38 | 0.56 |
| MissonZanja | 5159.057 | 4000cfs | 2837.13 | 1059.00 | 1067.83 | 1065.49 | 1068.89 | 0.003178 | 8.29 | 342.35 | 53.36 | 0.58 |
| MissonZanja | 5159.057 | 5000cfs | 3221.07 | 1059.00 | 1068.36 | 1065.96 | 1069.53 | 0.003266 | 8.68 | 371.16 | 54.92 | 0.59 |
| MissonZanja | 5159.057 | 6000cfs | 3578.83 | 1059.00 | 1068.83 | 1066.38 | 1070.09 | 0.003334 | 9.01 | 397.24 | 56.28 | 0.60 |
| | | | | | | | | | | | | |
| MissonZanja | 5076.909 | 1000cfs | 1000.00 | 1060.00 | 1063.74 | 1063.10 | 1064.60 | 0.006308 | 7.44 | 134.37 | 42.84 | 0.74 |
| MissonZanja | 5076.909 | 2000cfs | 1853.99 | 1060.00 | 1065.52 | 1064.52 | 1066.67 | 0.005395 | 8.60 | 215.56 | 48.44 | 0.72 |
| MissonZanja | 5076.909 | 3000cfs | 2391.09 | 1060.00 | 1066.44 | 1065.27 | 1067.74 | 0.005130 | 9.15 | 261.44 | 51.24 | 0.71 |
| MissonZanja | 5076.909 | 4000cfs | 2837.13 | 1060.00 | 1067.11 | 1065.83 | 1068.53 | 0.005032 | 9.57 | 296.54 | 53.28 | 0.71 |
| MissonZanja | 5076.909 | 5000cfs | 3221.07 | 1060.00 | 1067.64 | 1066.29 | 1069.16 | 0.004983 | 9.91 | 325.16 | 54.87 | 0.72 |
| MissonZanja | 5076.909 | 6000cfs | 3578.83 | 1060.00 | 1068.11 | 1066.69 | 1069.72 | 0.004940 | 10.19 | 351.23 | 56.27 | 0.72 |
| | | | | | | | | | | | | |
| MissonZanja | 5000.496 | 1000cfs | 1000.00 | 1059.00 | 1063.45 | 1062.44 | 1064.15 | 0.004579 | 6.71 | 149.00 | 43.54 | 0.64 |
| MissonZanja | 5000.496 | 2000cfs | 1853.99 | 1059.00 | 1065.28 | 1063.88 | 1066.25 | 0.004195 | 7.92 | 234.20 | 49.25 | 0.64 |
| MissonZanja | 5000.496 | 3000cfs | 2391.09 | 1059.00 | 1066.21 | 1064.62 | 1067.33 | 0.004106 | 8.49 | 281.61 | 52.10 | 0.64 |
| MissonZanja | 5000.496 | 4000cfs | 2837.13 | 1059.00 | 1066.89 | 1065.18 | 1068.13 | 0.004103 | 8.93 | 317.56 | 54.16 | 0.65 |
| MissonZanja | 5000.496 | 5000cfs | 3221.07 | 1059.00 | 1067.42 | 1065.64 | 1068.76 | 0.004121 | 9.29 | 346.78 | 55.81 | 0.66 |
| MissonZanja | 5000.496 | 6000cfs | 3578.83 | 1059.00 | 1067.89 | 1066.04 | 1069.32 | 0.004127 | 9.58 | 373.45 | 57.25 | 0.66 |
| | | | | | | | | | | | | |
| MissonZanja | 4912.866 | 1000cfs | 1000.00 | 1058.00 | 1063.30 | 1061.58 | 1063.78 | 0.002600 | 5.57 | 179.60 | 45.21 | 0.49 |
| MissonZanja | 4912.866 | 2000cfs | 1853.99 | 1058.00 | 1065.14 | 1063.03 | 1065.89 | 0.002802 | 6.92 | 267.78 | 50.59 | 0.53 |
| MissonZanja | 4912.866 | 3000cfs | 2391.09 | 1058.00 | 1066.08 | 1063.79 | 1066.97 | 0.002891 | 7.56 | 316.48 | 53.32 | 0.55 |
| MissonZanja | 4912.866 | 4000cfs | 2837.13 | 1058.00 | 1066.75 | 1064.36 | 1067.76 | 0.002982 | 8.03 | 353.14 | 55.28 | 0.56 |
| MissonZanja | 4912.866 | 5000cfs | 3221.07 | 1058.00 | 1067.28 | 1064.83 | 1068.38 | 0.003060 | 8.41 | 382.83 | 56.82 | 0.57 |
| MissonZanja | 4912.866 | 6000cfs | 3578.83 | 1058.00 | 1067.75 | 1065.23 | 1068.94 | 0.003122 | 8.74 | 409.64 | 58.17 | 0.58 |
| | | | | | | | | | | | | |
| MissonZanja | 4823.133 | 1000cfs | 1000.00 | 1059.00 | 1062.65 | 1061.94 | 1063.42 | 0.005660 | 7.04 | 141.99 | 45.56 | 0.70 |
| MissonZanja | 4823.133 | 2000cfs | 1853.99 | 1059.00 | 1064.60 | 1063.30 | 1065.56 | 0.004256 | 7.86 | 235.78 | 50.73 | 0.64 |
| MissonZanja | 4823.133 | 3000cfs | 2391.09 | 1059.00 | 1065.55 | 1064.01 | 1066.64 | 0.004047 | 8.39 | 285.13 | 53.16 | 0.64 |
| MissonZanja | 4823.133 | 4000cfs | 2837.13 | 1059.00 | 1066.21 | 1064.54 | 1067.43 | 0.004032 | 8.84 | 321.07 | 54.87 | 0.64 |
| MissonZanja | 4823.133 | 5000cfs | 3221.07 | 1059.00 | 1066.73 | 1065.00 | 1068.05 | 0.004057 | 9.21 | 349.73 | 56.18 | 0.65 |
| MissonZanja | 4823.133 | 6000cfs | 3578.83 | 1059.00 | 1067.18 | 1065.39 | 1068.59 | 0.004081 | 9.53 | 375.48 | 57.35 | 0.66 |
| | | | | | | | | | | | | |
| MissonZanja | 4725.811 | 1000cfs | 1000.00 | 1058.00 | 1062.18 | 1061.22 | 1062.90 | 0.004761 | 6.80 | 146.96 | 43.36 | 0.65 |
| MissonZanja | 4725.811 | 2000cfs | 1853.99 | 1058.00 | 1064.25 | 1062.65 | 1065.15 | 0.003754 | 7.65 | 242.48 | 49.28 | 0.61 |
| MissonZanja | 4725.811 | 3000cfs | 2391.09 | 1058.00 | 1065.20 | 1063.42 | 1066.25 | 0.003696 | 8.22 | 290.85 | 52.01 | 0.61 |
| MissonZanja | 4725.811 | 4000cfs | 2837.13 | 1058.00 | 1065.86 | 1063.98 | 1067.04 | 0.003770 | 8.72 | 325.53 | 53.87 | 0.62 |
| MissonZanja | 4725.811 | 5000cfs | 3221.07 | 1058.00 | 1066.36 | 1064.44 | 1067.65 | 0.003858 | 9.12 | 353.04 | 55.32 | 0.64 |
| MissonZanja | 4725.811 | 6000cfs | 3578.83 | 1058.00 | 1066.80 | 1064.83 | 1068.20 | 0.003929 | 9.47 | 377.85 | 56.58 | 0.65 |
| | | | | | | | | | | | | |
| MissonZanja | 4634.039 | 1000cfs | 1000.00 | 1057.71 | 1061.63 | 1060.89 | 1062.42 | 0.005620 | 7.14 | 140.01 | 43.75 | 0.70 |
| MissonZanja | 4634.039 | 2000cfs | 1853.99 | 1057.71 | 1063.95 | 1062.31 | 1064.81 | 0.003523 | 7.43 | 249.49 | 50.66 | 0.59 |
| MissonZanja | 4634.039 | 3000cfs | 2391.09 | 1057.71 | 1064.92 | 1063.01 | 1065.90 | 0.003447 | 7.97 | 299.90 | 53.50 | 0.59 |
| MissonZanja | 4634.039 | 4000cfs | 2837.13 | 1057.71 | 1065.57 | 1063.60 | 1066.68 | 0.003522 | 8.46 | 335.45 | 55.42 | 0.61 |
| MissonZanja | 4634.039 | 5000cfs | 3221.07 | 1057.71 | 1066.07 | 1064.04 | 1067.29 | 0.003611 | 8.86 | 363.52 | 56.88 | 0.62 |
| MissonZanja | 4634.039 | 6000cfs | 3578.83 | 1057.71 | 1066.51 | 1064.43 | 1067.83 | 0.003682 | 9.20 | 388.86 | 58.17 | 0.63 |
| | | | | | | | | | | | | |
| MissonZanja | 4551.292 | 1000cfs | 1000.00 | 1056.00 | 1061.54 | 1059.90 | 1062.02 | 0.002677 | 5.58 | 179.21 | 46.07 | 0.50 |
| MissonZanja | 4551.292 | 2000cfs | 1853.99 | 1056.00 | 1063.90 | 1061.32 | 1064.51 | 0.002128 | 6.27 | 295.91 | 52.69 | 0.47 |

HEC-RAS Plan: LW River: MissionZanja Reach: MissonZanja (Continued)

| Reach | River Sta | Profile | Q Total | Min Ch El | W.S. Elev | Crit W.S. | E.G. Elev | E.G. Slope | Vel Chnl | Flow Area | Top Width | Froude # Chl |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | (cfs) | (ft) | (ft) | (ft) | (ft) | (ft/ft) | (ft/s) | (sq ft) | (ft) | |
| MissonZanja | 4551.292 | 3000cfs | 2391.09 | 1056.00 | 1064.87 | 1062.07 | 1065.60 | 0.002219 | 6.86 | 348.45 | 55.48 | 0.48 |
| MissonZanja | 4551.292 | 4000cfs | 2837.13 | 1056.00 | 1065.52 | 1062.62 | 1066.36 | 0.002353 | 7.37 | 385.16 | 57.38 | 0.50 |
| MissonZanja | 4551.292 | 5000cfs | 3221.07 | 1056.00 | 1066.02 | 1063.08 | 1066.96 | 0.002470 | 7.78 | 414.15 | 93.55 | 0.52 |
| MissonZanja | 4551.292 | 6000cfs | 3578.83 | 1056.00 | 1066.46 | 1063.48 | 1067.49 | 0.002532 | 8.13 | 440.30 | 96.38 | 0.53 |
| | | | | | | | | | | | | |
| MissonZanja | 4472.627 | 1000cfs | 1000.00 | 1057.00 | 1061.05 | 1060.10 | 1061.73 | 0.004507 | 6.60 | 151.48 | 44.96 | 0.63 |
| MissonZanja | 4472.627 | 2000cfs | 1853.99 | 1057.00 | 1063.61 | 1061.47 | 1064.31 | 0.002650 | 6.72 | 275.74 | 52.21 | 0.52 |
| MissonZanja | 4472.627 | 3000cfs | 2391.09 | 1057.00 | 1064.57 | 1062.20 | 1065.40 | 0.002694 | 7.31 | 327.12 | 54.92 | 0.53 |
| MissonZanja | 4472.627 | 4000cfs | 2837.13 | 1057.00 | 1065.20 | 1062.76 | 1066.15 | 0.002817 | 7.84 | 362.16 | 95.14 | 0.55 |
| MissonZanja | 4472.627 | 5000cfs | 3221.07 | 1057.00 | 1065.67 | 1063.21 | 1066.74 | 0.002910 | 8.28 | 389.34 | 101.86 | 0.56 |
| MissonZanja | 4472.627 | 6000cfs | 3578.83 | 1057.00 | 1066.10 | 1063.59 | 1067.26 | 0.002984 | 8.65 | 413.82 | 106.78 | 0.57 |
| | | | | | | | | | | | | |
| MissonZanja | 4378.558 | 1000cfs | 1000.00 | 1056.00 | 1060.78 | 1059.36 | 1061.34 | 0.003234 | 6.02 | 166.19 | 43.89 | 0.54 |
| MissonZanja | 4378.558 | 2000cfs | 1853.99 | 1056.00 | 1063.45 | 1060.81 | 1064.06 | 0.002137 | 6.31 | 293.81 | 51.78 | 0.47 |
| MissonZanja | 4378.558 | 3000cfs | 2391.09 | 1056.00 | 1064.40 | 1061.58 | 1065.15 | 0.002233 | 6.95 | 344.23 | 75.05 | 0.48 |
| MissonZanja | 4378.558 | 4000cfs | 2837.13 | 1056.00 | 1065.01 | 1062.13 | 1065.88 | 0.002375 | 7.51 | 377.56 | 102.53 | 0.51 |
| MissonZanja | 4378.558 | 5000cfs | 3221.07 | 1056.00 | 1065.47 | 1062.60 | 1066.46 | 0.002457 | 7.98 | 405.94 | 122.23 | 0.52 |
| MissonZanja | 4378.558 | 6000cfs | 3578.83 | 1056.00 | 1065.90 | 1063.03 | 1066.98 | 0.002502 | 8.36 | 436.31 | 141.06 | 0.53 |
| | | | | | | | | | | | | |
| MissonZanja | 4282.948 | 1000cfs | 1000.00 | 1056.00 | 1060.38 | 1059.21 | 1061.00 | 0.003835 | 6.29 | 158.98 | 44.90 | 0.59 |
| MissonZanja | 4282.948 | 2000cfs | 1853.99 | 1056.00 | 1063.27 | 1060.61 | 1063.86 | 0.002054 | 6.16 | 300.96 | 53.62 | 0.46 |
| MissonZanja | 4282.948 | 3000cfs | 2391.09 | 1056.00 | 1064.21 | 1061.36 | 1064.92 | 0.002154 | 6.77 | 352.95 | 99.42 | 0.48 |
| MissonZanja | 4282.948 | 4000cfs | 2837.13 | 1056.00 | 1064.81 | 1061.87 | 1065.65 | 0.002283 | 7.33 | 387.15 | 104.89 | 0.50 |
| MissonZanja | 4282.948 | 5000cfs | 3221.07 | 1056.00 | 1065.27 | 1062.33 | 1066.22 | 0.002385 | 7.79 | 413.55 | 145.47 | 0.51 |
| MissonZanja | 4282.948 | 6000cfs | 3578.83 | 1056.00 | 1065.69 | 1062.78 | 1066.73 | 0.002444 | 8.18 | 437.33 | 145.47 | 0.52 |
| | | | | | | | | | | | | |
| MissonZanja | 4196.297 | 1000cfs | 1000.00 | 1055.00 | 1060.15 | 1058.56 | 1060.69 | 0.002940 | 5.87 | 170.25 | 43.26 | 0.52 |
| MissonZanja | 4196.297 | 2000cfs | 1853.99 | 1055.00 | 1063.13 | 1060.07 | 1063.68 | 0.001768 | 5.93 | 312.75 | 52.27 | 0.43 |
| MissonZanja | 4196.297 | 3000cfs | 2391.09 | 1055.00 | 1064.06 | 1060.84 | 1064.74 | 0.001931 | 6.59 | 362.59 | 138.47 | 0.45 |
| MissonZanja | 4196.297 | 4000cfs | 2837.13 | 1055.00 | 1064.65 | 1061.43 | 1065.45 | 0.002045 | 7.18 | 394.92 | 138.47 | 0.47 |
| MissonZanja | 4196.297 | 5000cfs | 3221.07 | 1055.00 | 1065.10 | 1061.90 | 1066.01 | 0.002157 | 7.68 | 419.37 | 138.47 | 0.49 |
| MissonZanja | 4196.297 | 6000cfs | 3578.83 | 1055.00 | 1065.50 | 1062.32 | 1066.52 | 0.002245 | 8.11 | 441.42 | 138.47 | 0.50 |
| | | | | | | | | | | | | |
| MissonZanja | 4103.837 | 1000cfs | 1000.00 | 1054.00 | 1059.65 | 1058.37 | 1060.35 | 0.003948 | 6.72 | 148.72 | 38.07 | 0.60 |
| MissonZanja | 4103.837 | 2000cfs | 1853.99 | 1054.00 | 1062.83 | 1059.97 | 1063.48 | 0.002195 | 6.50 | 285.09 | 48.32 | 0.47 |
| MissonZanja | 4103.837 | 3000cfs | 2391.09 | 1054.00 | 1063.71 | 1060.81 | 1064.52 | 0.002397 | 7.26 | 331.73 | 90.74 | 0.50 |
| MissonZanja | 4103.837 | 4000cfs | 2837.13 | 1054.00 | 1064.25 | 1061.44 | 1065.22 | 0.002600 | 7.92 | 362.10 | 106.53 | 0.53 |
| MissonZanja | 4103.837 | 5000cfs | 3221.07 | 1054.00 | 1064.66 | 1061.97 | 1065.77 | 0.002762 | 8.48 | 384.78 | 122.03 | 0.55 |
| MissonZanja | 4103.837 | 6000cfs | 3578.83 | 1054.00 | 1065.03 | 1062.42 | 1066.26 | 0.002884 | 8.95 | 405.43 | 138.27 | 0.57 |
| | | | | | | | | | | | | |
| MissonZanja | 4025.013 | 1000cfs | 1000.00 | 1054.00 | 1059.59 | 1057.72 | 1060.05 | 0.002346 | 5.43 | 184.04 | 44.36 | 0.47 |
| MissonZanja | 4025.013 | 2000cfs | 1853.99 | 1054.00 | 1062.84 | 1059.20 | 1063.29 | 0.001301 | 5.38 | 348.23 | 69.29 | 0.37 |
| MissonZanja | 4025.013 | 3000cfs | 2391.09 | 1054.00 | 1063.74 | 1059.97 | 1064.30 | 0.001436 | 6.04 | 402.27 | 106.85 | 0.40 |
| MissonZanja | 4025.013 | 4000cfs | 2837.13 | 1054.00 | 1064.30 | 1060.55 | 1064.97 | 0.001576 | 6.61 | 436.83 | 143.17 | 0.42 |
| MissonZanja | 4025.013 | 5000cfs | 3221.07 | 1054.00 | 1064.73 | 1061.01 | 1065.50 | 0.001687 | 7.09 | 462.89 | 144.53 | 0.44 |
| MissonZanja | 4025.013 | 6000cfs | 3578.83 | 1054.00 | 1065.11 | 1061.41 | 1065.97 | 0.001773 | 7.50 | 486.69 | 148.33 | 0.45 |
| | | | | | | | | | | | | |
| MissonZanja | 3943.174 | 1000cfs | 1000.00 | 1053.00 | 1059.41 | 1057.24 | 1059.86 | 0.002189 | 5.38 | 186.03 | 43.01 | 0.46 |
| MissonZanja | 3943.174 | 2000cfs | 1853.99 | 1053.00 | 1062.76 | 1058.88 | 1063.18 | 0.001306 | 5.20 | 356.29 | 103.83 | 0.37 |
| MissonZanja | 3943.174 | 3000cfs | 2391.09 | 1053.00 | 1063.65 | 1059.69 | 1064.18 | 0.001422 | 5.85 | 408.66 | 107.65 | 0.39 |
| MissonZanja | 3943.174 | 4000cfs | 2837.13 | 1053.00 | 1064.20 | 1060.32 | 1064.84 | 0.001565 | 6.42 | 441.67 | 143.61 | 0.42 |
| MissonZanja | 3943.174 | 5000cfs | 3221.07 | 1053.00 | 1064.61 | 1060.79 | 1065.35 | 0.001681 | 6.90 | 466.52 | 145.95 | 0.44 |
| MissonZanja | 3943.174 | 6000cfs | 3578.83 | 1053.00 | 1064.99 | 1061.29 | 1065.82 | 0.001771 | 7.31 | 489.26 | 148.14 | 0.45 |
| | | | | | | | | | | | | |
| MissonZanja | 3852.813 | 1000cfs | 1000.00 | 1054.00 | 1059.30 | 1056.93 | 1059.66 | 0.001640 | 4.77 | 209.75 | 45.14 | 0.39 |
| MissonZanja | 3852.813 | 2000cfs | 1853.99 | 1054.00 | 1062.69 | 1058.32 | 1063.06 | 0.000989 | 4.88 | 409.48 | 105.04 | 0.32 |
| MissonZanja | 3852.813 | 3000cfs | 2391.09 | 1054.00 | 1063.62 | 1059.06 | 1064.03 | 0.001030 | 5.30 | 507.50 | 106.24 | 0.33 |
| MissonZanja | 3852.813 | 4000cfs | 2837.13 | 1054.00 | 1064.21 | 1059.64 | 1064.66 | 0.001100 | 5.65 | 573.90 | 138.39 | 0.34 |
| MissonZanja | 3852.813 | 5000cfs | 3221.07 | 1054.00 | 1064.67 | 1060.09 | 1065.15 | 0.001119 | 5.89 | 642.94 | 150.81 | 0.35 |
| MissonZanja | 3852.813 | 6000cfs | 3578.83 | 1054.00 | 1065.10 | 1060.51 | 1065.59 | 0.001107 | 6.05 | 707.70 | 150.81 | 0.35 |
| | | | | | | | | | | | | |
| MissonZanja | 3790.98 | | Culvert | | | | | | | | | |
| | | | | | | | | | | | | |
| MissonZanja | 3732.985 | 1000cfs | 1000.00 | 1050.00 | 1053.88 | 1053.43 | 1055.07 | 0.008241 | 8.75 | 114.25 | 32.28 | 0.82 |
| MissonZanja | 3732.985 | 2000cfs | 1853.99 | 1050.00 | 1055.75 | 1055.07 | 1057.46 | 0.007829 | 10.48 | 176.96 | 35.43 | 0.83 |
| MissonZanja | 3732.985 | 3000cfs | 2391.09 | 1050.00 | 1056.67 | 1055.99 | 1058.67 | 0.008124 | 11.35 | 210.76 | 38.48 | 0.85 |
| MissonZanja | 3732.985 | 4000cfs | 2837.13 | 1050.00 | 1057.42 | 1056.72 | 1059.58 | 0.008009 | 11.80 | 240.45 | 40.94 | 0.86 |
| MissonZanja | 3732.985 | 5000cfs | 3221.07 | 1050.00 | 1057.94 | 1057.30 | 1060.28 | 0.008138 | 12.28 | 262.30 | 42.52 | 0.87 |
| MissonZanja | 3732.985 | 6000cfs | 3578.83 | 1050.00 | 1058.32 | 1057.74 | 1060.88 | 0.008500 | 12.84 | 278.73 | 43.63 | 0.90 |
| | | | | | | | | | | | | |
| MissonZanja | 3732 | | Lat Struct | | | | | | | | | |
| | | | | | | | | | | | | |
| MissonZanja | 3644.444 | 1000cfs | 1000.00 | 1048.83 | 1054.01 | 1052.05 | 1054.35 | 0.001805 | 4.70 | 212.56 | 52.86 | 0.41 |
| MissonZanja | 3644.444 | 2000cfs | 1853.99 | 1048.83 | 1056.07 | 1053.29 | 1056.58 | 0.001703 | 5.71 | 324.83 | 55.86 | 0.42 |
| MissonZanja | 3644.444 | 3000cfs | 2391.09 | 1048.83 | 1057.07 | 1053.97 | 1057.68 | 0.001756 | 6.26 | 381.70 | 57.58 | 0.43 |
| MissonZanja | 3644.444 | 4000cfs | 2837.13 | 1048.83 | 1057.87 | 1054.49 | 1058.55 | 0.001767 | 6.63 | 427.78 | 58.86 | 0.43 |
| MissonZanja | 3644.444 | 5000cfs | 3221.07 | 1048.83 | 1058.43 | 1054.88 | 1059.19 | 0.001826 | 6.98 | 461.53 | 61.34 | 0.44 |
| MissonZanja | 3644.444 | 6000cfs | 3578.83 | 1048.83 | 1058.87 | 1055.25 | 1059.71 | 0.001920 | 7.34 | 487.79 | 66.33 | 0.46 |
| | | | | | | | | | | | | |
| MissonZanja | 3550.638 | 1000cfs | 1000.00 | 1049.00 | 1053.74 | 1051.86 | 1054.16 | 0.002228 | 5.17 | 193.40 | 45.99 | 0.44 |
| MissonZanja | 3550.638 | 2000cfs | 1853.99 | 1049.00 | 1055.74 | 1053.22 | 1056.38 | 0.002325 | 6.39 | 289.93 | 50.85 | 0.47 |

HEC-RAS Plan: LW River: MissionZanja Reach: MissonZanja (Continued)

| Reach | River Sta | Profile | Q Total | Min Ch El | W.S. Elev | Crit W.S. | E.G. Elev | E.G. Slope | Vel Chnl | Flow Area | Top Width | Froude # Chl |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | (cfs) | (ft) | (ft) | (ft) | (ft) | (ft/ft) | (ft/s) | (sq ft) | (ft) | |
| MissonZanja | 3550.638 | 3000cfs | 2391.09 | 1049.00 | 1056.71 | 1053.92 | 1057.48 | 0.002446 | 7.03 | 340.25 | 53.58 | 0.49 |
| MissonZanja | 3550.638 | 4000cfs | 2837.13 | 1049.00 | 1057.48 | 1054.50 | 1058.34 | 0.002468 | 7.41 | 382.67 | 56.84 | 0.50 |
| MissonZanja | 3550.638 | 5000cfs | 3221.07 | 1049.00 | 1058.03 | 1054.96 | 1058.97 | 0.002559 | 7.79 | 413.53 | 62.96 | 0.51 |
| MissonZanja | 3550.638 | 6000cfs | 3578.83 | 1049.00 | 1058.43 | 1055.36 | 1059.47 | 0.002718 | 8.19 | 436.94 | 68.04 | 0.53 |
| | | | | | | | | | | | | |
| MissonZanja | 3458.747 | 1000cfs | 1000.00 | 1049.00 | 1053.49 | 1051.77 | 1053.94 | 0.002511 | 5.39 | 185.59 | 45.20 | 0.47 |
| MissonZanja | 3458.747 | 2000cfs | 1853.99 | 1049.00 | 1055.46 | 1053.11 | 1056.15 | 0.002581 | 6.64 | 279.16 | 49.72 | 0.49 |
| MissonZanja | 3458.747 | 3000cfs | 2391.09 | 1049.00 | 1056.40 | 1053.83 | 1057.23 | 0.002719 | 7.32 | 326.68 | 51.93 | 0.51 |
| MissonZanja | 3458.747 | 4000cfs | 2837.13 | 1049.00 | 1057.16 | 1054.39 | 1058.09 | 0.002741 | 7.73 | 367.08 | 59.81 | 0.52 |
| MissonZanja | 3458.747 | 5000cfs | 3221.07 | 1049.00 | 1057.68 | 1054.88 | 1058.71 | 0.002858 | 8.15 | 395.43 | 67.59 | 0.54 |
| MissonZanja | 3458.747 | 6000cfs | 3578.80 | 1049.00 | 1058.04 | 1055.28 | 1059.20 | 0.003078 | 8.61 | 415.54 | 120.05 | 0.56 |
| | | | | | | | | | | | | |
| MissonZanja | 3367.418 | 1000cfs | 1000.00 | 1048.00 | 1053.31 | 1051.15 | 1053.71 | 0.002168 | 5.11 | 195.70 | 45.43 | 0.43 |
| MissonZanja | 3367.418 | 2000cfs | 1853.99 | 1048.00 | 1055.27 | 1052.66 | 1055.91 | 0.002330 | 6.43 | 288.54 | 48.91 | 0.47 |
| MissonZanja | 3367.418 | 3000cfs | 2391.09 | 1048.00 | 1056.19 | 1053.43 | 1056.98 | 0.002521 | 7.16 | 334.01 | 60.02 | 0.49 |
| MissonZanja | 3367.418 | 4000cfs | 2837.13 | 1048.00 | 1056.94 | 1054.00 | 1057.84 | 0.002585 | 7.61 | 372.72 | 68.98 | 0.50 |
| MissonZanja | 3367.418 | 5000cfs | 3221.07 | 1048.00 | 1057.44 | 1054.45 | 1058.45 | 0.002741 | 8.07 | 399.09 | 95.90 | 0.52 |
| MissonZanja | 3367.418 | 6000cfs | 3578.74 | 1048.00 | 1057.77 | 1054.85 | 1058.92 | 0.002989 | 8.58 | 416.88 | 98.87 | 0.54 |
| | | | | | | | | | | | | |
| MissonZanja | 3273.833 | 1000cfs | 1000.00 | 1048.00 | 1053.08 | 1051.02 | 1053.51 | 0.002176 | 5.26 | 189.98 | 42.04 | 0.44 |
| MissonZanja | 3273.833 | 2000cfs | 1853.99 | 1048.00 | 1054.97 | 1052.45 | 1055.67 | 0.002631 | 6.76 | 274.45 | 47.85 | 0.50 |
| MissonZanja | 3273.833 | 3000cfs | 2391.09 | 1048.00 | 1055.84 | 1053.22 | 1056.72 | 0.002924 | 7.53 | 317.60 | 69.74 | 0.53 |
| MissonZanja | 3273.833 | 4000cfs | 2837.13 | 1048.00 | 1056.59 | 1053.83 | 1057.57 | 0.002949 | 7.96 | 356.39 | 87.97 | 0.54 |
| MissonZanja | 3273.833 | 5000cfs | 3221.03 | 1048.00 | 1057.06 | 1054.32 | 1058.17 | 0.003106 | 8.44 | 381.46 | 124.33 | 0.56 |
| MissonZanja | 3273.833 | 6000cfs | 3569.64 | 1048.00 | 1057.36 | 1054.78 | 1058.61 | 0.003333 | 8.99 | 398.50 | 129.91 | 0.58 |
| | | | | | | | | | | | | |
| MissonZanja | 3200.841 | 1000cfs | 1000.00 | 1048.00 | 1052.90 | 1050.95 | 1053.34 | 0.002288 | 5.32 | 187.88 | 42.79 | 0.45 |
| MissonZanja | 3200.841 | 2000cfs | 1853.99 | 1048.00 | 1054.75 | 1052.35 | 1055.48 | 0.002705 | 6.83 | 271.36 | 60.02 | 0.50 |
| MissonZanja | 3200.841 | 3000cfs | 2391.09 | 1048.00 | 1055.59 | 1053.13 | 1056.50 | 0.003015 | 7.66 | 312.25 | 86.03 | 0.54 |
| MissonZanja | 3200.841 | 4000cfs | 2837.13 | 1048.00 | 1056.32 | 1053.71 | 1057.34 | 0.003295 | 8.10 | 350.10 | 104.35 | 0.57 |
| MissonZanja | 3200.841 | 5000cfs | 3220.95 | 1048.00 | 1056.78 | 1054.22 | 1057.91 | 0.003785 | 8.55 | 376.68 | 113.63 | 0.61 |
| MissonZanja | 3200.841 | 6000cfs | 3554.43 | 1048.00 | 1057.09 | 1054.61 | 1058.34 | 0.004121 | 8.97 | 396.43 | 155.60 | 0.64 |
| | | | | | | | | | | | | |
| MissonZanja | 3106.227 | 1000cfs | 1000.00 | 1048.00 | 1052.58 | 1050.92 | 1053.09 | 0.002890 | 5.75 | 173.85 | 42.31 | 0.50 |
| MissonZanja | 3106.227 | 2000cfs | 1853.99 | 1048.00 | 1054.35 | 1052.36 | 1055.18 | 0.003356 | 7.32 | 253.30 | 65.34 | 0.56 |
| MissonZanja | 3106.227 | 3000cfs | 2391.09 | 1048.00 | 1055.12 | 1053.15 | 1056.17 | 0.003776 | 8.22 | 290.98 | 97.07 | 0.60 |
| MissonZanja | 3106.227 | 4000cfs | 2837.13 | 1048.00 | 1055.83 | 1053.76 | 1056.99 | 0.003824 | 8.67 | 327.15 | 103.68 | 0.61 |
| MissonZanja | 3106.227 | 5000cfs | 3219.67 | 1048.00 | 1056.16 | 1054.24 | 1057.52 | 0.004184 | 9.33 | 345.37 | 130.85 | 0.64 |
| MissonZanja | 3106.227 | 6000cfs | 3533.65 | 1048.00 | 1056.37 | 1054.63 | 1057.90 | 0.004538 | 9.92 | 357.64 | 136.77 | 0.67 |
| | | | | | | | | | | | | |
| MissonZanja | 3020.275 | 1000cfs | 1000.00 | 1048.00 | 1052.34 | 1050.79 | 1052.84 | 0.002919 | 5.67 | 176.47 | 55.02 | 0.50 |
| MissonZanja | 3020.275 | 2000cfs | 1853.99 | 1048.00 | 1054.09 | 1052.14 | 1054.89 | 0.003266 | 7.16 | 259.01 | 69.77 | 0.55 |
| MissonZanja | 3020.275 | 3000cfs | 2391.09 | 1048.00 | 1054.83 | 1052.90 | 1055.84 | 0.003692 | 8.06 | 296.51 | 85.82 | 0.60 |
| MissonZanja | 3020.275 | 4000cfs | 2831.39 | 1048.00 | 1055.53 | 1053.46 | 1056.59 | 0.004881 | 8.26 | 342.99 | 122.06 | 0.68 |
| MissonZanja | 3020.275 | 5000cfs | 3173.68 | 1048.00 | 1055.95 | 1053.87 | 1057.07 | 0.004658 | 8.49 | 373.86 | 122.68 | 0.67 |
| MissonZanja | 3020.275 | 6000cfs | 3439.04 | 1048.00 | 1056.22 | 1054.21 | 1057.40 | 0.004590 | 8.72 | 394.77 | 128.05 | 0.67 |
| | | | | | | | | | | | | |
| MissonZanja | 2937.583 | 1000cfs | 1000.00 | 1048.00 | 1051.93 | 1050.78 | 1052.55 | 0.003991 | 6.28 | 159.23 | 48.31 | 0.58 |
| MissonZanja | 2937.583 | 2000cfs | 1853.99 | 1048.00 | 1053.61 | 1052.14 | 1054.56 | 0.004240 | 7.84 | 236.62 | 69.35 | 0.63 |
| MissonZanja | 2937.583 | 3000cfs | 2391.09 | 1048.00 | 1054.19 | 1052.87 | 1055.45 | 0.005176 | 9.01 | 265.32 | 90.85 | 0.70 |
| MissonZanja | 2937.583 | 4000cfs | 2827.86 | 1048.00 | 1054.57 | 1053.44 | 1056.09 | 0.006112 | 9.92 | 285.15 | 97.59 | 0.76 |
| MissonZanja | 2937.583 | 5000cfs | 3147.42 | 1048.00 | 1054.83 | 1053.84 | 1056.54 | 0.006978 | 10.49 | 299.92 | 104.20 | 0.81 |
| MissonZanja | 2937.583 | 6000cfs | 3375.95 | 1048.00 | 1055.02 | 1054.12 | 1056.84 | 0.008174 | 10.83 | 311.68 | 113.38 | 0.88 |
| | | | | | | | | | | | | |
| MissonZanja | 2839.118 | 1000cfs | 1000.00 | 1047.00 | 1051.74 | 1050.01 | 1052.19 | 0.002496 | 5.39 | 185.64 | 54.77 | 0.47 |
| MissonZanja | 2839.118 | 2000cfs | 1853.99 | 1047.00 | 1053.39 | 1051.37 | 1054.16 | 0.003039 | 7.02 | 264.28 | 84.50 | 0.54 |
| MissonZanja | 2839.118 | 3000cfs | 2391.09 | 1047.00 | 1053.89 | 1052.11 | 1054.95 | 0.003884 | 8.26 | 289.64 | 87.89 | 0.61 |
| MissonZanja | 2839.118 | 4000cfs | 2825.96 | 1047.00 | 1054.18 | 1052.66 | 1055.51 | 0.004659 | 9.27 | 308.02 | 109.38 | 0.67 |
| MissonZanja | 2839.118 | 5000cfs | 3139.80 | 1047.00 | 1054.38 | 1053.04 | 1055.90 | 0.005147 | 9.93 | 322.57 | 109.64 | 0.71 |
| MissonZanja | 2839.118 | 6000cfs | 3350.13 | 1047.00 | 1054.46 | 1053.29 | 1056.14 | 0.005608 | 10.44 | 328.39 | 109.74 | 0.74 |
| | | | | | | | | | | | | |
| MissonZanja | 2745.981 | 1000cfs | 1000.00 | 1047.00 | 1051.54 | 1049.71 | 1051.96 | 0.002278 | 5.19 | 192.76 | 56.33 | 0.45 |
| MissonZanja | 2745.981 | 2000cfs | 1853.11 | 1047.00 | 1053.15 | 1051.05 | 1053.87 | 0.002855 | 6.81 | 275.00 | 108.37 | 0.52 |
| MissonZanja | 2745.981 | 3000cfs | 2358.81 | 1047.00 | 1053.63 | 1051.73 | 1054.58 | 0.003455 | 7.86 | 309.68 | 109.02 | 0.58 |
| MissonZanja | 2745.981 | 4000cfs | 2746.15 | 1047.00 | 1053.91 | 1052.22 | 1055.06 | 0.003957 | 8.65 | 330.48 | 109.41 | 0.63 |
| MissonZanja | 2745.981 | 5000cfs | 3027.91 | 1047.00 | 1054.12 | 1052.53 | 1055.39 | 0.004277 | 9.16 | 345.48 | 110.52 | 0.65 |
| MissonZanja | 2745.981 | 6000cfs | 3204.40 | 1047.00 | 1054.20 | 1052.78 | 1055.58 | 0.004570 | 9.54 | 351.57 | 110.94 | 0.68 |
| | | | | | | | | | | | | |
| MissonZanja | 2661.491 | 1000cfs | 1000.00 | 1047.00 | 1051.31 | 1049.65 | 1051.75 | 0.002594 | 5.36 | 186.72 | 64.04 | 0.48 |
| MissonZanja | 2661.491 | 2000cfs | 1851.18 | 1047.00 | 1052.84 | 1050.97 | 1053.61 | 0.003230 | 7.04 | 263.11 | 87.58 | 0.55 |
| MissonZanja | 2661.491 | 3000cfs | 2307.69 | 1047.00 | 1053.25 | 1051.56 | 1054.26 | 0.003935 | 8.09 | 289.52 | 108.95 | 0.61 |
| MissonZanja | 2661.491 | 4000cfs | 2645.29 | 1047.00 | 1053.49 | 1052.01 | 1054.70 | 0.004451 | 8.83 | 307.56 | 109.28 | 0.66 |
| MissonZanja | 2661.491 | 5000cfs | 2894.57 | 1047.00 | 1053.67 | 1052.31 | 1055.00 | 0.004808 | 9.33 | 320.22 | 109.51 | 0.69 |
| MissonZanja | 2661.491 | 6000cfs | 3039.53 | 1047.00 | 1053.74 | 1052.49 | 1055.17 | 0.005064 | 9.65 | 325.93 | 110.53 | 0.71 |
| | | | | | | | | | | | | |
| MissonZanja | 2566.589 | 1000cfs | 1000.00 | 1047.00 | 1051.03 | 1049.56 | 1051.49 | 0.002854 | 5.44 | 183.69 | 82.09 | 0.50 |
| MissonZanja | 2566.589 | 2000cfs | 1825.99 | 1047.00 | 1052.57 | 1050.80 | 1053.29 | 0.003138 | 6.87 | 273.93 | 108.41 | 0.55 |
| MissonZanja | 2566.589 | 3000cfs | 2206.86 | 1047.00 | 1053.01 | 1051.28 | 1053.87 | 0.003413 | 7.52 | 305.94 | 112.30 | 0.58 |
| MissonZanja | 2566.589 | 4000cfs | 2481.86 | 1047.00 | 1053.28 | 1051.66 | 1054.24 | 0.003578 | 7.97 | 327.05 | 119.57 | 0.59 |
| MissonZanja | 2566.589 | 5000cfs | 2684.20 | 1047.00 | 1053.49 | 1051.90 | 1054.51 | 0.003667 | 8.26 | 343.40 | 124.85 | 0.60 |
| MissonZanja | 2566.589 | 6000cfs | 2792.08 | 1047.00 | 1053.59 | 1052.12 | 1054.65 | 0.003713 | 8.41 | 352.07 | 127.54 | 0.61 |

HEC-RAS Plan: LW River: MissionZanja Reach: MissonZanja (Continued)

| Reach | River Sta | Profile | Q Total | Min Ch El | W.S. Elev | Crit W.S. | E.G. Elev | E.G. Slope | Vel Chnl | Flow Area | Top Width | Froude # Chl |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | (cfs) | (ft) | (ft) | (ft) | (ft) | (ft/ft) | (ft/s) | (sq ft) | (ft) | |
| | | | | | | | | | | | | |
| MissonZanja | 2484.523 | 1000cfs | 1000.00 | 1047.00 | 1050.36 | 1049.70 | 1051.13 | 0.006102 | 7.05 | 141.81 | 85.67 | 0.72 |
| MissonZanja | 2484.523 | 2000cfs | 1805.41 | 1047.00 | 1051.80 | 1050.96 | 1052.91 | 0.005867 | 8.47 | 213.19 | 94.61 | 0.74 |
| MissonZanja | 2484.523 | 3000cfs | 2136.23 | 1047.00 | 1052.07 | 1051.40 | 1053.44 | 0.006741 | 9.38 | 228.88 | 114.65 | 0.80 |
| MissonZanja | 2484.523 | 4000cfs | 2368.41 | 1047.00 | 1052.20 | 1051.69 | 1053.78 | 0.007510 | 10.08 | 238.30 | 114.85 | 0.84 |
| MissonZanja | 2484.523 | 5000cfs | 2536.69 | 1047.00 | 1052.28 | 1051.91 | 1054.01 | 0.008157 | 10.60 | 243.58 | 114.95 | 0.88 |
| MissonZanja | 2484.523 | 6000cfs | 2626.23 | 1047.00 | 1052.35 | 1052.14 | 1054.15 | 0.008271 | 10.78 | 248.98 | 115.06 | 0.89 |
| | | | | | | | | | | | | |
| MissonZanja | 2377.009 | 1000cfs | 1000.00 | 1046.00 | 1050.14 | 1048.64 | 1050.61 | 0.002797 | 5.49 | 182.30 | 98.37 | 0.50 |
| MissonZanja | 2377.009 | 2000cfs | 1772.59 | 1046.00 | 1051.64 | 1049.82 | 1052.34 | 0.003028 | 6.80 | 269.47 | 124.04 | 0.54 |
| MissonZanja | 2377.009 | 3000cfs | 2051.89 | 1046.00 | 1051.97 | 1050.21 | 1052.78 | 0.003246 | 7.29 | 293.15 | 124.63 | 0.56 |
| MissonZanja | 2377.009 | 4000cfs | 2239.48 | 1046.00 | 1052.15 | 1050.46 | 1053.04 | 0.003414 | 7.65 | 306.19 | 156.96 | 0.58 |
| MissonZanja | 2377.009 | 5000cfs | 2370.31 | 1046.00 | 1052.27 | 1050.62 | 1053.21 | 0.003524 | 7.88 | 314.87 | 156.96 | 0.59 |
| MissonZanja | 2377.009 | 6000cfs | 2451.09 | 1046.00 | 1052.36 | 1050.73 | 1053.33 | 0.003551 | 8.00 | 321.27 | 156.96 | 0.60 |
| | | | | | | | | | | | | |
| MissonZanja | 2275.296 | 1000cfs | 1000.00 | 1046.00 | 1049.23 | 1048.75 | 1050.13 | 0.007393 | 7.63 | 131.09 | 111.21 | 0.78 |
| MissonZanja | 2275.296 | 2000cfs | 1736.38 | 1046.00 | 1049.92 | 1049.92 | 1051.70 | 0.011607 | 10.70 | 162.20 | 122.31 | 1.00 |
| MissonZanja | 2275.296 | 3000cfs | 1951.89 | 1046.00 | 1050.26 | 1050.26 | 1052.13 | 0.010986 | 10.97 | 178.85 | 128.04 | 0.98 |
| MissonZanja | 2275.296 | 4000cfs | 2087.25 | 1046.00 | 1050.47 | 1050.47 | 1052.38 | 0.010605 | 11.11 | 189.35 | 128.35 | 0.97 |
| MissonZanja | 2275.296 | 5000cfs | 2178.82 | 1046.00 | 1050.59 | 1050.59 | 1052.55 | 0.010547 | 11.26 | 195.23 | 128.52 | 0.97 |
| MissonZanja | 2275.296 | 6000cfs | 2241.68 | 1046.00 | 1050.66 | 1050.66 | 1052.66 | 0.010526 | 11.37 | 199.11 | 128.63 | 0.98 |
| | | | | | | | | | | | | |
| MissonZanja | 2204.968 | 1000cfs | 1000.00 | 1045.94 | 1048.38 | 1048.38 | 1049.44 | 0.012716 | 8.27 | 120.88 | 138.37 | 1.00 |
| MissonZanja | 2204.968 | 2000cfs | 1726.29 | 1045.94 | 1049.36 | 1049.36 | 1050.80 | 0.011113 | 9.65 | 179.79 | 170.15 | 0.99 |
| MissonZanja | 2204.968 | 3000cfs | 1911.75 | 1045.94 | 1049.58 | 1049.58 | 1051.11 | 0.010753 | 9.92 | 194.11 | 175.92 | 0.98 |
| MissonZanja | 2204.968 | 4000cfs | 2021.67 | 1045.94 | 1049.71 | 1049.71 | 1051.28 | 0.010602 | 10.08 | 202.16 | 176.90 | 0.98 |
| MissonZanja | 2204.968 | 5000cfs | 2094.34 | 1045.94 | 1049.79 | 1049.79 | 1051.39 | 0.010472 | 10.17 | 207.63 | 177.57 | 0.98 |
| MissonZanja | 2204.968 | 6000cfs | 2147.48 | 1045.94 | 1049.85 | 1049.85 | 1051.47 | 0.010431 | 10.25 | 211.27 | 178.01 | 0.98 |
| | | | | | | | | | | | | |
| MissonZanja | 2176.960 | 1000cfs | 1000.00 | 1044.73 | 1046.64 | 1046.64 | 1047.54 | 0.013476 | 7.61 | 131.44 | 118.54 | 1.00 |
| MissonZanja | 2176.960 | 2000cfs | 1725.65 | 1044.73 | 1047.49 | 1047.49 | 1048.66 | 0.012128 | 8.68 | 198.75 | 169.66 | 1.00 |
| MissonZanja | 2176.960 | 3000cfs | 1909.65 | 1044.73 | 1047.66 | 1047.66 | 1048.91 | 0.011912 | 8.98 | 212.59 | 171.75 | 1.00 |
| MissonZanja | 2176.960 | 4000cfs | 2018.28 | 1044.73 | 1047.75 | 1047.75 | 1049.05 | 0.011865 | 9.17 | 220.16 | 173.19 | 1.00 |
| MissonZanja | 2176.960 | 5000cfs | 2089.68 | 1044.73 | 1047.81 | 1047.81 | 1049.14 | 0.011797 | 9.28 | 225.28 | 174.43 | 1.00 |
| MissonZanja | 2176.960 | 6000cfs | 2142.40 | 1044.73 | 1047.87 | 1047.87 | 1049.21 | 0.011543 | 9.30 | 230.26 | 175.64 | 0.99 |
| | | | | | | | | | | | | |
| MissonZanja | 2153.531 | 1000cfs | 1000.00 | 1034.44 | 1037.53 | 1037.53 | 1038.58 | 0.012938 | 8.23 | 121.54 | 57.95 | 1.00 |
| MissonZanja | 2153.531 | 2000cfs | 1725.65 | 1034.44 | 1038.48 | 1038.48 | 1039.95 | 0.011648 | 9.73 | 177.31 | 60.08 | 1.00 |
| MissonZanja | 2153.531 | 3000cfs | 1909.65 | 1034.44 | 1038.69 | 1038.69 | 1040.26 | 0.011404 | 10.03 | 190.35 | 60.50 | 1.00 |
| MissonZanja | 2153.531 | 4000cfs | 2018.28 | 1034.44 | 1038.82 | 1038.82 | 1040.43 | 0.011299 | 10.21 | 197.75 | 60.74 | 1.00 |
| MissonZanja | 2153.531 | 5000cfs | 2089.68 | 1034.44 | 1038.89 | 1038.89 | 1040.55 | 0.011281 | 10.33 | 202.29 | 60.90 | 1.00 |
| MissonZanja | 2153.531 | 6000cfs | 2142.40 | 1034.44 | 1038.96 | 1038.96 | 1040.63 | 0.011137 | 10.38 | 206.38 | 61.03 | 0.99 |
| | | | | | | | | | | | | |
| MissonZanja | 2119.327 | 1000cfs | 1000.00 | 1029.75 | 1034.56 | 1034.56 | 1036.02 | 0.017124 | 9.67 | 103.38 | 35.27 | 1.00 |
| MissonZanja | 2119.327 | 2000cfs | 1725.65 | 1029.75 | 1035.92 | 1035.92 | 1037.85 | 0.016204 | 11.16 | 154.66 | 40.43 | 1.01 |
| MissonZanja | 2119.327 | 3000cfs | 1909.65 | 1029.75 | 1036.24 | 1036.24 | 1038.25 | 0.015735 | 11.37 | 167.98 | 41.67 | 1.00 |
| MissonZanja | 2119.327 | 4000cfs | 2018.28 | 1029.75 | 1036.40 | 1036.40 | 1038.47 | 0.015707 | 11.54 | 174.84 | 42.29 | 1.00 |
| MissonZanja | 2119.327 | 5000cfs | 2089.68 | 1029.75 | 1036.53 | 1036.53 | 1038.62 | 0.015479 | 11.60 | 180.16 | 42.76 | 1.00 |
| MissonZanja | 2119.327 | 6000cfs | 2142.40 | 1029.75 | 1036.61 | 1036.61 | 1038.72 | 0.015471 | 11.68 | 183.43 | 43.05 | 1.00 |
| | | | | | | | | | | | | |
| MissonZanja | 2043.176 | 1000cfs | 1000.00 | 1024.49 | 1028.60 | 1028.60 | 1030.18 | 0.017351 | 10.11 | 98.91 | 31.20 | 1.00 |
| MissonZanja | 2043.176 | 2000cfs | 1725.65 | 1024.49 | 1030.08 | 1030.08 | 1032.18 | 0.016226 | 11.63 | 148.36 | 35.45 | 1.00 |
| MissonZanja | 2043.176 | 3000cfs | 1909.65 | 1024.49 | 1030.41 | 1030.41 | 1032.62 | 0.016017 | 11.93 | 160.05 | 36.32 | 1.00 |
| MissonZanja | 2043.176 | 4000cfs | 2018.28 | 1024.49 | 1030.59 | 1030.59 | 1032.86 | 0.015920 | 12.10 | 166.78 | 36.82 | 1.00 |
| MissonZanja | 2043.176 | 5000cfs | 2089.68 | 1024.49 | 1030.71 | 1030.71 | 1033.02 | 0.015845 | 12.20 | 171.22 | 37.14 | 1.00 |
| MissonZanja | 2043.176 | 6000cfs | 2142.40 | 1024.49 | 1030.80 | 1030.80 | 1033.14 | 0.015800 | 12.28 | 174.44 | 37.37 | 1.00 |
| | | | | | | | | | | | | |
| MissonZanja | 1971.614 | 1000cfs | 1000.00 | 1021.00 | 1025.10 | 1025.10 | 1026.60 | 0.017341 | 9.80 | 102.00 | 34.18 | 1.00 |
| MissonZanja | 1971.614 | 2000cfs | 1725.65 | 1021.00 | 1026.47 | 1026.47 | 1028.49 | 0.016340 | 11.42 | 151.12 | 37.84 | 1.01 |
| MissonZanja | 1971.614 | 3000cfs | 1909.65 | 1021.00 | 1026.77 | 1026.77 | 1028.91 | 0.016131 | 11.73 | 162.83 | 38.67 | 1.01 |
| MissonZanja | 1971.614 | 4000cfs | 2018.28 | 1021.00 | 1026.96 | 1026.96 | 1029.15 | 0.015864 | 11.86 | 170.21 | 39.18 | 1.00 |
| MissonZanja | 1971.614 | 5000cfs | 2089.68 | 1021.00 | 1027.08 | 1027.08 | 1029.30 | 0.015796 | 11.97 | 174.65 | 39.49 | 1.00 |
| MissonZanja | 1971.614 | 6000cfs | 2142.40 | 1021.00 | 1027.16 | 1027.16 | 1029.41 | 0.015736 | 12.04 | 177.94 | 39.71 | 1.00 |
| | | | | | | | | | | | | |
| MissonZanja | 1885.656 | 1000cfs | 1000.00 | 1019.00 | 1022.68 | 1022.68 | 1024.16 | 0.017655 | 9.76 | 102.50 | 34.98 | 1.00 |
| MissonZanja | 1885.656 | 2000cfs | 1725.65 | 1019.00 | 1024.04 | 1024.04 | 1026.02 | 0.016383 | 11.27 | 153.06 | 39.22 | 1.01 |
| MissonZanja | 1885.656 | 3000cfs | 1909.65 | 1019.00 | 1024.34 | 1024.34 | 1026.42 | 0.016171 | 11.58 | 164.97 | 40.12 | 1.01 |
| MissonZanja | 1885.656 | 4000cfs | 2018.28 | 1019.00 | 1024.52 | 1024.52 | 1026.66 | 0.016046 | 11.74 | 171.93 | 40.64 | 1.01 |
| MissonZanja | 1885.656 | 5000cfs | 2089.68 | 1019.00 | 1024.62 | 1024.62 | 1026.80 | 0.015984 | 11.85 | 176.40 | 40.98 | 1.01 |
| MissonZanja | 1885.656 | 6000cfs | 2142.40 | 1019.00 | 1024.71 | 1024.71 | 1026.91 | 0.015925 | 11.92 | 179.75 | 41.23 | 1.01 |
| | | | | | | | | | | | | |
| MissonZanja | 1793.017 | 1000cfs | 1000.00 | 1018.00 | 1021.92 | 1021.27 | 1022.75 | 0.009080 | 7.33 | 136.37 | 44.03 | 0.73 |
| MissonZanja | 1793.017 | 2000cfs | 1725.65 | 1018.00 | 1023.43 | 1022.47 | 1024.51 | 0.007966 | 8.34 | 206.99 | 49.42 | 0.72 |
| MissonZanja | 1793.017 | 3000cfs | 1909.65 | 1018.00 | 1023.76 | 1022.74 | 1024.89 | 0.007803 | 8.54 | 223.66 | 50.63 | 0.72 |
| MissonZanja | 1793.017 | 4000cfs | 2018.28 | 1018.00 | 1023.95 | 1022.89 | 1025.11 | 0.007720 | 8.65 | 233.31 | 51.31 | 0.71 |
| MissonZanja | 1793.017 | 5000cfs | 2089.68 | 1018.00 | 1024.07 | 1022.99 | 1025.25 | 0.007671 | 8.72 | 239.58 | 51.75 | 0.71 |
| MissonZanja | 1793.017 | 6000cfs | 2142.40 | 1018.00 | 1024.16 | 1023.06 | 1025.36 | 0.007636 | 8.77 | 244.17 | 52.07 | 0.71 |
| | | | | | | | | | | | | |
| MissonZanja | 1686.769 | 1000cfs | 1000.00 | 1017.00 | 1021.27 | 1020.20 | 1021.90 | 0.006156 | 6.37 | 157.05 | 47.05 | 0.61 |
| MissonZanja | 1686.769 | 2000cfs | 1725.65 | 1017.00 | 1022.94 | 1021.42 | 1023.73 | 0.005358 | 7.14 | 241.74 | 54.54 | 0.60 |
| MissonZanja | 1686.769 | 3000cfs | 1909.65 | 1017.00 | 1023.30 | 1021.69 | 1024.13 | 0.005256 | 7.30 | 261.56 | 56.15 | 0.60 |

HEC-RAS Plan: LW River: MissionZanja Reach: MissonZanja (Continued)

| Reach | River Sta | Profile | Q Total | Min Ch El | W.S. Elev | Crit W.S. | E.G. Elev | E.G. Slope | Vel Chnl | Flow Area | Top Width | Froude # Chl |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | (cfs) | (ft) | (ft) | (ft) | (ft) | (ft/ft) | (ft/s) | (sq ft) | (ft) | |
| MissonZanja | 1686.769 | 4000cfs | 2018.28 | 1017.00 | 1023.50 | 1021.84 | 1024.35 | 0.005205 | 7.39 | 273.01 | 57.06 | 0.60 |
| MissonZanja | 1686.769 | 5000cfs | 2089.68 | 1017.00 | 1023.63 | 1021.94 | 1024.49 | 0.005175 | 7.45 | 280.46 | 57.65 | 0.60 |
| MissonZanja | 1686.769 | 6000cfs | 2142.40 | 1017.00 | 1023.72 | 1022.01 | 1024.60 | 0.005154 | 7.49 | 285.90 | 58.07 | 0.60 |
| | | | | | | | | | | | | |
| MissonZanja | 1558.336 | 1000cfs | 1000.00 | 1015.00 | 1020.27 | 1019.18 | 1021.05 | 0.006982 | 7.06 | 141.66 | 39.20 | 0.65 |
| MissonZanja | 1558.336 | 2000cfs | 1725.65 | 1015.00 | 1021.88 | 1020.62 | 1022.92 | 0.007033 | 8.20 | 210.40 | 46.48 | 0.68 |
| MissonZanja | 1558.336 | 3000cfs | 1909.65 | 1015.00 | 1022.22 | 1020.93 | 1023.32 | 0.007046 | 8.43 | 226.45 | 47.99 | 0.68 |
| MissonZanja | 1558.336 | 4000cfs | 2018.28 | 1015.00 | 1022.41 | 1021.10 | 1023.55 | 0.007053 | 8.56 | 235.73 | 48.84 | 0.69 |
| MissonZanja | 1558.336 | 5000cfs | 2089.68 | 1015.00 | 1022.53 | 1021.22 | 1023.69 | 0.007058 | 8.64 | 241.76 | 49.39 | 0.69 |
| MissonZanja | 1558.336 | 6000cfs | 2142.40 | 1015.00 | 1022.62 | 1021.30 | 1023.80 | 0.007062 | 8.70 | 246.17 | 49.78 | 0.69 |
| | | | | | | | | | | | | |
| MissonZanja | 1405.649 | 1000cfs | 1000.00 | 1014.00 | 1019.44 | 1017.95 | 1020.09 | 0.005236 | 6.45 | 155.01 | 39.09 | 0.57 |
| MissonZanja | 1405.649 | 2000cfs | 1725.65 | 1014.00 | 1020.91 | 1019.38 | 1021.90 | 0.006185 | 7.97 | 216.52 | 44.72 | 0.64 |
| MissonZanja | 1405.649 | 3000cfs | 1909.65 | 1014.00 | 1021.22 | 1019.69 | 1022.29 | 0.006371 | 8.28 | 230.58 | 45.91 | 0.65 |
| MissonZanja | 1405.649 | 4000cfs | 2018.28 | 1014.00 | 1021.40 | 1019.87 | 1022.51 | 0.006474 | 8.46 | 238.66 | 46.58 | 0.66 |
| MissonZanja | 1405.649 | 5000cfs | 2089.68 | 1014.00 | 1021.51 | 1019.98 | 1022.65 | 0.006539 | 8.57 | 243.89 | 47.00 | 0.66 |
| MissonZanja | 1405.649 | 6000cfs | 2142.40 | 1014.00 | 1021.59 | 1020.07 | 1022.75 | 0.006585 | 8.65 | 247.72 | 47.31 | 0.67 |
| | | | | | | | | | | | | |
| MissonZanja | 1278.031 | 1000cfs | 1000.00 | 1014.00 | 1018.52 | 1017.61 | 1019.28 | 0.007582 | 7.02 | 142.52 | 42.87 | 0.68 |
| MissonZanja | 1278.031 | 2000cfs | 1725.65 | 1014.00 | 1019.95 | 1018.91 | 1021.01 | 0.007702 | 8.27 | 208.79 | 49.38 | 0.71 |
| MissonZanja | 1278.031 | 3000cfs | 1909.65 | 1014.00 | 1020.27 | 1019.19 | 1021.39 | 0.007690 | 8.50 | 224.57 | 50.77 | 0.71 |
| MissonZanja | 1278.031 | 4000cfs | 2018.28 | 1014.00 | 1020.45 | 1019.35 | 1021.60 | 0.007680 | 8.63 | 233.75 | 51.56 | 0.71 |
| MissonZanja | 1278.031 | 5000cfs | 2089.68 | 1014.00 | 1020.56 | 1019.45 | 1021.74 | 0.007674 | 8.72 | 239.71 | 52.07 | 0.72 |
| MissonZanja | 1278.031 | 6000cfs | 2142.40 | 1014.00 | 1020.64 | 1019.53 | 1021.84 | 0.007669 | 8.78 | 244.10 | 52.44 | 0.72 |
| | | | | | | | | | | | | |
| MissonZanja | 1126.390 | 1000cfs | 1000.00 | 1012.32 | 1016.12 | 1016.12 | 1017.53 | 0.017774 | 9.55 | 104.71 | 37.54 | 1.01 |
| MissonZanja | 1126.390 | 2000cfs | 1725.65 | 1012.32 | 1017.45 | 1017.45 | 1019.30 | 0.016161 | 10.92 | 158.00 | 42.66 | 1.00 |
| MissonZanja | 1126.390 | 3000cfs | 1909.65 | 1012.32 | 1017.73 | 1017.73 | 1019.68 | 0.015935 | 11.20 | 170.50 | 43.78 | 1.00 |
| MissonZanja | 1126.390 | 4000cfs | 2018.28 | 1012.32 | 1017.90 | 1017.90 | 1019.90 | 0.015816 | 11.35 | 177.75 | 44.42 | 1.00 |
| MissonZanja | 1126.390 | 5000cfs | 2089.68 | 1012.32 | 1018.00 | 1018.00 | 1020.04 | 0.015739 | 11.45 | 182.48 | 44.83 | 1.00 |
| MissonZanja | 1126.390 | 6000cfs | 2142.40 | 1012.32 | 1018.08 | 1018.08 | 1020.14 | 0.015685 | 11.52 | 185.95 | 45.12 | 1.00 |
| | | | | | | | | | | | | |
| MissonZanja | 966.6074 | 1000cfs | 1000.00 | 1007.00 | 1011.94 | 1011.94 | 1013.51 | 0.017479 | 10.05 | 99.51 | 32.10 | 1.01 |
| MissonZanja | 966.6074 | 2000cfs | 1725.65 | 1007.00 | 1013.42 | 1013.42 | 1015.43 | 0.016292 | 11.37 | 151.80 | 38.31 | 1.01 |
| MissonZanja | 966.6074 | 3000cfs | 1909.65 | 1007.00 | 1013.74 | 1013.74 | 1015.84 | 0.016095 | 11.63 | 164.16 | 39.61 | 1.01 |
| MissonZanja | 966.6074 | 4000cfs | 2018.28 | 1007.00 | 1013.92 | 1013.92 | 1016.07 | 0.015975 | 11.78 | 171.38 | 40.33 | 1.01 |
| MissonZanja | 966.6074 | 5000cfs | 2089.68 | 1007.00 | 1014.04 | 1014.04 | 1016.22 | 0.015910 | 11.87 | 176.06 | 40.81 | 1.01 |
| MissonZanja | 966.6074 | 6000cfs | 2142.40 | 1007.00 | 1014.13 | 1014.12 | 1016.33 | 0.015799 | 11.92 | 179.76 | 41.18 | 1.01 |
| | | | | | | | | | | | | |
| MissonZanja | 840.1522 | 1000cfs | 1000.00 | 1004.00 | 1010.88 | 1009.57 | 1011.73 | 0.006869 | 7.38 | 135.50 | 33.21 | 0.64 |
| MissonZanja | 840.1522 | 2000cfs | 1725.65 | 1004.00 | 1012.63 | 1011.23 | 1013.79 | 0.007291 | 8.64 | 199.62 | 40.25 | 0.68 |
| MissonZanja | 840.1522 | 3000cfs | 1909.65 | 1004.00 | 1012.99 | 1011.58 | 1014.22 | 0.007359 | 8.89 | 214.71 | 41.75 | 0.69 |
| MissonZanja | 840.1522 | 4000cfs | 2018.28 | 1004.00 | 1013.20 | 1011.78 | 1014.47 | 0.007392 | 9.03 | 223.45 | 42.59 | 0.69 |
| MissonZanja | 840.1522 | 5000cfs | 2089.68 | 1004.00 | 1013.33 | 1011.90 | 1014.63 | 0.007411 | 9.12 | 229.14 | 43.13 | 0.70 |
| MissonZanja | 840.1522 | 6000cfs | 2142.40 | 1004.00 | 1013.43 | 1012.00 | 1014.74 | 0.007424 | 9.18 | 233.32 | 43.52 | 0.70 |
| | | | | | | | | | | | | |
| MissonZanja | 703.8411 | 1000cfs | 1000.00 | 1004.00 | 1010.45 | 1008.25 | 1010.97 | 0.003604 | 5.77 | 173.31 | 38.18 | 0.48 |
| MissonZanja | 703.8411 | 2000cfs | 1725.65 | 1004.00 | 1012.14 | 1009.79 | 1012.92 | 0.004327 | 7.08 | 243.73 | 45.17 | 0.54 |
| MissonZanja | 703.8411 | 3000cfs | 1909.65 | 1004.00 | 1012.50 | 1010.12 | 1013.34 | 0.004452 | 7.34 | 260.26 | 46.68 | 0.55 |
| MissonZanja | 703.8411 | 4000cfs | 2018.28 | 1004.00 | 1012.70 | 1010.31 | 1013.57 | 0.004518 | 7.48 | 269.85 | 47.54 | 0.55 |
| MissonZanja | 703.8411 | 5000cfs | 2089.68 | 1004.00 | 1012.84 | 1010.44 | 1013.72 | 0.004558 | 7.57 | 276.10 | 48.09 | 0.56 |
| MissonZanja | 703.8411 | 6000cfs | 2142.40 | 1004.00 | 1012.93 | 1010.53 | 1013.83 | 0.004586 | 7.63 | 280.68 | 48.49 | 0.56 |
| | | | | | | | | | | | | |
| MissonZanja | 541.4196 | 1000cfs | 1000.00 | 1004.00 | 1009.73 | 1008.06 | 1010.30 | 0.004586 | 6.08 | 164.35 | 40.94 | 0.54 |
| MissonZanja | 541.4196 | 2000cfs | 1725.65 | 1004.00 | 1011.30 | 1009.48 | 1012.15 | 0.005097 | 7.40 | 233.31 | 46.47 | 0.58 |
| MissonZanja | 541.4196 | 3000cfs | 1909.65 | 1004.00 | 1011.64 | 1009.78 | 1012.55 | 0.005192 | 7.67 | 249.10 | 47.57 | 0.59 |
| MissonZanja | 541.4196 | 4000cfs | 2018.28 | 1004.00 | 1011.83 | 1009.95 | 1012.78 | 0.005246 | 7.82 | 258.17 | 48.19 | 0.60 |
| MissonZanja | 541.4196 | 5000cfs | 2089.68 | 1004.00 | 1011.95 | 1010.07 | 1012.92 | 0.005278 | 7.91 | 264.08 | 48.59 | 0.60 |
| MissonZanja | 541.4196 | 6000cfs | 2142.40 | 1004.00 | 1012.04 | 1010.15 | 1013.03 | 0.005303 | 7.98 | 268.39 | 48.89 | 0.60 |
| | | | | | | | | | | | | |
| MissonZanja | 355.1155 | 1000cfs | 1000.00 | 1004.00 | 1008.65 | 1007.45 | 1009.32 | 0.005964 | 6.57 | 152.32 | 41.72 | 0.61 |
| MissonZanja | 355.1155 | 2000cfs | 1725.65 | 1004.00 | 1010.00 | 1008.76 | 1011.03 | 0.006953 | 8.14 | 212.06 | 46.86 | 0.67 |
| MissonZanja | 355.1155 | 3000cfs | 1909.65 | 1004.00 | 1010.29 | 1009.08 | 1011.40 | 0.007128 | 8.45 | 225.87 | 47.94 | 0.69 |
| MissonZanja | 355.1155 | 4000cfs | 2018.28 | 1004.00 | 1010.46 | 1009.23 | 1011.61 | 0.007227 | 8.63 | 233.78 | 48.55 | 0.69 |
| MissonZanja | 355.1155 | 5000cfs | 2089.68 | 1004.00 | 1010.57 | 1009.35 | 1011.75 | 0.007277 | 8.74 | 239.05 | 48.95 | 0.70 |
| MissonZanja | 355.1155 | 6000cfs | 2142.40 | 1004.00 | 1010.64 | 1009.39 | 1011.85 | 0.007318 | 8.82 | 242.84 | 49.23 | 0.70 |
| | | | | | | | | | | | | |
| MissonZanja | 225.5310 | 1000cfs | 1000.00 | 1004.00 | 1007.59 | 1006.92 | 1008.38 | 0.008845 | 7.13 | 140.32 | 46.44 | 0.72 |
| MissonZanja | 225.5310 | 2000cfs | 1725.65 | 1004.00 | 1008.63 | 1008.10 | 1009.90 | 0.010714 | 9.04 | 190.95 | 50.77 | 0.82 |
| MissonZanja | 225.5310 | 3000cfs | 1909.65 | 1004.00 | 1008.86 | 1008.37 | 1010.24 | 0.011043 | 9.42 | 202.73 | 51.75 | 0.84 |
| MissonZanja | 225.5310 | 4000cfs | 2018.28 | 1004.00 | 1008.99 | 1008.50 | 1010.43 | 0.011253 | 9.64 | 209.31 | 52.29 | 0.85 |
| MissonZanja | 225.5310 | 5000cfs | 2089.68 | 1004.00 | 1009.07 | 1008.60 | 1010.56 | 0.011376 | 9.78 | 213.65 | 52.66 | 0.86 |
| MissonZanja | 225.5310 | 6000cfs | 2142.40 | 1004.00 | 1009.13 | 1008.67 | 1010.65 | 0.011466 | 9.88 | 216.82 | 52.92 | 0.86 |
| | | | | | | | | | | | | |
| MissonZanja | 81.74349 | 1000cfs | 1000.00 | 1003.61 | 1006.84 | 1006.03 | 1007.36 | 0.005002 | 5.78 | 173.14 | 63.50 | 0.62 |
| MissonZanja | 81.74349 | 2000cfs | 1725.65 | 1003.61 | 1007.97 | 1006.96 | 1008.73 | 0.005008 | 6.97 | 247.71 | 78.86 | 0.64 |
| MissonZanja | 81.74349 | 3000cfs | 1909.65 | 1003.61 | 1008.23 | 1007.17 | 1009.04 | 0.005001 | 7.19 | 265.63 | 81.72 | 0.65 |
| MissonZanja | 81.74349 | 4000cfs | 2018.28 | 1003.61 | 1008.38 | 1007.29 | 1009.21 | 0.005009 | 7.32 | 275.79 | 83.18 | 0.65 |
| MissonZanja | 81.74349 | 5000cfs | 2089.68 | 1003.61 | 1008.47 | 1007.37 | 1009.32 | 0.005008 | 7.40 | 282.50 | 84.09 | 0.65 |
| MissonZanja | 81.74349 | 6000cfs | 2142.40 | 1003.61 | 1008.54 | 1007.44 | 1009.41 | 0.005006 | 7.45 | 287.41 | 84.73 | 0.65 |

# Attachment 3 – Photo Log

**Photo 1: Gage Canal Drop Structure**


**Photo 2: Tippecanoe Ave Culvert – Upstream Face**


**Photo 3: Tippecanoe Ave Culvert – Downstream Face**

**Photo 4: Richardson Bridge – Looking upstream**

**Photo 5: Richardson Bridge – Looking downstream**

**Photo 6: Mountain View Bridge – Looking upstream**


**Photo 7: Mountain View Bridge – Looking downstream (from survey photo)**

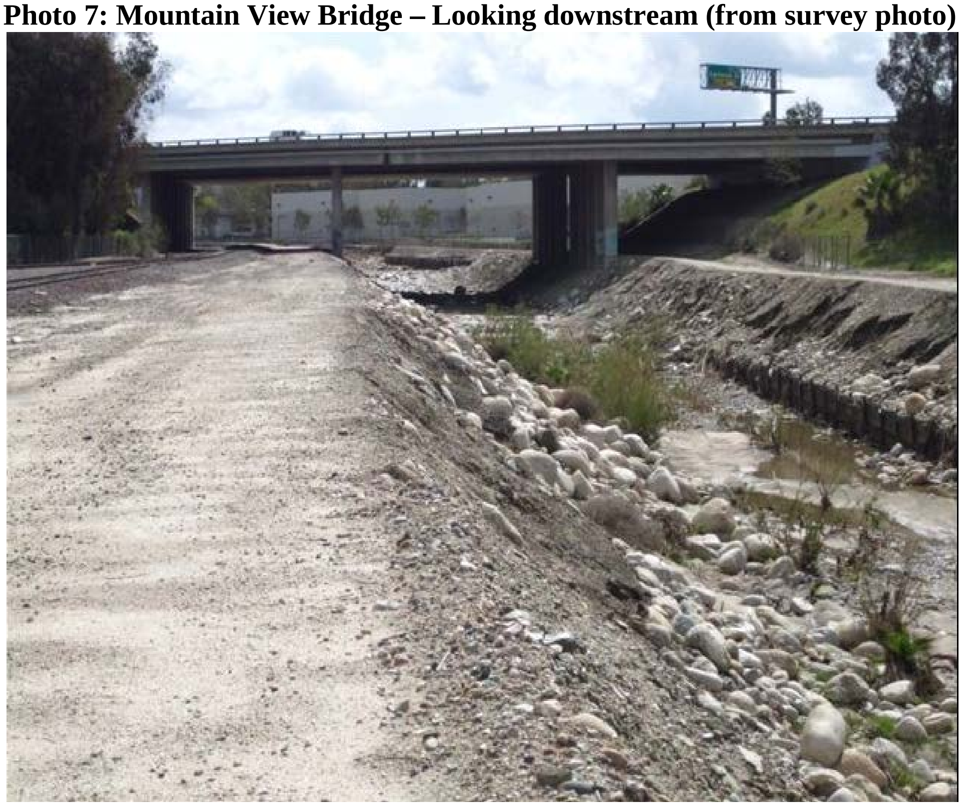


**Photo 8: I-10 Bridge- Looking Upstream**

**Photo 9: I-10 Bridge- Looking Downstream**

**Photo 10: Bryn Mawr Bridge- Looking Upstream**

**Photo 11: Bryn Mawr Bridge- Looking Downstream**

**Photo 12: Bridge 9.4**

# Attachment 4 – Digital Information (CD)

CD available upon request.

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# Memo

| | | | |
|---|---|---|---|
| To: | Michael Shaver, HDR | | |
| From: | Mark Seits, P.E., CFM | Project: | Evaluation of Hydraulic Impact on Bryn Mawr Bridge Alternatives |
| CC: | | | |
| Date: | 1/05/2013 | Job No: | 193026 |

Document2

## Evaluation of Hydraulic Impact on Bryn Mawr Bridge Alternatives

### *Purpose*

The purpose of this memo is to evaluate the hydraulics and potential hydraulic impact for the proposed Mission Zanja Channel grading and Bryn Mawr Bridge alternatives.

### *Background*

Due to urbanization and limited improvements along the Mission Zanja Channel (Channel), runoff from even small storms (i.e. less than 5-year events) has the potential to exceed existing channel capacity, resulting in overflow and flooding of the surrounding areas. The Bryn Mawr bridge area is one of the areas experienced historical flooding and it is considered to have less than adequate flood conveyance capacity. HDR (2012) previously performed hydraulic analysis on the existing Mission Zanja Channel reach which includes Bryn Mawr Bridge. The proposed condition includes the Channel grading and Bryn Mawr Bridge alternatives. Exhibit 1 shows the limits and proposed contour of the Channel grading. The grading is approximately 550-foot long and the centerline was shifted slightly to the south of the existing centerline. The design of Bryn Mawr Bridge is primarily governed by rail and structural needs. The purpose of this analysis is to evaluate the hydraulic impact based on proposed conditions.

### *Hydrology*

A range of flowrates was analyzed to approximate the proposed channel and Bryn Mawr Bridge Alternative capacities. The Comprehensive Storm Drain Plan for the Mission Zanja watershed indicates a future condition 100-year discharge of 7,555 cfs at Bryn Mawr Bridge, but regional detention basins upstream of the Channel are proposed to reduce the peak flow.

### *Hydraulic Modeling*

Hydraulic modeling was conducted using the USACE HEC-RAS (v.4.1) program. Existing FEMA effective modeling was not available for Mission Zanja Channel reach. Therefore, channel geometry was generated based on the topographic map by using HEC-GeoRAS program (v.4.1.1), an extension for support of HEC-RAS using ArcGIS. The topographic map is the one-foot topographic map prepared for RPRP project. An approximate centerline was laid out along the Channel. Cross sections were cut perpendicular to the Channel centerline. Six existing cross sections (from section 11966 to 12507) are within the proposed grading limits. These existing cross sections were revised based on the grading to model the proposed condition. There are two proposed Bryn Mawr bridge alternatives. Alternative 1 is a 27” CIP PS Box Girder and Alternative 2 is a PC/PS I Girder. Both alternatives were modeled and analyzed. The HEC-RAS model developed for the Mission Zanja Channel was used as the base model and existing condition model. The six cross sections within the grading limits and the two Bryn Mawr Bridge alternatives were modified in the model to reflect the proposed conditions with the following assumptions:

- Manning's n values were based on the aerial imagery. Same values apply to existing and proposed condition.
- Ineffective flow areas were added to cross sections as needed to account for blockage of flow.
- The model was run under subcritical flow conditions.

***Hydraulic Results***

The results of the channel capacity for the existing and proposed conditions are show in Table 1. Cross sections 12507, 12361 and 12253 are located upstream of Bryn Mawr Bridge, and cross sections 12206, 12158 and 11966 are located downstream of Bryn Mawr Bridge. The hydraulic model results confirm the frequent flooding potential in the area. For the existing condition, the channel upstream of Bryn Mawr Bridge and the Bridge itself has a capacity of approximately 1450 cfs (less than 2-year storm event). For the proposed condition, the proposed Bridge (see table 2) and upstream channel capacity is more than doubled, but is still less than a 5-year storm event capacity for both alternatives. The channel downstream of the Bryn Mawr Bridge has adequate capacity for both existing and proposed conditions. The capacity of the upstream grading reach has increased from existing to proposed condition, but it is still limited by the bridge capacity due to the backwater effect.

**Table 1. Channel Capacity**

| Cross Section | Existing (cfs) | Alternative 1 (cfs) | Alternative 2 (cfs) |
|---|---|---|---|
| 12507 | 3000 | 4000 | 4000 |
| 12361 | 1450 | 3900 | 3100 |
| 12253 | 1450 | 3900 | 3500 |
| 12206 | >7600 | >7600 | >7600 |
| 12158 | >7600 | >7600 | >7600 |
| 11966 | >7600 | >7600 | >7600 |

**Table 2. Bryn Mawr Bridge Capacity**

| Cross Section | Existing (cfs) | Alternative 1 (cfs) | Alternative 2 (cfs) |
|---|---|---|---|
| 12226 | 1450 | 3900 | 3050 |

For the proposed graded sections, the model results indicate higher velocities for a range of flows. This is likely due to the modified channel sections and corresponding lower water surface elevations. Table 3 shows the channel velocity upstream of Bryn Mawr Bridge and Table 4 shows the channel velocity downstream of Bryn Mawr Bridge. The velocities are erosive and would require armoring, either way, so the increase in velocity may not be significant. The armoring would need to be addressed at the design phase.

**Table 3. Upstream Channel Velocity within the Grading Reach**

| Flow (cfs) | Existing (ft/s) | Alternative 1(ft/s) | Alternative 2 (ft/s) |
|---|---|---|---|
| 2000 | 5-9 | 9-11 | 9-11 |
| 3000 | 7-10 | 10-12 | 10-12 |
| 4000 | 8-12 | 7-10 | 7-10 |
| 5000 | 8-13 | 7-11 | 7-11 |

**Table 4. Downstream Channel Velocity within the Grading Reach**

| Flow (cfs) | Existing (ft/s) | Alternative 1(ft/s) | Alternative 2 (ft/s) |
|---|---|---|---|
| 2000 | 8-11 | 11-12 | 11-12 |
| 3000 | 9-12 | 12-13 | 12-13 |
| 4000 | 10-12 | 12-14 | 12-13 |
| 5000 | 10-13 | 13-14 | 13-14 |

Figures 1 and 2 show the profiles of the Bryn Mawr Bridge model reach for Alternatives 1 and 2, respectively.

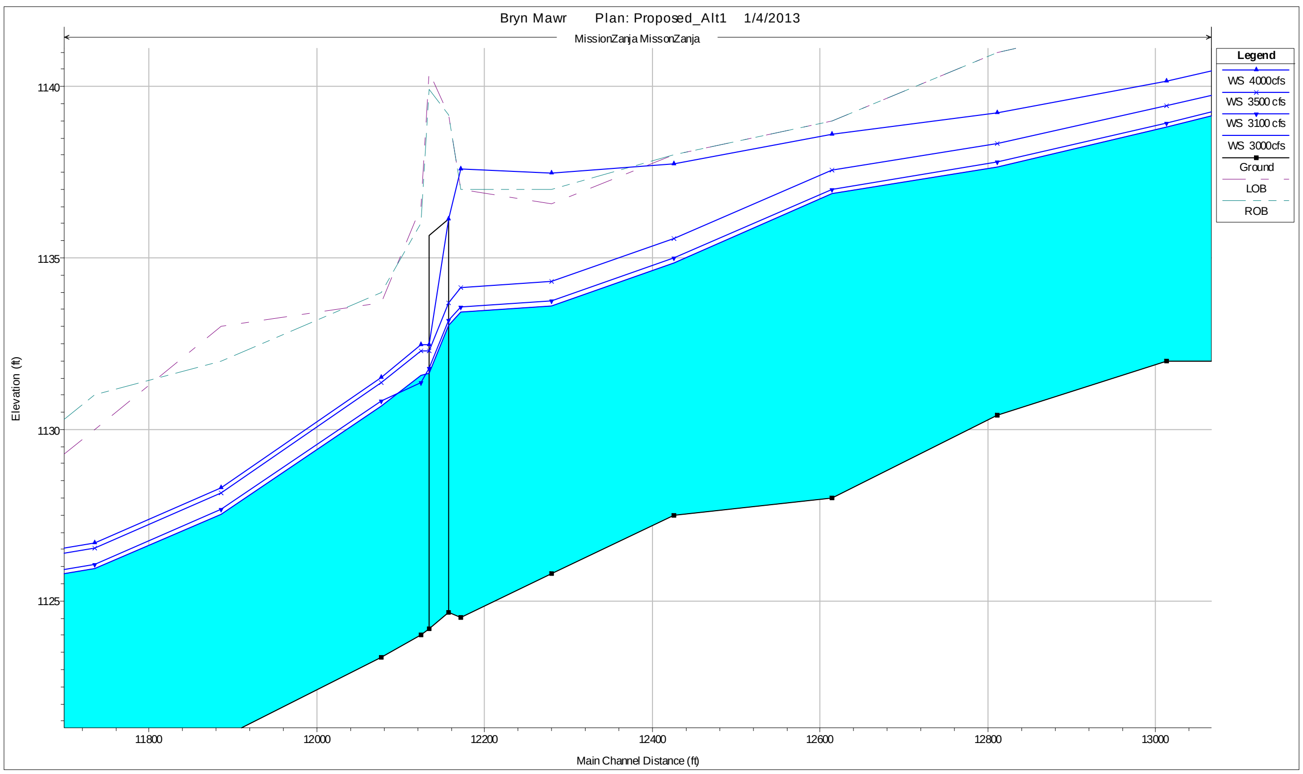


**Figure 1. Bryn Mawr Bridge Alternative 1 Profile**

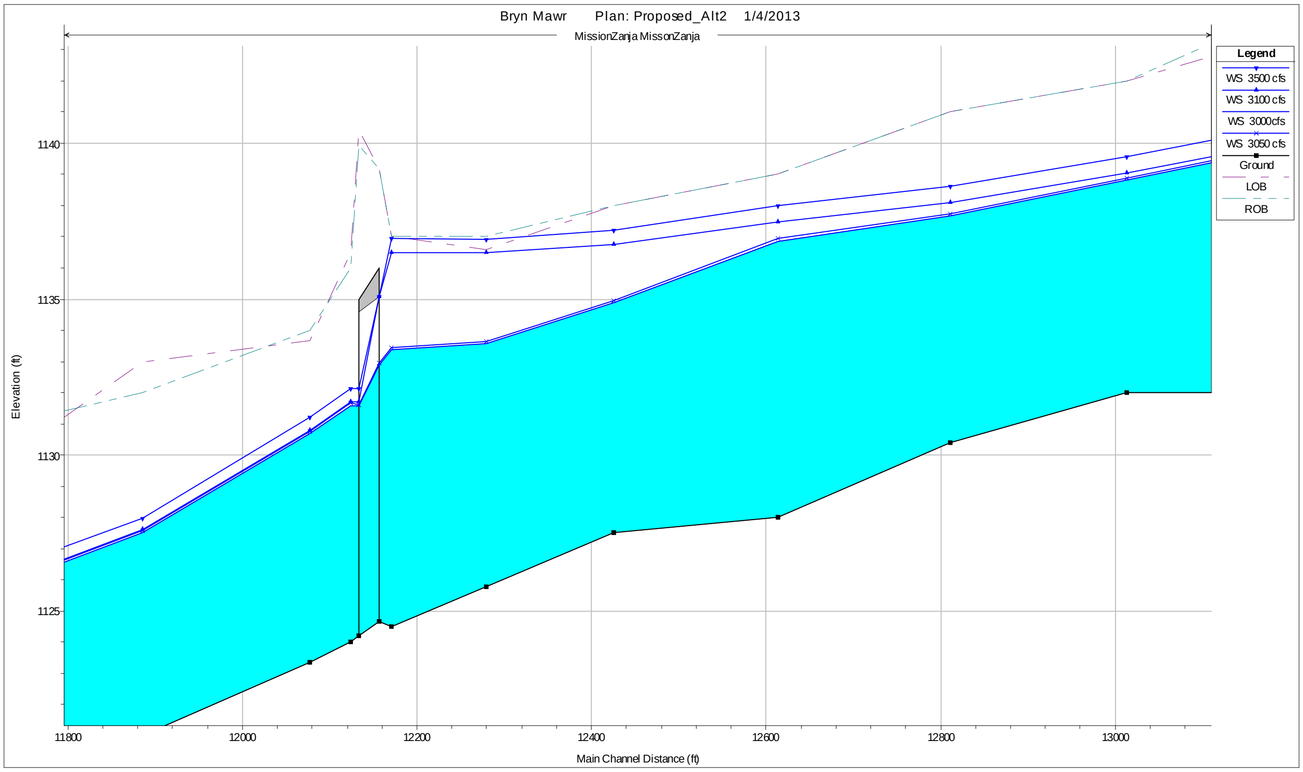


**Figure 2. Bryn Mawr Bridge Alternative 2 Profile**

### *Conclusion*

The proposed Channel grading and Bryn Mawr Bridge improvements would increase the channel capacity upstream of the Bryn Mawr Bridge. Alternatives 1 and 2 would increase the existing capacity of 1450 cfs, to a minimum capacity of 3,900 cfs and 3,000 cfs, respectively. The downstream channel capacity is not significantly impacted by the proposed improvements. The capacity increase still can't meet the future condition 100-year flow of 7,600 cfs upstream of the bridge. The upstream master planned detention basin(s) would be required to prevent the overflow and flooding in the surrounding area (assuming the flow could get to the study reach). The proposed grading would result in slightly higher velocities for a range of flows. The velocities are erosive and would require armoring. The armoring needs would need to be addressed in the design phase.

### *Attachments:*

- Attachment 1 - HEC-RAS Models (digital)
- Exhibit 1

### *References:*


FEMA (2008). San Bernardino County Flood Insurance Study.

U.S. Army Corps of Engineers (USACE) (2010). HEC-RAS v.4.1 User's Manual and Technical Reference Manual

Federal Emergency Management Agency (FEMA) (2008). Flood Insurance Study, San Bernardino County, California.

U.S. Army Corps of Engineers (USACE) (2004). Corpscon 6.0.1

Parsons (2009), Concept Drainage Report, Interstate 10 High Occupancy Vehicle Lane Addition Project.

Metcalf & Eddy (1987), Mission Zanja Creek Channel Improvement Study.

HDR (2012), Hydraulic Evaluation of Mission Zanja Channel.




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# Bryn Mawr Bridge

**EXHIBIT 1**

SANBAG | Redlands Passenger Rail Project | Hydraulic Report

# PRELIMINARY WATER QUALITY MANAGEMENT PLAN (PWQMP)

Even though the current template is dated May 1, 2012, it is basically the same template from expired Santa Ana Regional Water Quality Control Board (SARWQCB), Order No. R8-2002-0012 (NPDES Permit No. CAS618036); this document has been modified to comply with current Order No. R8-2010-0036

**for**

## Redlands Passenger Rail Project, Phase I
## (Preliminary Engineering)

Project No. ______________

**<u>Location</u>**

BNSF Railroad Corridor, from E Street, City of San Bernardino to Cook Street, City of Redlands
REDLANDS SUBDIVISION – MP 1.0 to 10.0

**<u>Prepared for/Owned by:</u>**

San Bernardino Associated Governments (SANBAG)
1170 West 3rd Street, 2nd Floor
San Bernardino, CA 92410-1715
(909) 884-8276

**<u>Prepared by:</u>**

HDR Engineering, Inc.
2280 Market St, Suite 100
Riverside, CA 92501
(951) 320-7300
Bill Flores Jr., PE

Date: December 17, 2012

## PWQMP Disclaimer

This Preliminary Water Quality Management Plan (PWQMP) is only for purposes of obtaining approval of a 401 Water Quality Certification from the Santa Ana Regional Water Quality Control Board to satisfy requirements of the Environmental Document. SANBAG is not a co-permittee to the current San Bernardino County Municipal Separate Storm Sewer System (MS4) permit and is not required to submit the PWQMP to an agency for approval. However, the PWQMP will be submitted to the City of San Bernardino, City of Redlands and other stakeholders for courtesy review and comment.

# TABLE OF CONTENTS

## Tables



## Attachments

# List of Acronyms and Abbreviations

| | |
|---|---|
| BAT | Best Available Technology Economically Achievable |
| BCT | Best Conventional Pollution Control Technology |
| BMP | Best Management Practice |
| BNSF | Burlington Northern Santa Fe |
| Caltrans | California Department of Transportation |
| CASQA | California Stormwater Quality Association |
| CDFG | California Department of Fish and Game |
| CEQA | California Environmental Quality Act |
| CGP | Construction General Permit |
| CTC | California Transportation Commission |
| CWA | Clean Water Act |
| DAMP | Drainage Area Management Plan |
| DTSC | Department of Toxic Substances Control |
| EA | Environmental Assessment |
| EHM | Engineered, Hardened, and Maintained |
| EIR | Environmental Impact Report |
| ESRI | Environmental Systems Research Institute, Inc. |
| GIS | Geographic Information System |
| HCOC | Hydrologic Conditions of Concern |
| I-10 | Interstate 10 |
| IGP | Industrial General Permit |
| IVDA | Inland Valley Development Agency |
| LID | Low Impact Development |
| LRP | Legally Responsible Person |
| MEP | Maximum Extent Practicable |
| MP | Mile Post |
| MPO | Metropolitan Planning Organization |
| MS4 | Municipal Separate Storm Sewer System |
| MSWMP | Municipal Storm Water Management Program |
| NEPA | National Environmental Policy Act |
| NOI | Notice of Intent |
| NPDES | National Pollutant Discharge Elimination System |
| POC | Pollutants of Concern |
| PS&E | Plans, Specifications, and Estimate |
| PWQMP | Preliminary Water Quality Management Plan |
| RMC | Redlands Municipal Code |
| ROW | Right-of-Way |
| RPRP | Redlands Passenger Rail Project |
| RTP | Regional Transportation Plan |
| RTPA | Regional Transportation Planning Agency |

| | |
|---|---|
| RUSLE | Revised Universal Soil Loss Equation |
| RWQCB | Regional Water Quality Control Board |
| SANBAG | San Bernardino Associated Governments |
| SAR | Santa Ana River |
| SBCFCD | San Bernardino County Flood District |
| SBVMWD | San Bernardino Valley Municipal Water District |
| SCAG | Southern California Association of Governments |
| SCS | Sustainable Communities Strategy |
| SIC | Standard Industrial Code |
| SUSMP | Standard Urban Storm Water Mitigation Plan |
| SWDR | Storm Water Data Report |
| SWRCB | State Water Resources Control Board |
| TMDL | Total Maximum Daily Load |
| USACE | U.S. Army Corps of Engineers |
| USEPA | U.S. Environmental Protection Agency |
| WAP | Watershed Action Plan |
| WDID | Waste Discharge Identification |
| WQMP | Water Quality Management Plan |
| WQO | Water Quality Objectives |
| WRWQTR | Water Resources and Water Quality Technical Report |
| Z2DA | Zone 2 Drainage Area |
| Z3DA | Zone 3 Drainage Area |

# Executive Summary

The purpose of Preliminary Water Quality Control Board (PWQMP) is to obtain approval of a 401 Water Quality Certification from the Santa Ana Regional Water Quality Control Board (RWQCB) to satisfy the requirements of the Environmental Document. The PWQMP will provide a preliminary overview and analysis of stormwater quality impacts resulting from the Project (Redlands Passenger Rail Project (RPRP)).

The Project is located within the eastern portion of the San Bernardino Valley, within the southwestern corner of the County of San Bernardino, California. The Study Area for the Project follows an approximate nine-mile railroad Right-of-Way (ROW) owned by the San Bernardino Associated Governments (SANBAG) extending from the City of San Bernardino on the west to the City of Redlands on the east. The Project would consist of the construction of transit infrastructure and operation of passenger rail service between E Street in the City of San Bernardino and the University of Redlands in the City of Redlands. Passenger rail service would be facilitated via five station stops. SANBAG proposes the replacement of the existing rail line, reconstruction of existing bridge structures, construction of new station platforms and a train layover facility, and auxiliary improvements such as parking, drainage infrastructure, grade crossings, and pedestrian access as part of the Project.

The project is included in the Santa Ana River (SAR) Watershed and is divided by the SAR into the north/west segment and the south/east segment, with each side draining tributary onsite and offsite areas into the SAR either by surface flow, local drainage facilities, or major stormwater conveyance systems. The project is tributary to Reach 4 (downstream - minority) and Reach 5 (upstream - majority) of the SAR. San Bernardino County Flood Control District (SBCFCD) manages the major stormwater conveyance systems within San Bernardino County. Consequently, the project is located in Flood Control Zone 2 and 3 with the boundary between these zones lying along the SAR. Zone 2 and 3 lies west and east of the SAR and correspond to the north/west (Zone 2 Drainage Area (Z2DA)) and south/east (Zone 3 Drainage Area (Z3DA)) segment of the project, respectively.

The major stormwater conveyance systems that cross or are adjacent to the project are Warm Creek (Historic), Twin Creek, SAR, Mission Zanja Creek, and Mill Creek Zanja. The Z2DA and the Z3DA are part of the Warm Creek/Twin Creek and Zanja basins, respectively. Portions of City of San Bernardino and City of Redlands are located in both Zones. Beside SBCFCD, related drainage infrastructure tributary to the project is also under the jurisdiction of City of San Bernardino, City of Redlands, Caltrans and U.S. Army Corps of Engineers (USACE).

Similarly, the drainage from the Z3DA is part of the Mission Zanja drainage basin. The mainstem of the Mission Zanja drainage basin is the Zanja Creek which is the principal flood control facility for the City of Redlands. The Zanja Creek crosses the County of San Bernardino, City of Redlands, and City of San Bernardino. It consists of three segments. The Creek is a partially improved open channel from the SAR to 1st Street (City of Redlands) and is referred to as the

"Mission Zanja Channel." The Creek continues upstream under downtown Redlands from 1st Street to 9th Street (City of Redlands) as the "Mission Storm Drain." Finally, the "Mill Creek Zanja" is the upstream segment of the Creek system and extends from 9th Street to the Mill Creek confluence at the upstream (east) end (San Bernardino County).

The project is under the jurisdiction of the Santa Ana Regional Water Quality Control Board (RWQCB), Region 8. The SAR watershed is divided into Hydrologic Areas (HA) that are subdivided into Hydrologic Sub Areas (HSA). According to the Basin Plan of the Santa Ana RWQCB, the project is located within the Upper SAR HA 801.50; specifically HSA 801.52 (Bunker Hill) and 801.53 (Redlands) on the west and east end of the project, respectively, with the HSA boundary at approximately New York Street in the City of Redlands. However, the northern/western end of the project (from Mill Street north – City of San Bernardino) drains to Colton HSA 801.44 (part of Colton-Rialto HA 801.40) by way of the Warm Creek Bypass and Lytle Creek Channels which confluences with the SAR in Reach 4. The SAR transitions from Reach 5 to Reach 4 at the San Jacinto Fault, just southwest of the project area, which is the boundary between Bunker Hill HSA and Colton HSA. (Reach 4 is defined as the portion of the SAR from Mission Boulevard in City of Riverside to the San Jacinto Fault in City of San Bernardino).

The existing rail corridor consists of railroad tracks with side ditches surrounded by various land uses including residential, commercial, industrial and open spaces. The ditches convey storm runoff and the underlying soil provides some level of treatment to applicable pollutants mobilized by storms via infiltration. Expected pollutants of concern associated with rail projects include metals, organic compounds, sediments, trash and debris, and oil and grease. The proposed design within the rail right-of-way (ROW) and corridor will perpetuate existing drainage patterns and flows consistent with California Drainage Law. Also, since land use is not changing in the corridor, the proposed conditions would have the same expected pollutants of concern. These pollutants would be treated by the earthen ditches as well as perforated underdrain systems which are incorporated into the track ballast section.However, proposed improvements in the stations/platforms and parking lots will consider implementation of feasible Best Management Practices (BMPs) such as, but not limited to, vegetated swales, infiltration basins, rain gardens and permeable pavements during the final design phase. Emphasis will be focused on Low Impact Development (LID) techniques during BMP design. The proposed layover facility will also consider BMPs to mitigate any increase in runoff flow and volumes and will be coordinated with those required of the applicable industrial Storm Water Pollution Prevention Plan (SWPPP). The Project proposed to increase impervious area by 21 acres, and required water quality flow and volume is 6 cfs and 2.1 acres-feet, respectively. The soil disturbance area ranges from 129 to 144 acres.

Maintenance of required BMPs will be the responsibility of SANBAG for the rail ROW includeing the layover facility, and the local stakeholders, as agreed to with SANBAG, for the proposed stations and parking lots. Maintenance of post-construction BMPs in the layover facility will be coordinated with the industrial SWPPP.

Based on preliminary Project design and research of stormwater quality requirements, it was concluded that the Project does not significantly impact the area from a water quality perspective. During final design, the project will mitigate any increase in runoff and volume due to addition of impervious areas for flood control (less frequent storm events) and water quality (more frequent storm events) to not cause a Hydrologic Condition of Concern (HCOC). This will require coordination with the drainage improvement design. Also the project will mitigate water quality impacts by incorporating feasible and appropriate BMPs.

# Project Site Information

Name of Project: Redlands Passenger Rail Project (Preliminary Engineering Phase)

Project Location: Along SANBAG railroad corridor, Redlands Subdivision (Mile Post (MP) 1.0/10.0), From E Street, City of San Bernardino to Cook Street, City of Redlands

Size of Significant Re-Development on an Already Developed Site (in acres): 129-144

Size of New Development (in $feet^2$): Not Applicable

Number of Home Subdivisions: Not Applicable

SIC Codes: 4011, 4013

Erosive Site Conditions? : Yes

Natural Slope More Than 25%? : No

# PROJECT CATEGORY SELECTION

Check the appropriate project category below:

**Project Categories**

| | |
|---|---|
| **X** | 1. All significant re-development projects. Significant re-development is defined as the addition or creation of 5,000 or more square feet of impervious surface on an already developed site. This includes, but is not limited to, additional buildings and/or structures, extension of existing footprint of a building, construction of parking lots, etc. Where redevelopment results in an increase of less than fifty percent of the impervious surfaces of a previously existing development, and the existing development was not subject to Standard Urban Stormwater Management Plans (SUSMPs), the design standards apply only to the addition, and not the entire development. When the redevelopment results in an increase of more than fifty percent of the impervious surfaces, then a Water Quality Management Plan (WQMP) is required for the entire development (new and existing). |
| | 2. Home subdivisions of 10 units or more. This includes single family residences, multi-family residence, condominiums, apartments, etc. |
| | 3. Industrial/commercial developments of 100,000 square feet or more. Commercial developments include non-residential developments such as hospitals, educational institutions, recreational facilities, mini-malls, hotels, office buildings, warehouses, and light industrial facilities. |
| | 4. Automotive repair shops with Standard Industrial Codes (SIC) codes 5013, 5014, 5541, 7532- 7534, 7536-7539). |
| | 5. Restaurants where the land area of development is 5,000 square feet or more. |
| | 6. Hillside developments of 10,000 square feet or more which are located on areas with known erosive soil conditions or where the natural slope is twenty-five percent or more. |
| | 7. Developments of 2,500 square feet of impervious surface or more adjacent to (within 200 feet) or discharging directly into environmentally sensitive areas such as areas designated in the Ocean Plan as areas of special biological significance or water bodies listed on the Clean Water Act (CWA) Section 303(d) list of impaired waters. |
| | 8. Parking lots of 5,000 square feet or more exposed to storm water. Parking lot is defined as land area or facility for the temporary storage of motor vehicles. |
| | The project does not fall into any of the categories described above. (If the project requires a precise plan of development [e.g. all commercial or industrial projects, residential projects of less than 10 dwelling units, and all other land development projects with potential for significant adverse water quality impacts] or subdivision of land, it is defined as a Non-Category Project.) |

# 1. Introduction and Project Description

This section provides the reason for preparing this document including identification of water quality components that could result in impacts to the environment. This section identifies project objectives, the regional and project area location, existing setting, surrounding land uses, and characteristics of the proposed project.

## 1.1. Objective and Purpose

The Santa Ana Regional Water Quality Control Board (RWQCB) has adopted an area-wide Municipal Separate Storm Sewer System (MS4) National Pollutant Discharge Elimination System (NPDES) Permit and Waste Discharge Requirements for San Bernardino County (Order No R8-2010-0036, CAS618036) (Permit). City of San Bernardino and City of Redlands are co-permittees of the Permit. The Permit requires post-construction Best Management Practices (BMPs) to be implemented for new development and significant redevelopment, for both private and public agency projects. Each permittee, which includes local cities and the County, requires a project-specific Water Quality Management Plan (WQMP) to address the detrimental effects of urbanization on the beneficial uses of receiving waters, including effects caused by increased pollutant loads and changes in hydrology. Consequently, SANBAG is not a permittee to this Permit (nor are they included in Attachment 3 of the MS4 Permit “List of Other Entities with the Potential to Discharge Pollutants to the San Bernardino County Storm Water Conveyance System”) and is not required to submit the Preliminary WQMP (PWQMP) to a local agency for approval. However, the PWQMP will be submitted to the City of San Bernardino, City of Redlands and other stakeholders for courtesy review and comment.

The purpose of the PWQMP is to obtain approval of a 401 Water Quality Certification from the Santa Ana RWQCB to satisfy the requirements of the Environmental Document. The PWQMP will provide a comprehensive overview and analysis of stormwater quality impacts resulting from the project, considering tributary onsite and offsite drainage from surface and subsurface sources.

## 1.2. Authorization and Focus

The scope of services for the PWQMP task as authorized by SANBAG is to prepare a PWQMP and associated analysis to identify potential impacts or changes to water quality within the corridor and as a result of the project. Depending on the results of the analysis, permanent BMPs may be proposed as mitigation measures to meet water quality goals for post construction.

The PWQMP and associated BMPs will be developed to meet the requirements of the co-permittees along the Redlands Corridor and as a part of the Regional Water

Quality Control Board's implementation Order No. R8-2010-0036 (NPDES No. CAS 618036) Area-wide Urban Storm Water Runoff Management Program, San Bernardino County MS4 Permit. This includes the evaluation of Low Impact Development (LID) techniques to be incorporated into the project where feasible.

The primary goal of LID is to preserve the project's footprint predevelopment hydrology. The effect of changes to runoff patterns caused by land use modifications, or hydromodification, may be reduced by recommending the use of structural and non-structural techniques that store, infiltrate, evaporate, and/or detain storm related runoff.

This report has been prepared in accordance with the Model Water Quality Management Plan Guidance and the WQMP template from the San Bernardino County Stormwater Program, dated February 14, 2012 (based on Order no. R8-2002-012), but modified to comply with the latest permit, Order No. R8-2010-0036. In spite of the date, the Guidance and template substantially reflect the same information from the previous documents consistent with expired permit (Order No. R8-2002-0012). Update of the PWQMP to be in compliance with the forthcoming regular or roadway WQMP templates (consistent with Order No. 2010-0036) is not part of this scope. These templates were scheduled for public release on July 29, 2011, and January 29, 2012, respectively, and are still forthcoming as of the date of this report.

The hydromodification map of the Hydromodification Assessment Technical Memorandum for San Bernardino County Flood Control District (SBCFCD), January 2011 (Draft Phase 1 Watershed Action Plan), identifies Mission Zanja Channel as having a high hydromodification classification from approximately the Gage Canal to Santa Ana River (SAR). The remaining segments near the projects are identified as an Engineered, Hardened, and Maintained (EHM) facility. Since the mandated Hydromodification Management Plan, as part of the Watershed Action Plan, has not been prepared or approved by the County, this scope does not include analysis and evaluation of hydromodification impacts along the Mission Zanja Channel from tributary drainages outside of project limits. It is not expected that the project will have unmitigated Hydrologic Conditions of Concern (HCOC).

Once completed, a draft and final PWQMP will be prepared and submitted to SANBAG for concurrence before it is submitted to the City of San Bernardino and City of Redlands for review in accordance with the project schedule. A meeting is proposed with both Cities before submittal of the PWQMP to SANBAG to receive feedback on the approach.

## 1.3. Project Staff

The following individuals from HDR Engineering were involved in preparation of this report:

- Bill Flores, Task Manager
- Steve Mano, Reviewer

## 1.4. Project Information

- Name of project owner: San Bernardino Associated Governments (SANBAG)
- Address of project owner: 1170 West 3rd Street, 2nd Floor, San Bernardino, CA 92410-1715
- Telephone for project owner: (909) 884-8276
- Project site address: BNSF Railroad Corridor, from E Street, City of San Bernardino to Cook Street, City of Redlands, Redlands Subdivision (MP 1.0 to 10.0).

## 1.5. Permits

It is anticipated that the following permits that impact water quality will be required for the project:

1. NPDES General Permit for Storm Water Discharges Associated with Construction Activity (Construction General Permit - CGP), Order No. 2009-0009-DWQ and (NPDES No. CAS000002) and amendments. Associated Waste Discharge Identification (WDID) number will be processed during the Plans, Specifications and Estimate (PS&E) phase;
2. State Water Resources Control Board Water Quality Order No. 97-03-DWQ NPDES General Permit No. CAS000001 (Industrial General Permit - IGP) Waste Discharge Requirements for Discharges of Storm Water Associated with Industrial Activities Excluding Construction Activities. If this project includes a layover facility, or maintenance yard, then compliance with this Order would be necessary;
3. General Waste Discharge Requirements for Discharges to Surface Waters that Pose an Insignificant (De Minimus) Threat to Water Quality (Order No. R8-2009-0003, NPDES No. CAG998001), Santa Ana RWQCB. If this project requires dewatering, then compliance with this Order would be necessary;

4. California Department of Transportation (Caltrans) Encroachment Permit;
5. SBCFCD Encroachment Permit;
6. U.S. Army Corps of Engineers (USACE) Section 404 Nationwide Permit;
7. USACE Section 408 Permit;
8. California Department of Fish and Game Section 1602 Streambed Alteration Agreement; and
9. RWQCB Section 401 Water Quality Certification.

It is anticipated that the following discretionary permits will not be required from local agencies for the Project: grading permits, building permits, etc. These permits would normally trigger a formal submittal of the project PWQMP to the local agencies for approval. However this is not the case; see Section 1.1.

Encroachment permits will be required from City of San Bernardino and City of Redlands for the Grade Crossing Improvements and Caltrans for the two Interstate 10 (I-10) Overpass crossings. As a ministerial permit, the encroachment permit is not expected to trigger a formal requirement to submit the PWQMP.

The Interstate 10 (I-10) passes over the Project at two locations along the corridor (MP 5.65 and MP 9.48). It is understood that SANBAG has senior rights over Caltrans with regard to the freeway. However, an encroachment permit may still be required to modify or otherwise construct railroad facilities around Caltrans facilities. It is assumed a cooperative agreement will be required between SANBAG and Caltrans and that this agreement will stipulate the type of permit to be issued. It is assumed a Caltrans Storm Water Data Report will not required.

## 1.6. Project Description

The project proposes to re-introduce passenger rail service along the existing railroad right-of-way (ROW) owned by SANBAG from the City of San Bernardino on the west to the City of Redlands on the east, in southwestern San Bernardino County, California (see Figure 1, Regional Location and Project Area Map). This ROW is commonly referred to as the “Redlands Branch Line” and the “Redlands Subdivision, Redlands Spur, or Redlands Corridor.” The entire Redlands Corridor is an approximately 10-mile rail segment that extends from the Santa Fe Depot in the City of San Bernardino to the University of Redlands in the City of Redlands. As a part of this project, most of the existing railroad infrastructure would be reconstructed as described in more detail below. The Project Study Area for the Redlands Passenger Rail Project (RPRP) extends from E Street in the City of San Bernardino to Cook Street in the City of Redlands. This linear corridor area will be evaluated in the Environmental Impact Report/Environmental Assessment (EIR/EA) and is generally limited to the existing railroad ROW and, in limited instances, areas immediately adjacent (e.g., generally less than 200 feet from the rail ROW).

The Project would include the development of new railroad infrastructure along an approximate nine-mile section of rail corridor owned by SANBAG and part of the former Atchison, Topeka and Santa Fe (now the Burlington Northern Santa Fe Railway (BNSF)) Railroad's Redlands Subdivision. SANBAG purchased this piece of the railroad along with others in the County from the BNSF in 1993 along with other agencies in Southern California and as a part of the divestiture of the physical assets of the BNSF. The Project would include the development of five new stations consisting of boarding platforms with supporting amenities, parking, and pedestrian access improvements. The Project would include a new train layover/storage facility with storage tracks, a vehicle wash, a 10,000-square-foot building, and ancillary facilities. Track upgrades would include signal improvements, replacement or retrofit of four existing bridge structures, and approximately 28 at-grade highway-rail crossings. Some existing at-grade highway-rail crossings may be closed (blocked off) as a part of the Project. The Project would also involve culvert replacements and extensions, utility replacements and relocations, and implementation of safety warning devices. Passenger rail service would occur from five stations located at E Street and Tippecanoe Avenue in the City of San Bernardino and New York Street, Orange Street (Downtown Redlands), and University Street (University of Redlands) in the City of Redlands. The station platforms at E Street would be constructed as part of a separate project that would extend Metrolink service east from the Santa Fe Depot.

The selected Project alternatives would be constructed within the corridor identified in Figure 2, RPRP Study Area. SANBAG proposes the construction of a single track with a one-mile long passing siding located near the midpoint of the alignment. Project components would include the following with construction planned to start in 2015:

- Track Improvements. Proposed track improvements include a redesign of the existing single track alignment and track ballast and subgrade foundation from E Street in San Bernardino to Cook Street in Redlands. Existing rail and railroad ties will be salvaged as part of the Project.
- E Street, Tippecanoe Avenue, New York Street, Downtown Redlands, and University of Redlands Rail Stations. The proposed rail stations will include the installation of new station boarding platforms (with the exception of the E Street Station), ticket vending machines, a shade canopy with some seating, accessible walkways to the public ROW or parking area, lighting, and parking area(s).
- Grade Crossings. Twenty-eight existing highway-rail at-grade crossings and two existing grade separated crossings are within the limits of the project and may be modified to improve and update the safety warning systems at each crossing. Some crossings may be closed to improve roadway related safety associated with the Project. The two existing grade separated crossings of Interstate Route 10 (I-10) will remain.

- Parcel Acquisitions and Relocations. Acquisition of additional ROW is required. At this time, SANBAG is not certain of the number of affected parcels as the project is currently in preliminary design phases. In some instances, the acquired parcels may contain active businesses requiring relocation.
- Culvert Replacements, Extensions, and Relocations. Drainage facilities along the rail corridor, such as culverts that extend under the existing railroad track, will require replacement, extension, or relocation. New culverts may be added to improve drainage across (under) the rail corridor.
- Utility Replacement and Relocation. Storm drains, sewer lines, water lines, under drains, railroad signal houses, street lights, power poles and conductors, telephone and/or fiber optic communications lines, commercial billboards, and an oil line will require replacement, relocation, or extension.
- Traffic and Rail Signals. Additional rail and traffic signals will be installed for the corridor based on the final project design. The new passenger rail system will operate under Automatic or Centralized Traffic Control with a single passing siding. A new communications fiber optic backbone communications line will be constructed within the railroad corridor.
- Rail Operations. An operating plan has been developed using Rail Traffic Controller modeling and operational analysis based on input from SANBAG, Metrolink, and BNSF. Operations are projected to commence in 2018. Passenger rail service would utilize previously-owned rail vehicles consisting of a single trainset composed of one locomotive and up to two cars.
- Maintenance. Typical railroad maintenance will be required during the operational phase of the project and would be completed from a centralized layover facility proposed to the west of California Street; immediately south of I-10.

The EIR/EA will include consideration of alternatives to the Project consistent with the requirements of California Environmental Quality Act (CEQA) and National Environmental Policy Act (NEPA). At this time, SANBAG anticipates that this may include the consideration of a No Project/Action Alternative and an Alternative Layover Facility Location. Other build alternatives may also be considered.

The potential environmental effects of the project include, but are not limited to, the following: aesthetics, air quality/greenhouse gases, biological resources, cultural resources, hazards and hazardous materials, hydrology and water quality, land use and planning, noise, acquisitions/displacements, environmental justice, and transportation/circulation. These topics will be analyzed in the EIR/EA.

## 1.7. Other Stakeholders

Other stakeholders, both public and private, that are involved from a stormwater quality perspective are City of San Bernardino, City of Redlands, Caltrans, ESRI, SBCFCD and University of Redlands. ESRI, a private company, is involved as they are financing the construction and maintenance of the New York station and surrounding applicable improvements. The nexus for the stakeholders' involvement is identified in the document herein.

## 1.8. Drainage System

### 1.8.1. Watershed Background

The Project is located in the Santa Ana Watershed and is divided by the SAR, the mainstem, at approximate MP 3.4. This corresponds to SAR River Mile 28.62 (approximate) and is part of System No. 2-701-1A (SBCFCD System Index, January 2010). Specifically located within the Upper Santa Ana Watershed, the SAR divides the project into the north/west segment (3.4 miles, 34 %) and the south/east segment (6.6 miles, 66 %), with each side draining tributary onsite and offsite areas into the SAR either by surface flow, local drainage facilities, or major stormwater conveyance systems. The project is tributary to Reach 4 (downstream - minority) and Reach 5 (upstream - majority) of the SAR. See Figure 3 in Appendix A.

The Project is located in SBCFCD Flood Control Zones 2 (318 square miles) and 3 (366 square miles) with the boundary between these zones lying along the SAR. Zones 2 and 3 lie west and east of the SAR and correspond to the north/west and south/east segment of the project, respectively. From this point forward in the document, the north/west and the south/east segment of the tributary drainage of the project will be referred to as the Zone 2 Drainage Area (Z2DA) and Zone 3 Drainage Area (Z3DA), respectively. Within the project, the major stormwater conveyance systems that cross or are adjacent to the project are Warm Creek (Historic), Twin Creek, SAR, Mission Zanja Creek, and Mill Creek Zanja. The Z2DA and the Z3DA are part of the Warm Creek/Twin Creek and Zanja basins, respectively. Portions of City of San Bernardino and City of Redlands are located in both zones. Beside SBCFCD, related drainage infrastructure tributary to the project is also under the jurisdiction of City of San Bernardino, City of Redlands, Caltrans USACE.

Within the Z2DA, the westerly drainage area flows to Warm Creek (Historic) [part of Subarea J which is part of the below report] and outlets to Warm Creek via the Warm Creek Bypass Channel. This part of Z2DA is tributary to Reach 4 of the SAR. Second, the easterly drainage area flows to the East Twin Creek and Warm Creek Channel (also known as Twin Creek) [part of Subarea M which is part of the below report] and outlets to Reach 5 of the SAR. The small remainder of the Z2DA south of the above drainage area surface flows directly to Reach 5 of the SAR. The Z2DA lies entirely within the City of San Bernardino (USACE, Review Report, Lytle and Warm Creek).

Similarly, the drainage from the Z3DA is part of the Zanja drainage basin (26 square miles) and is located in the County of San Bernardino, City of San Bernardino, and City of Redlands. The basin flows westward for about 12 miles until it confluences with Reach 5 of the SAR. The mainstem of the Zanja drainage basin is the Zanja Creek which is the principal flood control facility for the City of Redlands. In various historical and technical documents, the Zanja Creek is also referred to as Mission Zanja Creek, Mission Channel, Mill Creek Zanja, Sylvan Creek (per railroad documentation) and the Zanja.

The Zanja Creek consists of three segments. The Creek is a partially improved open channel from the SAR to 1st Street (City of Redlands) and is referred to as the Mission Zanja Channel. The Creek continues upstream under downtown Redlands from 1st Street to 9th Street (City of Redlands) as the Mission Storm Drain. Finally, the Mill Creek Zanja is the upstream segment of the Creek system and extends from 9th Street to the Mill Creek confluence at the upstream (east) end (San Bernardino County).

The project is under the jurisdiction of the Santa Ana RWQCB, Region 8 for water quality issues. The Santa Ana Watershed is divided into Hydrologic Areas (HA) that are subdivided into Hydrologic Sub Areas (HSA). According to the Basin Plan of the Santa Ana RWQCB, the project is located within the Upper SAR HA 801.50; specifically HSA 801.52 (Bunker Hill) and 801.53 (Redlands) on the west and east end of the project, respectively, with the HSA boundary at approximately New York Street in the City of Redlands. However, the northern/western end of the project (from Mill Street north – City of San Bernardino) drains to Colton HSA 801.44 (part of Colton-Rialto HA 801.40) by way of the Warm Creek Bypass and Lytle Creek Channels which confluences with the SAR in Reach 4. The SAR transitions from Reach 5 to Reach 4 at the San Jacinto Fault, just southwest of the project area, which is the boundary between Bunker Hill HSA and Colton HSA. Reach 4 is defined as the portion of the SAR from Mission Boulevard in Riverside to the San Jacinto Fault in San Bernardino. The remainder of the project, from Twin Creek (MP 2.2) to University of Redlands (MP 10.0), drains to Reach 5 and is associated with HSA 801.52 (Bunker Hill) and 801.53 (Redlands).

### 1.8.2. Local Drainage

Onsite drainage is storm runoff generated within the project's existing ROW limits. In contrast, offsite drainage is storm runoff that originates outside of the existing railroad ROW, but tributary to the project site either by way of surface and/or subsurface conveyance. However, once onsite and offsite drainage is collected in an onsite system, it will discharge to either an existing or proposed local storm drain system, or modification thereof, or an existing major flood control facility. Local drainage consists of either public water or private water and may comingle depending on its location. Local storm drain systems are under the jurisdiction of

City of San Bernardino, City of Redlands or Caltrans. Drainage along I-10, from the West I-10 Overpass to the East I-10 Overpass, is part of the offsite drainage tributary to the project at various locations. Caltrans has jurisdiction over the I-10 drainage (SANBAG, Preliminary Hydrology & Hydraulics Study).

### 1.8.3. Major Flood Control Facilities

A total of five major flood control facilities either cross or are located longitudinally to the project. The crossings from west to east are known as Warm Creek (Historic) [Bridge 1.1], Twin Creek [Bridge 2.2], Santa Ana River [Bridge 3.4], and Mill Creek Zanja [Bridge 9.4]. Mission Zanja Channel is the one major offsite facility located adjacent to a segment of the project (Mile Post (MP) 3.4 to 6.1). The numbers associated with the bridge designations correspond to the railroad Mile Post. See Figure 3. The table below summarizes the existing major flood control facilities discussed above.

**Table 1-1. Existing Major Flood Control Facilities**

| Name | Mile Post | Jurisdiction | Q100 (cfs) | Description |
|---|---|---|---|---|
| Warm Creek (Historic) | 1.1 | City of San Bernardino | 2,525 cfs | 17 ft wide by 9 ft high RCC |
| Twin Creek | 2.2 | SBCFCD, Zone 2 | 22,000 cfs SPF* | 60 ft wide by 14 ft high RCC |
| Santa Ana River | 3.4 | SBCFCD, Zone 2 & 3 | 67,000 cfs | Unimproved trapezoidal channel |
| Mill Creek Zanja (aka Sylvan Creek) | 9.4 | City of Redlands | 3,000 – 4,000 cfs | Unimproved channel, no fixed geometry |
| Mission Zanja Channel | 3.4 to 6.1 | SBCFCD, Zone 3 | 1,000 – 6,000 cfs | Unimproved trapezoidal channel |

The stormwater runoff from these facilities are considered project run-on for purposes of this document. For additional information, refer to the Preliminary H&H Study and the Floodplain Evaluation Technical Memorandum.

### 1.8.4. Coordination with Impacted Planned/Designed Projects

**Arrowhead Parking Lot (MP 1.3)**

Ludwig Engineering is contracted with the City of San Bernardino to provide final engineering plans for a proposed temporary parking lot at the southeast corner of Rialto Avenue and Arrowhead Avenue, which is adjacent to the north side of the RPRP in the City of San Bernardino. The purpose of the lot is to provide temporary parking for the construction workers of the new Justice Center at 3rd Street and Arrowhead Avenue. The Justice Center is under construction and is scheduled to last approximately two years and should be completed by March 2014. Once the Justice Center is completed, the temporary parking lot will be removed and the parcel will be restored to its original condition (City of San Bernardino, March/May, 2012).
The proposed parking lot will be paved and will consist of a 351-foot long by 62-foot wide by 0.5-foot (minimum) high detention basin located in the northwest portion of the temporary parking lot to which the entire lot will drain. The basin will outlet to an existing 12-inch diameter storm drain at the southeast corner of Rialto Avenue and Arrowhead Avenue. A proposed 2:1 slope embankment will be constructed along the north railroad ROW to separate the railroad offsite flows from the project flows. In the existing condition, the parcel drains to a low point just north of the south property line and about 150 feet east of the west property line. The north side of RPRP also drains to this low point. This basin will also serve for water quality treatment in accordance with the project WQMP.

**I-10 HOV Widening Project (MP 5.61/9.45)**

http://www.sanbag.ca.gov/projects/mi_fwy_I-10-HOV.html

SANBAG is working with Caltrans to prepare a project report and environmental document to add a carpool lane, also known as an express lane or HOV lane, in each direction of I-10 between Haven Avenue (PM 8.20) in Ontario and Ford Street (PM 33.43) in Redlands, a 25-mile span. The I-10 HOV project will extend the carpool lanes east from where the existing carpool lanes end. In addition to the carpool lanes, the project proposes to widen outside existing lanes, pave medians, widen several existing under-crossings, rebuild over-crossings where needed, construct a concrete median barrier, improve drainage and add auxiliary lanes to improve weaving between on-ramps and off-ramps.

As part of the Project Approval and Environmental Documentation (PA&ED) phase, Parsons Transportation Group (PTG) is evaluating several alternatives for the project under contract with SANBAG. SANBAG estimates that the PA&ED will be approved by 2017. Final design and acquisition of ROW is tentatively set to be approved and certified by 2014. If funds are available, construction could start by 2015, and portions of the project could be completed by 2020. This schedule is based on funding availability and subject to change.

As discussed in Section 1.8.2, some of the onsite and offsite drainage along I-10 is conveyed across or along the RPRP via pipes and lined/unlined ditches.

The Water Resources and Water Quality Technical Report (WRWQTR) assesses potential impacts to surface waters, groundwater, flooding, water quality, and designated beneficial uses that could result from the proposed construction and operation of the I-10 HOV Widening project.

During the preliminary project design, various Treatment BMPs were assessed to determine their applicability to the proposed project based on identified site-specific pollutants, project design features, and site conditions, including available ROW. With the implementation of Construction Site BMPs, Design Pollution Prevention BMPs, and Treatment BMPs, the effects to water quality associated with the construction and operation of the proposed project would be less than significant. In conclusion, the I-10 HOV Lane Addition Project would not result in significant effects to water resources or water quality.

The WRWQTR identifies various proposed BMPs along the I-10 HOV Widening Project. The closes one to the project is BMP 39, which is located on south side of the I-10 low point between the West I-10 Overpass (Mission Zanja Channel crossing) and California Street in the City of Redlands. Proposed BMP 45, located at the northeast corner of I-10 and Orange Street, is identified as treating the freeway drainage from University Street west to Orange Street in the City of Redlands, including the East I-10 Overpass (Mill Creek Zanja crossing).

Similarly, a Storm Water Data Report (SWDR) was prepared for the project which is a Caltrans document that summarizes the stormwater quality issues from a technical standpoint, and is normally coordinated with the WRWQTR. The SWDR identifies BMP 39 as a proposed bioswale (I-10 station 1310+00 right), and BMP 45 as a proposed infiltration basin, detention basin, or media filter (I-10 station 1474+00 left).

**Mountain View Avenue Street Improvements (MP 5.2)**

In 2006, Inland Valley Development Agency (IVDA) awarded a contract to T.Y. Lin for professional services to design improvements for Mountain View Avenue from Palm Meadows Drive/Central Avenue to I-10. The project is currently designed to be constructed in two phases. The first phase (design completed) will consist of the bridge structure over the SAR and includes road and infrastructure improvements southbound to Riverview Avenue/San Bernardino Avenue. The second phase of the project (design 95 percent complete) will complete the road improvements from

Riverview Avenue/San Bernardino Avenue southbound to the I-10 interchange and includes a second, smaller bridge structure at the Mission Zanja Creek crossing (culvert to convey Creek flows). Phase 1 construction began in October 2012 with Phase 2 planned to commence construction shortly thereafter. Both phases are scheduled to be completed by 2013.

The project drains from south to north along the street; specifically, from I-10 to Mission Zanja Creek, and from Mission Zanja Creek north to SAR. Drainage from the southern portion will be intercepted at a sump by a proposed catch basin just south of Mission Zanja Creek, then will be intercepted by an existing 69-inch RCP, and enter stormwater treatment devices (BMPs) before it is discharged to Mission Zanja Channel. The BMPs consist of two Contech StormFilter vaults utilizing cartridges and related details are reflected in the project WQMP.

**Redlands Boulevard/Alabama Street Intersection Improvements**

http://www.cityofredlands.org/redlandsalabamaintersection

The City of Redlands has contacted with Parsons Brinckerhoff to provide an engineering design to the Redlands Boulevard, Alabama Street, and Colton Avenue Street Improvement project. The project is intended to improve traffic flow to two Redlands Boulevard intersections – at Alabama Street and at Colton Avenue. Currently, the schedule for approval of the related environmental document and securing funding are unknown. This current City project intersects the RPRP at Colton Avenue and Alabama Street. Water quality treatment to tributary offsite City drainage approaching these two streets will be addressed in the project WQMP.

University of Redlands (UOR) Center for the Arts Infiltration Basin

The UOR constructed improvements at the Center for the Arts in 2008 which included an infiltration basin for purposes of water quality. These improvements front Park Avenue and are adjacent to University Street on the east. The infiltration basin, owned by UOR, is adjacent to the RPRP and close to the proposed UOR station. During PS&E phase, there might be an opportunity to mitigate for added runoff volume and water treatment from the proposed UOR station. This will require coordination with the UOR and the associated project-approved WQMP.

## 1.9. Existing Conditions

In its current state, the RPRP does not include any structural devices that function as BMPs for storm water quality. Typical of railroads, the mainline includes side ditches that may be considered as soft non-structural BMP features that drain and infiltrate railroad runoff mostly for the low intensity storms. Similarly, the railroad permeable ballast serves to infiltrate runoff and provides some level of treatment from the underlying soil. The Project does not include impermeable surfaces such as pavements (0 acres) except for those areas at grade crossings that are asphalt paved.

## 1.10. Proposed Conditions

The Project proposes drainage improvements such as earth ditches, concrete-lined ditches, culverts, perforated underdrain systems, and limited storm drains along the rail ROW. Of these, the earth ditches and underdrain systems will provide some level of treatment by the underlying soil. The impervious area of the Project is proposed to be approximately 21 acres, and includes pavements at the platforms, parking lots, and layover facility in addition to the concrete-lined ditches. Furthermore, the soil disturbance area ranges from 129 to 144 acres. The impervious area and soil disturbance area will be further refined during the PS&E phase.

## 1.11. Drinking Water Reservoir and/or Recharge Facilities

There are no current drinking water reservoirs or recharge facilities in the Project. According to the California Department of Water Resources, there are 17 wells near the Project. The depth to groundwater ranges from 0.2 to 149.4 feet, and the corresponding elevation ranges from 940.9 to 1022.8 feet. Based on Project geotechnical field data, the groundwater depth ranges from 33 feet to 96 feet, and the corresponding elevation ranges from 920.5 to 1080 feet (SANBAG, Geotechnical Report).

## 1.12. Geotechnical

As of the preparation of this report, the draft geotechnical report is still forthcoming. Once the draft geotechnical report is available, this section will be summarized.

## 1.13. Groundwater

The groundwater management agency in the City of San Bernardino and City of Redlands that overlays the project is the San Bernardino Valley Municipal Water District (SBVMWD) which is the wholesaler of potable water to the area. SBVMWD sells water to the local retailers, City of San Bernardino Water Department and City of Redlands Water Department. The project is overlaid by these two retailers.

It will be determined during PS&E if infiltration basins will be used as BMPs for the Project. If infiltration basins are proposed, concurrence will be sought from SBVMWD to consider the use of infiltration basins consistent with Section XI.E.3 of the permit order R8-2010-0036.

## 1.14. Construction Phase Risk Level

The CGP requires construction BMPs to be implemented for virtually all projects in the state. All traditional construction projects that disturb 1 acre or more must apply for CGP coverage. Since the soil disturbance area ranges from 129 to 144 acres and falls into the traditional project category, the project will be required to comply with the CGP during the construction phase.

The CGP follows a risk-based permitting approach. Each project is evaluated for *sediment discharge risk* and *receiving water risk*. These factors combine to determine the project Risk Level (1, 2, or 3) according to tables in the CGP (i.e., Risk Level 1 is the lowest risk and Risk Level 3 is the highest risk). Permit requirements progressively increase with risk level as identified in the CGP. Some of those permit requirements based on risk are related to minimum BMPs, Numeric Action Levels, Numeric Effluent Limitations, Visual Monitoring, Runoff Monitoring, and Receiving Water Monitoring. Another significant change to this permit is identification of the Legally Responsible Person (LRP). The LRP is generally the entity with real estate interest that is associated with the project being proposed for construction. In this case, the LRP is SANBAG and they are ultimately responsible for compliance with the CGP.

There are two aspects involved in developing a risk determination analysis for a specific project site. The first is to determine the Sediment Risk which involves an R-factor (rainfall erosivity), K-factor (soil erodibility) and LS-factor (topographic). The second is to determine the Receiving Water Risk which involves the impact runoff will have on the receiving water body. Combining these two Risks in a table will determine the overall Risk Level for the project. See Appendix F for determination of construction risk level.

Sediment Risk

There are two approaches for determining the sediment risk level according to the CGP; Geographic Information System (GIS) Map method or Site-Specific Information method. This analysis was based on GIS Map information. The sediment risk is based upon the Revised Universal Soil Loss Equation (RUSLE) equation with the three aforementioned factors and is separated into three risk level categories; < 15 tons/acre (low), >15 and <75 tons/acre (medium) and >75 tons/acre (high).

The R-factor is based upon the location and duration of construction. The location used to determine the R-factor was determined using Google Earth. It is anticipated that the construction schedule will begin January 1, 2015, and end on December 31, 2017. The resultant R-factor is 120. Based on the GIS data available from the SWRCB, Google Earth reflected the K-factors for the project to vary from 0.2 to 0.24; a rounded value was used. Hence, the resultant K-factor is 0.2. Based on the GIS data available from the SWRCB, Google Earth reflected the LS-factors to vary from west to east as 1.19, 1.98, 0.99, and 0.82. To be conservative, an average LS-factor of 1.3 is assumed. Based on the aforementioned factors, the Project's Sediment Risk is computed to be 31.2 tons/acre and is categorized as *Medium*.

Receiving Water Risk

The Project discharges to the SAR Reaches 4 and 5. According to the 2006 303(d) List and the 2010 Integrated Report, the SAR Reaches 4 and 5 is not a water body that is impaired by sediment. This was also confirmed by the SWRCB GIS map data on Google Earth. In addition, the receiving water body's designated Beneficial Uses does not include SPAWN, COLD and MIGATORY. Since both of these criteria do not pertain to the Project the resultant Receiving Water Risk is *Low*.

Overall Project

Based on the Sediment Risk and Receiving Water Risk categories, the entire Project is categorized as a combined ***Risk Level 2***.

## 1.15. Regulatory Setting

The purpose of this section is to discuss the regulatory framework of the project as it applies to stormwater quality and its impacts with an emphasis on post-construction phases. The discussion will include Federal, State, Regional, and Local levels.

### 1.15.1. Federal

#### 1.15.1.1. Federal Water Pollution Control Act (Clean Water Act, or CWA)

In 1972, the Federal Water Pollution Control Act (also referred to as the Clean Water Act, or CWA) was amended to provide that the discharge of pollutants to waters of the United States from any point (such as discharge from an industrial facility) or non-point (surface and farmland water runoff) source is unlawful unless the discharge is in compliance with an NPDES permit. In November 1990, the U.S. Environmental Protection Agency (USEPA) published final regulations that established stormwater permit application requirements for specified categories of industries.

The CWA was enacted with the intent of restoring and maintaining the chemical, physical, and biological integrity of the waters of the United States. The CWA requires states to set standards to protect, maintain, and restore water quality through the regulation of point source pollution and certain non-point source discharges to waters of the U.S. Those discharges are regulated by the NPDES permit process (CWA Section 402). In

California, NPDES permitting authority is delegated to, and administered by, the nine RWQCBs.

**Section 303(d) and Total Maximum Daily Loads (TMDLs)**. Section 303(d) of the CWA bridges the technology-based and water quality-based approaches for managing water quality. Section 303(d) requires that states compile a list of waters that are not attaining standards after the technology-based limits are enacted. For waters on this list, the states are to develop TMDLs. TMDLs are established at the level necessary to implement applicable water quality standards. A TMDL must account for all sources of pollutants that cause the water to be listed. Federal regulations require that TMDLs, at a minimum, account for contributions from point sources and nonpoint sources.

### 1.15.1.2. U.S. Environmental Protection Agency (USEPA)

The USEPA is the federal agency responsible for water quality management and administration of the CWA. The USEPA has delegated most of the administration of the CWA in California to the SWRCB. Much of the responsibility for implementation of the SWRCB's policies is delegated to the RWQCB, as described below. USEPA conducts groundwater protection and contaminated site remediation programs, such as installation of groundwater cleanup systems.

### 1.15.1.3. NPDES

The goal of the NPDES diffuse source regulations is to improve the quality of stormwater discharged to receiving waters to the "maximum extent practicable" through the use of BMPs. The NPDES permit system was established in the CWA to regulate point source discharges (a municipal or industrial discharge at a specific location or pipe) and certain types of diffuse source dischargers. As defined in the federal regulations, nonpoint sources are generally exempt from federal NPDES permit program requirements. Nonpoint pollution sources are diffuse and originate over a wide area rather than from a definable point. Nonpoint pollution often enters receiving water in the form of surface runoff and is not conveyed by way of pipelines or discrete conveyances. Urban stormwater runoff and construction site runoff, however, are diffuse-sources regulated under the NPDES permit program because they discharge to receiving waters at discrete locations in a confined conveyance system. Sections 401 and 402 of the CWA contain general requirements regarding NPDES permits. For diffuse-source discharges (e.g., municipal stormwater and construction runoff), the NPDES program establishes a comprehensive stormwater quality program to manage urban stormwater and minimize pollution of the environment to the maximum extent practicable. The NPDES program consists of (1) characterizing receiving water quality, (2) identifying harmful constituents, (3) targeting potential sources of pollutants, and (4) implementing a Comprehensive Stormwater Management Program. State implementation of the NPDES program as it relates to the proposed project is discussed below under state and regional regulations.

Direct discharges of pollutants into waters of the United States are not allowed, except in accordance with the NPDES program established in Section 402 of the CWA. The main goal of the NPDES program is to protect human health and the environment. Pursuant to the NPDES program, permits that apply to stormwater discharges from municipal storm drain systems, specific industrial activities, and construction activities that disturb 1 acre or more have been issued. NPDES permits establish enforceable effluent limitations on discharges, require monitoring of discharges, designate reporting requirements, and require the permittee to perform BMPs. Industrial (point source) storm water permits are required to meet effluent limitations. Municipal permits are governed by the Maximum Extent Practicable (MEP) or the Best Available Technology Economically Achievable (BAT)/Best Conventional Pollution Control Technology (BCT) application of BMPs.

### 1.15.2. State

#### 1.15.2.1. SWRCB

As described above, the EPA has delegated most of the administration of the CWA in California to the SWRCB. In turn, much of the responsibility for the implementation of the SWRCB's policies is delegated to the nine RWQCBs. The nine RWQCBs develop and enforce water quality objectives and implementation plans. The SWRCB establishes statewide policies and regulations for the implementation of water quality control programs mandated by federal and state water quality statutes and regulations. The RWQCBs develop and implement Water Quality Control Plans (Basin Plans) that consider regional beneficial uses, water quality characteristics, and water quality problems. In cases where the Basin Plan does not contain a standard for a particular pollutant, other criteria are used to establish a standard.

Section 401 of the CWA requires water quality certification from the SWRCB or from a RWQCB when a project requires a CWA Section 404 permit. Section 404 of the CWA requires a permit from the USACE to discharge dredged or fill material into waters of the United States.

Section 303(d) of the CWA requires the SWRCB to list impaired water bodies in the state and determine total maximum daily loads (TMDLs) of pollutants or other stressors that are contributing excessively to these impaired waters. SWRCB is also responsible for granting water rights permits, approving water right transfers, investigating violations, and may reconsider or amend water rights.

#### 1.15.2.2. California Department of Toxic Substances Control (DTSC)

DTSC is responsible for oversight of hazardous substances and remediation of contaminated sites, including water sources in some cases.

To fill in the gap between the water quality control plans and CWA requirements, on May 18, 2000, the USEPA promulgated the California Toxics Rule based on the Administrator's determination that numeric criteria are necessary in the State of California to protect human health and the environment. These federal criteria are numeric water quality criteria for priority toxic pollutants and other provisions for water quality standards legally applicable in the State of California for inland surface waters, enclosed bays, and estuaries for all purposes and programs under the CWA.

#### 1.15.2.3. California Department of Fish and Game (CDFG)

CDFG has jurisdiction over conservation and protection of fish, wildlife, plants, and habitat. Through provisions of California Fish and Game Code Section 1602, CDFG is empowered to issue agreements for any alteration of a river, stream, or lake where fish or wildlife resources may be adversely affected. CDFG determines stream flow requirements in certain streams, acts as permitting agency for streambed alterations, and enforces the California Endangered Species Act.

The California Fish and Game Code Section 1602 requires any person, State or local governmental agency, or public utility to notify the CDFG before beginning any activity that will result in one or more of the following: (1) substantially obstruct or divert the natural flow of a river, stream, or lake; (2) substantially change or use any material from the bed, channel, or bank of a river, stream, or lake; or (3) deposit or dispose of debris, waste, or other material containing crumbled, flaked, or ground pavement where it can pass into a river, stream, or lake. California Fish and Game Code Section 1602 applies to all perennial, intermittent, and ephemeral rivers, streams, and lakes in the State.

### 1.15.2.4. Porter Cologne Water Quality Control Act

The Porter Cologne Water Quality Control Act of 1967 (Water Code Section 13000 et seq.) establishes a regulatory program to protect water quality and to protect beneficial uses of State waters. It empowers the SWRCB and the nine RWQCBs to formulate and adopt, for all areas within the regions, Basin Plans that designates beneficial uses and establish such water quality objectives that in its judgment will ensure reasonable protection of beneficial uses. Each RWQCB establishes water quality objectives that will ensure the reasonable protection of beneficial uses and the prevention of nuisance. The California Water Code provides flexibility for some change in water quality, provided beneficial uses are not adversely affected.

The Porter-Cologne Water Quality Control Act authorizes the State boards to adopt, review, and revise policies for all waters of the state (including both surface and ground waters).

### 1.15.2.5. NPDES CGP

On September 2, 2009, the California SWRCB adopted the current NPDES General Permit for Storm Water Discharges Associated with Construction and Land Disturbance Activities, Order No. 2009-0009-DWQ, NPDES No. CAS000002, otherwise known as the CGP. The 5-year cycle permit became effective on July 1, 2010, and is expected to expire by September 2, 2014. The CGP has since been amended twice. As a result of the latest amendment, the Numeric Effluent Limitations (NELs) for pH and turbidity at Risk Level 3 and LUP Type 3 construction sites contained in Order 2009-0009-DWQ are no longer in effect. In addition, receiving water monitoring requirements are also suspended at this time.

In accordance with NPDES regulations, the State of California requires that any construction activity disturbing 1 acre or more of soil comply with the Construction General Permit. To obtain authorization for proposed storm water discharges pursuant to this permit, the landowner (discharger) is required to submit Permit Registration Documents, including a risk assessment, site map, Storm Water Pollution Prevention Plan (SWPPP), annual fee, and signed certification statement to the SWRCB. Dischargers are required to implement BMPs meeting the technological standards of BAT and BCT to reduce or eliminate storm water pollution. BMPs include programs, technologies, processes, practices, and devices that control, prevent, or remove or reduce pollution. Permittees must also maintain BMPs and conduct inspection and sampling programs as required by the permit. Dischargers are also required to comply with monitoring and reporting requirements to ensure that discharges comply with the numeric action levels and numeric effluent limitations specified in the permit. The proposed project is subject to the requirements of the Construction General Permit because it would disturb more than 1 acre of soil during construction. For more information see the State Water Board Storm Water page: http://www.swrcb.ca.gov/water_issues/programs/stormwater/construction.shtml.

#### 1.15.2.6. NPDES IGP

In 1997, the California SWRCB adopted the current National Pollutant Discharge Elimination System (NPDES) General Permit for Waste Discharge Requirements for Discharges of Storm Water Associated with Industrial Activities Excluding Construction Activities, Order No. 97-03-DWQ, NPDES No. CAS000001, otherwise known as the IGP. The permit became effective in 1997 and has been administratively extended until the renewed permit is adopted. A draft of the renewed permit has been issued for public release. At the earliest, the renewed permit is expected to be adopted in 2013.

In accordance with NPDES regulations, the State of California requires that storm water associated with industrial activity (storm water) that discharges either directly to surface waters or indirectly through municipal separate storm sewers must be regulated by an NPDES permit. USEPA developed a four-tier permit issuance strategy for storm water discharges associated with industrial activity (e.g., Tier I to Tier IV). The regulations allow California, as an authorized state, to issue general permits or individual permits to regulate storm water discharges.

This General Permit generally requires facility operators to

1. Eliminate unauthorized non-storm water discharges;
2. Develop and implement a SWPPP; and
3. Perform monitoring of storm water discharges and authorized non-storm water discharges.

The IGP is intended to cover all new or existing storm water discharges and authorized non-storm water discharges from facilities required by Federal regulations to obtain a permit. As such, the project will include facilities, such layover yards, whose storm water discharge will meet permit requirements and is associated with Category 8, “Transportation facilities that conduct any type of vehicle maintenance such as fueling, cleaning, repairing, etc.” For more information see the State Water Board Storm Water, Industrial General Permit page:

http://www.swrcb.ca.gov/water_issues/programs/stormwater/gen_indus.shtml#indus

### 1.15.3. Regional

#### 1.15.3.1. Santa Ana Region Basin Plan (Basin Plan)

The project site is within the jurisdiction of the Santa Ana RWQCB. The Santa Ana RWQCB provides permits that affect surface waters and groundwater. Under Section 303(d) of the CWA, the Santa Ana RWQCB is also responsible of the CWA for protecting surface waters and groundwater from both point and non-point sources of pollution within the project site and for establishing water quality standards and objectives in its Basin Plan that protect the beneficial uses of various waters. The State has developed TMDLs, which is a calculation of the maximum amount of a pollutant that a waterbody can have and still meet Water Quality Objectives (WQOs) established in the Basin Plan, in order to protect the valuable uses of its waters.

#### 1.15.3.2. General Waste Discharge Requirements for De Minimis Discharges

On March 27, 2009, the Santa Ana RWQCB adopted the General Waste Discharge Requirements for Discharges to Surface Waters that Pose an Insignificant (De Minimus) Threat to Water Quality (Order No. R8-2009-0003, NPDES No. CAG998001). This permit covers discharge of groundwater and non-storm water construction dewatering waste in the Santa Ana region. For coverage under this permit, a discharger is required to submit a Notice of Intent to the Santa Ana RWQCB. Under this permit, discharges must comply with discharge specifications, receiving water limitations, and monitoring and reporting requirements detailed in the permit. The Project is not subject to the requirements of the De Minimus Permit because groundwater and other non-storm water discharge are not anticipated during construction.

#### 1.15.3.3. SCAG Regional Transportation Plan (RTP)

Southern California Association of Governments (SCAG) is the federally designated Metropolitan Planning Organization (MPO) under for the six-county region that includes the counties of Imperial, Los Angeles, Orange, Riverside, San Bernardino, and Ventura. SCAG is required to prepare a RTP and pursuant to State Government Code. The State requirements largely mirror the federal requirements and require each Regional Transportation Planning Agency (RTPA) in urban areas to adopt and submit an updated

RTP to the California Transportation Commission (CTC) and the California Department of Transportation (Caltrans) every four years.

The purpose of the 2012-2035 RTP/Sustainable Communities Strategy (SCS) is to provide a clear, long-term vision of the regional transportation goals, policies, objectives and strategies for the SCAG region while at the same time providing strategies to reduce greenhouse gas emissions as required by Senate Bill (SB) 375. The 2012-2035 RTP/SCS is a long-range Regional Transportation Plan that includes projects, policies, and strategies to create a blueprint for the region's growth through 2035. The Plan includes improvements to the transportation system and is intended to meet the changing socioeconomic, transportation infrastructure, financial, technological and environmental conditions of the region. On April 4, 2012, SCAG adopted the 2012-2035 RTP/SCS.

Impacts to water resources from the 2012–2035 RTP/SCS include potential water quality impairment from increased impervious surfaces. Increased impervious surfaces in water recharge areas potentially impact groundwater recharge and groundwater quality. Cumulative impacts include increased impervious surfaces; increased development in alluvial fan floodplains; and increased water demand and associated impacts, such as drawdown of groundwater aquifers. These impacts can occur at the localized scale and in relation to existing conditions, as the Plan itself does not affect the total amount of growth in the region. Increased output of greenhouse gases from the region's transportation system impacts the security and reliability of the imported water supply.

The water resources mitigation program includes, but is not limited to, the following types of example measures:

- Utilizing advanced water capture and filtration techniques, showing a preference for naturalized systems and designs, to control stormwater at the source;
- Avoiding any new construction of impervious surfaces in non-urbanized areas, such as wetlands, habitat areas, parks, and near river systems;
- Avoiding any new construction that provides access to flood-prone areas, such as in alluvial fans and slide zones;
- Protection and preservation of existing natural flood control systems, such as wetlands and riparian buffers, and expansion of such systems in areas where they do not currently exist;

- Constructing projects according to Best Management Practices for water quality protection and water conservation, including low-impact development and green building standards; and
- Coordinating project development and construction efforts across jurisdictional, agency, and departmental boundaries, to increase project benefits.

As part of this process, the related Final Program EIR was approved. The EIR describes the current water resources in the SCAG region, discusses the potential impacts of the 2012-2035 RTP/SCS on water resources, identifies mitigation measures for the impacts, and evaluates the residual impacts.

### 1.15.4. Local

#### 1.15.4.1. San Bernardino County NPDES MS4 Permit, Santa Ana Region

The Cities of San Bernardino and Redlands are co-permittees under the NPDES Permit and Waste Discharge Requirements for the San Bernardino County Flood Control District, the County of San Bernardino, and the Incorporated Cities of San Bernardino County within the Santa Ana Region, Order No. R8-2010-0036 (NPDES No. CAS618036). The NPDES permit prohibits discharges, sets limits on pollutants being discharged into receiving waters, and requires implementation of technology-based standards.

Under the NPDES permit, the respective Cities as co-permittees are responsible for the management of storm drain systems within their jurisdiction. Cities are required to implement management programs, monitoring programs, implementation plans, and all BMPs outlined in the Municipal Storm Water Management Program (MSWMP) (previously identified as the Drainage Area Management Plan (DAMP) in the County’s two prior NPDES permits) and to take any other actions as may be necessary to protect water quality to the MEP. In addition, each city is required to implement a MSWMP and develop a long-term assessment strategy for effectiveness of the MSWMP.

Category Projects within the City are required to develop and implement Water Quality Management Plans (WQMPs) to reduce pollutants and maintain and reduce downstream erosion and stream habitat from all new development and significant redevelopment projects that fall into one of the categories of priority projects. The co-permittees must ensure that a Category Project meets WQMP requirements. Category Projects include significant redevelopment projects that create 5,000 square feet or more of impervious surface, home subdivisions of 10 units or more, industrial/commercial developments of 100,000 square feet or more, automotive repair shops, restaurants of 5,000 square feet or more, hillside developments of 10,000 square feet or more, developments of 2,500 square feet of impervious surface or more adjacent to or discharging directly into environmentally sensitive areas, or parking lots of 5,000 square feet or more. In addition, Non-Category Projects that have a precise plan of development (e.g., all commercial or industrial projects, residential projects <10 dwelling units, and all other land development projects with potential for significant adverse water quality impacts) or subdivision of land must prepare and implement a WQMP. San Bernardino County has prepared a Model Water Quality Management Plan Guidance document for preparation of project-specific WQMPs. The Model Water Quality Management Plan Guidance document was approved by the Santa Ana RWQCB on April 30, 2004, and updated on January 17, 2012.

SANBAG or BNSF is not a co-permittee of the NPDES permit; however, they are a potential discharger of urban runoff in the permitted areas. Under the permit, it is expected that SANBAG work cooperatively with the permittees to manage urban runoff. Pursuant to 40 Code of Federal Regulations (CFR) 122.26(a), the Santa Ana RWQCB has the authority to require non-cooperating entities to adhere to the requirements of the NPDES permit or issue individual discharge permits to those entities. Therefore, to comply with this requirement, this PWQMP has been prepared for the proposed project that specifies the BMPs to be implemented during operation.

#### 1.15.4.2. City of San Bernardino General Plan

The City of San Bernardino's General Plan contains several policies regarding water quality in the Utilities Element (Chapter 9, Storm Drains and Flood Control Facilities section) and Energy and Water Conservation Element (Chapter 13). Specifically, it provides a framework and guiding policies to guide future development to comply with water quality regulations within the City. The guiding policies in regards to water quality as they apply to this project are as follows:

1. Policy 9.4.8: Minimize the amount of impervious surfaces in conjunction with new development.
2. Policy 9.4.9: Develop and implement policies for adopting Sustainable Stormwater Management approaches that rely on infiltration of stormwater into soils over detention basins or channels. Sustainable Stormwater Management techniques include

use of pervious pavements, garden roofs, and bioswales to treat stormwater, and reusing stormwater for non-potable water uses such as landscape irrigation and toilet/urinal flushing.

3. Policy 9.4.10: Ensure compliance with the Federal Clean Water Act requirements for National Pollutant Discharge Elimination System (NPDES) permits, including requiring the development of Water Quality Management Plans, Erosion and Sediment Control Plans, and Storm Water Pollution Prevention Plans for all qualifying public and private development and significant redevelopment in the City.
4. Policy 9.4.11: Implement an urban runoff reduction program consistent with regional and federal requirements, which includes requiring and encouraging the following examples of Best Management Practices (BMPs) in all developments:
    a. Increase permeable areas, utilize pervious materials, install filtration controls (including grass lined swales and gravel beds), and divert flow to these permeable areas to allow more percolation of runoff into the ground;
    b. Replanting and hydroseeding of native vegetation to reduce slope erosion, filter runoff, and provide habitat;
    c. Use of porous pavement systems with an underlying stone reservoir in parking areas;
    d. Use natural drainage, detention ponds, or infiltration pits to collect and filter runoff;
    e. Prevent rainfall from entering material and waste storage areas and pollution-laden surfaces; and
    f. Require new development and significant redevelopment to utilize site preparation, grading, and other BMPs that provide erosion and sediment control to prevent construction-related contaminants from leaving the site and polluting waterways.
5. Policy 13.2.7: Require that new development incorporate improvements to channel storm runoff to public storm drainage systems and prevent discharge of pollutants into the groundwater basins and waterways. (LU-1).
6. Policy 13.2.8: Require that Best Management Practices (BMPs) are implemented for each project to control the discharge of point source and non-point source pollutants both during construction

and for the life of the projects to protect the City's water quality. (LU-1).

7. Policy 13.2.9: Require that new construction on a site that is at least one acre comply with the General Permit for Discharges of Storm Water Associated with Construction Activity (Construction General Permit 99-08-DWQ)). (LU-1).

### 1.15.4.3. City of San Bernardino Municipal Code

Storm water discharge is regulated under Chapter 8.80 – Storm Water Drainage System of the City of San Bernardino Code of Ordinances. Under Chapter 8.80 discharge of nonstormwater is permissible only when connection to the storm drain system is made in accordance with a valid city permit, approved construction plan, or a NPDES permit and/or Notice of Intent (NOI). In addition, projects within the City are required to comply with the requirements of the Construction General Permit and the Municipal NPDES Permit, which includes preparation of a SWPPP and implementation of construction and post-construction BMPs.

### 1.15.4.4. City of Redlands General Plan

The City of Redlands' General Plan contains several policies regarding water quality in the Health and Safety Element. Specifically, it provides a framework and guiding policies to guide future development to comply with water quality regulations within the City. The guiding policies in regards to water quality are as follows:

1. Policy 8.20a: Work with the local and regional water agencies to improve and enhance groundwater quality in the region. The RWQCB's Water Quality Control Plan: Santa Ana River Basin, 1984, with amendments through 1994, specifies regional water quality objectives and implementation measures.
2. Policy 8.20i: The City will actively protect all water supply sources, to the extent legally possible, from contamination and from a diminution of supply, will undertake all necessary steps to provide a secure supply of high quality water to meet the present and future needs of its citizens.
3. Policy 8.40d: Where feasible given flood control requirements, maintain the natural condition of waterways and flood plains to ensure adequate groundwater recharge and water quality, preservation of habitat, and access to mineral resources.

#### 1.15.4.5. City of Redlands Municipal Code

Storm water discharge is regulated under Chapter 13.54 – Storm Drains of the Redlands Municipal Code (RMC). The majority of this Chapter references Ordinance No. 2274. Ordinance No. 2742, approved by the City Council on November 16, 2010, revised portions of this Chapter as well as Chapter 5.04.

Under Chapter 13.54 discharge of nonstormwater is permissible only when connection to the storm drain system is made in accordance with a valid city permit, approved construction plan, or a NPDES permit and/or NOI. In addition, projects within the City are required to comply with the requirements of the Construction General Permit and the Municipal NPDES Permit, which includes preparation of a SWPPP and implementation of construction and post-construction BMPs, not to mention required reporting, and collection of NPDES Program Regulatory Fees.

# 2. Pollutants of Concern and Hydrologic Conditions of Concern

## 2.1. Pollutants of Concern (POCs)

The 2012-2035 RTP/SCS provides a background of pollutant sources from transportation projects and focuses on the nexus of transportation projects and impervious surfaces. Projects that increase impervious surface areas increase urban runoff, resulting in the transport of greater quantities of contaminants to receiving waters that may currently be impaired. Even though this document centers on highway projects, there is similarity of this impact to rail projects although without the extensive impervious areas typically associated with highways. Rail projects are not known for pollutants in urban runoff attributable to landscape irrigation as are the case for highway projects. However, like highway runoff, railroad runoff is a component of urban runoff contributing oil and grease, sediment, nutrients, heavy metals, and toxic substances. Table 2-1 lists the pollutants commonly associated with transportation.

**Table 2-1. Pollutants Associated with Transportation**

| Pollutant | Source |
|---|---|
| Asbestos | Clutch plates, brake linings |
| Cadmium | Tire wear(1) and insecticides |
| Copper | Thrust-bearing, bushing, brake linings, and fungicides and insecticides |
| Chromium | Pavement materials(2), metal plating, rocker arms, crankshafts, rings, and brake linings |
| Cyanide | Anti-caking compound in de-icing salt |
| Lead | Leaded gasoline, motor oil, transmission babbit metal bearings, tire wear(1) |
| Iron | Auto-body rust(3), steel highway structures, moving engine parts |
| Manganese | Moving engine parts |
| Nickel | Diesel fuel and gasoline, pavement material(2), lubricating oil, metal plating, bushing wear, and brake linings |
| Nitrogen and Phosphorus | Motor oil additives, fertilizers |
| Sulphates | Roadway beds(1), fuel, and de-icing salt(1) |
| Zinc | Motor oil and tires(1) |
| Grease and Hydrocarbons | Spills and leaks of oil and n-parafin lubricants, antifreeze, hydraulic fluids |
| Rubber | Tire wear(1) |
| Sediment | Pavement wear(2), construction and maintenance activities |
| **SOURCE**: USEPA Office of Water. (1995) *Controlling Nonpoint Source Runoff Pollution from Roads, Highways, and Bridges*. (EPA-841-F-95-008a). Washington DC | |

Notes:
(1) Normally associated with highway use and not railroad use.
(2) Normally associated with highway use; may be associated with rail use especially at yards and maintenance facilities, and access/maintenance roads.
(3) The railroad equivalent is train car body rust.

Pollutants of Concern (POCs) will only be identified and addressed for drainage associated with the Project ROW (onsite) in addition to station improvements (i.e., platforms, pedestrian crossovers, walkways, parking lots, etc.). It is assumed the Project ROW is owned by SANBAG or will be owned by SANBAG through acquisition to accommodate proposed improvements. POCs related to tributary offsite drainage areas are not the responsibility of the project and will not be focused in this discussion.

### 2.1.1. Existing Conditions

Onsite/Corridor

An existing "red board" is located west of Tippecanoe Avenue that prevents any rail traffic further east. No rail activity has occurred east of MP 4.3 or Tippecanoe Avenue since 1938. However, for purposes of this discussion, it will be assumed that rail activity is ongoing for the entire project and are currently generating associated POCs as discussed below.

Under existing conditions pollutants generated by the project site include: heavy metals, organic compounds, sediments, trash and debris, and oil and grease. Table 2-2 below identifies the expected and potential pollutants anticipated to be generated by the development. It is assumed that the pollutants generated by this project are similar to those in the street/highway/freeway project category, as listed in Table 2-2 below (Table 2-1 of the WQMP Guidance).

**Table 2-2. Pollutant of Concern Project Category Summary**

| Pollutant Type | Expected | Potential | Listed for Receiving Water |
|---|---|---|---|
| Bacteria/Virus (3) | | X | Santa Ana River, Reach 4 |
| Heavy Metals | X | | No |
| Nutrients (1) | | X | No |
| Pesticides (1) | | X | No |
| Organic Compounds (2) | X | | No |
| Sediments | X | | No |
| Trash & Debris | X | | No |
| Oxygen Demanding Substances (1) | | X | No |
| Oil & Grease | X | | No |
| Other—specify pollutant(s): | | | N/A |

Notes:
(1) A potential pollutant if landscaping or open area is present on site.
(2) Including petroleum hydrocarbons.
(3) Bacterial indicators are routinely detected in pavement runoff.

According to Table 2-2, this project category has the potential to produce the following pollutants of concern: bacteria/virus, nutrients, pesticides, and oxygen demanding substances.

Bacteria and viruses are commonly found in organic materials that are part of stormwater. Principal sources include sanitary sewer overflows and leakages, animal excrement from farms, food particles, water used to prepare or clean food or food packaging, and restaurants. The presence of pathogens can transform an otherwise attractive stream or lake into a public hazard that must be avoided. Animal excrement may also be found along pedestrian walkways or parks when pets are present. However, since such amenities and other described uses above do not exist onsite, the Project is not expected to produce bacteria/virus related pollutants and they are not considered POCs.

Nutrients, pesticides, and oxygen demanding substances are commonly found in landscaped and open areas. Landscaping and open grassed areas do not exist onsite, therefore nutrients and oxygen demanding substances are not considered pollutants of concern. However, herbicides are used by the railroad as part of the ongoing maintenance program to control plant growth and reduce fire risk from overgrowth of vegetation. Consequently, the pesticides category is expected as a POC because it includes pesticides, herbicides, and insecticides.

The use of wood ties which are treated with creosote and other preservatives which can leak into the underlying soil and be mobilized in stormwater runoff to the detriment of water quality. Creosote is obtained from high temperature distillation of coal tar. Historical research has determined that the existing railroad ballast does not include metal slag which has the potential to leak hazardous metals.

Heavy metals, organic compounds, sediments, trash and debris, and oil and grease are all expected POCs associated with this project category. Therefore, a summary of the POC expected from the existing conditions of the site can be found below in Table 2-3.

**Table 2-3. Pollutant of Concern Project Category Summary**

| Pollutant Type | Expected | Listed for Receiving Water |
|---|---|---|
| Heavy Metals | X | No |
| Pesticides | X | No |
| Organic Compounds | X | No |
| Sediments | X | No |
| Trash & Debris | X | No |
| Oil & Grease | X | No |

Comparison of the anticipated pollutants listed in Table 2-3 above and the receiving water bodies' impairments identify no primary pollutants of concern. Therefore all categories listed above in Table 2-3 are considered secondary pollutants of concern.

Within Reach 4 of the SAR, the project is associated with a receiving water body that is listed on the 2006 and the 2010 CWA Section 303(d) list of impaired water bodies. Listed pollutants, for both lists, are pathogens along the SAR. However, there are no listed impaired water bodies on either list for Reach 5 of the SAR. No TMDLs have been identified for the project. There are no known pre-existing water quality problems at the project site.

Offsite (Properties, Grade Crossings)

As stated above, POCs from tributary offsite areas are the responsibility of other stakeholders within their respective ROW such as private properties, City of Redlands, City of San Bernardino, Caltrans and SBCFCD.

### 2.1.2. Proposed Conditions

Onsite/Corridor

Under proposed conditions, pollutants generated by the project site will be the same as those identified for existing conditions. Refer to the Existing Conditions section for expected and potential pollutants and Table 2-2.

Amenities such as platforms, pedestrian crossovers, and walkways in proposed stations will be expected to produce bacteria/virus related pollutants and they are considered POCs. Such amenities invite pets that are the source of such pollutants, and paved areas are also documented to be such sources as well. Impervious areas are also proposed along concrete-lined ditches and the layover facility. The layover facility will include impervious areas for related parking areas and maintenance access roads.

Nutrients, pesticides, and oxygen demanding substances are commonly found in landscaped and open areas. Landscaping and open grassed areas are proposed as part of the Project station improvements, therefore nutrients and oxygen demanding substances not considered pollutants of concern. Herbicides will continue to be used by the railroad as part of the ongoing maintenance program to control plant growth and reduce fire risk from overgrowth of vegetation. Consequently, the pesticides category is expected as a POC because it includes pesticides, herbicides, and insecticides.

Heavy metals, organic compounds, sediments, trash and debris, and oil and grease are assumed to continue to be expected pollutants of concern associated with this project category.
Concrete ties are proposed to replace the wood ties (and at greater separation spacings than wood ties) which will have a water quality benefit; hence, there will be more wood ties removed than replaced with concrete ties.

The Project will not increase the concentrations of pollutants beyond their current concentrations because the onsite land use is not changing. In fact, potential of pollutants in runoff will most likely be reduced since all the wood ties will be removed. Therefore, a summary of the pollutants of concern expected from the re-development associated with this project can be found in Table 2-3.

In order to prevent degradation of receiving water quality, Source Control, Site Design, and Treatment Control BMPs will be implemented to target constituents of concern in runoff from the project area.

Offsite (Properties, Grade Crossings)

As stated above, POCs from tributary offsite areas are the responsibility of other stakeholders within their respective ROW such as private properties, City of Redlands, City of San Bernardino, Caltrans and SBCFCD. These POCs and their impacts will not be identified or addressed.

The extent of the offsite amenities such as parking lots (associated with proposed stations) and how they are associated with the Project are yet to be defined in forthcoming Memoranda of Understanding. Once these agreements are defined, the POCs from associated improvements will be identified and be mitigated as part of the PS&E phase. These POCs and their impacts will not be identified or addressed

## 2.2. Hydrologic Conditions of Concern

Table 2-3 below is used to identify any hydrologic conditions of concern (HCOC) that will be caused by the project. Once identified, site design, source control, and/or treatment control BMPs will be implemented to address identified impacts.

**Table 2-3. Hydrologic Condition of Concern**

| **1.** Determine if the project will create a Hydrologic Condition of Concern. Check “yes” or “no” as applicable and proceed to the appropriate section as outlined below. | **Yes** | **No** |
|---|---|---|
| **A.** All downstream conveyance channels, that will receive runoff from the project, are engineered, hardened (concrete, riprap or other), and regularly maintained to ensure design flow capacity, and no sensitive stream habitat areas will be affected. Engineered, hardened, and maintained channels include channel reaches that have been fully and properly approved (including CEQA review, and permitting by USACOE, RWQCB and California Dept. of Fish & Game) by June 1, 2004 for construction and hardening to achieve design capacity, whether construction of the channels is complete. Discharge from the project will be in full compliance with Agency requirements for connections and discharges to the MS4, including both quality and quantity requirements, and the project will be permitted by the Agency for the connection or discharge to the MS4. | | **X** |
| **B.** Project runoff rates, volumes, velocities, and flow duration for the post-development condition will not exceed those of the pre-development condition for 1-year, 2-year and 5-year frequency storm events. This condition will be substantiated with hydrologic modeling methods that are acceptable to the Agency, to the U.S. Army Corps of Engineers (USACOE), and to local watershed authorities. See supporting documentation below. | **X** | |

| | | | |
|---|---|---|---|
| **C.** | Can the conditions in part A or B above be demonstrated for the project? | **X** | |
| | ▪ If the answer for A, B, and/or C above is yes, then the project does not create a HCOC.<br>▪ If the answer for C above is no, then the project does create a HCOC, and an evaluation must be performed. | | |

The project proposes to mitigate the increase in the post-development runoff rates, volumes, velocities, and flow durations to meet the condition specified above; therefore according Section B of the above table, this project will not create a HCOC. Even though the impervious area is being increased, the computations to justify this will be provided in the WQMP during PS&E phase when the design is further refined. See Section 2.2.3 for more information.

### 2.2.1. Design Methodology

During PS&E, the project will utilize Rational Method software, developed by AES software to calculate the unit hydrographs for the impervious areas that have an HCOC impact. The AES software is an approved software by the SBCFCD and is in accordance with the San Bernardino County Hydrology Manual.

### 2.2.2. Existing Conditions

There are no existing HCOCs for the project.

### 2.2.3. Proposed Conditions

<u>Analysis</u>

The Project will include features to address stormwater quantity and quality. Approximately 21 acres of impervious area will be created, mostly at the stations, parking lots and layover facility, and will be associated with an increase in runoff rates, volumes, velocities, and flow duration and therefore require additional mitigation. Per Order No. R8-2010-0036 the 2-year frequency will have to be analyzed during PS&E using the Unit Hydrograph Method.

For each return frequency under the pre- and post-development conditions the total runoff volume, the peak flow rate, and the time of duration, of runoff hydrograph flow rates that exceed the flow rate in 10 percent increments from 90 percent to 10 percent (90 percent of peak flow rate to 10 percent peak flow rate) will be computed. The values will be populated below in Table 2-4 for each of the stations. Refer to Appendix A, Project Exhibits for additional information and Preliminary H&H Study for existing and proposed hydrology calculations.

**Table 2-4. Pre- and Post-development Hydrology Comparison Worksheet**

**(To be filled in during PS&E phase)**

| Return Period | Total Volume | | Peak Flow | | Flow Time Duration | | | Sediment Transport [1] | |
|---|---|---|---|---|---|---|---|---|---|
| | Pre | Post | Pre | Post | % of Peak | Pre | Post | Pre | Post |
| **1-year** | ___ Ac-Ft | ___ Ac-Ft | ___ CFS | __ CFS | | 5 min | 0 min | - | - |
| | | | | | | 10 min | 0 min | - | - |
| | | | | | | 20 min | 0 min | - | - |
| | | | | | | 20 min | 0 min | - | - |
| | | | | | | 25 min | 0 min | - | - |
| | | | | | | 30 min | 0 min | - | - |
| | | | | | | 30 min | 0 min | - | - |
| | | | | | | 45 min | 0 min | - | - |
| | | | | | | 85 min | 0 min | - | - |
| **2-year** | ___ Ac-Ft | 0 Ac-Ft | ___ CFS | 0 CFS | | 5 min | 0 min | - | - |
| | | | | | | 10 min | 0 min | - | - |
| | | | | | | 20 min | 0 min | - | - |
| | | | | | | 20 min | 0 min | - | - |
| | | | | | | 25 min | 0 min | - | - |
| | | | | | | 30 min | 0 min | - | - |
| | | | | | | 45 min | 0 min | - | - |
| | | | | | | 55 min | 0 min | - | - |
| | | | | | | 115 min | 0 min | - | - |
| **5-year** | ___ Ac-Ft | 0 Ac-Ft | ___ CFS | 0 CFS | | 5 min | 0 min | - | - |
| | | | | | | 10 min | 0 min | - | - |
| | | | | | | 20 min | 0 min | - | - |
| | | | | | | 20 min | 0 min | - | - |
| | | | | | | 30 min | 0 min | - | - |
| | | | | | | 30 min | 0 min | - | - |
| | | | | | | 45 min | 0 min | - | - |
| | | | | | | 60 min | 0 min | - | - |
| | | | | | | 145 min | 0 min | - | - |

Notes:
(1) Sediment Transport not applicable. See justification below.

Sediment risk analysis was evaluated in the Risk Determination Analysis for the construction phase using the RUSLE to obtain an estimate of project-related bare ground soil loss expressed in tons/acre. Sediment transport does not apply to this analysis because sediment discharge during operation is not expected by the project.

<u>Results</u>

The proposed project increases the impervious cover onsite, and therefore creates an increase in stormwater runoff and volume. The Project will mitigate this increase in runoff through the implementation of various BMPs, such as, but not limited to, vegetated swales, small infiltration basins, permeable surfaces, to be determined during the PS&E phase. The will be designed to retain and infiltrate the 100-year storm, returning the overall discharge from the site to existing conditions. Refer to the Preliminary H&H Study for a detailed description of the analysis for the 100-year design. Section 2.3 of the WQMP Guidance only requires that the 1-, 2-, and 5-year storm be analyzed for water quality management. Refer to the Preliminary H&H Study for a summary of the flows from the proposed onsite watershed complying with the aforementioned requirements.

During PS&E, the Project will demonstrate that the proposed conditions discharges and volumes for the analyzed watershed, which accounts for the proposed features described above in Section 2.1.2 will be less than the existing conditions discharges. As such, the project will not create a HCOC.

## 2.3. Watershed Impacts of Project

According to Section 2.1, there are six categories of pollutants of concern which can be expected from the re-development of the project site: heavy metals, pesticides including herbicides and insecticides, organic compounds, sediments, trash and debris, and oil and grease. The SAR is the receiving water for the project site, and none of the aforementioned pollutants are listed as POCs for this water body; therefore these pollutants are all considered secondary pollutants of concern. Treatment of these pollutants will be discussed in Section 3.3 below.

According to Section 2.1.2, the proposed project will create an increase in runoff. A discussion of the design for these BMPs, and for all treatment BMPs can be found below in Section 3.3. The project is required to implement all BMPs as described in Sections 3.1, 3.2, and 3.3 below; these BMPs will further refined during PS&E. As such it has been determined that the project will not cause any significant impact(s) to any downstream receiving waters.

## 2.4. Future Conditions (Watershed Action Plan)

As required by the current San Bernardino County Municipal Separate Storm Sewer System (MS4) permit, San Bernardino County and the permittees (including City of San Bernardino and Redlands) are required to develop a Watershed Action Plan (WAP) in two phases, one of many mandated document required to be in compliance with the permit. The WAP Phase 1 was developed through a collaborative process with the County, the co-permittees, and other watershed stakeholders. The WAP development involved several WAP Task Force meetings and WAP development workshops where watershed stakeholders provided input on the WAP and watershed development processes. The County and co-permittees intend to use the WAP to help improve water quality and to implement an integrated water resources approach in the Santa Ana River Watershed.

The WAP is structured to help the County, co-permittees, and stakeholders collaborate with Orange and Riverside Counties to ensure a holistic approach to watershed management throughout the SAR Watershed. Its purpose is to improve integration of water quality, stream protection, stormwater management, water conservation and re-use, and flood protection with land use planning and development processes. This goal will be accomplished using:

- An Integrated Watershed Management Approach, an imperative methodology that should be used whenever planning a sustainable development or community intended to coexist with and compliment the native environment and ecosystem in which it resides in.
- Watershed protection principles and policies necessary for water quality protection, including avoiding disturbance of water bodies, minimizing changes in hydrology and pollutant loading, preserving wetlands and other natural areas, using appropriate Best Management Practices, employing the Ahwahnee Principles of community design, using CEQA and Low Impact Development, and others.

The Hydromodification Plan (Appendix B, Hydromodification Assessment Technical Memorandum) of the WAP Phase 1 identified those stream reaches that are subject to adverse impacts from hydromodificatin and identified the drainage areas tributary to those streams that are determined to be at risk. All Major Flood Control Facilities crossed by the project are identified as Engineered, Hardened and Maintained (EHM) channels (armored drainage conveyances that are not vulnerable to geomorphological changes and hydromodification). The only exception is (1) Mission Zanja Channel which is categorized as a non-EHM facility and has an associated high hydromodification classification from SAR to Gage Canal (MP 3.4/3.9), and (2) Mill Creek Zanja which is categorized as a non-EHM facility and has an associated medium hydromodification classification from Division Street to Cook Street. Offsite areas tributary to Warm Creek (Historic) and Mission Zanja Channel are identified on the plan as subject to hydromodification. Specifically, for Warm Creek (Historic), the extent of the hydromodification area spans from E Street to Arrowhead Avenue. For Mission Zanja Channel, the hydromodification area spans throughout the associated Project extents, except the portion from the SAR to Mountain View Avenue the area only applies along the south side of the Channel; from Mountain View Avenue east the area applies to both sides (north and south) of the Channel.

Phase 1 of the WAP was submitted and approved by the Santa Ana RWQCB on July 6, 2011. WAP Phase 2 is currently under preparation and slated for submittal to the Santa Ana RWQCB by early 2013. WAP Phase 2 will include development and implementation of a Hydromodification Management Plan that is prioritized based on drainage feature/susceptibility/risk assessments and opportunities for restoration. Additionally, by January 29, 2013, each co-permittee shall review the watershed protection principles and policies in its General Plan or related documents (such as Development Standards, Zoning Codes, Conditions of Approval, Development Project Guidance) to determine consistency with the WAP.

# 3. Best Management Practice Selection Process

## 3.1. Site Design BMPs

Table 3-1 below identifies information on proposed site design BMPs used and associated descriptions and justifications. These BMPs will be further refined during PS&E. Refer to Appendix A for Project Exhibits and Appendix C, CASQA BMP Fact Sheets, for more information on proposed BMPs.

**Table 3-1. Site Design BMPs**

| **1. Minimize Stormwater Runoff, Minimize Project's Impervious Footprint, and Conserve Natural Areas** | | |
|---|---|---|
| A. Maximize the permeable area. This can be achieved in various ways, including but not limited to, increasing building density (number of stories above or below ground) and developing land use regulations seeking to limit impervious surfaces. | | |
| Yes | No X | |
| Describe actions taken or justification/alternative:<br><br>*The existing condition for the project area consists of the mainline tracks, and surrounding pervious areas which are mostly covered with gravel or bare earth. The proposed project will include the improvement of rail tracks, the addition of five stations, parking lots, layover facility, and site drainage features as described in Section 1.6 above. The proposed track section is considered as permeable as the existing track section. Stormwater filtered through the ballast contacts the impervious sub-ballast layer and drains to the left/right until it continues percolating into the underlying soil. Proposed maintenance roads at the layover facility may be gravel/ballast and are considered to be pervious, but this will not be decided until PS&E. All replaced wood ties will be replaced with concrete ties (but at a lower replacement ratio since the spacing between concrete ties is greater than that for wood ties) but given that wood ties are considered as impermeable as concrete ties, there is no increase in the impermeable areas from the track sections. Hence, the tracks and other site features will be considered pervious.*<br><br>*During PS&E, consideration will be given to reducing the impervious area at the proposed platforms/station and parking areas. Likewise, for the proposed layover facility.* | | |
| B. Runoff from developed areas may be reduced by using alternative materials or surfaces with a lower Coefficient of Runoff, or "C-Factor". | | |
| Yes | No X | |
| Describe actions taken or justification/alternative:<br><br>*For the tracks, there are no alternative materials or surface types which would satisfy the design requirements. These portions of the project will be assumed to be as pervious as the existing tracks; hence, there will not be a change to the C-factor. There are no alternative materials to create the base of this structure which would satisfy the design requirements. The maintenance roads will be gravel/ballast, considered pervious, and have a lower C-factor than other traditional materials like asphalt.*<br><br>*During PS&E, consideration will be given to using materials that have a lower C-factor in the stations/platforms and layover facility such as permeable pavements.* | | |

C. Conserve natural areas. This can be achieved by concentrating or clustering development on the least environmentally sensitive portions of a site while leaving the remaining land in a natural, undisturbed condition.

| | | |
|---|---|---|
| Yes | No X | |

Describe actions taken or justification/alternative:

*The project is not conducive to concentrating or clustering development as the project alignment is along the existing SANBAG rail alignment which is already disturbed and absent of most vegetation. The area proximate to proposed stations/platforms will conserve natural areas as feasible. Any environmentally sensitive areas (ESA) which are disturbed in the existing condition will remain disturbed.*

*There may opportunities to conserve natural area at the proposed stations/platforms especially at the New York station. This will be further refined during PS&E phase.*

D. Construct walkways, trails, patios, overflow parking lots, alleys, driveways, low-traffic streets, and other low-traffic areas with open-jointed paving materials or permeable surfaces, such as pervious concrete, porous asphalt, unit pavers, and granular materials.

| | | |
|---|---|---|
| Yes | No X | |

Describe actions taken or justification/alternative:

*The rail corridor is not conducive to these types of improvements and these BMPs are not included as part of the rail corridor. However, the proposed platforms will include sidewalks, parking lots and other paved surfaces that are good opportunities for permeable surfaces. The feasibility to incorporate these elements will be further investigated during the PS&E phase.*

E. Construct streets, sidewalks, and parking lot aisles to the minimum widths necessary, provided that public safety and a pedestrian friendly environment are not compromised (1). Incorporate landscaped buffer areas between sidewalks and streets.

| | | |
|---|---|---|
| Yes | No X | |

Describe actions taken or justification/alternative:

*Sidewalks will be constructed as part of the platforms and at certain grade crossing locations as identified in Item D above. Any parking lots will be designed to local standards. There will be opportunities at the stations to include landscaped buffer areas and will be determined during the PS&E phase.*

F. Reduce widths of street where off-street parking is available (2).

| | | |
|---|---|---|
| Yes | No X | |

Describe actions taken or justification/alternative:

*This practice does not apply to the project since the project will not include street improvements other than grade crossing improvements. At various grading crossings, curb medians will be constructed for public safety and to reduce the traveled way in each direction, but the outside curb-to-curb distance will remain the same. Due to SANBAG standards, off-street parking is not permitted near grade crossings.*

| | | |
|---|---|---|
| G. Maximize canopy interception and water conservation by preserving existing native trees and shrubs, and planting additional native or drought tolerant trees and large shrubs. | | |
| Yes | No X | |
| Describe actions taken or justification/alternative:<br><br>*The majority of the project disturbance will be in areas that are covered by tracks, ballast, or bare earth in the existing condition. Existing canopy interception and preservation of existing landscaping do not apply to these areas. There are small portions of the work which may involve disturbance of the slopes along both I-10 overpasses and associated on-ramps. Some of these areas are covered with grass and sparse shrubs in the existing conditions, and will be restored in accordance with project specifications and the project SWPPP.*<br><br>*There may be opportunities in the proposed stations/platform to maximize canopy interception.* | | |
| H. Other comparable site design options that are equally effective. | | |
| Describe actions taken or justification/alternative:<br><br>*Other than site design options that may be incorporated into the stations and parking lots, no other site design BMPs are viable to incorporate into the project.* | | |
| I. Minimize the use of impervious surfaces, such as decorative concrete, in the landscape design. | | |
| Yes | No X | |
| Describe actions taken or justification/alternative:<br><br>*The railroad corridor will not incorporate these features as they are not feasible and not consistent with SCRRA and SANBAG standards. However, the proposed stations have the opportunity to incorporate these features in coordination with the proposed landscaping improvements. Likewise, there may be an opportunity to use these features in the maintenance roads and parking lots at the layover facility.* | | |
| J. Use natural drainage systems. | | |
| Yes | No X | |
| Describe actions taken or justification/alternative:<br><br>*There are no onsite natural drainage systems that may be used. However, several natural drainage systems convey offsite flows and intersect the project such as the SAR, Warm Creek (Historic), Twin Creek, Mission Zanja Channel, and Mill Creek Zanja and are identified as jurisdictional delineated (JD) features. Tributary onsite drainage will be treated onsite before it discharges via ditches, local culverts and City master drainage facilities to these features. All features ultimately outlet to the SAR. After construction, the JD features will continue being JD features.* | | |
| K. Where soils conditions are suitable, use perforated pipe or gravel filtration pits for low flow infiltration [(3)]. | | |
| Yes | No X | |
| Describe actions taken or justification/alternative:<br><br>*For the tracks, perforated underdrain pipe systems will be used for drainage of the track ballast. Runoff from the rail tracks will drain to the adjoining graded ditches (no cover) and will infiltrate directly into the underlying native soils. This design will provide the same level of infiltration and treatment as perforated pipes or gravel* | | |

*filtration pits. For the proposed stations, perforated pipes or gravel filtration pits will not be used. There will be opportunities to use other infiltration-type BMPs to be consistent with LID. The specific BMPs to be used will be determined during the PS&E phase.*

| | | |
|---|---|---|
| L. Construct onsite ponding areas, rain gardens, or retention facilities to increase opportunities for infiltration, while being cognizant of the need to prevent the development of vector breeding areas. | | |
| Yes X | No | |
| Describe actions taken or justification/alternative:<br><br>*The only elements of the project that may incorporate these features are the proposed stations. Every opportunity will be provided to incorporate these BMPs into the stations and parking lots. Any proposed impoundments will have a maximum drawdown time of 48 hours to be consistent with State Public Health requirements and CASQA Stormwater BMP Handbooks. See Sections 3.3 and 4 for discussions of the design and maintenance of these facilities, respectively.* | | |
| **2. Minimize Directly Connected Impervious Areas** | | |
| A. Where landscaping is proposed, drain rooftops into adjacent landscaping prior to discharging to the storm drain. | | |
| Yes | No X | |
| Describe actions taken or justification/alternative:<br><br>*There are portions of the rail corridor adjacent to buildings that will accept historical runoff from roof drains. But the roof drain runoff will discharge to the proposed side ditches without causing impacts to the building/property owners. This runoff will be treated by the ditches before it discharges to any associated public storm drain systems. The only elements of the project that may incorporate landscaping are the proposed stations and parking lots. However, the stations do not include buildings that would rely on roof drains.* | | |
| B. Where landscaping is proposed, drain impervious sidewalks, walkways, trails, and patios into adjacent landscaping. | | |
| Yes | No X | |
| Describe actions taken or justification/alternative:<br><br>*The only elements of the project that may incorporate these features are the proposed stations. Every opportunity will be leveraged to slope proposed impervious surfaces into adjacent proposed landscaping improvements, if applicable.* | | |
| C. Increase the use of vegetated drainage swales in lieu of underground piping or imperviously lined swales. | | |
| Yes | No X | |
| Describe actions taken or justification/alternative:<br><br>*The proposed design incorporates pervious drainage swales (ditches) along the edges of the tracks where feasible (i.e., ROW is available). SANBAG requirements do not allow vegetated cover drainage side ditches in order to reduce fire risks; therefore these ditches will consist of compacted native soil (soft). However, it is expected that infiltration along the underlying soil and soft drainage swales will provide some level of treatment of runoff.* | | |

*Every opportunity will be leveraged to use vegetated drainage swales in the proposed stations. This will be coordinated with the proposed landscaping and irrigation improvements during PS&E phase.*

| D. Use one or more of the following: | | |
|---|---|---|
| Yes | No | Design Feature |
| | X | Rural swale system: street sheet flows to vegetated swale or gravel shoulder, curbs at street corners, culverts under driveways and street crossings |
| | X | Urban curb/swale system; street slopes to curb; periodic swale inlets drain to vegetated swale/biofilter. |
| | X | Dual drainage system: First flush captured in street catch basins and discharged to adjacent vegetated swale or gravel shoulder, high flows connect directly to municipal storm drain systems. |
| | X | Other comparable design concepts that are equally effective. |

Describe actions taken or justification/alternative:

*The requirements of this project are such that the rail portion does not apply to reduction of directly connected impervious areas. The nature of the rail portion is such that impervious areas do not exist nor are they proposed. The only opportunity to include any of the above mentioned design features are at the proposed stations and parking lots. This will be evaluated for the proposed stations during PS&E phase.*

| E. Use one or more of the following features for design of driveways and private residential parking areas: | | |
|---|---|---|
| Yes | No | Design Feature |
| | X | Design driveways with shared access, flared (single lane at street) or wheel strips (paving only under tires); or, drain into landscaping prior to discharging to the municipal storm drain system. |
| | X | Uncovered temporary or guest parking on private residential lots may be paved with a permeable surface; or designed to drain into landscaping prior to discharging to the municipal storm drain system. |
| | X | Other comparable design concepts that are equally effective. |

Describe actions taken or justification/alternative:

*This practice does not apply to the rail portion of the project. However, there may be an opportunity to leverage the design of the proposed stations and parking lots to incorporate these features. This will be evaluated for the proposed stations and parking lots during PS&E phase. The project does not include residential parking areas.*

| F. Use one or more of the following design concepts for the design of parking areas: | | |
|---|---|---|
| Yes | No | Design Feature |
| X | | Where landscaping is proposed in parking areas, incorporate landscape areas into the drainage design. |
| X | | Overflow parking (parking stalls provided in excess of the Agency's minimum parking requirements) may be constructed with permeable paving. |

| | | |
|---|---|---|
| X | | Other comparable design concepts that are equally effective. |
| Describe actions taken or justification/alternative:<br><br>*This practice only applies to the proposed stations and parking lots. Every opportunity will be leveraged to include these design features in the proposed station improvements during PS&E phase.* | | |

Notes:
(1) Sidewalk widths must still comply with Americans with Disabilities Act regulations and other life safety requirements.
(2) However, street widths must still comply with life safety requirements for fire and emergency vehicle access.
(3) However, projects must still comply with hillside grading ordinances that limit or restrict infiltration of runoff. Infiltration areas may be subject to regulation as Class V injection wells and may require a report to the USEPA. Consult the Agency for more information on use of this type of facility.

## 3.2. Source Control BMPs

This section will serve as a guide to implementation of planned Source Control BMPs proposed for the project. BMPs selected in Table 3-2 below will be implemented for the project, and all BMPs will be justified for their use or non applicability in Table 3-3 below. Refer to Appendix A for Project Exhibits and Appendix C, CASQA BMP Fact Sheets, for more information on proposed BMPs.

**Table 3-2. Source Control BMP Selection Matrix**

| Source Control BMPs | Significant Re-development |
|---|---|
| Education of Property Owners | X |
| Activity Restrictions | X |
| Spill Contingency Plan | X |
| Employee Training/Education Program | X |
| Street Sweeping Private Street and Parking Lots | X |
| Common Areas Catch Basin Inspection | X |
| Landscape Planning (SD-10) | X |
| Hillside Landscaping | |
| Roof Runoff Controls (SD-11) | |
| Efficient Irrigation (SD-12) | X |
| Protect Slopes and Channels | X |
| Storm Drain Signage (SD-13) | X |
| Inlet Trash Racks | |
| Energy Dissipaters | X |
| Trash Storage Areas (SD-32) and Litter Control | X |
| Fueling Areas (SD-30) | X |

| | |
|---|---|
| Air/Water Supply Area Drainage | |
| Maintenance Bays and Docks (SD-31) | X |
| Vehicle Washing Areas (SD-33) | X |
| Outdoor Material Storage Areas (SD-34) | X |
| Outdoor Work Areas (SD-35) | X |
| Outdoor Processing Areas (SD-36) | X |
| Wash Water Controls for Food Preparation Areas | |
| Pervious Pavement (SD-20) | X |
| Alternative Building Materials (SD-21) | X |

**Table 3-3. Justification for Source Control BMPs**

| Source Control BMP | Used in Project (yes/no)? | Justification/Alternative | Implementation Description |
|---|---|---|---|
| A. Education of Property Owner | Yes | There is no Property Owners Association for this project, as the property is owned by SANBAG. | SANBAG will be provided with the Stormwater Pollution Prevention Best Management Practices for Homeowner's Associations, Property Managers and Property Owners Manual. Refer to Appendix D for a copy of this manual. |
| B. Activity Restrictions | Yes | Certain activities are restricted to comply with OSHA under 29 C.F.R. 1910.120(q) and also with the Industrial General Permit. Information is to be provided to personnel who may become involved in a hazardous materials incident. | Pesticide applications along the bare soil sections will be performed by an applicator certified by the California Department of Pesticide Regulation. Also, SANBAG will implement SANBAG Hazardous Material Emergency Response Plan (insert date when available).Also all activities will be done in accordance with the Industrial SWPPP. |
| C. Spill Contingency Plan | Yes | Certain activities are restricted to comply with OSHA under 29 C.F.R. 1910.120(q). Information is to be provided to personnel who may become involved in a hazardous materials incident. | SANBAG will implement SANBAG Hazardous Material Emergency Response Plan (insert date when available) and will coordinate with the Industrial SWPPP. |
| D. Employee Training / Education Program | Yes | Refer to Item A, B, and C of this table. | Refer to Item A, B, and C of this table. |

| | | | |
|---|---|---|---|
| E. Street Sweeping Private Street and Parking Lots | Yes | Street sweeping of private streets does not apply. Also street sweeping of grade crossings does not apply as this is the jurisdiction of the local respective City. However, sweeping of stations/parking lots would be the responsibility of SANBAG. | See Section 4 for stormwater BMP maintenance requirements. |
| F. Common Areas Catch Basin Inspection | Yes | All drainage facilities including inlets and catch basins within railroad ROW will be inspected and maintained by SANBAG. | See Section 4 for stormwater BMP maintenance requirements. |
| G. Landscape Planning (SD-10) | Yes | The project will include landscape planning in the proposed station and parking lot design. | The approach to landscaping will be reflected in the PS&E phase. Associated maintenance procedures will be documented. |
| H. Hillside Landscaping | No | Practice does not apply to project as project does not contain post-construction hillside landscaping. | Not applicable |
| I. Roof Runoff Controls (SD-11) | No | Practice does not apply to project as project does not contain residential or commercial roof runoff controls. However, the project will coordinate offsite tributary drainage from these adjacent sources. | Not applicable |
| J. Efficient Irrigation (SD-12) | Yes | The project will include irrigation to support landscape planning in the proposed station designs. This practice will be coordinated with Item G above. | The approach to irrigation will be reflected in the final station designs, and associated operation and maintenance procedures will be documented. |
| K. Protect Slopes and Channels | Yes | All slopes along proposed tracks, embankments, and access roads and channel slopes will be graded at a maximum of 2:1 or per SANBAG requirements. | All proposed runoff along these slopes will sheet flow, and will not be concentrated to form rills or gullies. The north bank of the Mission Zanja Channel will be armored to protect the respective project limits. |

| | | | |
|---|---|---|---|
| L. Storm Drain Signage (SD-13) | Yes | Project will include signage which instructs that no dumping be permitted in the storm drain inlets, catch basins, side ditches or other BMP features, and for pedestrians to avoid Mission Zanja Channel. | The project will include concrete, non-toxic paint stamping, or equivalent, of all storm water conveyance system inlets and catch basins within the project area with prohibitive language (e.g., "No Dumping – I Live in Santa Ana River"), satisfactory to SANBAG. The project will also include signs and prohibitive language and/or graphical icons, which prohibit illegal dumping at public access points at the stations. Refer to CASQA New Development & Redevelopment BMP Handbook, Source Control BMP Fact Sheet SD-13, Storm Drain Signage. |
| M. Inlet Trash Racks | No | Practice does not apply to project as project does not contain drainage features which require trash racks. | Not applicable |
| N. Energy Dissipaters | Yes | Project will include energy dissipaters at the entrance of all piping to applicable culverts, especially those that outlet to Mission Zanja Channel. | Refer to the drainage-related improvement plans during the PS&E phase which will show this information. Riprap will be installed at the inlet/outlet of all storm drain piping to/from culverts to prevent erosion. |
| O. Trash Storage Areas (SD-32) and Litter Control | Yes | The project will be expected to generate trash and litter by pedestrians at the proposed stations. The layover facility will also generate trash and litter as part of its operations. | During PS&E phase, SANBAG will include trash receptacles in the final design plans at the proposed stations and layover facility. Trash receptacles will be covered and comply with local requirements. This item will be coordinated with the Industrial SWPPP. |
| P. Fueling Areas (SD-30) | Yes | Fueling will be required at the layover facility. | During PS&E phase, SANBAG will include fueling areas at the layover facility in the final design plans. This item will be coordinated with the Industrial SWPPP. |
| Q. Air/Water Supply Area Drainage | No | Practice does not apply to project as project does not contain air/water supply drainage areas. | Not applicable |

| | | | |
|---|---|---|---|
| R. Maintenance Bays and Docks (SD-31) | Yes | Maintenance areas will be required at the layover facility. | During PS&E phase, SANBAG will include maintenance areas at the layover facility in the final design plans. This item will be coordinated with the Industrial SWPPP. |
| S. Vehicle Washing Areas (SD-33) | Yes | Vehicle washing areas will be required at the layover facility. | During PS&E phase, SANBAG will include vehicle washing areas at the layover facility in the final design plans. This item will be coordinated with the Industrial SWPPP. |
| T. Outdoor Material Storage Areas (SD-34) | Yes | Outdoor material storage areas will be required at the layover facility. | During PS&E phase, SANBAG will include outdoor material storage areas at the layover facility in the final design plans. This item will be coordinated with the Industrial SWPPP. |
| U. Outdoor Work Areas (SD-35) | Yes | Outdoor work areas will be required at the layover facility. | During PS&E phase, SANBAG will include outdoor work areas at the layover facility in the final design plans. This item will be coordinated with the Industrial SWPPP. |
| V. Outdoor Processing Areas (SD-36) | Yes | Outdoor processing areas will be required at the layover facility. | Not applicable. This item will be coordinated with the Industrial SWPPP. |
| W. Wash Water Controls for Food Preparation Areas | No | Practice does not apply to project as project does not contain food preparation areas. | Not applicable |
| X. Pervious Pavement (SD-20) | Yes | This Practice may have benefit to decrease runoff peak flow, volume and provide required treatment at the proposed stations, thereby minimizing applicable capital cost and O&M responsibilities. | This application will be further evaluated during final design to determine its feasibility. |

| | | | |
|---|---|---|---|
| Y. Alternative Building Materials (SD-21) | Yes | Project will include concrete ties as an alternative to wood ties for the design of the proposed tracks. | Although concrete ties are equally as impermeable as wood ties and do not provide any aid in the reduction of stormwater runoff, they do provide benefit to the project regarding source control for water quality. Wood ties are treated with creosote and other preservatives which can infiltrate into the underlying soil and be mobilized in stormwater runoff. The USEPA released the preliminary risk assessment for creosote, which consisted of a description of creosote and its regulatory history, as well as preliminary human health and ecological risk estimates associated with its use. Therefore, the USEPA suggests the use of plastic and cement railroad ties in place of these wood ties because they do not contain potentially harmful chemicals and are not known to leach any pollutants of concern into stormwater runoff. (Environmental Protection Agency, 2007) |

## 3.3. Treatment Control BMPs

Selection of treatment control BMPs are influenced by primary pollutants of concern, removal efficiencies, expected flows, and applicability to site design constraints. As stated in Section 2.1, there are six categories of pollutants of concern which can be expected from the re-development, however, all are considered secondary as they are not listed for the SAR. Treatment control BMP selection criteria from the WQMP Guidance were used for the selection of treatment BMPs. Table 3-4 below lists the secondary pollutants of concern produced by the project and the relative effectiveness of treatment facilities as provided in Table 2-5 of the WQMP Guidance. See Appendix E for related water quality calculations.

## Table 3-4. Treatment Control BMP Selection Matrix

| Pollutant of Concern | | Treatment Control BMP Categories | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | **Biofilters** | **Detention Basins** | **Infiltration Basins** | **Wet Ponds or Wetlands** | **Filtration** | **Water Quality Inlets** | **Hydrodynamic Separator Systems** | **Manufactured/ Proprietary Devices** |
| Sediment/Turbidity | | H/M | M | H/M | H/M | H/M | L | H/M (L for turbidity) | U |
| Yes/No? | Yes | | | X | | | | | |
| Nutrients | | L | M | H/M | H/M | L/M | L | L | U |
| Yes/No? | Yes | | | X | | | | | |
| Organic Compounds | | U | U | U | U | H/M | L | L | U |
| Yes/No? | Yes | | | X | | | | | |
| Trash & Debris | | L | M | U | U | H/M | M | H/M | U |
| Yes/No? | Yes | | | X | | | | | |
| Oxygen Demanding Substances | | L | M | H/M | H/M | H/M | L | L | U |
| Yes/No? | No | | | | | | | | |
| Bacteria & Viruses | | U | U | H/M | U | H/M | L | L | U |
| Yes/No? | No | | | | | | | | |
| Oils & Grease | | H/M | M | U | U | H/M | M | L/M | U |
| Yes/No? | Yes | | | X | | | | | |
| Pesticides (non-soil bound) | | U | U | U | U | U | L | L | U |
| Yes/No? | Yes | | | X | | | | | |
| Metals | | H/M | M | H | H | H | L | L | U |
| Yes/No? | Yes | | | X | | | | | |

Notes:

(1) H/M: High or medium removal efficiency;
L: Low removal efficiency;
U: Unknown removal efficiency

(2) Sources: Guidance Specifying Management Measures for Sources of Nonpoint Pollution in Coastal Waters (1993), National Stormwater Best Management Practices Database (2001), and Guide for BMP Selection in Urban Developed Areas (2001), California Stormwater BMP Handbook—New Development and Redevelopment (2003).

Secondary pollutants of concern for the project are: heavy metals, pesticides including herbicides and insecticides, organic compounds, sediments, trash and debris, and oil and grease. Treatment control BMPs that most effectively remove these pollutants from stormwater runoff include: detention basins, infiltration basins, wet ponds or wetlands, and filtration. As these are not primary pollutants of concern, it is not mandatory that the chosen BMP have high or medium removal efficiency for every category.

During this preliminary engineering phase, the project does not have sufficient detailed information to design required BMPs. Forthcoming results from the geotechnical investigation will be used to design BMPs during the PS&E phase. The use of site design and source control BMPs described in Sections 3.1 and 3.2, respectively, in conjunction with the treatment BMPs, will also ensure that there is no risk of groundwater contamination.

Based on the location of the project site, drainage patterns, site constraints, treatment efficiencies, maintenance concerns, and the factors listed above, the BMPs to be chosen during final design will be focused on LID and have a preference towards infiltration.

## 3.4. BMP Design Criteria

Table 3-5 below identifies the types of treatment control BMPs to be considered for implementation to the Project during PS&E phase.

**Table 3-5. Design Basis of Treatment Control BMPs**

| Implemented | Treatment Control BMP | Design Basis |
|---|---|---|
| X | Vegetated Buffer Strips | Flow-Based |
| X | Vegetated Swale | |
| | Multiple Systems | |
| | Manufactured/Proprietary | |
| X | Bioretention | Volume-Based |
| | Wet Pond | |
| | Constructed Wetland | |
| X | Extended Detention Basin | |
| X | Water Quality Inlet | |
| | Retention/Irrigation | |
| X | Infiltration Basins | |
| X | Infiltration Trench | |
| | Media Filter | |
| | Manufactured/Proprietary | |

### 3.4.1. Volume-Based Design Criteria

As described in Section 1.1, 21 acres of impervious acres will be the basis for determining the water quality volume to be treated. Per the preliminary calculations in Appendix E, the required treatment volume will be 2.1 acre-feet. The water quality volumes were calculated in accordance with Attachment D, Section B, of the WQMP Guidance. This required volume may be reduced if the related BMPs are combined with flow-based BMPs.

### 3.4.2. Flow-Based Design Criteria

Flow-based BMPs will be determined during the PS&E phase. Specific hydrology calculations for 2-year storm events will be performed for each BMP subarea.

# 4. Operation and Maintenance (O&M)

Operation and maintenance (O&M) will be required for all Source Control, Site Design, and Treatment Control BMPs identified within the PWQMP. Procedures for operating and maintaining each potential BMP will be provided in the WQMP during the PS&E phase. See Appendix C, CASQA BMP Fact Sheets. Refer to Exhibit 3 of Appendix A additional information.

## 4.1. Inspection & Monitoring Requirements

SANBAG will be responsible for and provide self inspections and record keeping of BMPs at the frequencies identified in the WQMP (PS&E phase) for as long as SANBAG owns the Project.

## 4.2. Identification of Responsible Parties

The Project owner, SANBAG, will be responsible for the operation and maintenance of all Project-related BMPs identified in the WQMP (PS&E phase) as necessary into perpetuity. SANBAG is aware that periodic and continuous maintenance is required to assure peak performance of all BMPs in the WQMP and that such maintenance activity will require compliance with all local, state, or federal laws. SANBAG will provide access to City representative(s) for inspection, sampling, and testing, as required, of the BMPs on an agreed upon basis by all affected parties. More detailed information on the responsibilities of liable stakeholders and pertinent operation and maintenance agreements among the parties will be provided in the WQMP which will be prepared during the final design phase.

# 5. Funding

## 5.1. Funding

SANBAG will be financially responsible for all BMPs, including treatment control BMPs within its ROW. Other stakeholders will be financially responsible for other applicable BMPs within their respective ROW, agency authority or as stipulated by agreement. This is yet to be determined and will be identified in more detail during the PS&E phase.

# 6. WQMP Certification

## 6.1. Certification

Since this is a Preliminary WQMP, the document does not include the Certification Statement. The signed Certification Statement is only required and is normally included in the Final WQMP for qualified projects under the jurisdiction of the permittees and will be in accordance with the current WQMP template at the time the Final WQMP is prepared. However, since the project proponent is not a permittee, it is not anticipated that the Final WQMP will include a Certification Statement from SANBAG. The Final WQMP will only include a Certification Statement from other stakeholders if those stakeholders are responsible for elements of the Project such as, but not limited to, the stations and the parking lots.

## 7. References

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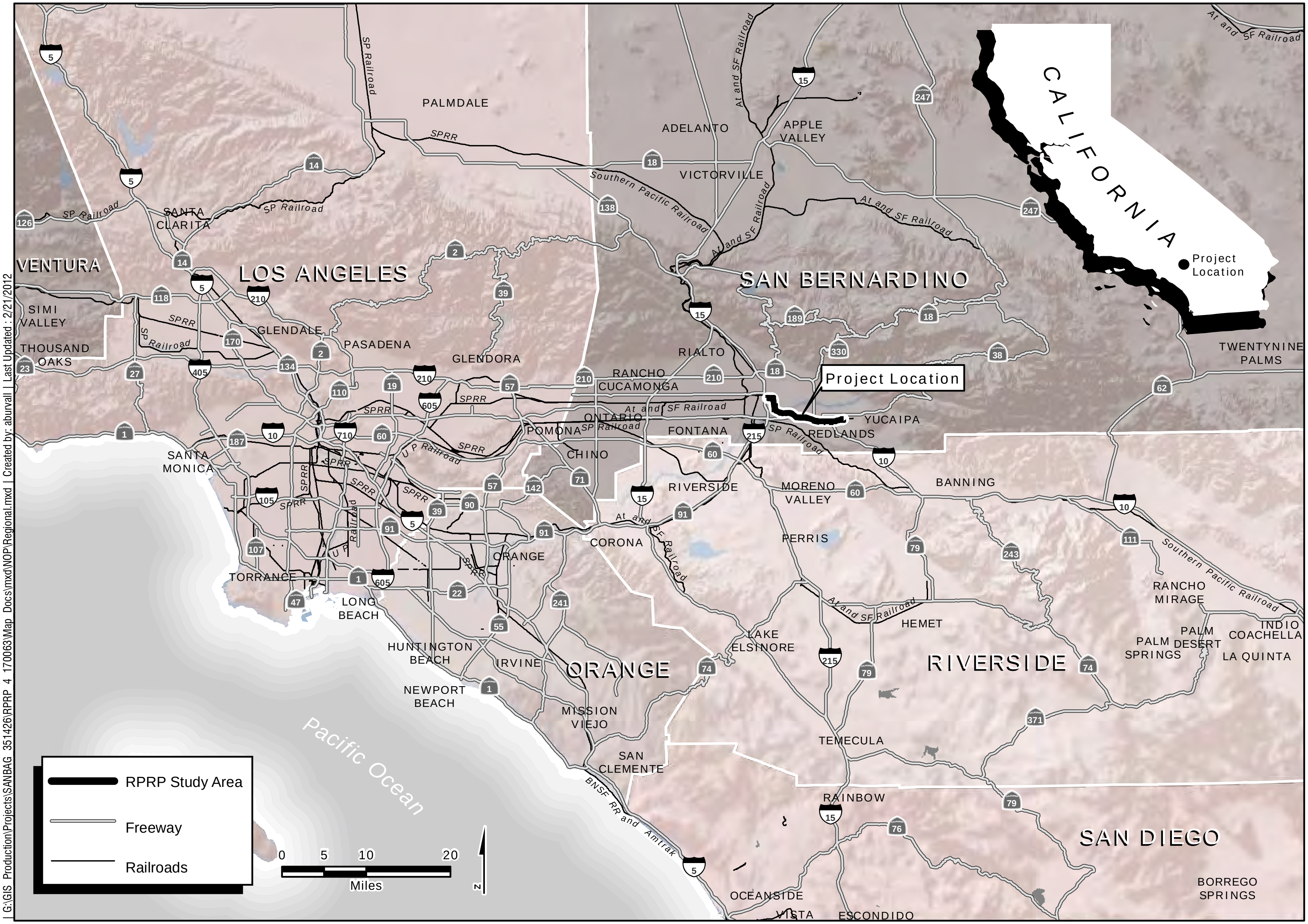
# Appendix A
# Project Exhibits




# Regional Location and Project Area

**FIGURE 1**

SANBAG/FTA | Redlands Passenger Rail Project | NOP

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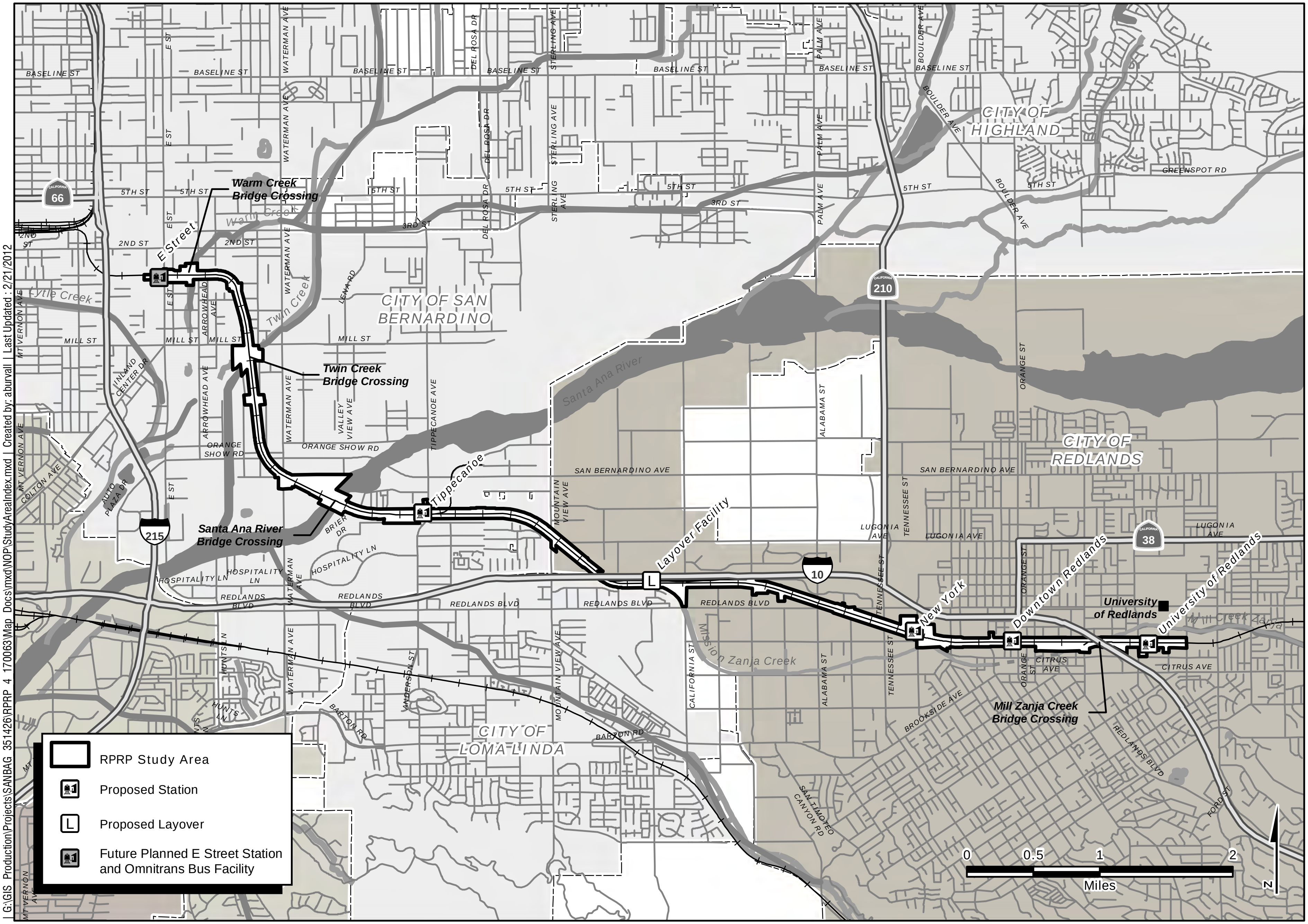


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**RPRP Study Area**

**FIGURE 2**

SANBAG | Redlands Passenger Rail Project | NOP

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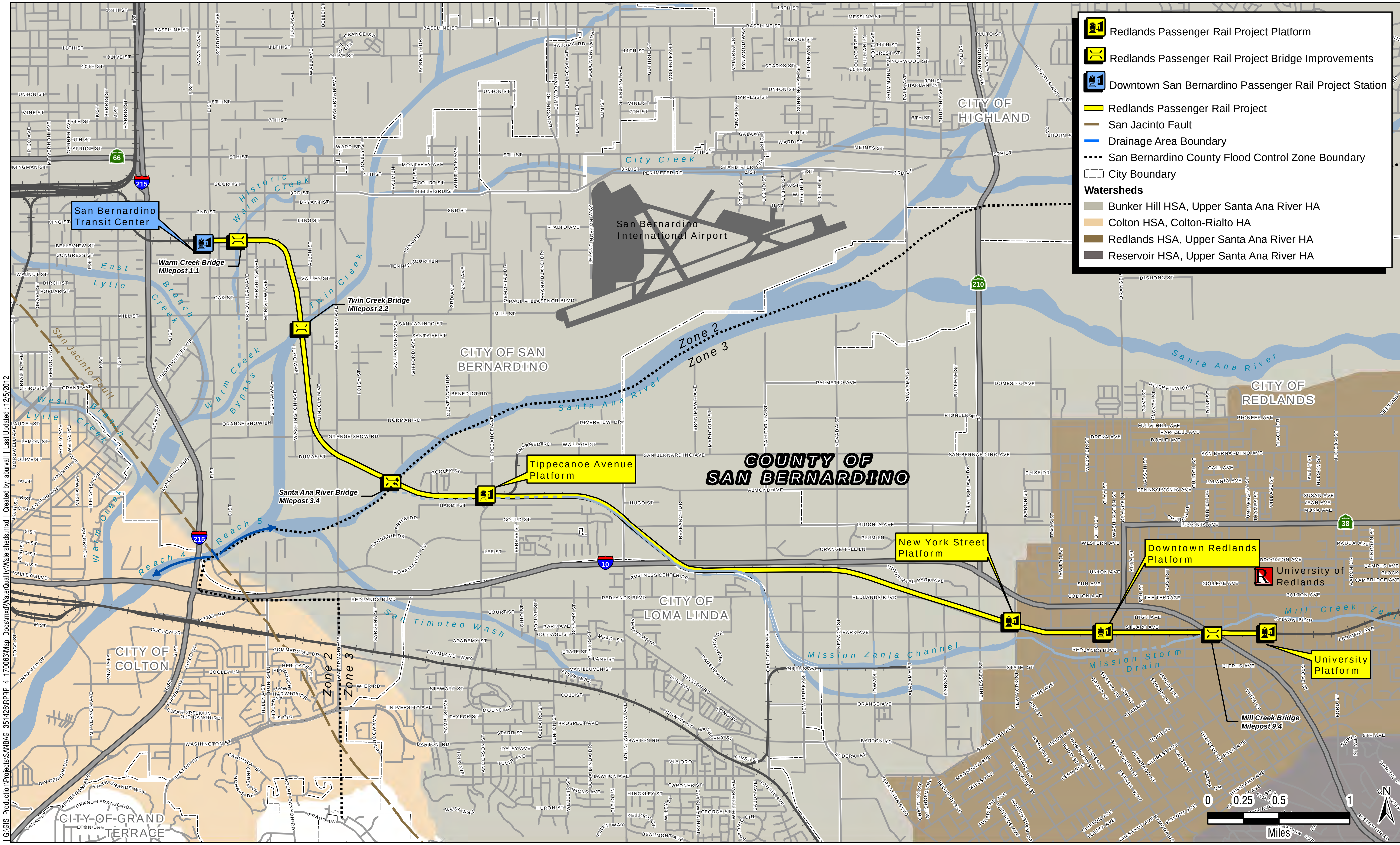


# Watersheds and Surface Waters

**FIGURE 3**

SANBAG | Redlands Passenger Rail Project

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# Appendix B
# Miscellaneous

# National Pollutant Discharge Elimination System (NPDES) Requirements

The City of San Bernardino is subject to National Pollutant Discharge Elimination System (NPDES) permit requirements. The NPDES program stems from the Federal Environmental Protection Agency's (EPA) Clean Water Act Section 402 (p). The purpose of this permit is to help protect the beneficial uses of receiving waters (in this case the Santa Ana River and all its tributaries) from urban runoff pollution and hydrological flow degradation.

The EPA has delegated The State Water Resource Control Board to monitor permittee compliance with all NPDES permit requirements. The State Water Resource Control Board has in turn, allocated these responsibilities to the California Regional Water Quality Control Boards.

The City of San Bernardino is under the jurisdiction of the Santa Ana Regional Water Quality Control Board. This Board has stipulated that the City implement and monitor all permit requirements. Therefore, the City of San Bernardino will require all proposed project proponents to review section 1.2 and Table 1-1 of the Water Quality Management Plan (WQMP) guidance manual to determine whether the proponent's project will require the development of a WQMP. Also, all projects meeting at least one of the categories in Table 1-1 must have a preliminary WQMP prepared and reviewed during the planning process. No entitlements will be issued without the approval of the preliminary WQMP. The final WQMP will be included in the conditions of approval for all projects meeting WQMP submittal guidelines and will be reviewed and approved by the City prior to any permit issuance.

The WQMP guidance document and template are located on:

The San Bernardino County Website at:
http://www.co.san-bernardino.ca.us/stormwater/educational_materials.htm
(Scroll down to Reference Material)

or the Santa Ana Regional Water Quality Control Board at:
http://www.waterboards.ca.gov/santaana/water_issues/programs/stormwater/sb_wqmp.shtml

In addition, all projects that do not meet the criteria of "categorical" projects, as described in section 1.2 and Table 1-1 of the WQMP template, will be required to have a "Non-Categorical" WQMP prepared. The Non-Categorical WQMP shall focus on site design and source control pollutant prevention measures. The Non-Categorical WQMP template can be found on the City website at: http://www.sbcity.org/depts/devserv/public_works/storm_water_requirements.asp

Please be aware that a WQMP is not a Storm Water Pollution Prevention Plan (SWPPP). A SWPPP only covers the constructional phase of a project; whereas, a WQMP focuses on post-construction water quality protection through the use of site design, source control, and treatment control Best Management Practices (BMPs).

Also, please note the City of San Bernardino will not authorize nor will it accept fiscal responsibility, maintenance or liability for any site, source or treatment control BMP(s) in the

City's right-of-way. All structural BMPs must be placed on the project proponent(s) own property.

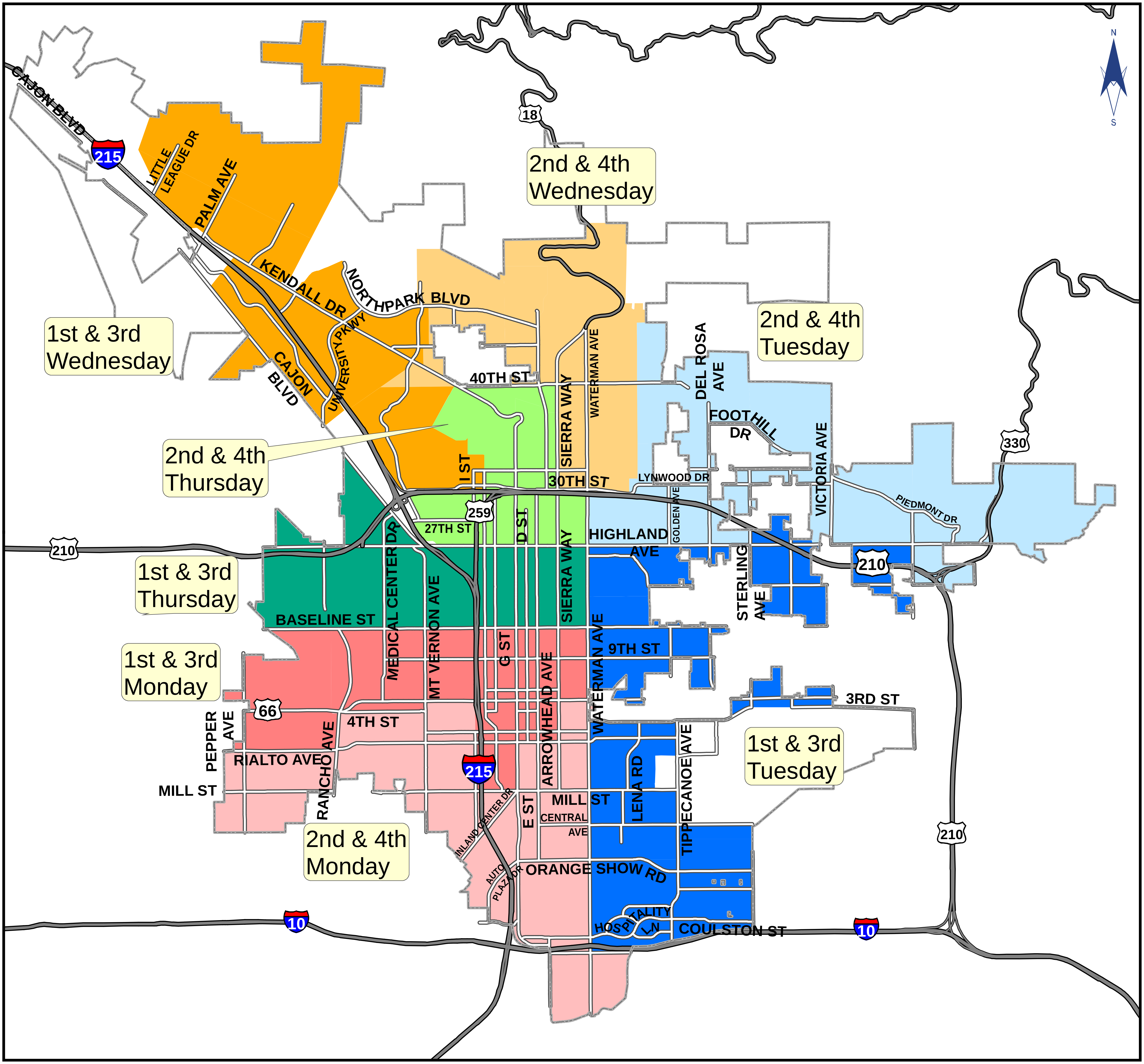
The Regional Water Quality Control Board requires all construction projects over one acre to obtain coverage under the statewide general construction permit. The production of a SWPPP is a requirement of the general construction permit and the City will review the SWPPP before any permits are issued. The City asks project proponents to follow the SWPPP template and production guidelines located in the California Stormwater Quality Association (CASQA) Construction Best Management Practices Handbook.

This information can be located at:
http://www.cabmphandbooks.com/Construction.asp

(Scroll to bottom of the page for SWPPP template and guidelines)

For projects under one acre (including demolition projects) an erosion//waste management control plan that delineates all proposed BMPs will be required and will be reviewed by City staff before permits are issued.

For further information on WQMPs or SWPPPs contact Jennifer Shepardson, Development Services Department, at (909) 384-5154 or Shepardson_Je@SBCity.org




# CITY OF SAN BERNARDINO
## Street Sweeping

Made by M Torrence Printed: Date: 4/7/2011 Path: I:_MXDs\Wards\StreetSweeping2010_12x12.mxd Coordinate System: NAD 1983 StatePlane California V FIPS 0405 Feet

# Appendix C
# CASQA BMP Fact Sheets

## Description

Vortex separators: (alternatively, swirl concentrators) are gravity separators, and in principle are essentially wet vaults. The difference from wet vaults, however, is that the vortex separator is round, rather than rectangular, and the water moves in a centrifugal fashion before exiting. By having the water move in a circular fashion, rather than a straight line as is the case with a standard wet vault, it is possible to obtain significant removal of suspended sediments and attached pollutants with less space. Vortex separators were originally developed for combined sewer overflows (CSOs), where it is used primarily to remove coarse inorganic solids. Vortex separation has been adapted to stormwater treatment by several manufacturers.

## California Experience

There are currently about 100 installations in California.

## Advantages

- May provide the desired performance in less space and therefore less cost.
- May be more cost-effective pre-treatment devices than traditional wet or dry basins.
- Mosquito control may be less of an issue than with traditional wet basins.

## Limitations

- As some of the systems have standing water that remains between storms, there is concern about mosquito breeding.
- It is likely that vortex separators are not as effective as wet vaults at removing fine sediments, on the order 50 to 100 microns in diameter and less.
- The area served is limited by the capacity of the largest models.
- As the products come in standard sizes, the facilities will be oversized in many cases relative to the design treatment storm, increasing the cost.
- The non-steady flows of stormwater decreases the efficiency of vortex separators from what may be estimated or determined from testing under constant flow.
- Do not remove dissolved pollutants.

## Design Considerations

- Service Area
- Settling Velocity
- Appropriate Sizing
- Inlet Pipe Diameter

## Targeted Constituents

| | | |
|---|---|---|
| ☑ | Sediment | ▲ |
| ☑ | Nutrients | ● |
| ☑ | Trash | |
| ☑ | Metals | ● |
| | Bacteria | |
| ☑ | Oil and Grease | |
| ☑ | Organics | |

**Legend** ***(Removal Effectiveness)***

● Low ■ High

▲ Medium

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- A loss of dissolved pollutants may occur as accumulated organic matter (e.g., leaves) decomposes in the units.

## Design and Sizing Guidelines

The stormwater enters, typically below the effluent line, tangentially into the basin, thereby imparting a circular motion in the system. Due to centrifugal forces created by the circular motion, the suspended particles move to the center of the device where they settle to the bottom. There are two general types of vortex separation: free vortex and dampened (or impeded) vortex. Free vortex separation becomes dampened vortex separation by the placement of radial baffles on the weir-plate that impede the free vortex-flow pattern

It has been stated with respect to CSOs that the practical lower limit of vortex separation is a particle with a settling velocity of 12 to 16.5 feet per hour (0.10 to 0.14 cm/s). As such, the focus for vortex separation in CSOs has been with settleable solids generally 200 microns and larger, given the presence of the lighter organic solids. For inorganic sediment, the above settling velocity range represents a particle diameter of 50 to 100 microns. Head loss is a function of the size of the target particle. At 200 microns it is normally minor but increases significantly if the goal is to remove smaller particles.

The commercial separators applied to stormwater treatment vary considerably with respect to geometry, and the inclusion of radial baffles and internal circular chambers. At one extreme is the inclusion of a chamber within the round concentrator. Water flows initially around the perimeter between the inner and outer chambers, and then into the inner chamber, giving rise to a sudden change in velocity that purportedly enhances removal efficiency. The opposite extreme is to introduce the water tangentially into a round manhole with no internal parts of any kind except for an outlet hood. Whether the inclusion of chambers and baffles gives better performance is unknown. Some contend that free vortex, also identified as swirl concentration, creates less turbulence thereby increasing removal efficiency. One product is unique in that it includes a static separator screen.

- Sized is based on the peak flow of the design treatment event as specified by local government.

- If an in-line facility, the design peak flow is four times the peak of the design treatment event.

- If an off-line facility, the design peak flow is equal to the peak of the design treatment event.

- Headloss differs with the product and the model but is generally on the order of one foot or less in most cases.

### *Construction/Inspection Considerations*

No special considerations.

## Performance

Manufacturer's differ with respect to performance claims, but a general statement is that the manufacturer's design and rated capacity (cfs) for each model is based on and believed to achieve an aggregate reduction of 90% of all particles with a specific gravity of 2.65 (glacial sand) down to 150 microns, and to capture the floatables, and oil and grease. Laboratory tests of two products support this claim. The stated performance expectation therefore implies that a lesser removal efficiency is obtained with particles less than 150 microns, and the lighter, organic settleables. Laboratory tests of one of the products found about 60% removal of 50 micron sand at the expected average operating flow rate

Experience with the use of vortex separators for treating combined sewer overflows (CSOs), the original application of this technology, suggests that the lower practical limit for particle removal are particles with a settling velocity of 12 feet per hour (Sullivan, 1982), which represents a particle diameter of 100 to 200 microns, depending on the specific gravity of the particle. The CSO experience therefore seems consistent with the limited experience with treating stormwater, summarized above

Traditional treatment technologies such as wet ponds and extended detention basins are generally believed to be more effective at removing very small particles, down to the range of 10 to 20 microns. Hence, it is intuitively expected that vortex separators do not perform as well as the traditional wet and dry basins, and filters. Whether this matters depends on the particle size distribution of the sediments in stormwater. If the distribution leans towards small material, there should be a marked difference between vortex separators and, say, traditional wet vaults. There are little data to support this conjecture

In comparison to other treatment technologies, such as wet ponds and grass swales, there are few studies of vortex separators. Only two of manufactured products currently available have been field tested. Two field studies have been conducted. Both achieved in excess of 80% removal of TSS. However, the test was conducted in the Northeast (New York state and Maine) where it is possible the stormwater contained significant quantities of deicing sand. Consequently, the influent TSS concentrations and particle size are both likely considerably higher than is found in California stormwater. These data suggest that if the stormwater particles are for the most part fine (i.e., less than 50 microns), vortex separators will not be as efficient as traditional treatment BMPs such as wet ponds and swales, if the latter are sized according to the recommendations of this handbook.

There are no equations that provide a straightforward determination of efficiency as a function of unit configuration and size. Design specifications of commercial separators are derived from empirical equations that are unique and proprietary to each manufacturer. However, some general relationships between performance and the geometry of a separator have been developed. CSO studies have found that the primary determinants of performance of vortex separators are the diameters of the inlet pipe and chamber with all other geometry proportional to these two.

Sullivan et al. (1982) found that performance is related to the ratios of chamber to inlet diameters, $D2/D1$, and height between the inlet and outlet and the inlet diameter, $H1/D1$, shown in Figure 3. The relationships are: as $D2/D1$ approaches one, the efficiency decreases; and, as the $H1/D1$ ratio decreases, the efficiency decreases. These relationships may allow qualitative comparisons of the alternative designs of manufacturers. Engineers who wish to apply these concepts should review relevant publications presented in the References.

### Siting Criteria

There are no particularly unique siting criteria. The size of the drainage area that can be served by vortex separators is directly related to the capacities of the largest models.

## Additional Design Guidelines

Vortex separators have two capacities if positioned as in-line facilities, a treatment capacity and a hydraulic capacity. Failure to recognize the difference between the two may lead to significant under sizing; i.e., too small a model is selected. This observation is relevant to three of the five products. These three technologies all are designed to experience a unit flow rate of about 24 gallons/square foot of separator footprint at the peak of the design treatment event. This is the horizontal area of the separator zone within the container, not the total footprint of the unit. At this unit flow rate, laboratory tests by these manufacturers have established that the performance will meet the general claims previously described. However, the units are sized to handle 100 gallons/square foot at the peak of the hydraulic event. Hence, in selecting a particular model the design engineer must be certain to match the peak flow of the design event to the stated treatment capacity, not the hydraulic capacity. The former is one-fourth the latter. If the unit is positioned as an off-line facility, the model selected is based on the capacity equal to the peak of the design treatment event.

## Maintenance

Maintenance consists of the removal of accumulated material with an eductor truck. It may be necessary to remove and dispose the floatables separately due to the presence of petroleum product.

### *Maintenance Requirements*

Remove all accumulated sediment, and litter and other floatables, annually, unless experience indicates the need for more or less frequent maintenance.

## Cost

Manufacturers provide costs for the units including delivery. Installation costs are generally on the order of 50 to 100 % of the manufacturer's cost. For most sites the units are cleaned annually.

### *Cost Considerations*

The different geometry of the several manufactured separators suggests that when comparing the costs of these systems to each other, that local conditions (e.g., groundwater levels) may affect the relative cost-effectiveness.

## References and Sources of Additional Information

Field, R., 1972, The swirl concentrator as a combined sewer overflow regulator facility, EPA/R2-72-008, U.S. Environmental Protection Agency, Washington, D.C.

Field, R., D. Averill, T.P. O'Connor, and P. Steel, 1997, Vortex separation technology, Water Qual. Res. J. Canada, 32, 1, 185

Manufacturers technical materials

Sullivan, R.H., et al., 1982, Design manual – swirl and helical bend pollution control devices, EPA-600/8-82/013, U.S. Environmental Protection Agency, Washington, D.C.

Sullivan, R.H., M.M. Cohn, J.E. Ure, F.F. Parkinson, and G. Caliana, 1974, Relationship between diameter and height for the design of a swirl concentrator as a combined sewer overflow regulator, EPA 670/2-74-039, U.S. Environmental Protection Agency, Washington, D.C.

Sullivan, R.H., M.M. Cohn, J.E. Ure, F.F. Parkinson, and G. Caliana, 1974, The swirl concentrator as a grit separator device, EPA670/2-74-026, U.S. Environmental Protection Agency, Washington, D.C.

Sullivan, R.H., M.M. Cohn, J.E. Ure, F.F. Parkinson, and G. Caliana, 1978, Swirl primary separator device and pilot demonstration, EPA600/2-78-126, U.S. Environmental Protection Agency, Washington, D.C.

# Drain Inserts

# MP-52

## Design Considerations

- Use with other BMPs
- Fit and Seal Capacity within Inlet

## Targeted Constituents

- ☑ Sediment
- ☑ Nutrients
- ☑ Trash
- ☑ Metals
- Bacteria
- ☑ Oil and Grease
- ☑ Organics

***Removal Effectiveness***

See New Development and Redevelopment Handbook-Section 5.

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## Description

Drain inserts are manufactured filters or fabric placed in a drop inlet to remove sediment and debris. There are a multitude of inserts of various shapes and configurations, typically falling into one of three different groups: socks, boxes, and trays. The sock consists of a fabric, usually constructed of polypropylene. The fabric may be attached to a frame or the grate of the inlet holds the sock. Socks are meant for vertical (drop) inlets. Boxes are constructed of plastic or wire mesh. Typically a polypropylene "bag" is placed in the wire mesh box. The bag takes the form of the box. Most box products are one box; that is, the setting area and filtration through media occur in the same box. Some products consist of one or more trays or mesh grates. The trays may hold different types of media. Filtration media vary by manufacturer. Types include polypropylene, porous polymer, treated cellulose, and activated carbon.

## California Experience

The number of installations is unknown but likely exceeds a thousand. Some users have reported that these systems require considerable maintenance to prevent plugging and bypass.

## Advantages

- Does not require additional space as inserts as the drain inlets are already a component of the standard drainage systems.
- Easy access for inspection and maintenance.
- As there is no standing water, there is little concern for mosquito breeding.
- A relatively inexpensive retrofit option.

## Limitations

Performance is likely significantly less than treatment systems that are located at the end of the drainage system such as ponds and vaults. Usually not suitable for large areas or areas with trash or leaves than can plug the insert.

## Design and Sizing Guidelines

Refer to manufacturer's guidelines. Drain inserts come any many configurations but can be placed into three general groups: socks, boxes, and trays. The sock consists of a fabric, usually constructed of polypropylene. The fabric may be attached to a frame or the grate of the inlet holds the sock. Socks are meant for vertical (drop) inlets. Boxes are constructed of plastic or wire mesh. Typically a polypropylene "bag" is placed in the wire mesh box. The bag takes the form of the box. Most box products are one box; that is, the setting area and filtration through media occurs in the same box. One manufacturer has a double-box. Stormwater enters the first box where setting occurs. The stormwater flows into the second box where the filter media is located. Some products consist of one or more trays or mesh grates. The trays can hold different types of media. Filtration media vary with the manufacturer: types include polypropylene, porous polymer, treated cellulose, and activated carbon.

### *Construction/Inspection Considerations*

Be certain that installation is done in a manner that makes certain that the stormwater enters the unit and does not leak around the perimeter. Leakage between the frame of the insert and the frame of the drain inlet can easily occur with vertical (drop) inlets.

### Performance

Few products have performance data collected under field conditions.

### Siting Criteria

It is recommended that inserts be used only for retrofit situations or as pretreatment where other treatment BMPs presented in this section area used.

### Additional Design Guidelines

Follow guidelines provided by individual manufacturers.

### Maintenance

Likely require frequent maintenance, on the order of several times per year.

### Cost

- The initial cost of individual inserts ranges from less than $100 to about $2,000. The cost of using multiple units in curb inlet drains varies with the size of the inlet.

- The low cost of inserts may tend to favor the use of these systems over other, more effective treatment BMPs. However, the low cost of each unit may be offset by the number of units that are required, more frequent maintenance, and the shorter structural life (and therefore replacement).

### References and Sources of Additional Information

Hrachovec, R., and G. Minton, 2001, Field testing of a sock-type catch basin insert, Planet CPR, Seattle, Washington

Interagency Catch Basin Insert Committee, Evaluation of Commercially-Available Catch Basin Inserts for the Treatment of Stormwater Runoff from Developed Sites, 1995

Larry Walker Associates, June 1998, NDMP Inlet/In-Line Control Measure Study Report

Manufacturers literature

Santa Monica (City), Santa Monica Bay Municipal Stormwater/Urban Runoff Project - Evaluation of Potential Catch basin Retrofits, Woodward Clyde, September 24, 1998

Woodward Clyde, June 11, 1996, Parking Lot Monitoring Report, Santa Clara Valley Nonpoint Source Pollution Control Program.

## Design Objectives

- ☑ Maximize Infiltration
- ☑ Provide Retention
- ☑ Slow Runoff
- ☑ Minimize Impervious Land Coverage
- Prohibit Dumping of Improper Materials
- Contain Pollutants
- Collect and Convey

## Description

Each project site possesses unique topographic, hydrologic, and vegetative features, some of which are more suitable for development than others. Integrating and incorporating appropriate landscape planning methodologies into the project design is the most effective action that can be done to minimize surface and groundwater contamination from stormwater.

## Approach

Landscape planning should couple consideration of land suitability for urban uses with consideration of community goals and projected growth. Project plan designs should conserve natural areas to the extent possible, maximize natural water storage and infiltration opportunities, and protect slopes and channels.

## Suitable Applications

Appropriate applications include residential, commercial and industrial areas planned for development or redevelopment.

## Design Considerations

Design requirements for site design and landscapes planning should conform to applicable standards and specifications of agencies with jurisdiction and be consistent with applicable General Plan and Local Area Plan policies.

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***Designing New Installations***

Begin the development of a plan for the landscape unit with attention to the following general principles:

- Formulate the plan on the basis of clearly articulated community goals. Carefully identify conflicts and choices between retaining and protecting desired resources and community growth.

- Map and assess land suitability for urban uses. Include the following landscape features in the assessment: wooded land, open unwooded land, steep slopes, erosion-prone soils, foundation suitability, soil suitability for waste disposal, aquifers, aquifer recharge areas, wetlands, floodplains, surface waters, agricultural lands, and various categories of urban land use. When appropriate, the assessment can highlight outstanding local or regional resources that the community determines should be protected (e.g., a scenic area, recreational area, threatened species habitat, farmland, fish run). Mapping and assessment should recognize not only these resources but also additional areas needed for their sustenance.

Project plan designs should conserve natural areas to the extent possible, maximize natural water storage and infiltration opportunities, and protect slopes and channels.

*Conserve Natural Areas during Landscape Planning*

If applicable, the following items are required and must be implemented in the site layout during the subdivision design and approval process, consistent with applicable General Plan and Local Area Plan policies:

- Cluster development on least-sensitive portions of a site while leaving the remaining land in a natural undisturbed condition.

- Limit clearing and grading of native vegetation at a site to the minimum amount needed to build lots, allow access, and provide fire protection.

- Maximize trees and other vegetation at each site by planting additional vegetation, clustering tree areas, and promoting the use of native and/or drought tolerant plants.

- Promote natural vegetation by using parking lot islands and other landscaped areas.

- Preserve riparian areas and wetlands.

*Maximize Natural Water Storage and Infiltration Opportunities Within the Landscape Unit*

- Promote the conservation of forest cover. Building on land that is already deforested affects basin hydrology to a lesser extent than converting forested land. Loss of forest cover reduces interception storage, detention in the organic forest floor layer, and water losses by evapotranspiration, resulting in large peak runoff increases and either their negative effects or the expense of countering them with structural solutions.

- Maintain natural storage reservoirs and drainage corridors, including depressions, areas of permeable soils, swales, and intermittent streams. Develop and implement policies and regulations to discourage the clearing, filling, and channelization of these features. Utilize them in drainage networks in preference to pipes, culverts, and engineered ditches.

- Evaluating infiltration opportunities by referring to the stormwater management manual for the jurisdiction and pay particular attention to the selection criteria for avoiding groundwater contamination, poor soils, and hydrogeological conditions that cause these facilities to fail. If necessary, locate developments with large amounts of impervious surfaces or a potential to produce relatively contaminated runoff away from groundwater recharge areas.

*Protection of Slopes and Channels during Landscape Design*

- Convey runoff safely from the tops of slopes.
- Avoid disturbing steep or unstable slopes.
- Avoid disturbing natural channels.
- Stabilize disturbed slopes as quickly as possible.
- Vegetate slopes with native or drought tolerant vegetation.
- Control and treat flows in landscaping and/or other controls prior to reaching existing natural drainage systems.
- Stabilize temporary and permanent channel crossings as quickly as possible, and ensure that increases in run-off velocity and frequency caused by the project do not erode the channel.
- Install energy dissipaters, such as riprap, at the outlets of new storm drains, culverts, conduits, or channels that enter unlined channels in accordance with applicable specifications to minimize erosion. Energy dissipaters shall be installed in such a way as to minimize impacts to receiving waters.
- Line on-site conveyance channels where appropriate, to reduce erosion caused by increased flow velocity due to increases in tributary impervious area. The first choice for linings should be grass or some other vegetative surface, since these materials not only reduce runoff velocities, but also provide water quality benefits from filtration and infiltration. If velocities in the channel are high enough to erode grass or other vegetative linings, riprap, concrete, soil cement, or geo-grid stabilization are other alternatives.
- Consider other design principles that are comparable and equally effective.

### *Redeveloping Existing Installations*

Various jurisdictional stormwater management and mitigation plans (SUSMP, WQMP, etc.) define "redevelopment" in terms of amounts of additional impervious area, increases in gross floor area and/or exterior construction, and land disturbing activities with structural or impervious surfaces. The definition of " redevelopment" must be consulted to determine whether or not the requirements for new development apply to areas intended for redevelopment. If the definition applies, the steps outlined under "designing new installations" above should be followed.

Redevelopment may present significant opportunity to add features which had not previously been implemented. Examples include incorporation of depressions, areas of permeable soils, and swales in newly redeveloped areas. While some site constraints may exist due to the status of already existing infrastructure, opportunities should not be missed to maximize infiltration, slow runoff, reduce impervious areas, disconnect directly connected impervious areas.

## Other Resources

A Manual for the Standard Urban Stormwater Mitigation Plan (SUSMP), Los Angeles County Department of Public Works, May 2002.

Stormwater Management Manual for Western Washington, Washington State Department of Ecology, August 2001.

Model Standard Urban Storm Water Mitigation Plan (SUSMP) for San Diego County, Port of San Diego, and Cities in San Diego County, February 14, 2002.

Model Water Quality Management Plan (WQMP) for County of Orange, Orange County Flood Control District, and the Incorporated Cities of Orange County, Draft February 2003.

Ventura Countywide Technical Guidance Manual for Stormwater Quality Control Measures, July 2002.

# Efficient Irrigation SD-12

### Design Objectives

☑ Maximize Infiltration

☑ Provide Retention

☑ Slow Runoff

Minimize Impervious Land Coverage

Prohibit Dumping of Improper Materials

Contain Pollutants

Collect and Convey

### Description
Irrigation water provided to landscaped areas may result in excess irrigation water being conveyed into stormwater drainage systems.

### Approach
Project plan designs for development and redevelopment should include application methods of irrigation water that minimize runoff of excess irrigation water into the stormwater conveyance system.

### Suitable Applications
Appropriate applications include residential, commercial and industrial areas planned for development or redevelopment. (Detached residential single-family homes are typically excluded from this requirement.)

### Design Considerations
***Designing New Installations***

The following methods to reduce excessive irrigation runoff should be considered, and incorporated and implemented where determined applicable and feasible by the Permittee:

- Employ rain-triggered shutoff devices to prevent irrigation after precipitation.
- Design irrigation systems to each landscape area's specific water requirements.
- Include design featuring flow reducers or shutoff valves triggered by a pressure drop to control water loss in the event of broken sprinkler heads or lines.
- Implement landscape plans consistent with County or City water conservation resolutions, which may include provision of water sensors, programmable irrigation times (for short cycles), etc.

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- Design timing and application methods of irrigation water to minimize the runoff of excess irrigation water into the storm water drainage system.
- Group plants with similar water requirements in order to reduce excess irrigation runoff and promote surface filtration. Choose plants with low irrigation requirements (for example, native or drought tolerant species). Consider design features such as:
  - Using mulches (such as wood chips or bar) in planter areas without ground cover to minimize sediment in runoff
  - Installing appropriate plant materials for the location, in accordance with amount of sunlight and climate, and use native plant materials where possible and/or as recommended by the landscape architect
  - Leaving a vegetative barrier along the property boundary and interior watercourses, to act as a pollutant filter, where appropriate and feasible
  - Choosing plants that minimize or eliminate the use of fertilizer or pesticides to sustain growth
- Employ other comparable, equally effective methods to reduce irrigation water runoff.

### *Redeveloping Existing Installations*
Various jurisdictional stormwater management and mitigation plans (SUSMP, WQMP, etc.) define "redevelopment" in terms of amounts of additional impervious area, increases in gross floor area and/or exterior construction, and land disturbing activities with structural or impervious surfaces. The definition of " redevelopment" must be consulted to determine whether or not the requirements for new development apply to areas intended for redevelopment. If the definition applies, the steps outlined under "designing new installations" above should be followed.

### Other Resources
A Manual for the Standard Urban Stormwater Mitigation Plan (SUSMP), Los Angeles County Department of Public Works, May 2002.

Model Standard Urban Storm Water Mitigation Plan (SUSMP) for San Diego County, Port of San Diego, and Cities in San Diego County, February 14, 2002.

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## Design Objectives

- Maximize Infiltration
- Provide Retention
- Slow Runoff
- Minimize Impervious Land Coverage
- ☑ Prohibit Dumping of Improper Materials
- Contain Pollutants
- Collect and Convey

## Description

Waste materials dumped into storm drain inlets can have severe impacts on receiving and ground waters. Posting notices regarding discharge prohibitions at storm drain inlets can prevent waste dumping. Storm drain signs and stencils are highly visible source controls that are typically placed directly adjacent to storm drain inlets.

## Approach

The stencil or affixed sign contains a brief statement that prohibits dumping of improper materials into the urban runoff conveyance system. Storm drain messages have become a popular method of alerting the public about the effects of and the prohibitions against waste disposal.

## Suitable Applications

Stencils and signs alert the public to the destination of pollutants discharged to the storm drain. Signs are appropriate in residential, commercial, and industrial areas, as well as any other area where contributions or dumping to storm drains is likely.

## Design Considerations

Storm drain message markers or placards are recommended at all storm drain inlets within the boundary of a development project. The marker should be placed in clear sight facing toward anyone approaching the inlet from either side. All storm drain inlet locations should be identified on the development site map.

### *Designing New Installations*

The following methods should be considered for inclusion in the project design and show on project plans:

- Provide stenciling or labeling of all storm drain inlets and catch basins, constructed or modified, within the project area with prohibitive language. Examples include "NO DUMPING

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– DRAINS TO OCEAN" and/or other graphical icons to discourage illegal dumping.

- Post signs with prohibitive language and/or graphical icons, which prohibit illegal dumping at public access points along channels and creeks within the project area.

Note - Some local agencies have approved specific signage and/or storm drain message placards for use. Consult local agency stormwater staff to determine specific requirements for placard types and methods of application.

### *Redeveloping Existing Installations*

Various jurisdictional stormwater management and mitigation plans (SUSMP, WQMP, etc.) define "redevelopment" in terms of amounts of additional impervious area, increases in gross floor area and/or exterior construction, and land disturbing activities with structural or impervious surfaces. If the project meets the definition of "redevelopment", then the requirements stated under " designing new installations" above should be included in all project design plans.

## Additional Information

### *Maintenance Considerations*

- Legibility of markers and signs should be maintained. If required by the agency with jurisdiction over the project, the owner/operator or homeowner's association should enter into a maintenance agreement with the agency or record a deed restriction upon the property title to maintain the legibility of placards or signs.

### *Placement*

- Signage on top of curbs tends to weather and fade.

- Signage on face of curbs tends to be worn by contact with vehicle tires and sweeper brooms.

## Supplemental Information

### *Examples*

- Most MS4 programs have storm drain signage programs. Some MS4 programs will provide stencils, or arrange for volunteers to stencil storm drains as part of their outreach program.

## Other Resources

A Manual for the Standard Urban Stormwater Mitigation Plan (SUSMP), Los Angeles County Department of Public Works, May 2002.

Model Standard Urban Storm Water Mitigation Plan (SUSMP) for San Diego County, Port of San Diego, and Cities in San Diego County, February 14, 2002.

Model Water Quality Management Plan (WQMP) for County of Orange, Orange County Flood Control District, and the Incorporated Cities of Orange County, Draft February 2003.

Ventura Countywide Technical Guidance Manual for Stormwater Quality Control Measures, July 2002.

# Pervious Pavements SD-20

## Design Objectives

☑ Maximize Infiltration

☑ Provide Retention

☑ Slow Runoff

☑ Minimize Impervious Land Coverage

Prohibit Dumping of Improper Materials

Contain Pollutants

Collect and Convey

## Description

Pervious paving is used for light vehicle loading in parking areas. The term describes a system comprising a load-bearing, durable surface together with an underlying layered structure that temporarily stores water prior to infiltration or drainage to a controlled outlet. The surface can itself be porous such that water infiltrates across the entire surface of the material (e.g., grass and gravel surfaces, porous concrete and porous asphalt), or can be built up of impermeable blocks separated by spaces and joints, through which the water can drain. This latter system is termed 'permeable' paving. Advantages of pervious pavements is that they reduce runoff volume while providing treatment, and are unobtrusive resulting in a high level of acceptability.

## Approach

Attenuation of flow is provided by the storage within the underlying structure or sub base, together with appropriate flow controls. An underlying geotextile may permit groundwater recharge, thus contributing to the restoration of the natural water cycle. Alternatively, where infiltration is inappropriate (e.g., if the groundwater vulnerability is high, or the soil type is unsuitable), the surface can be constructed above an impermeable membrane. The system offers a valuable solution for drainage of spatially constrained urban areas.

Significant attenuation and improvement in water quality can be achieved by permeable pavements, whichever method is used. The surface and subsurface infrastructure can remove both the soluble and fine particulate pollutants that occur within urban runoff. Roof water can be piped into the storage area directly, adding areas from which the flow can be attenuated. Also, within lined systems, there is the opportunity for stored runoff to be piped out for reuse.

## Suitable Applications

Residential, commercial and industrial applications are possible. The use of permeable pavement may be restricted in cold regions, arid regions or regions with high wind erosion. There are some specific disadvantages associated with permeable pavement, which are as follows:

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- Permeable pavement can become clogged if improperly installed or maintained. However, this is countered by the ease with which small areas of paving can be cleaned or replaced when blocked or damaged.
- Their application should be limited to highways with low traffic volumes, axle loads and speeds (less than 30 mph limit), car parking areas and other lightly trafficked or non-trafficked areas. Permeable surfaces are currently not considered suitable for adoptable roads due to the risks associated with failure on high speed roads, the safety implications of ponding, and disruption arising from reconstruction.
- When using un-lined, infiltration systems, there is some risk of contaminating groundwater, depending on soil conditions and aquifer susceptibility. However, this risk is likely to be small because the areas drained tend to have inherently low pollutant loadings.
- The use of permeable pavement is restricted to gentle slopes.
- Porous block paving has a higher risk of abrasion and damage than solid blocks.

## Design Considerations

### *Designing New Installations*

If the grades, subsoils, drainage characteristics, and groundwater conditions are suitable, permeable paving may be substituted for conventional pavement on parking areas, cul de sacs and other areas with light traffic. Slopes should be flat or very gentle. Scottish experience has shown that permeable paving systems can be installed in a wide range of ground conditions, and the flow attenuation performance is excellent even when the systems are lined.

The suitability of a pervious system at a particular pavement site will, however, depend on the loading criteria required of the pavement.

Where the system is to be used for infiltrating drainage waters into the ground, the vulnerability of local groundwater sources to pollution from the site should be low, and the seasonal high water table should be at least 4 feet below the surface.

Ideally, the pervious surface should be horizontal in order to intercept local rainfall at source. On sloping sites, pervious surfaces may be terraced to accommodate differences in levels.

*Design Guidelines*

The design of each layer of the pavement must be determined by the likely traffic loadings and their required operational life. To provide satisfactory performance, the following criteria should be considered:

- The subgrade should be able to sustain traffic loading without excessive deformation.
- The granular capping and sub-base layers should give sufficient load-bearing to provide an adequate construction platform and base for the overlying pavement layers.
- The pavement materials should not crack of suffer excessive rutting under the influence of traffic. This is controlled by the horizontal tensile stress at the base of these layers.

There is no current structural design method specifically for pervious pavements. Allowances should be considered the following factors in the design and specification of materials:

- Pervious pavements use materials with high permeability and void space. All the current UK pavement design methods are based on the use of conventional materials that are dense and relatively impermeable. The stiffness of the materials must therefore be assessed.
- Water is present within the construction and can soften and weaken materials, and this must be allowed for.
- Existing design methods assume full friction between layers. Any geotextiles or geomembranes must be carefully specified to minimize loss of friction between layers.
- Porous asphalt loses adhesion and becomes brittle as air passes through the voids. Its durability is therefore lower than conventional materials.

The single sized grading of materials used means that care should be taken to ensure that loss of finer particles between unbound layers does not occur.

Positioning a geotextile near the surface of the pervious construction should enable pollutants to be trapped and retained close to the surface of the construction. This has both advantages and disadvantages. The main disadvantage is that the filtering of sediments and their associated pollutants at this level may hamper percolation of waters and can eventually lead to surface ponding. One advantage is that even if eventual maintenance is required to reinstate infiltration, only a limited amount of the construction needs to be disturbed, since the sub-base below the geotextile is protected. In addition, the pollutant concentration at a high level in the structure allows for its release over time. It is slowly transported in the stormwater to lower levels where chemical and biological processes may be operating to retain or degrade pollutants.

The design should ensure that sufficient void space exists for the storage of sediments to limit the period between remedial works.

- Pervious pavements require a single size grading to give open voids. The choice of materials is therefore a compromise between stiffness, permeability and storage capacity.
- Because the sub-base and capping will be in contact with water for a large part of the time, the strength and durability of the aggregate particles when saturated and subjected to wetting and drying should be assessed.
- A uniformly graded single size material cannot be compacted and is liable to move when construction traffic passes over it. This effect can be reduced by the use of angular crushed rock material with a high surface friction.

In pollution control terms, these layers represent the site of long term chemical and biological pollutant retention and degradation processes. The construction materials should be selected, in addition to their structural strength properties, for their ability to sustain such processes. In general, this means that materials should create neutral or slightly alkaline conditions and they should provide favorable sites for colonization by microbial populations.

*Construction/Inspection Considerations*

- Permeable surfaces can be laid without cross-falls or longitudinal gradients.
- The blocks should be lain level
- They should not be used for storage of site materials, unless the surface is well protected from deposition of silt and other spillages.
- The pavement should be constructed in a single operation, as one of the last items to be built, on a development site. Landscape development should be completed before pavement construction to avoid contamination by silt or soil from this source.
- Surfaces draining to the pavement should be stabilized before construction of the pavement.
- Inappropriate construction equipment should be kept away from the pavement to prevent damage to the surface, sub-base or sub-grade.

*Maintenance Requirements*

The maintenance requirements of a pervious surface should be reviewed at the time of design and should be clearly specified. Maintenance is required to prevent clogging of the pervious surface. The factors to be considered when defining maintenance requirements must include:

- Type of use
- Ownership
- Level of trafficking
- The local environment and any contributing catchments

Studies in the UK have shown satisfactory operation of porous pavement systems without maintenance for over 10 years and recent work by Imbe et al. at 9th ICUD, Portland, 2002 describes systems operating for over 20 years without maintenance. However, performance under such regimes could not be guaranteed, Table 1 shows typical recommended maintenance regimes:

**Table 1 Typical Recommended Maintenance Regimes**

| Activity | Schedule |
|---|---|
| ▪ Minimize use of salt or grit for de-icing<br>▪ Keep landscaped areas well maintained<br>▪ Prevent soil being washed onto pavement | Ongoing |
| ▪ Vacuum clean surface using commercially available sweeping machines at the following times:<br>- End of winter (April)<br>- Mid-summer (July / August)<br>- After Autumn leaf-fall (November) | 2/3 x per year |
| ▪ Inspect outlets | Annual |
| ▪ If routine cleaning does not restore infiltration rates, then reconstruction of part of the whole of a pervious surface may be required.<br>▪ The surface area affected by hydraulic failure should be lifted for inspection of the internal materials to identify the location and extent of the blockage.<br>▪ Surface materials should be lifted and replaced after brush cleaning. Geotextiles may need complete replacement.<br>▪ Sub-surface layers may need cleaning and replacing.<br>▪ Removed silts may need to be disposed of as controlled waste. | As needed (infrequent)<br>Maximum 15-20 years |

Permeable pavements are up to 25 % cheaper (or at least no more expensive than the traditional forms of pavement construction), when all construction and drainage costs are taken into account. (Accepting that the porous asphalt itself is a more expensive surfacing, the extra cost of which is offset by the savings in underground pipework etc.) (Niemczynowicz, et al., 1987)

Table 1 gives US cost estimates for capital and maintenance costs of porous pavements (Landphair et al., 2000)

### *Redeveloping Existing Installations*

Various jurisdictional stormwater management and mitigation plans (SUSMP, WQMP, etc.) define "redevelopment" in terms of amounts of additional impervious area, increases in gross floor area and/or exterior construction, and land disturbing activities with structural or impervious surfaces. The definition of " redevelopment" must be consulted to determine whether or not the requirements for new development apply to areas intended for redevelopment. If the definition applies, the steps outlined under "designing new installations" above should be followed.

## Additional Information

*Cost Considerations*

Permeable pavements are up to 25 % cheaper (or at least no more expensive than the traditional forms of pavement construction), when all construction and drainage costs are taken into account. (Accepting that the porous asphalt itself is a more expensive surfacing, the extra cost of which is offset by the savings in underground pipework etc.) (Niemczynowicz, et al., 1987)

Table 2 gives US cost estimates for capital and maintenance costs of porous pavements (Landphair et al., 2000)

**Table 2 Engineer's Estimate for Porous Pavement**

| Porous Pavement | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Item | Units | Price | Cycles/ Year | Quant. 1 Acre WS | Total | Quant. 2 Acre WS | Total | Quant. 3 Acre WS | Total | Quant. 4 Acre WS | Total | Quant. 5 Acre WS | Total |
| Grading | SY | $2.00 | | 604 | $1,208 | 1209 | $2,418 | 1812 | $3,624 | 2419 | $4,838 | 3020 | $6,040 |
| Paving | SY | $19.00 | | 212 | $4,028 | 424 | $8,056 | 636 | $12,084 | 848 | $16,112 | 1060 | $20,140 |
| Excavation | CY | $3.60 | | 201 | $724 | 403 | $1,451 | 604 | $2,174 | 806 | $2,902 | 1008 | $3,629 |
| Filter Fabric | SY | $1.15 | | 700 | $805 | 1400 | $1,610 | 2000 | $2,300 | 2800 | $3,220 | 3600 | $4,140 |
| Stone Fill | CY | $16.00 | | 201 | $3,216 | 403 | $6,448 | 604 | $9,664 | 806 | $12,896 | 1008 | $16,128 |
| Sand | CY | $7.00 | | 100 | $700 | 200 | $1,400 | 300 | $2,100 | 400 | $2,800 | 500 | $3,500 |
| Sight Well | EA | $300.00 | | 2 | $600 | 3 | $900 | 4 | $1,200 | 7 | $2,100 | 7 | $2,100 |
| Seeding | LF | $0.05 | | 644 | $32 | 1288 | $64 | 1932 | $97 | 2576 | $129 | 3220 | $161 |
| Check Dam | CY | $35.00 | | 0 | $0 | 0 | $0 | 0 | $0 | 0 | $0 | 0 | $0 |
| Total Construction Costs | | | | | $10,105 | | $19,929 | | $29,619 | | $40,158 | | $49,798 |
| Construction Costs Amortized for 20 Years | | | | | $505 | | $996 | | $1,481 | | $2,008 | | $2,490 |

| Annual Maintenance Expense | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Item | Units | Price | Cycles/ Year | Quant. 1 Acre WS | Total | Quant. 2 Acre WS | Total | Quant. 3 Acre WS | Total | Quant. 4 Acre WS | Total | Quant. 5 Acre WS | Total |
| Sweeping | AC | $250.00 | 6 | 1 | $1,500 | 2 | $3,000 | 3 | $4,500 | 4 | $6,000 | 5 | $7,500 |
| Washing | AC | $250.00 | 6 | 1 | $1,500 | 2 | $3,000 | 3 | $4,500 | 4 | $6,000 | 5 | $7,500 |
| Inspection | MH | $20.00 | 5 | 5 | $100 | 5 | $100 | 5 | $100 | 5 | $100 | 5 | $100 |
| Deep Clean | AC | $450.00 | 0.5 | 1 | $225 | 2 | $450 | 3 | $675 | 3.9 | $878 | 5 | $1,125 |
| Total Annual Maintenance Expense | | | | | $3,960 | | $7,792 | | $11,651 | | $15,483 | | $19,370 |

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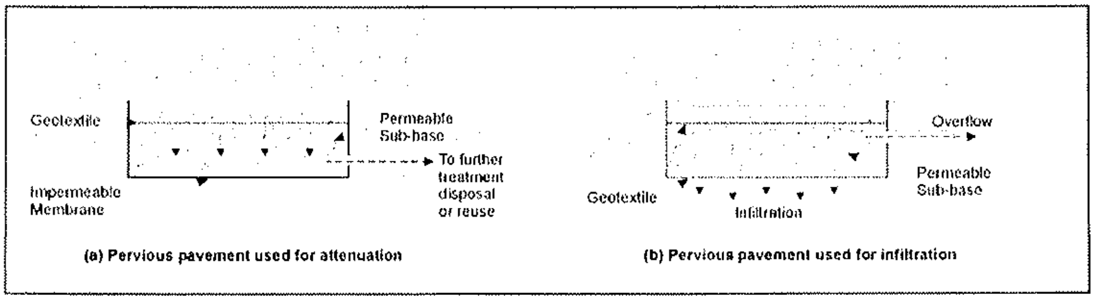


**Schematics of a Pervious Pavement System**

# Alternative Building Materials SD-21

## Design Objectives

☑ Maximize Infiltration

☑ Provide Retention

☑ Source Control

Minimize Impervious Land Coverage

Prohibit Dumping of Improper Materials

Contain Pollutant

Collect and Convey

## Description

Alternative building materials are selected instead of conventional materials for new construction and renovation. These materials reduce potential sources of pollutants in stormwater runoff by eliminating compounds that can leach into runoff, reducing the need for pesticide application, reducing the need for painting and other maintenance, or by reducing the volume of runoff.

## Approach

Alternative building materials are available for use as lumber for decking, roofing materials, home siding, and paving for driveways, decks, and sidewalks.

## Suitable Applications

Appropriate applications include residential, commercial and industrial areas planned for development or redevelopment.

## Design Considerations

### *Designing New Installations*

*Decking*

One of the most common materials for construction of decks and other outdoor construction has traditionally been pressure treated wood, which is now being phased out. The standard treatment is called CCA, for chromated copper arsenate. The key ingredients are arsenic (which kills termites, carpenter ants and other insects), copper (which kills the fungi that cause wood to rot) and chromium (which reacts with the other ingredients to bind them to the wood). The amount of arsenic is far from trivial. A deck just 8 feet x 10 feet contains more than 1 1/3 pounds of this highly potent poison. Replacement materials include a new type of pressure treated wood, plastic and composite lumber.

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There are currently over 20 products in the market consisting of plastic or plastic-wood composites. Plastic lumber is made from 100% recycled plastic, # 2 HDPE and polyethylene plastic milk jugs and soap bottles. Plastic-wood composites are a combination of plastic and wood fibers or sawdust. These materials are a long lasting exterior weather, insect, and chemical resistant wood lumber replacement for non structural applications. Use it for decks, docks, raised garden beds and planter boxes, pallets, hand railings, outdoor furniture, animal pens, boat decks, etc.

New pressure treated wood uses a much safer recipe, ACQ, which stands for ammoniacal copper quartenary. It contains no arsenic and no chromium. Yet the American Wood Preservers Association has found it to be just as effective as the standard formula. ACQ is common in Japan and Europe.

*Roofing*

Several studies have indicated that metal used as roofing material, flashing, or gutters can leach metals into the environment. The leaching occurs because rainfall is slightly acidic and slowly dissolved the exposed metals. Common traditional applications include copper sheathing and galvanized (zinc) gutters.

Coated metal products are available for both roofing and gutter applications. These products eliminate contact of bare metal with rainfall, eliminating one source of metals in runoff. There are also roofing materials made of recycled rubber and plastic that resemble traditional materials.

A less traditional approach is the use of green roofs. These roofs are not just green, they're alive. Planted with grasses and succulents, low- profile green roofs reduce the urban heat island effect, stormwater runoff, and cooling costs, while providing wildlife habitat and a connection to nature for building occupants. These roofs are widely used on industrial facilities in Europe and have been established as experimental installations in several locations in the US, including Portland, Oregon. Their feasibility is questionable in areas of California with prolonged, dry, hot weather.

*Paved Areas*

Traditionally, concrete is used for construction of patios, sidewalks, and driveways. Although it is non-toxic, these paved areas reduce stormwater infiltration and increase the volume and rate of runoff. This increase in the amount of runoff is the leading cause of stream channel degradation in urban areas.

There are a number of alternative materials that can be used in these applications, including porous concrete and asphalt, modular blocks, and crushed granite. These materials, especially modular paving blocks, are widely available and a well established method to reduce stormwater runoff.

*Building Siding*

Wood siding is commonly used on the exterior of residential construction. This material weathers fairly rapidly and requires repeated painting to prevent rotting. Alternative "new" products for this application include cement-fiber and vinyl. Cement-fiber siding is a masonry product made from Portland cement, sand, and cellulose and will not burn, cup, swell, or shrink.

Pesticide Reduction
A common use of powerful pesticides is for the control of termites. Chlordane was used for many years for this purpose and is now found in urban streams and lakes nationwide. There are a number of physical barriers that can be installed during construction to help reduce the use of pesticides.

Sand barriers for subterranean termites are a physical deterrent because the termites cannot tunnel through it. Sand barriers can be applied in crawl spaces under pier and beam foundations, under slab foundations, and between the foundation and concrete porches, terraces, patios and steps. Other possible locations include under fence posts, underground electrical cables, water and gas lines, telephone and electrical poles, inside hollow tile cells and against retaining walls.

Metal termite shields are physical barriers to termites which prevent them from building invisible tunnels. In reality, metal shields function as a helpful termite detection device, forcing them to build tunnels on the outside of the shields which are easily seen. Metal termite shields also help prevent dampness from wicking to adjoining wood members which can result in rot, thus making the material more attractive to termites and other pests. Metal flashing and metal plates can also be used as a barrier between piers and beams of structures such as decks, which are particularly vulnerable to termite attack.

### *Redeveloping Existing Installations*
Various jurisdictional stormwater management and mitigation plans (SUSMP, WQMP, etc.) define "redevelopment" in terms of amounts of additional impervious area, increases in gross floor area and/or exterior construction, and land disturbing activities with structural or impervious surfaces. The definition of "redevelopment" must be consulted to determine whether or not the requirements for new development apply to areas intended for redevelopment. If the definition applies, the steps outlined under "designing new installations" above should be followed.

## Other Resources
There are no good, independent, comprehensive sources of information on alternative building materials for use in minimizing the impacts of stormwater runoff. Most websites or other references to "green" or "alternative" building materials focus on indoor applications, such as formaldehyde free plywood and low VOC paints, carpets, and pads. Some supplemental information on alternative materials is available from the manufacturers.

Fires are a source of concern in many areas of California. Information on the flammability of alternative decking materials is available from the University of California Forest Product Laboratory (UCFPL) website at: http://www.ucfpl.ucop.edu/WDDeckIntro.htm


Photo Credit: Geoff Brosseau

## Design Objectives

- Maximize Infiltration
- Provide Retention
- Slow Runoff
- Minimize Impervious Land Coverage
- Prohibit Dumping of Improper Materials
- ☑ Contain Pollutants
- ☑ Collect and Convey

## Description

Fueling areas have the potential to contribute oil and grease, solvents, car battery acid, coolant and gasoline to the stormwater conveyance system. Spills at vehicle and equipment fueling areas can be a significant source of pollution because fuels contain toxic materials and heavy metals that are not easily removed by stormwater treatment devices.

## Approach

Project plans must be developed for cleaning near fuel dispensers, emergency spill cleanup, containment, and leak prevention.

## Suitable Applications

Appropriate applications include commercial, industrial, and any other areas planned to have fuel dispensing equipment, including retail gasoline outlets, automotive repair shops, and major non-retail dispensing areas.

## Design Considerations

Design requirements for fueling areas are governed by Building and Fire Codes and by current local agency ordinances and zoning requirements. Design requirements described in this fact sheet are meant to enhance and be consistent with these code and ordinance requirements.

***Designing New Installations***

*Covering*

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Fuel dispensing areas should provide an overhanging roof structure or canopy. The cover's minimum dimensions must be equal to or greater than the area within the grade break. The cover must not drain onto the fuel dispensing area and the downspouts must be routed to prevent drainage across the fueling area. The fueling area should drain to the project's treatment control BMP(s) prior to discharging to the stormwater conveyance system. Note - If fueling large equipment or vehicles that would prohibit the use of covers or roofs, the fueling island should be designed to sufficiently accommodate the larger vehicles and equipment and to prevent stormwater run-on and runoff. Grade to direct stormwater to a dead-end sump.

*Surfacing*

Fuel dispensing areas should be paved with Portland cement concrete (or equivalent smooth impervious surface). The use of asphalt concrete should be prohibited. Use asphalt sealant to protect asphalt paved areas surrounding the fueling area. This provision may be made to sites that have pre-existing asphalt surfaces.

The concrete fuel dispensing area should be extended a minimum of 6.5 ft from the corner of each fuel dispenser, or the length at which the hose and nozzle assembly may be operated plus 1 ft, whichever is less.

*Grading/Contouring*

Dispensing areas should have an appropriate slope to prevent ponding, and be separated from the rest of the site by a grade break that prevents run-on of urban runoff. (Slope is required to be 2 to 4% in some jurisdictions' stormwater management and mitigation plans.)

Fueling areas should be graded to drain toward a dead-end sump. Runoff from downspouts/roofs should be directed away from fueling areas. Do not locate storm drains in the immediate vicinity of the fueling area.

### *Redeveloping Existing Installations*

Various jurisdictional stormwater management and mitigation plans (SUSMP, WQMP, etc.) define "redevelopment" in terms of amounts of additional impervious area, increases in gross floor area and/or exterior construction, and land disturbing activities with structural or impervious surfaces. The definition of " redevelopment" must be consulted to determine whether or not the requirements for new development apply to areas intended for redevelopment. If the definition applies, the steps outlined under "designing new installations" above should be followed.

## Additional Information

- In the case of an emergency, provide storm drain seals, such as isolation valves, drain plugs, or drain covers, to prevent spills or contaminated stormwater from entering the stormwater conveyance system.

## Other Resources

A Manual for the Standard Urban Stormwater Mitigation Plan (SUSMP), Los Angeles County Department of Public Works, May 2002.

Model Standard Urban Storm Water Mitigation Plan (SUSMP) for San Diego County, Port of San Diego, and Cities in San Diego County, February 14, 2002.

Model Water Quality Management Plan (WQMP) for County of Orange, Orange County Flood Control District, and the Incorporated Cities of Orange County, Draft February 2003.

Ventura Countywide Technical Guidance Manual for Stormwater Quality Control Measures, July 2002.

## Design Objectives

- Maximize Infiltration
- Provide Retention
- Slow Runoff
- Minimize Impervious Land Coverage
- ☑ Prohibit Dumping of Improper Materials
- ☑ Contain Pollutants
- Collect and Convey

## Description

Several measures can be taken to prevent operations at maintenance bays and loading docks from contributing a variety of toxic compounds, oil and grease, heavy metals, nutrients, suspended solids, and other pollutants to the stormwater conveyance system.

## Approach

In designs for maintenance bays and loading docks, containment is encouraged. Preventative measures include overflow containment structures and dead-end sumps. However, in the case of loading docks from grocery stores and warehouse/distribution centers, engineered infiltration systems may be considered.

## Suitable Applications

Appropriate applications include commercial and industrial areas planned for development or redevelopment.

## Design Considerations

Design requirements for vehicle maintenance and repair are governed by Building and Fire Codes, and by current local agency ordinances, and zoning requirements. The design criteria described in this fact sheet are meant to enhance and be consistent with these code requirements.

### *Designing New Installations*

Designs of maintenance bays should consider the following:

- Repair/maintenance bays and vehicle parts with fluids should be indoors; or designed to preclude urban run-on and runoff.
- Repair/maintenance floor areas should be paved with Portland cement concrete (or equivalent smooth impervious surface).

- Repair/maintenance bays should be designed to capture all wash water leaks and spills. Provide impermeable berms, drop inlets, trench catch basins, or overflow containment structures around repair bays to prevent spilled materials and wash-down waters form entering the storm drain system. Connect drains to a sump for collection and disposal. Direct connection of the repair/maintenance bays to the storm drain system is prohibited. If required by local jurisdiction, obtain an Industrial Waste Discharge Permit.

- Other features may be comparable and equally effective.

The following designs of loading/unloading dock areas should be considered:

- Loading dock areas should be covered, or drainage should be designed to preclude urban run-on and runoff.

- Direct connections into storm drains from depressed loading docks (truck wells) are prohibited.

- Below-grade loading docks from grocery stores and warehouse/distribution centers of fresh food items should drain through water quality inlets, or to an engineered infiltration system, or an equally effective alternative. Pre-treatment may also be required.

- Other features may be comparable and equally effective.

### *Redeveloping Existing Installations*

Various jurisdictional stormwater management and mitigation plans (SUSMP, WQMP, etc.) define "redevelopment" in terms of amounts of additional impervious area, increases in gross floor area and/or exterior construction, and land disturbing activities with structural or impervious surfaces. The definition of " redevelopment" must be consulted to determine whether or not the requirements for new development apply to areas intended for redevelopment. If the definition applies, the steps outlined under "designing new installations" above should be followed.

## Additional Information

Stormwater and non-stormwater will accumulate in containment areas and sumps with impervious surfaces. Contaminated accumulated water must be disposed of in accordance with applicable laws and cannot be discharged directly to the storm drain or sanitary sewer system without the appropriate permit.

## Other Resources

A Manual for the Standard Urban Stormwater Mitigation Plan (SUSMP), Los Angeles County Department of Public Works, May 2002.

Model Standard Urban Storm Water Mitigation Plan (SUSMP) for San Diego County, Port of San Diego, and Cities in San Diego County, February 14, 2002.

Model Water Quality Management Plan (WQMP) for County of Orange, Orange County Flood Control District, and the Incorporated Cities of Orange County, Draft February 2003.

Ventura Countywide Technical Guidance Manual for Stormwater Quality Control Measures, July 2002.

# Trash Storage Areas SD-32

### Design Objectives

Maximize Infiltration

Provide Retention

Slow Runoff

Minimize Impervious Land Coverage

Prohibit Dumping of Improper Materials

☑ Contain Pollutants

Collect and Convey

## Description

Trash storage areas are areas where a trash receptacle (s) are located for use as a repository for solid wastes. Stormwater runoff from areas where trash is stored or disposed of can be polluted. In addition, loose trash and debris can be easily transported by water or wind into nearby storm drain inlets, channels, and/or creeks. Waste handling operations that may be sources of stormwater pollution include dumpsters, litter control, and waste piles.

## Approach

This fact sheet contains details on the specific measures required to prevent or reduce pollutants in stormwater runoff associated with trash storage and handling. Preventative measures including enclosures, containment structures, and impervious pavements to mitigate spills, should be used to reduce the likelihood of contamination.

## Suitable Applications

Appropriate applications include residential, commercial and industrial areas planned for development or redevelopment. (Detached residential single-family homes are typically excluded from this requirement.)

## Design Considerations

Design requirements for waste handling areas are governed by Building and Fire Codes, and by current local agency ordinances and zoning requirements. The design criteria described in this fact sheet are meant to enhance and be consistent with these code and ordinance requirements. Hazardous waste should be handled in accordance with legal requirements established in Title 22, California Code of Regulation.

Wastes from commercial and industrial sites are typically hauled by either public or commercial carriers that may have design or access requirements for waste storage areas. The design criteria in this fact sheet are recommendations and are not intended to be in conflict with requirements established by the waste hauler. The waste hauler should be contacted prior to the design of your site trash collection areas. Conflicts or issues should be discussed with the local agency.

### *Designing New Installations*

Trash storage areas should be designed to consider the following structural or treatment control BMPs:

- Design trash container areas so that drainage from adjoining roofs and pavement is diverted around the area(s) to avoid run-on. This might include berming or grading the waste handling area to prevent run-on of stormwater.

- Make sure trash container areas are screened or walled to prevent off-site transport of trash.

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- Use lined bins or dumpsters to reduce leaking of liquid waste.
- Provide roofs, awnings, or attached lids on all trash containers to minimize direct precipitation and prevent rainfall from entering containers.
- Pave trash storage areas with an impervious surface to mitigate spills.
- Do not locate storm drains in immediate vicinity of the trash storage area.
- Post signs on all dumpsters informing users that hazardous materials are not to be disposed of therein.

### *Redeveloping Existing Installations*

Various jurisdictional stormwater management and mitigation plans (SUSMP, WQMP, etc.) define "redevelopment" in terms of amounts of additional impervious area, increases in gross floor area and/or exterior construction, and land disturbing activities with structural or impervious surfaces. The definition of " redevelopment" must be consulted to determine whether or not the requirements for new development apply to areas intended for redevelopment. If the definition applies, the steps outlined under "designing new installations" above should be followed.

## Additional Information

### *Maintenance Considerations*

The integrity of structural elements that are subject to damage (i.e., screens, covers, and signs) must be maintained by the owner/operator. Maintenance agreements between the local agency and the owner/operator may be required. Some agencies will require maintenance deed restrictions to be recorded of the property title. If required by the local agency, maintenance agreements or deed restrictions must be executed by the owner/operator before improvement plans are approved.

## Other Resources

A Manual for the Standard Urban Stormwater Mitigation Plan (SUSMP), Los Angeles County Department of Public Works, May 2002.

Model Standard Urban Storm Water Mitigation Plan (SUSMP) for San Diego County, Port of San Diego, and Cities in San Diego County, February 14, 2002.

Model Water Quality Management Plan (WQMP) for County of Orange, Orange County Flood Control District, and the Incorporated Cities of Orange County, Draft February 2003.

Ventura Countywide Technical Guidance Manual for Stormwater Quality Control Measures, July 2002.

# Vehicle Washing Areas SD-33

Photo Credit: Geoff Brosseau

## Design Objectives

- ☑ Maximize Infiltration
- Provide Retention
- Slow Runoff
- Minimize Impervious Land Coverage
- Prohibit Dumping of Improper Materials
- ☑ Contain Pollutants
- ☑ Collect and Convey

## Description

Vehicle washing, equipment washing, and steam cleaning may contribute high concentrations of metals, oil and grease, solvents, phosphates, and suspended solids to wash waters that drain to stormwater conveyance systems.

## Approach

Project plans should include appropriately designed area(s) for washing-steam cleaning of vehicles and equipment. Depending on the size and other parameters of the wastewater facility, wash water may be conveyed to a sewer, an infiltration system, recycling system or other alternative. Pretreatment may be required for conveyance to a sanitary sewer.

## Suitable Applications

Appropriate applications include commercial developments, restaurants, retail gasoline outlets, automotive repair shops and others.

## Design Considerations

Design requirements for vehicle maintenance are governed by Building and Fire Codes, and by current local agency ordinances, and zoning requirements. Design criteria described in this fact sheet are meant to enhance and be consistent with these code requirements.

### *Designing New Installations*

Areas for washing/steam cleaning should incorporate one of the following features:

- Be self-contained and/or covered with a roof or overhang
- Be equipped with a clarifier or other pretreatment facility
- Have a proper connection to a sanitary sewer

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- Include other features which are comparable and equally effective

CAR WASH AREAS - Some jurisdictions' stormwater management plans include vehicle-cleaning area source control design requirements for community car wash racks in complexes with a large number of dwelling units. In these cases, wash water from the areas may be directed to the sanitary sewer, to an engineered infiltration system, or to an equally effective alternative. Pre-treatment may also be required.

Depending on the jurisdiction, developers may be directed to divert surface water runoff away from the exposed area around the wash pad ( parking lot, storage areas), and wash pad itself to alternatives other than the sanitary sewer. Roofing may be required for exposed wash pads.

It is generally advisable to cover areas used for regular washing of vehicles, trucks, or equipment, surround them with a perimeter berm, and clearly mark them as a designated washing area. Sumps or drain lines can be installed to collect wash water, which may be treated for reuse or recycling, or for discharge to the sanitary sewer. Jurisdictions may require some form of pretreatment, such as a trap, for these areas.

### *Redeveloping Existing Installations*

Various jurisdictional stormwater management and mitigation plans (SUSMP, WQMP, etc.) define "redevelopment" in terms of amounts of additional impervious area, increases in gross floor area and/or exterior construction, and land disturbing activities with structural or impervious surfaces. The definition of " redevelopment" must be consulted to determine whether or not the requirements for new development apply to areas intended for redevelopment.

## Additional Information

### *Maintenance Considerations*

Stormwater and non-stormwater will accumulate in containment areas and sumps with impervious surfaces. Contaminated accumulated water must be disposed of in accordance with applicable laws and cannot be discharged directly to the storm drain or sanitary sewer system without the appropriate permit.

## Other Resources

A Manual for the Standard Urban Stormwater Mitigation Plan (SUSMP), Los Angeles County Department of Public Works, May 2002.

Model Standard Urban Storm Water Mitigation Plan (SUSMP) for San Diego County, Port of San Diego, and Cities in San Diego County, February 14, 2002.

Model Water Quality Management Plan (WQMP) for County of Orange, Orange County Flood Control District, and the Incorporated Cities of Orange County, Draft February 2003.

Ventura Countywide Technical Guidance Manual for Stormwater Quality Control Measures, July 2002.

# Outdoor Material Storage Areas SD-34


## Design Objectives

- Maximize Infiltration
- Provide Retention
- Slow Runoff
- Minimize Impervious Land Coverage
- Prohibit Dumping of Improper Materials
- ☑ Contain Pollutant
- Collect and Convey

## Description

Proper design of outdoor storage areas for materials reduces opportunity for toxic compounds, oil and grease, heavy metals, nutrients, suspended solids, and other pollutants to enter the stormwater conveyance system. Materials may be in the form of raw products, by-products, finished products, and waste products. The type of pollutants associated with the materials will vary depending on the type of commercial or industrial activity.

## Approach

Outdoor storage areas require a drainage approach different from the typical infiltration/detention strategy. In outdoor storage areas, infiltration is discouraged. Containment is encouraged. Preventative measures include enclosures, secondary containment structures and impervious surfaces.

## Suitable Applications

Appropriate applications include residential, commercial and industrial areas planned for development or redevelopment.

## Design Considerations

Some materials are more of a concern than others. Toxic and hazardous materials must be prevented from coming in contact with stormwater. Non-toxic or non-hazardous materials do not have to be prevented from stormwater contact. However, these materials may have toxic effects on receiving waters if allowed to be discharged with stormwater in significant quantities. Accumulated material on an impervious surface could result in significant impact on the rivers or streams that receive the runoff.

Material may be stored in a variety of ways, including bulk piles, containers, shelving, stacking, and tanks. Stormwater contamination may be prevented by eliminating the possibility of stormwater contact with the material storage areas either through diversion, cover, or capture of the stormwater. Control measures may also include minimizing the storage area. Design

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requirements for material storage areas are governed by Building and Fire Codes, and by current City or County ordinances and zoning requirements. Control measures are site specific, and must meet local agency requirements.

***Designing New Installations***

Where proposed project plans include outdoor areas for storage of materials that may contribute pollutants to the stormwater conveyance system, the following structural or treatment BMPS should be considered:

- Materials with the potential to contaminate stormwater should be: (1) placed in an enclosure such as, but not limited to, a cabinet, shed, or similar structure that prevents contact with runoff or spillage to the stormwater conveyance system, or (2) protected by secondary containment structures such as berms, dikes, or curbs.

- The storage area should be paved and sufficiently impervious to contain leaks and spills.

- The storage area should slope towards a dead-end sump to contain spills and direct runoff from downspouts/roofs should be directed away from storage areas.

- The storage area should have a roof or awning that extends beyond the storage area to minimize collection of stormwater within the secondary containment area. A manufactured storage shed may be used for small containers.

Note that the location(s) of installations of where these preventative measures will be employed must be included on the map or plans identifying BMPs.

***Redeveloping Existing Installations***

Various jurisdictional stormwater management and mitigation plans (SUSMP, WQMP, etc.) define "redevelopment" in terms of amounts of additional impervious area, increases in gross floor area and/or exterior construction, and land disturbing activities with structural or impervious surfaces. The definition of " redevelopment" must be consulted to determine whether or not the requirements for new development apply to areas intended for redevelopment. If the definition applies, the steps outlined under "designing new installations" above should be followed.

## Additional Information

Stormwater and non-stormwater will accumulate in containment areas and sumps with impervious surfaces. Contaminated accumulated water must be disposed of in accordance with applicable laws and cannot be discharged directly to the storm drain or sanitary sewer system without the appropriate permits.

## Other Resources

A Manual for the Standard Urban Stormwater Mitigation Plan (SUSMP), Los Angeles County Department of Public Works, May 2002.

Model Standard Urban Storm Water Mitigation Plan (SUSMP) for San Diego County, Port of San Diego, and Cities in San Diego County, February 14, 2002.

Model Water Quality Management Plan (WQMP) for County of Orange, Orange County Flood Control District, and the Incorporated Cities of Orange County, Draft February 2003.

Ventura Countywide Technical Guidance Manual for Stormwater Quality Control Measures, July 2002.

# Outdoor Work Areas SD-35

Photo Credit: Geoff Brosseau

### Design Objectives

- ☐ Maximize Infiltration
- ☐ Provide Retention
- ☐ Slow Runoff
- ☐ Minimize Impervious Land Coverage
- ☐ Prohibit Dumping of Improper Materials
- ☑ Contain Pollutant
- ☑ Collect and Convey

## Description

Proper design of outdoor work areas for materials reduces opportunity for toxic compounds, oil and grease, heavy metals, nutrients, suspended solids, and other pollutants to enter the stormwater conveyance system.

## Approach

Outdoor work areas require a drainage approach different from the typical infiltration/detention strategy. In outdoor work areas, infiltration is discouraged; collection and conveyance are encouraged. In outdoor work areas, infiltration is discouraged and runoff is often routed directly to the sanitary sewer, not the storm drain. Because this runoff is being added to the loads normally received by the wastewater treatment plants, municipal stormwater programs and/or private developers must work with the local plant to develop solutions that minimize effects on the treatment facility. These concerns are best addressed in the planning and design stage of the outdoor work area.

## Suitable Applications

Appropriate applications include residential, commercial, and industrial areas planned for development or redevelopment.

## Design Considerations

Design requirements for outdoor work areas are governed by Building and Fire Codes, and by current local agency ordinances, and zoning requirements.

### *Designing New Installations*

Outdoor work areas can be designed in particular ways to reduce impacts on both stormwater quality and sewage treatment plants.

- Create an impermeable surface such as concrete or asphalt, or a prefabricated metal drip pan, depending on the use.

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- Cover the area with a roof. This prevents rain from falling on the work area and becoming polluted runoff.
- Berm or perform mounding around the perimeter of the area to prevent water from adjacent areas from flowing on to the surface of the work area.
- Directly connect runoff. Unlike other areas, runoff from work areas is directly connected to the sanitary sewer or other specialized containment system(s). This allows the more highly concentrated pollutants from these areas to receive special treatment that removes particular constituents. Approval for this connection must be obtained from the appropriate sanitary sewer agency.
- Locate the work area away from storm drains or catch basins.

### *Redeveloping Existing Installations*

Various jurisdictional stormwater management and mitigation plans (SUSMP, WQMP, etc.) define "redevelopment" in terms of amounts of additional impervious area, increases in gross floor area and/or exterior construction, and land disturbing activities with structural or impervious surfaces. The definition of " redevelopment" must be consulted to determine whether or not the requirements for new development apply to areas intended for redevelopment. If the definition applies, the steps outlined under "designing new installations" above should be followed.

## Other Resources

A Manual for the Standard Urban Stormwater Mitigation Plan (SUSMP), Los Angeles County Department of Public Works, May 2002.

Model Standard Urban Storm Water Mitigation Plan (SUSMP) for San Diego County, Port of San Diego, and Cities in San Diego County, February 14, 2002.

Model Water Quality Management Plan (WQMP) for County of Orange, Orange County Flood Control District, and the Incorporated Cities of Orange County, Draft February 2003.

Ventura Countywide Technical Guidance Manual for Stormwater Quality Control Measures, July 2002.

# Outdoor Processing Areas SD-36

## Design Objectives

- Maximize Infiltration
- Provide Retention
- Slow Runoff
- Minimize Impervious Land Coverage
- Prohibit Dumping of Improper Materials
- ☑ Contain Pollutants
- ☑ Collect and Convey

## Description

Outdoor process equipment operations such as rock grinding or crushing, painting or coating, grinding or sanding, degreasing or parts cleaning, landfills, waste piles, wastewater and solid waste treatment and disposal, and others operations may contribute a variety of toxic compounds, oil and grease, heavy metals, nutrients, suspended solids, and other pollutants to the storm conveyance system.

## Approach

Outdoor processing areas require a drainage approach different from the typical infiltration/detention strategy. In outdoor process equipment areas, infiltration is discouraged. Containment is encouraged, accompanied by collection and conveyance. Preventative measures include enclosures, secondary containment structures, dead-end sumps, and conveyance to treatment facilities in accordance with conditions established by the applicable sewer agency.

## Suitable Applications

Appropriate applications include commercial and industrial areas planned for development or redevelopment.

## Design Considerations

Design requirements for outdoor processing areas are governed by Building and Fire codes, and by current local agency ordinances, and zoning requirements.

### *Designing New Installations*

Operations determined to be a potential threat to water quality should consider to the following recommendations:

- Cover or enclose areas that would be the most significant source of pollutants; or slope the area toward a dead-end sump; or, discharge to the sanitary sewer system following appropriate treatment in accordance with conditions established by the applicable sewer agency.
- Grade or berm area to prevent run-on from surrounding areas.
- Do not install storm drains in areas of equipment repair.
- Consider other features that are comparable or equally effective.
- Provide secondary containment structures (not double wall containers) where wet material processing occurs (e.g., electroplating), to hold spills resulting from accidents, leaking tanks, or equipment, or any other unplanned releases (Note:

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if these are plumbed to the sanitary sewer, they must be with the prior approval of the sewering agency.)

***Redeveloping Existing Installations***

Various jurisdictional stormwater management and mitigation plans (SUSMP, WQMP, etc.) define "redevelopment" in terms of amounts of additional impervious area, increases in gross floor area and/or exterior construction, and land disturbing activities with structural or impervious surfaces. The definition of " redevelopment" must be consulted to determine whether or not the requirements for new development apply to areas intended for redevelopment. If the definition applies, the steps outlined under "designing new installations" above should be followed.

## Additional Information

Stormwater and non-stormwater will accumulate in containment areas and sumps with impervious surfaces. Contaminated accumulated water must be disposed of in accordance with applicable laws and cannot be discharged directly to the storm drain or sanitary sewer system without the appropriate permit.

## Other Resources

A Manual for the Standard Urban Stormwater Mitigation Plan (SUSMP), Los Angeles County Department of Public Works, May 2002.

Model Standard Urban Storm Water Mitigation Plan (SUSMP) for San Diego County, Port of San Diego, and Cities in San Diego County, February 14, 2002.

Model Water Quality Management Plan (WQMP) for County of Orange, Orange County Flood Control District, and the Incorporated Cities of Orange County, Draft February 2003.

Ventura Countywide Technical Guidance Manual for Stormwater Quality Control Measures, July 2002.

## Design Considerations

- Accumulation of Metals
- Clogged Soil Outlet Structures
- Vegetation/Landscape Maintenance

## Description

An infiltration trench is a long, narrow, rock-filled trench with no outlet that receives stormwater runoff. Runoff is stored in the void space between the stones and infiltrates through the bottom and into the soil matrix. Infiltration trenches perform well for removal of fine sediment and associated pollutants. Pretreatment using buffer strips, swales, or detention basins is important for limiting amounts of coarse sediment entering the trench which can clog and render the trench ineffective.

## California Experience

Caltrans constructed two infiltration trenches at highway maintenance stations in Southern California. Of these, one failed to operate to the design standard because of average soil infiltration rates lower than that measured in the single infiltration test. This highlights the critical need for appropriate evaluation of the site. Once in operation, little maintenance was required at either site.

## Advantages

- Provides 100% reduction in the load discharged to surface waters.

- An important benefit of infiltration trenches is the approximation of pre-development hydrology during which a significant portion of the average annual rainfall runoff is infiltrated rather than flushed directly to creeks.

- If the water quality volume is adequately sized, infiltration trenches can be useful for providing control of channel forming (erosion) and high frequency (generally less than the 2-year) flood events.

## Targeted Constituents

| | | |
|---|---|---|
| ☑ | Sediment | ■ |
| ☑ | Nutrients | ■ |
| ☑ | Trash | ■ |
| ☑ | Metals | ■ |
| ☑ | Bacteria | ■ |
| ☑ | Oil and Grease | ■ |
| ☑ | Organics | ■ |

**Legend** ***(Removal Effectiveness)***

● Low ■ High

▲ Medium

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- As an underground BMP, trenches are unobtrusive and have little impact of site aesthetics.

**Limitations**

- Have a high failure rate if soil and subsurface conditions are not suitable.
- May not be appropriate for industrial sites or locations where spills may occur.
- The maximum contributing area to an individual infiltration practice should generally be less than 5 acres.
- Infiltration basins require a minimum soil infiltration rate of 0.5 inches/hour, not appropriate at sites with Hydrologic Soil Types C and D.
- If infiltration rates exceed 2.4 inches/hour, then the runoff should be fully treated prior to infiltration to protect groundwater quality.
- Not suitable on fill sites or steep slopes.
- Risk of groundwater contamination in very coarse soils.
- Upstream drainage area must be completely stabilized before construction.
- Difficult to restore functioning of infiltration trenches once clogged.

**Design and Sizing Guidelines**

- Provide pretreatment for infiltration trenches in order to reduce the sediment load. Pretreatment refers to design features that provide settling of large particles before runoff reaches a management practice, easing the long-term maintenance burden. Pretreatment is important for all structural stormwater management practices, but it is particularly important for infiltration practices. To ensure that pretreatment mechanisms are effective, designers should incorporate practices such as grassed swales, vegetated filter strips, detention, or a plunge pool in series.
- Specify locally available trench rock that is 1.5 to 2.5 inches in diameter.
- Determine the trench volume by assuming the WQV will fill the void space based on the computed porosity of the rock matrix (normally about 35%).
- Determine the bottom surface area needed to drain the trench within 72 hr by dividing the WQV by the infiltration rate.

$$d = \frac{WQV + RFV}{SA}$$

- Calculate trench depth using the following equation:

where:

D = Trench depth

| | | |
|---|---|---|
| WQV | = | Water quality volume |
| RFV | = | Rock fill volume |
| SA | = | Surface area of the trench bottom |

- The use of vertical piping, either for distribution or infiltration enhancement shall not be allowed to avoid device classification as a Class V injection well per 40 CFR146.5(e)(4).
- Provide observation well to allow observation of drain time.
- May include a horizontal layer of filter fabric just below the surface of the trench to retain sediment and reduce the potential for clogging.

### *Construction/Inspection Considerations*

Stabilize the entire area draining to the facility before construction begins. If impossible, place a diversion berm around the perimeter of the infiltration site to prevent sediment entrance during construction. Stabilize the entire contributing drainage area before allowing any runoff to enter once construction is complete.

## Performance

Infiltration trenches eliminate the discharge of the water quality volume to surface receiving waters and consequently can be considered to have 100% removal of all pollutants within this volume. Transport of some of these constituents to groundwater is likely, although the attenuation in the soil and subsurface layers will be substantial for many constituents.

Infiltration trenches can be expected to remove up to 90 percent of sediments, metals, coliform bacteria and organic matter, and up to 60 percent of phosphorus and nitrogen in the infiltrated runoff (Schueler, 1992). Biochemical oxygen demand (BOD) removal is estimated to be between 70 to 80 percent. Lower removal rates for nitrate, chlorides and soluble metals should be expected, especially in sandy soils (Schueler, 1992). Pollutant removal efficiencies may be improved by using washed aggregate and adding organic matter and loam to the subsoil. The stone aggregate should be washed to remove dirt and fines before placement in the trench. The addition of organic material and loam to the trench subsoil may enhance metals removal through adsorption.

## Siting Criteria

The use of infiltration trenches may be limited by a number of factors, including type of native soils, climate, and location of groundwater table. Site characteristics, such as excessive slope of the drainage area, fine-grained soil types, and proximate location of the water table and bedrock, may preclude the use of infiltration trenches. Generally, infiltration trenches are not suitable for areas with relatively impermeable soils containing clay and silt or in areas with fill.

As with any infiltration BMP, the potential for groundwater contamination must be carefully considered, especially if the groundwater is used for human consumption or agricultural purposes. The infiltration trench is not suitable for sites that use or store chemicals or hazardous materials unless hazardous and toxic materials are prevented from entering the trench. In these areas, other BMPs that do not allow interaction with the groundwater should be considered.

The potential for spills can be minimized by aggressive pollution prevention measures. Many municipalities and industries have developed comprehensive spill prevention control and countermeasure (SPCC) plans. These plans should be modified to include the infiltration trench and the contributing drainage area. For example, diversion structures can be used to prevent spills from entering the infiltration trench. Because of the potential to contaminate groundwater, extensive site investigation must be undertaken early in the site planning process to establish site suitability for the installation of an infiltration trench.

Longevity can be increased by careful geotechnical evaluation prior to construction and by designing and implementing an inspection and maintenance plan. Soil infiltration rates and the water table depth should be evaluated to ensure that conditions are satisfactory for proper operation of an infiltration trench. Pretreatment structures, such as a vegetated buffer strip or water quality inlet, can increase longevity by removing sediments, hydrocarbons, and other materials that may clog the trench. Regular maintenance, including the replacement of clogged aggregate, will also increase the effectiveness and life of the trench.

Evaluation of the viability of a particular site is the same as for infiltration basins and includes:

- Determine soil type (consider RCS soil type 'A, B or C' only) from mapping and consult USDA soil survey tables to review other parameters such as the amount of silt and clay, presence of a restrictive layer or seasonal high water table, and estimated permeability. The soil should not have more than 30 percent clay or more than 40 percent of clay and silt combined. Eliminate sites that are clearly unsuitable for infiltration.

- Groundwater separation should be at least 3 m from the basin invert to the measured ground water elevation. There is concern at the state and regional levels of the impact on groundwater quality from infiltrated runoff, especially when the separation between groundwater and the surface is small.

- Location away from buildings, slopes and highway pavement (greater than 6 m) and wells and bridge structures (greater than 30 m). Sites constructed of fill, having a base flow or with a slope greater than 15 percent should not be considered.

- Ensure that adequate head is available to operate flow splitter structures (to allow the basin to be offline) without ponding in the splitter structure or creating backwater upstream of the splitter.

- Base flow should not be present in the tributary watershed.

### *Secondary Screening Based on Site Geotechnical Investigation*

- At least three in-hole conductivity tests shall be performed using USBR 7300-89 or Bouwer-Rice procedures (the latter if groundwater is encountered within the boring), two tests at different locations within the proposed basin and the third down gradient by no more than approximately 10 m. The tests shall measure permeability in the side slopes and the bed within a depth of 3 m of the invert.

- The minimum acceptable hydraulic conductivity as measured in any of the three required test holes is 13 mm/hr. If any test hole shows less than the minimum value, the site should be disqualified from further consideration.

- Exclude from consideration sites constructed in fill or partially in fill unless no silts or clays are present in the soil boring. Fill tends to be compacted, with clays in a dispersed rather than flocculated state, greatly reducing permeability.

- The geotechnical investigation should be such that a good understanding is gained as to how the stormwater runoff will move in the soil (horizontally or vertically) and if there are any geological conditions that could inhibit the movement of water.

## Maintenance

Infiltration trenches required the least maintenance of any of the BMPs evaluated in the Caltrans study, with approximately 17 field hours spent on the operation and maintenance of each site. Inspection of the infiltration trench was the largest field activity, requiring approximately 8 hr/yr.

In addition to reduced water quality performance, clogged infiltration trenches with surface standing water can become a nuisance due to mosquito breeding. If the trench takes more than 72 hours to drain, then the rock fill should be removed and all dimensions of the trench should be increased by 2 inches to provide a fresh surface for infiltration.

## Cost

### *Construction Cost*

Infiltration trenches are somewhat expensive, when compared to other stormwater practices, in terms of cost per area treated. Typical construction costs, including contingency and design costs, are about \$5 per $ft^3$ of stormwater treated (SWRPC, 1991; Brown and Schueler, 1997). Actual construction costs may be much higher. The average construction cost of two infiltration trenches installed by Caltrans in southern California was about \$50/$ft^3$; however, these were constructed as retrofit installations.

Infiltration trenches typically consume about 2 to 3 percent of the site draining to them, which is relatively small. In addition, infiltration trenches can fit into thin, linear areas. Thus, they can generally fit into relatively unusable portions of a site.

### *Maintenance Cost*

One cost concern associated with infiltration practices is the maintenance burden and longevity. If improperly sited or maintained, infiltration trenches have a high failure rate. In general, maintenance costs for infiltration trenches are estimated at between 5 percent and 20 percent of the construction cost. More realistic values are probably closer to the 20-percent range, to ensure long-term functionality of the practice.

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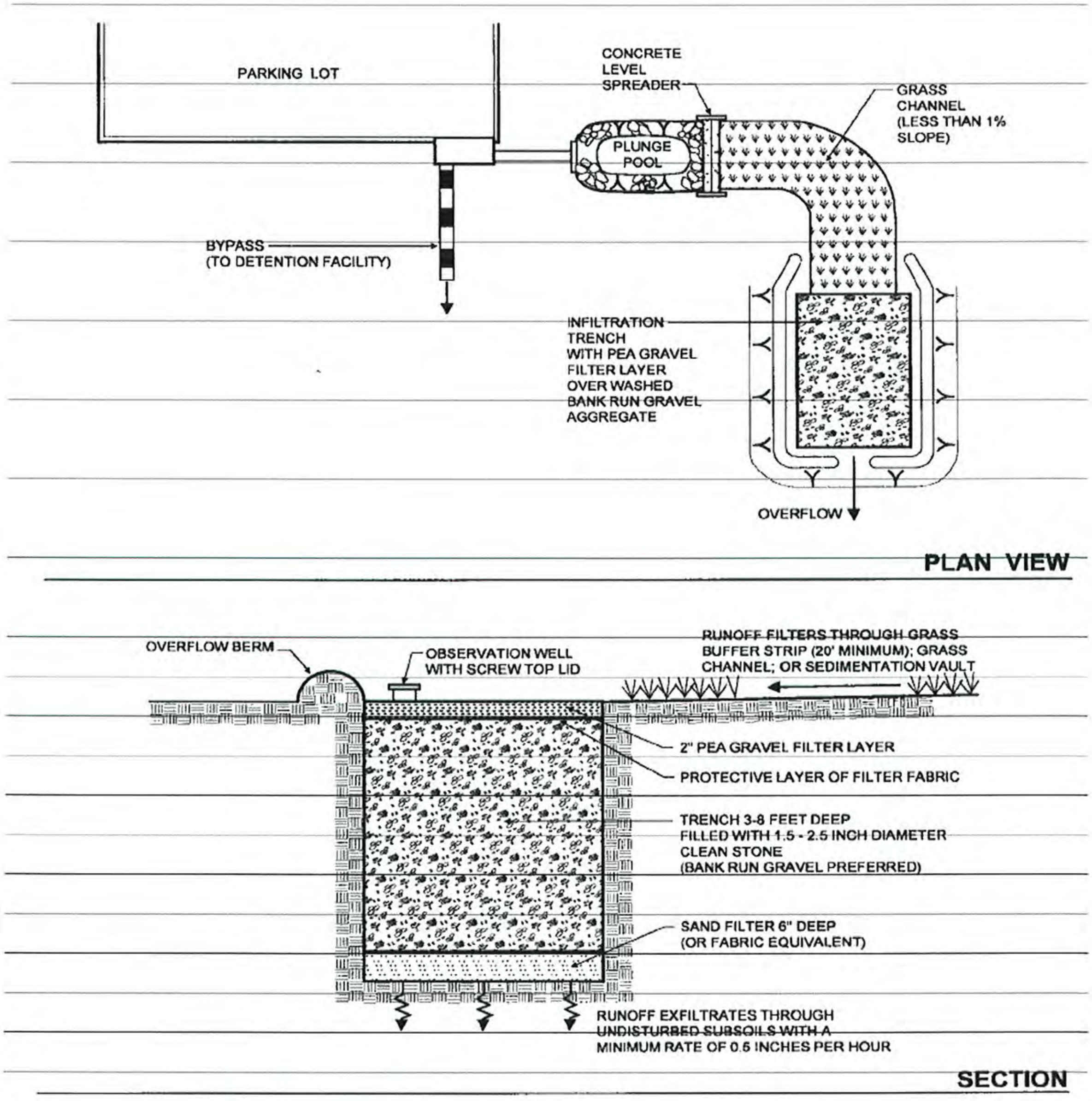

PARKING LOT
CONCRETE LEVEL SPREADER
GRASS CHANNEL (LESS THAN 1% SLOPE)
PLUNGE POOL
BYPASS (TO DETENTION FACILITY)
INFILTRATION TRENCH WITH PEA GRAVEL FILTER LAYER OVER WASHED BANK RUN GRAVEL AGGREGATE
OVERFLOW
PLAN VIEW
OVERFLOW BERM
OBSERVATION WELL WITH SCREW TOP LID
RUNOFF FILTERS THROUGH GRASS BUFFER STRIP (20' MINIMUM); GRASS CHANNEL; OR SEDIMENTATION VAULT
2" PEA GRAVEL FILTER LAYER
PROTECTIVE LAYER OF FILTER FABRIC
TRENCH 3-8 FEET DEEP FILLED WITH 1.5 - 2.5 INCH DIAMETER CLEAN STONE (BANK RUN GRAVEL PREFERRED)
SAND FILTER 6" DEEP (OR FABRIC EQUIVALENT)
RUNOFF EXFILTRATES THROUGH UNDISTURBED SUBSOILS WITH A MINIMUM RATE OF 0.5 INCHES PER HOUR
SECTION


## Design Considerations

- Soil for Infiltration
- Slope
- Aesthetics

## Targeted Constituents

| | | |
|---|---|---|
| ☑ | Sediment | ■ |
| ☑ | Nutrients | ■ |
| ☑ | Trash | ■ |
| ☑ | Metals | ■ |
| ☑ | Bacteria | ■ |
| ☑ | Oil and Grease | ■ |
| ☑ | Organics | ■ |

**Legend** ***(Removal Effectiveness)***

● Low ■ High

▲ Medium

## Description

An infiltration basin is a shallow impoundment that is designed to infiltrate stormwater. Infiltration basins use the natural filtering ability of the soil to remove pollutants in stormwater runoff. Infiltration facilities store runoff until it gradually exfiltrates through the soil and eventually into the water table. This practice has high pollutant removal efficiency and can also help recharge groundwater, thus helping to maintain low flows in stream systems. Infiltration basins can be challenging to apply on many sites, however, because of soils requirements. In addition, some studies have shown relatively high failure rates compared with other management practices.

## California Experience

Infiltration basins have a long history of use in California, especially in the Central Valley. Basins located in Fresno were among those initially evaluated in the National Urban Runoff Program and were found to be effective at reducing the volume of runoff, while posing little long-term threat to groundwater quality (EPA, 1983; Schroeder, 1995). Proper siting of these devices is crucial as underscored by the experience of Caltrans in siting two basins in Southern California. The basin with marginal separation from groundwater and soil permeability failed immediately and could never be rehabilitated.

## Advantages

- Provides 100% reduction in the load discharged to surface waters.
- The principal benefit of infiltration basins is the approximation of pre-development hydrology during which a

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significant portion of the average annual rainfall runoff is infiltrated and evaporated rather than flushed directly to creeks.

- If the water quality volume is adequately sized, infiltration basins can be useful for providing control of channel forming (erosion) and high frequency (generally less than the 2-year) flood events.

## Limitations

- May not be appropriate for industrial sites or locations where spills may occur.
- Infiltration basins require a minimum soil infiltration rate of 0.5 inches/hour, not appropriate at sites with Hydrologic Soil Types C and D.
- If infiltration rates exceed 2.4 inches/hour, then the runoff should be fully treated prior to infiltration to protect groundwater quality.
- Not suitable on fill sites or steep slopes.
- Risk of groundwater contamination in very coarse soils.
- Upstream drainage area must be completely stabilized before construction.
- Difficult to restore functioning of infiltration basins once clogged.

## Design and Sizing Guidelines

- Water quality volume determined by local requirements or sized so that 85% of the annual runoff volume is captured.
- Basin sized so that the entire water quality volume is infiltrated within 48 hours.
- Vegetation establishment on the basin floor may help reduce the clogging rate.

### *Construction/Inspection Considerations*

- Before construction begins, stabilize the entire area draining to the facility. If impossible, place a diversion berm around the perimeter of the infiltration site to prevent sediment entrance during construction or remove the top 2 inches of soil after the site is stabililized. Stabilize the entire contributing drainage area, including the side slopes, before allowing any runoff to enter once construction is complete.
- Place excavated material such that it can not be washed back into the basin if a storm occurs during construction of the facility.
- Build the basin without driving heavy equipment over the infiltration surface. Any equipment driven on the surface should have extra-wide ("low pressure") tires. Prior to any construction, rope off the infiltration area to stop entrance by unwanted equipment.
- After final grading, till the infiltration surface deeply.
- Use appropriate erosion control seed mix for the specific project and location.

## Performance

As water migrates through porous soil and rock, pollutant attenuation mechanisms include precipitation, sorption, physical filtration, and bacterial degradation. If functioning properly, this approach is presumed to have high removal efficiencies for particulate pollutants and moderate removal of soluble pollutants. Actual pollutant removal in the subsurface would be expected to vary depending upon site-specific soil types. This technology eliminates discharge to surface waters except for the very largest storms; consequently, complete removal of all stormwater constituents can be assumed.

There remain some concerns about the potential for groundwater contamination despite the findings of the NURP and Nightingale (1975; 1987a,b,c; 1989). For instance, a report by Pitt et al. (1994) highlighted the potential for groundwater contamination from intentional and unintentional stormwater infiltration. That report recommends that infiltration facilities not be sited in areas where high concentrations are present or where there is a potential for spills of toxic material. Conversely, Schroeder (1995) reported that there was no evidence of groundwater impacts from an infiltration basin serving a large industrial catchment in Fresno, CA.

## Siting Criteria

The key element in siting infiltration basins is identifying sites with appropriate soil and hydrogeologic properties, which is critical for long term performance. In one study conducted in Prince George's County, Maryland (Galli, 1992), all of the infiltration basins investigated clogged within 2 years. It is believed that these failures were for the most part due to allowing infiltration at sites with rates of less than 0.5 in/hr, basing siting on soil type rather than field infiltration tests, and poor construction practices that resulted in soil compaction of the basin invert.

A study of 23 infiltration basins in the Pacific Northwest showed better long-term performance in an area with highly permeable soils (Hilding, 1996). In this study, few of the infiltration basins had failed after 10 years. Consequently, the following guidelines for identifying appropriate soil and subsurface conditions should be rigorously adhered to.

- Determine soil type (consider RCS soil type 'A, B or C' only) from mapping and consult USDA soil survey tables to review other parameters such as the amount of silt and clay, presence of a restrictive layer or seasonal high water table, and estimated permeability. The soil should not have more than 30% clay or more than 40% of clay and silt combined. Eliminate sites that are clearly unsuitable for infiltration.

- Groundwater separation should be at least 3 m from the basin invert to the measured ground water elevation. There is concern at the state and regional levels of the impact on groundwater quality from infiltrated runoff, especially when the separation between groundwater and the surface is small.

- Location away from buildings, slopes and highway pavement (greater than 6 m) and wells and bridge structures (greater than 30 m). Sites constructed of fill, having a base flow or with a slope greater than 15% should not be considered.

- Ensure that adequate head is available to operate flow splitter structures (to allow the basin to be offline) without ponding in the splitter structure or creating backwater upstream of the splitter.

- Base flow should not be present in the tributary watershed.

***Secondary Screening Based on Site Geotechnical Investigation***

- At least three in-hole conductivity tests shall be performed using USBR 7300-89 or Bouwer-Rice procedures (the latter if groundwater is encountered within the boring), two tests at different locations within the proposed basin and the third down gradient by no more than approximately 10 m. The tests shall measure permeability in the side slopes and the bed within a depth of 3 m of the invert.
- The minimum acceptable hydraulic conductivity as measured in any of the three required test holes is 13 mm/hr. If any test hole shows less than the minimum value, the site should be disqualified from further consideration.
- Exclude from consideration sites constructed in fill or partially in fill unless no silts or clays are present in the soil boring. Fill tends to be compacted, with clays in a dispersed rather than flocculated state, greatly reducing permeability.
- The geotechnical investigation should be such that a good understanding is gained as to how the stormwater runoff will move in the soil (horizontally or vertically) and if there are any geological conditions that could inhibit the movement of water.

## Additional Design Guidelines

(1) Basin Sizing - The required water quality volume is determined by local regulations or sufficient to capture 85% of the annual runoff.

(2) Provide pretreatment if sediment loading is a maintenance concern for the basin.

(3) Include energy dissipation in the inlet design for the basins. Avoid designs that include a permanent pool to reduce opportunity for standing water and associated vector problems.

(4) Basin invert area should be determined by the equation:

$$A = \frac{WQV}{kt}$$

where A = Basin invert area ($m^2$)

WQV = water quality volume ($m^3$)

k = 0.5 times the lowest field-measured hydraulic conductivity (m/hr)

t = drawdown time ( 48 hr)

(5) The use of vertical piping, either for distribution or infiltration enhancement shall not be allowed to avoid device classification as a Class V injection well per 40 CFR146.5(e)(4).

## Maintenance

Regular maintenance is critical to the successful operation of infiltration basins. Recommended operation and maintenance guidelines include:

- Inspections and maintenance to ensure that water infiltrates into the subsurface completely (recommended infiltration rate of 72 hours or less) and that vegetation is carefully managed to prevent creating mosquito and other vector habitats.
- Observe drain time for the design storm after completion or modification of the facility to confirm that the desired drain time has been obtained.
- Schedule semiannual inspections for beginning and end of the wet season to identify potential problems such as erosion of the basin side slopes and invert, standing water, trash and debris, and sediment accumulation.
- Remove accumulated trash and debris in the basin at the start and end of the wet season.
- Inspect for standing water at the end of the wet season.
- Trim vegetation at the beginning and end of the wet season to prevent establishment of woody vegetation and for aesthetic and vector reasons.
- Remove accumulated sediment and regrade when the accumulated sediment volume exceeds 10% of the basin.
- If erosion is occurring within the basin, revegetate immediately and stabilize with an erosion control mulch or mat until vegetation cover is established.
- To avoid reversing soil development, scarification or other disturbance should only be performed when there are actual signs of clogging, rather than on a routine basis. Always remove deposited sediments before scarification, and use a hand-guided rotary tiller, if possible, or a disc harrow pulled by a very light tractor.

## Cost

Infiltration basins are relatively cost-effective practices because little infrastructure is needed when constructing them. One study estimated the total construction cost at about $2 per ft (adjusted for inflation) of storage for a 0.25-acre basin (SWRPC, 1991). As with other BMPs, these published cost estimates may deviate greatly from what might be incurred at a specific site. For instance, Caltrans spent about $18/ft$^3$ for the two infiltration basins constructed in southern California, each of which had a water quality volume of about 0.34 ac.-ft. Much of the higher cost can be attributed to changes in the storm drain system necessary to route the runoff to the basin locations.

Infiltration basins typically consume about 2 to 3% of the site draining to them, which is relatively small. Additional space may be required for buffer, landscaping, access road, and fencing. Maintenance costs are estimated at 5 to 10% of construction costs.

One cost concern associated with infiltration practices is the maintenance burden and longevity. If improperly maintained, infiltration basins have a high failure rate. Thus, it may be necessary to replace the basin with a different technology after a relatively short period of time.

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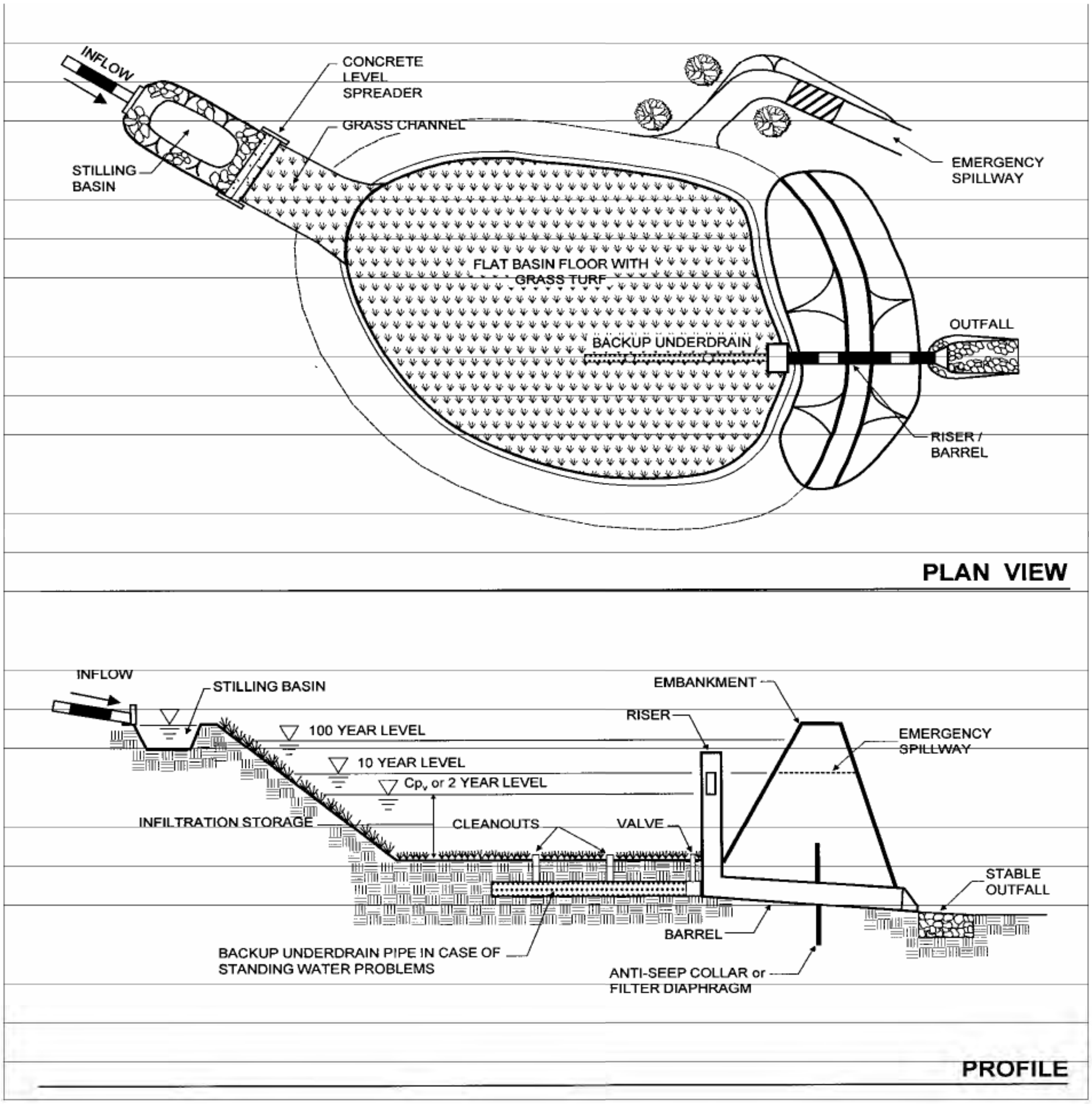
INFLOW
CONCRETE LEVEL SPREADER
GRASS CHANNEL
STILLING BASIN
EMERGENCY SPILLWAY
FLAT BASIN FLOOR WITH GRASS TURF
OUTFALL
BACKUP UNDERDRAIN
RISER / BARREL
PLAN VIEW
INFLOW
STILLING BASIN
EMBANKMENT
RISER
100 YEAR LEVEL
EMERGENCY SPILLWAY
10 YEAR LEVEL
Cpv or 2 YEAR LEVEL
INFILTRATION STORAGE
CLEANOUTS
VALVE
STABLE OUTFALL
BARREL
BACKUP UNDERDRAIN PIPE IN CASE OF STANDING WATER PROBLEMS
ANTI-SEEP COLLAR or FILTER DIAPHRAGM
PROFILE

# Extended Detention Basin TC-22

## Design Considerations

- Tributary Area
- Area Required
- Hydraulic Head

## Description

Dry extended detention ponds (a.k.a. dry ponds, extended detention basins, detention ponds, extended detention ponds) are basins whose outlets have been designed to detain the stormwater runoff from a water quality design storm for some minimum time (e.g., 48 hours) to allow particles and associated pollutants to settle. Unlike wet ponds, these facilities do not have a large permanent pool. They can also be used to provide flood control by including additional flood detention storage.

## California Experience

Caltrans constructed and monitored 5 extended detention basins in southern California with design drain times of 72 hours. Four of the basins were earthen, less costly and had substantially better load reduction because of infiltration that occurred, than the concrete basin. The Caltrans study reaffirmed the flexibility and performance of this conventional technology. The small headloss and few siting constraints suggest that these devices are one of the most applicable technologies for stormwater treatment.

## Advantages

- Due to the simplicity of design, extended detention basins are relatively easy and inexpensive to construct and operate.
- Extended detention basins can provide substantial capture of sediment and the toxics fraction associated with particulates.
- Widespread application with sufficient capture volume can provide significant control of channel erosion and enlargement caused by changes to flow frequency

## Targeted Constituents

| | Constituent | Effectiveness |
|---|---|---|
| ☑ | Sediment | ▲ |
| ☑ | Nutrients | ● |
| ☑ | Trash | ■ |
| ☑ | Metals | ▲ |
| ☑ | Bacteria | ▲ |
| ☑ | Oil and Grease | ▲ |
| ☑ | Organics | ▲ |

**Legend** ***(Removal Effectiveness)***

● Low ■ High

▲ Medium

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relationships resulting from the increase of impervious cover in a watershed.

## Limitations

- Limitation of the diameter of the orifice may not allow use of extended detention in watersheds of less than 5 acres (would require an orifice with a diameter of less than 0.5 inches that would be prone to clogging).
- Dry extended detention ponds have only moderate pollutant removal when compared to some other structural stormwater practices, and they are relatively ineffective at removing soluble pollutants.
- Although wet ponds can increase property values, dry ponds can actually detract from the value of a home due to the adverse aesthetics of dry, bare areas and inlet and outlet structures.

## Design and Sizing Guidelines

- Capture volume determined by local requirements or sized to treat 85% of the annual runoff volume.
- Outlet designed to discharge the capture volume over a period of hours.
- Length to width ratio of at least 1.5:1 where feasible.
- Basin depths optimally range from 2 to 5 feet.
- Include energy dissipation in the inlet design to reduce resuspension of accumulated sediment.
- A maintenance ramp and perimeter access should be included in the design to facilitate access to the basin for maintenance activities and for vector surveillance and control.
- Use a draw down time of 48 hours in most areas of California. Draw down times in excess of 48 hours may result in vector breeding, and should be used only after coordination with local vector control authorities. Draw down times of less than 48 hours should be limited to BMP drainage areas with coarse soils that readily settle and to watersheds where warming may be determined to downstream fisheries.

## Construction/Inspection Considerations

- Inspect facility after first large to storm to determine whether the desired residence time has been achieved.
- When constructed with small tributary area, orifice sizing is critical and inspection should verify that flow through additional openings such as bolt holes does not occur.

## Performance

One objective of stormwater management practices can be to reduce the flood hazard associated with large storm events by reducing the peak flow associated with these storms. Dry extended detention basins can easily be designed for flood control, and this is actually the primary purpose of most detention ponds.

Dry extended detention basins provide moderate pollutant removal, provided that the recommended design features are incorporated. Although they can be effective at removing some pollutants through settling, they are less effective at removing soluble pollutants because of the absence of a permanent pool. Several studies are available on the effectiveness of dry extended detention ponds including one recently concluded by Caltrans (2002).

The load reduction is greater than the concentration reduction because of the substantial infiltration that occurs. Although the infiltration of stormwater is clearly beneficial to surface receiving waters, there is the potential for groundwater contamination. Previous research on the effects of incidental infiltration on groundwater quality indicated that the risk of contamination is minimal.

There were substantial differences in the amount of infiltration that were observed in the earthen basins during the Caltrans study. On average, approximately 40 percent of the runoff entering the unlined basins infiltrated and was not discharged. The percentage ranged from a high of about 60 percent to a low of only about 8 percent for the different facilities. Climatic conditions and local water table elevation are likely the principal causes of this difference. The least infiltration occurred at a site located on the coast where humidity is higher and the basin invert is within a few meters of sea level. Conversely, the most infiltration occurred at a facility located well inland in Los Angeles County where the climate is much warmer and the humidity is less, resulting in lower soil moisture content in the basin floor at the beginning of storms.

Vegetated detention basins appear to have greater pollutant removal than concrete basins. In the Caltrans study, the concrete basin exported sediment and associated pollutants during a number of storms. Export was not as common in the earthen basins, where the vegetation appeared to help stabilize the retained sediment.

### Siting Criteria

Dry extended detention ponds are among the most widely applicable stormwater management practices and are especially useful in retrofit situations where their low hydraulic head requirements allow them to be sited within the constraints of the existing storm drain system. In addition, many communities have detention basins designed for flood control. It is possible to modify these facilities to incorporate features that provide water quality treatment and/or channel protection. Although dry extended detention ponds can be applied rather broadly, designers need to ensure that they are feasible at the site in question. This section provides basic guidelines for siting dry extended detention ponds.

In general, dry extended detention ponds should be used on sites with a minimum area of 5 acres. With this size catchment area, the orifice size can be on the order of 0.5 inches. On smaller sites, it can be challenging to provide channel or water quality control because the orifice diameter at the outlet needed to control relatively small storms becomes very small and thus prone to clogging. In addition, it is generally more cost-effective to control larger drainage areas due to the economies of scale.

Extended detention basins can be used with almost all soils and geology, with minor design adjustments for regions of rapidly percolating soils such as sand. In these areas, extended detention ponds may need an impermeable liner to prevent ground water contamination.

The base of the extended detention facility should not intersect the water table. A permanently wet bottom may become a mosquito breeding ground. Research in Southwest Florida (Santana et al., 1994) demonstrated that intermittently flooded systems, such as dry extended detention ponds, produce more mosquitoes than other pond systems, particularly when the facilities remained wet for more than 3 days following heavy rainfall.

A study in Prince George's County, Maryland, found that stormwater management practices can increase stream temperatures (Galli, 1990). Overall, dry extended detention ponds increased temperature by about 5°F. In cold water streams, dry ponds should be designed to detain stormwater for a relatively short time (i.e., 24 hours) to minimize the amount of warming that occurs in the basin.

## Additional Design Guidelines

In order to enhance the effectiveness of extended detention basins, the dimensions of the basin must be sized appropriately. Merely providing the required storage volume will not ensure maximum constituent removal. By effectively configuring the basin, the designer will create a long flow path, promote the establishment of low velocities, and avoid having stagnant areas of the basin. To promote settling and to attain an appealing environment, the design of the basin should consider the length to width ratio, cross-sectional areas, basin slopes and pond configuration, and aesthetics (Young et al., 1996).

Energy dissipation structures should be included for the basin inlet to prevent resuspension of accumulated sediment. The use of stilling basins for this purpose should be avoided because the standing water provides a breeding area for mosquitoes.

Extended detention facilities should be sized to completely capture the water quality volume. A micropool is often recommended for inclusion in the design and one is shown in the schematic diagram. These small permanent pools greatly increase the potential for mosquito breeding and complicate maintenance activities; consequently, they are not recommended for use in California.

A large aspect ratio may improve the performance of detention basins; consequently, the outlets should be placed to maximize the flowpath through the facility. The ratio of flowpath length to width from the inlet to the outlet should be at least 1.5:1 (L:W) where feasible. Basin depths optimally range from 2 to 5 feet.

The facility's drawdown time should be regulated by an orifice or weir. In general, the outflow structure should have a trash rack or other acceptable means of preventing clogging at the entrance to the outflow pipes. The outlet design implemented by Caltrans in the facilities constructed in San Diego County used an outlet riser with orifices

**Figure 1**
**Example of Extended Detention Outlet Structure**

sized to discharge the water quality volume, and the riser overflow height was set to the design storm elevation. A stainless steel screen was placed around the outlet riser to ensure that the orifices would not become clogged with debris. Sites either used a separate riser or broad crested weir for overflow of runoff for the 25 and greater year storms. A picture of a typical outlet is presented in Figure 1.

The outflow structure should be sized to allow for complete drawdown of the water quality volume in 72 hours. No more than 50% of the water quality volume should drain from the facility within the first 24 hours. The outflow structure can be fitted with a valve so that discharge from the basin can be halted in case of an accidental spill in the watershed.

### *Summary of Design Recommendations*

(1) Facility Sizing - The required water quality volume is determined by local regulations or the basin should be sized to capture and treat 85% of the annual runoff volume. See Section 5.5.1 of the handbook for a discussion of volume-based design.

Basin Configuration – A high aspect ratio may improve the performance of detention basins; consequently, the outlets should be placed to maximize the flowpath through the facility. The ratio of flowpath length to width from the inlet to the outlet should be at least 1.5:1 (L:W). The flowpath length is defined as the distance from the inlet to the outlet as measured at the surface. The width is defined as the mean width of the basin. Basin depths optimally range from 2 to 5 feet. The basin may include a sediment forebay to provide the opportunity for larger particles to settle out.

A micropool should not be incorporated in the design because of vector concerns. For online facilities, the principal and emergency spillways must be sized to provide 1.0 foot of freeboard during the 25-year event and to safely pass the flow from 100-year storm.

(2) Pond Side Slopes - Side slopes of the pond should be 3:1 (H:V) or flatter for grass stabilized slopes. Slopes steeper than 3:1 (H:V) must be stabilized with an appropriate slope stabilization practice.

(3) Basin Lining – Basins must be constructed to prevent possible contamination of groundwater below the facility.

(4) Basin Inlet – Energy dissipation is required at the basin inlet to reduce resuspension of accumulated sediment and to reduce the tendency for short-circuiting.

(5) Outflow Structure - The facility's drawdown time should be regulated by a gate valve or orifice plate. In general, the outflow structure should have a trash rack or other acceptable means of preventing clogging at the entrance to the outflow pipes.

The outflow structure should be sized to allow for complete drawdown of the water quality volume in 72 hours. No more than 50% of the water quality volume should drain from the facility within the first 24 hours. The outflow structure should be fitted with a valve so that discharge from the basin can be halted in case of an accidental spill in the watershed. This same valve also can be used to regulate the rate of discharge from the basin.

The discharge through a control orifice is calculated from:

$$Q = CA(2g(H-H_o))^{0.5}$$

where: $Q$ = discharge ($ft^3/s$)
$C$ = orifice coefficient
$A$ = area of the orifice ($ft^2$)
$g$ = gravitational constant (32.2)
$H$ = water surface elevation (ft)
$H_o$ = orifice elevation (ft)

Recommended values for C are 0.66 for thin materials and 0.80 when the material is thicker than the orifice diameter. This equation can be implemented in spreadsheet form with the pond stage/volume relationship to calculate drain time. To do this, use the initial height of the water above the orifice for the water quality volume. Calculate the discharge and assume that it remains constant for approximately 10 minutes. Based on that discharge, estimate the total discharge during that interval and the new elevation based on the stage volume relationship. Continue to iterate until H is approximately equal to $H_o$. When using multiple orifices the discharge from each is summed.

(6) Splitter Box - When the pond is designed as an offline facility, a splitter structure is used to isolate the water quality volume. The splitter box, or other flow diverting approach, should be designed to convey the 25-year storm event while providing at least 1.0 foot of freeboard along pond side slopes.

(7) Erosion Protection at the Outfall - For online facilities, special consideration should be given to the facility's outfall location. Flared pipe end sections that discharge at or near the stream invert are preferred. The channel immediately below the pond outfall should be modified to conform to natural dimensions, and lined with large stone riprap placed over filter cloth. Energy dissipation may be required to reduce flow velocities from the primary spillway to non-erosive velocities.

(8) Safety Considerations - Safety is provided either by fencing of the facility or by managing the contours of the pond to eliminate dropoffs and other hazards. Earthen side slopes should not exceed 3:1 (H:V) and should terminate on a flat safety bench area. Landscaping can be used to impede access to the facility. The primary spillway opening must not permit access by small children. Outfall pipes above 48 inches in diameter should be fenced.

## Maintenance

Routine maintenance activity is often thought to consist mostly of sediment and trash and debris removal; however, these activities often constitute only a small fraction of the maintenance hours. During a recent study by Caltrans, 72 hours of maintenance was performed annually, but only a little over 7 hours was spent on sediment and trash removal. The largest recurring activity was vegetation management, routine mowing. The largest absolute number of hours was associated with vector control because of mosquito breeding that occurred in the stilling basins (example of standing water to be avoided) installed as energy dissipaters. In most cases, basic housekeeping practices such as removal of debris accumulations and vegetation management to ensure that the basin dewaters completely in 48-72 hours is sufficient to prevent creating mosquito and other vector habitats.

Consequently, maintenance costs should be estimated based primarily on the mowing frequency and the time required. Mowing should be done at least annually to avoid establishment of woody vegetation, but may need to be performed much more frequently if aesthetics are an important consideration.

Typical activities and frequencies include:

- Schedule semiannual inspection for the beginning and end of the wet season for standing water, slope stability, sediment accumulation, trash and debris, and presence of burrows.
- Remove accumulated trash and debris in the basin and around the riser pipe during the semiannual inspections. The frequency of this activity may be altered to meet specific site conditions.
- Trim vegetation at the beginning and end of the wet season and inspect monthly to prevent establishment of woody vegetation and for aesthetic and vector reasons.
- Remove accumulated sediment and re-grade about every 10 years or when the accumulated sediment volume exceeds 10 percent of the basin volume. Inspect the basin each year for accumulated sediment volume.

## Cost

### *Construction Cost*

The construction costs associated with extended detention basins vary considerably. One recent study evaluated the cost of all pond systems (Brown and Schueler, 1997). Adjusting for inflation, the cost of dry extended detention ponds can be estimated with the equation:

$$C = 12.4V^{0.760}$$

where: C = Construction, design, and permitting cost, and
V = Volume ($ft^3$).

Using this equation, typical construction costs are:

$ 41,600 for a 1 acre-foot pond

$ 239,000 for a 10 acre-foot pond

$ 1,380,000 for a 100 acre-foot pond

Interestingly, these costs are generally slightly higher than the predicted cost of wet ponds (according to Brown and Schueler, 1997) on a cost per total volume basis, which highlights the difficulty of developing reasonably accurate construction estimates. In addition, a typical facility constructed by Caltrans cost about $160,000 with a capture volume of only 0.3 ac-ft.

An economic concern associated with dry ponds is that they might detract slightly from the value of adjacent properties. One study found that dry ponds can actually detract from the perceived value of homes adjacent to a dry pond by between 3 and 10 percent (Emmerling-Dinovo, 1995).

### Maintenance Cost

For ponds, the annual cost of routine maintenance is typically estimated at about 3 to 5 percent of the construction cost (EPA website). Alternatively, a community can estimate the cost of the maintenance activities outlined in the maintenance section. Table 1 presents the maintenance costs estimated by Caltrans based on their experience with five basins located in southern California. Again, it should be emphasized that the vast majority of hours are related to vegetation management (mowing).

**Table 1 Estimated Average Annual Maintenance Effort**

| Activity | Labor Hours | Equipment & Material ($) | Cost |
|---|---|---|---|
| Inspections | 4 | 7 | 183 |
| Maintenance | 49 | 126 | 2282 |
| Vector Control | 0 | 0 | 0 |
| Administration | 3 | 0 | 132 |
| Materials | - | 535 | 535 |
| **Total** | **56** | **$668** | **$3,132** |

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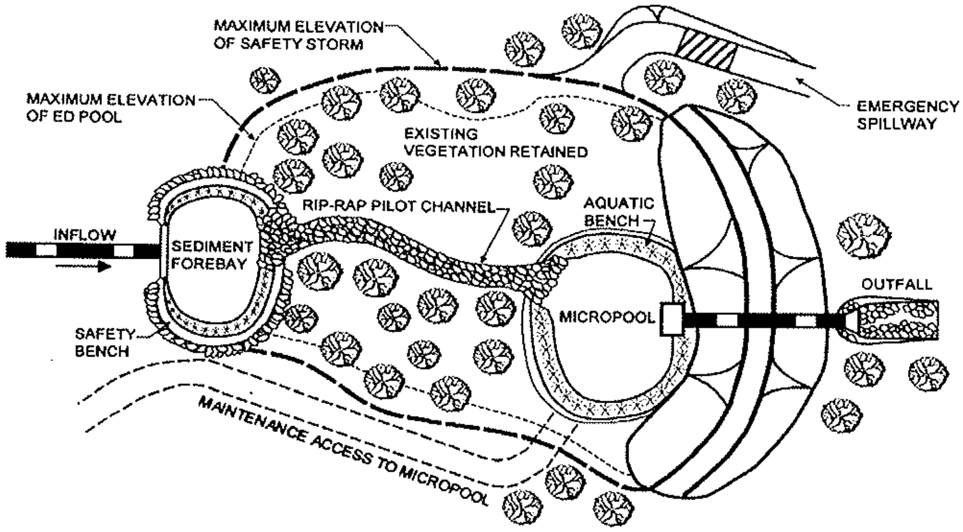
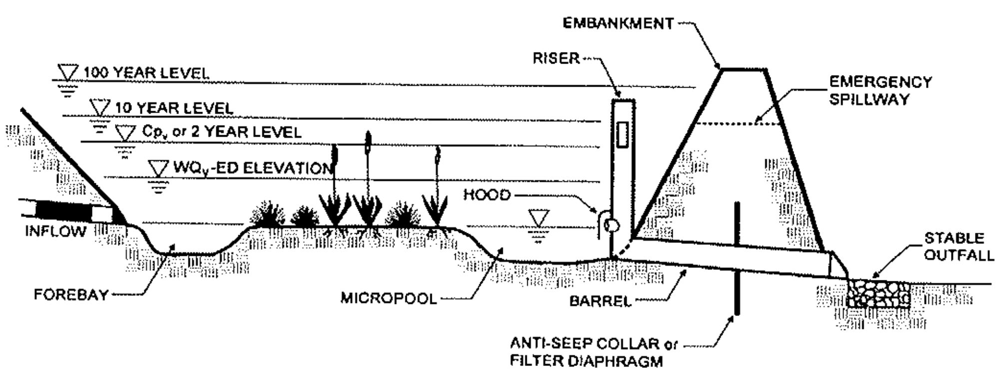



PLAN VIEW




PROFILE

**Schematic of an Extended Detention Basin (MDE, 2000)**

## Design Considerations

- Tributary Area
- Area Required
- Slope
- Water Availability

## Description

Vegetated swales are open, shallow channels with vegetation covering the side slopes and bottom that collect and slowly convey runoff flow to downstream discharge points. They are designed to treat runoff through filtering by the vegetation in the channel, filtering through a subsoil matrix, and/or infiltration into the underlying soils. Swales can be natural or manmade. They trap particulate pollutants (suspended solids and trace metals), promote infiltration, and reduce the flow velocity of stormwater runoff. Vegetated swales can serve as part of a stormwater drainage system and can replace curbs, gutters and storm sewer systems.

## Targeted Constituents

| | | |
|---|---|---|
| ☑ | Sediment | ▲ |
| ☑ | Nutrients | ● |
| ☑ | Trash | ● |
| ☑ | Metals | ▲ |
| ☑ | Bacteria | ● |
| ☑ | Oil and Grease | ▲ |
| ☑ | Organics | ▲ |

**Legend *(Removal Effectiveness)***

● Low ■ High

▲ Medium

## California Experience

Caltrans constructed and monitored six vegetated swales in southern California. These swales were generally effective in reducing the volume and mass of pollutants in runoff. Even in the areas where the annual rainfall was only about 10 inches/yr, the vegetation did not require additional irrigation. One factor that strongly affected performance was the presence of large numbers of gophers at most of the sites. The gophers created earthen mounds, destroyed vegetation, and generally reduced the effectiveness of the controls for TSS reduction.

## Advantages

- If properly designed, vegetated, and operated, swales can serve as an aesthetic, potentially inexpensive urban development or roadway drainage conveyance measure with significant collateral water quality benefits.

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- Roadside ditches should be regarded as significant potential swale/buffer strip sites and should be utilized for this purpose whenever possible.

## Limitations

- Can be difficult to avoid channelization.
- May not be appropriate for industrial sites or locations where spills may occur
- Grassed swales cannot treat a very large drainage area. Large areas may be divided and treated using multiple swales.
- A thick vegetative cover is needed for these practices to function properly.
- They are impractical in areas with steep topography.
- They are not effective and may even erode when flow velocities are high, if the grass cover is not properly maintained.
- In some places, their use is restricted by law: many local municipalities require curb and gutter systems in residential areas.
- Swales are mores susceptible to failure if not properly maintained than other treatment BMPs.

## Design and Sizing Guidelines

- Flow rate based design determined by local requirements or sized so that 85% of the annual runoff volume is discharged at less than the design rainfall intensity.
- Swale should be designed so that the water level does not exceed 2/3rds the height of the grass or 4 inches, which ever is less, at the design treatment rate.
- Longitudinal slopes should not exceed 2.5%
- Trapezoidal channels are normally recommended but other configurations, such as parabolic, can also provide substantial water quality improvement and may be easier to mow than designs with sharp breaks in slope.
- Swales constructed in cut are preferred, or in fill areas that are far enough from an adjacent slope to minimize the potential for gopher damage. Do not use side slopes constructed of fill, which are prone to structural damage by gophers and other burrowing animals.
- A diverse selection of low growing, plants that thrive under the specific site, climatic, and watering conditions should be specified. Vegetation whose growing season corresponds to the wet season are preferred. Drought tolerant vegetation should be considered especially for swales that are not part of a regularly irrigated landscaped area.
- The width of the swale should be determined using Manning's Equation using a value of 0.25 for Manning's n.

### *Construction/Inspection Considerations*

- Include directions in the specifications for use of appropriate fertilizer and soil amendments based on soil properties determined through testing and compared to the needs of the vegetation requirements.
- Install swales at the time of the year when there is a reasonable chance of successful establishment without irrigation; however, it is recognized that rainfall in a given year may not be sufficient and temporary irrigation may be used.
- If sod tiles must be used, they should be placed so that there are no gaps between the tiles; stagger the ends of the tiles to prevent the formation of channels along the swale or strip.
- Use a roller on the sod to ensure that no air pockets form between the sod and the soil.
- Where seeds are used, erosion controls will be necessary to protect seeds for at least 75 days after the first rainfall of the season.

## Performance

The literature suggests that vegetated swales represent a practical and potentially effective technique for controlling urban runoff quality. While limited quantitative performance data exists for vegetated swales, it is known that check dams, slight slopes, permeable soils, dense grass cover, increased contact time, and small storm events all contribute to successful pollutant removal by the swale system. Factors decreasing the effectiveness of swales include compacted soils, short runoff contact time, large storm events, frozen ground, short grass heights, steep slopes, and high runoff velocities and discharge rates.

Conventional vegetated swale designs have achieved mixed results in removing particulate pollutants. A study performed by the Nationwide Urban Runoff Program (NURP) monitored three grass swales in the Washington, D.C., area and found no significant improvement in urban runoff quality for the pollutants analyzed. However, the weak performance of these swales was attributed to the high flow velocities in the swales, soil compaction, steep slopes, and short grass height.

Another project in Durham, NC, monitored the performance of a carefully designed artificial swale that received runoff from a commercial parking lot. The project tracked 11 storms and concluded that particulate concentrations of heavy metals (Cu, Pb, Zn, and Cd) were reduced by approximately 50 percent. However, the swale proved largely ineffective for removing soluble nutrients.

The effectiveness of vegetated swales can be enhanced by adding check dams at approximately 17 meter (50 foot) increments along their length (See Figure 1). These dams maximize the retention time within the swale, decrease flow velocities, and promote particulate settling. Finally, the incorporation of vegetated filter strips parallel to the top of the channel banks can help to treat sheet flows entering the swale.

Only 9 studies have been conducted on all grassed channels designed for water quality (Table 1). The data suggest relatively high removal rates for some pollutants, but negative removals for some bacteria, and fair performance for phosphorus.

**Table 1 Grassed swale pollutant removal efficiency data**

| Study | TSS | TP | TN | $NO_3$ | Metals | Bacteria | Type |
|---|---|---|---|---|---|---|---|
| | **Removal Efficiencies (% Removal)** | | | | | | |
| Caltrans 2002 | 77 | 8 | 67 | 66 | 83-90 | -33 | dry swales |
| Goldberg 1993 | 67.8 | 4.5 | - | 31.4 | 42–62 | -100 | grassed channel |
| Seattle Metro and Washington Department of Ecology 1992 | 60 | 45 | - | -25 | 2–16 | -25 | grassed channel |
| Seattle Metro and Washington Department of Ecology, 1992 | 83 | 29 | - | -25 | 46–73 | -25 | grassed channel |
| Wang et al., 1981 | 80 | - | - | - | 70–80 | - | dry swale |
| Dorman et al., 1989 | 98 | 18 | - | 45 | 37–81 | - | dry swale |
| Harper, 1988 | 87 | 83 | 84 | 80 | 88–90 | - | dry swale |
| Kercher et al., 1983 | 99 | 99 | 99 | 99 | 99 | - | dry swale |
| Harper, 1988. | 81 | 17 | 40 | 52 | 37–69 | - | wet swale |
| Koon, 1995 | 67 | 39 | - | 9 | -35 to 6 | - | wet swale |

While it is difficult to distinguish between different designs based on the small amount of available data, grassed channels generally have poorer removal rates than wet and dry swales, although some swales appear to export soluble phosphorus (Harper, 1988; Koon, 1995). It is not clear why swales export bacteria. One explanation is that bacteria thrive in the warm swale soils.

## Siting Criteria

The suitability of a swale at a site will depend on land use, size of the area serviced, soil type, slope, imperviousness of the contributing watershed, and dimensions and slope of the swale system (Schueler et al., 1992). In general, swales can be used to serve areas of less than 10 acres, with slopes no greater than 5 %. Use of natural topographic lows is encouraged and natural drainage courses should be regarded as significant local resources to be kept in use (Young et al., 1996).

### *Selection Criteria (NCTCOG, 1993)*

- Comparable performance to wet basins
- Limited to treating a few acres
- Availability of water during dry periods to maintain vegetation
- Sufficient available land area

Research in the Austin area indicates that vegetated controls are effective at removing pollutants even when dormant. Therefore, irrigation is not required to maintain growth during dry periods, but may be necessary only to prevent the vegetation from dying.

The topography of the site should permit the design of a channel with appropriate slope and cross-sectional area. Site topography may also dictate a need for additional structural controls. Recommendations for longitudinal slopes range between 2 and 6 percent. Flatter slopes can be used, if sufficient to provide adequate conveyance. Steep slopes increase flow velocity, decrease detention time, and may require energy dissipating and grade check. Steep slopes also can be managed using a series of check dams to terrace the swale and reduce the slope to within acceptable limits. The use of check dams with swales also promotes infiltration.

## Additional Design Guidelines

Most of the design guidelines adopted for swale design specify a minimum hydraulic residence time of 9 minutes. This criterion is based on the results of a single study conducted in Seattle, Washington (Seattle Metro and Washington Department of Ecology, 1992), and is not well supported. Analysis of the data collected in that study indicates that pollutant removal at a residence time of 5 minutes was not significantly different, although there is more variability in that data. Therefore, additional research in the design criteria for swales is needed. Substantial pollutant removal has also been observed for vegetated controls designed solely for conveyance (Barrett et al, 1998); consequently, some flexibility in the design is warranted.

Many design guidelines recommend that grass be frequently mowed to maintain dense coverage near the ground surface. Recent research (Colwell et al., 2000) has shown mowing frequency or grass height has little or no effect on pollutant removal.

### *Summary of Design Recommendations*

1) The swale should have a length that provides a minimum hydraulic residence time of at least 10 minutes. The maximum bottom width should not exceed 10 feet unless a dividing berm is provided. The depth of flow should not exceed 2/3rds the height of the grass at the peak of the water quality design storm intensity. The channel slope should not exceed 2.5%.

2) A design grass height of 6 inches is recommended.

3) Regardless of the recommended detention time, the swale should be not less than 100 feet in length.

4) The width of the swale should be determined using Manning's Equation, at the peak of the design storm, using a Manning's n of 0.25.

5) The swale can be sized as both a treatment facility for the design storm and as a conveyance system to pass the peak hydraulic flows of the 100-year storm if it is located "on-line." The side slopes should be no steeper than 3:1 (H:V).

6) Roadside ditches should be regarded as significant potential swale/buffer strip sites and should be utilized for this purpose whenever possible. If flow is to be introduced through curb cuts, place pavement slightly above the elevation of the vegetated areas. Curb cuts should be at least 12 inches wide to prevent clogging.

7) Swales must be vegetated in order to provide adequate treatment of runoff. It is important to maximize water contact with vegetation and the soil surface. For general purposes, select fine, close-growing, water-resistant grasses. If possible, divert runoff (other than necessary irrigation) during the period of vegetation

establishment. Where runoff diversion is not possible, cover graded and seeded areas with suitable erosion control materials.

## Maintenance

The useful life of a vegetated swale system is directly proportional to its maintenance frequency. If properly designed and regularly maintained, vegetated swales can last indefinitely. The maintenance objectives for vegetated swale systems include keeping up the hydraulic and removal efficiency of the channel and maintaining a dense, healthy grass cover.

Maintenance activities should include periodic mowing (with grass never cut shorter than the design flow depth), weed control, watering during drought conditions, reseeding of bare areas, and clearing of debris and blockages. Cuttings should be removed from the channel and disposed in a local composting facility. Accumulated sediment should also be removed manually to avoid concentrated flows in the swale. The application of fertilizers and pesticides should be minimal.

Another aspect of a good maintenance plan is repairing damaged areas within a channel. For example, if the channel develops ruts or holes, it should be repaired utilizing a suitable soil that is properly tamped and seeded. The grass cover should be thick; if it is not, reseed as necessary. Any standing water removed during the maintenance operation must be disposed to a sanitary sewer at an approved discharge location. Residuals (e.g., silt, grass cuttings) must be disposed in accordance with local or State requirements. Maintenance of grassed swales mostly involves maintenance of the grass or wetland plant cover. Typical maintenance activities are summarized below:

- Inspect swales at least twice annually for erosion, damage to vegetation, and sediment and debris accumulation preferably at the end of the wet season to schedule summer maintenance and before major fall runoff to be sure the swale is ready for winter. However, additional inspection after periods of heavy runoff is desirable. The swale should be checked for debris and litter, and areas of sediment accumulation.

- Grass height and mowing frequency may not have a large impact on pollutant removal. Consequently, mowing may only be necessary once or twice a year for safety or aesthetics or to suppress weeds and woody vegetation.

- Trash tends to accumulate in swale areas, particularly along highways. The need for litter removal is determined through periodic inspection, but litter should always be removed prior to mowing.

- Sediment accumulating near culverts and in channels should be removed when it builds up to 75 mm (3 in.) at any spot, or covers vegetation.

- Regularly inspect swales for pools of standing water. Swales can become a nuisance due to mosquito breeding in standing water if obstructions develop (e.g. debris accumulation, invasive vegetation) and/or if proper drainage slopes are not implemented and maintained.

## Cost

### *Construction Cost*

Little data is available to estimate the difference in cost between various swale designs. One study (SWRPC, 1991) estimated the construction cost of grassed channels at approximately \$0.25 per $ft^2$. This price does not include design costs or contingencies. Brown and Schueler (1997) estimate these costs at approximately 32 percent of construction costs for most stormwater management practices. For swales, however, these costs would probably be significantly higher since the construction costs are so low compared with other practices. A more realistic estimate would be a total cost of approximately \$0.50 per $ft^2$, which compares favorably with other stormwater management practices.

**Table 2 Swale Cost Estimate (SEWRPC, 1991)**

| Component | Unit | Extent | Unit Cost | | | Total Cost | | |
|---|---|---|---|---|---|---|---|---|
| | | | Low | Moderate | High | Low | Moderate | High |
| Mobilization / Demobilization-Light | Swale | 1 | $107 | $274 | $441 | $107 | $274 | $441 |
| Site Preparation | | | | | | | | |
| Clearing[b]............... | Acre | 0.5 | $2,200 | $3,800 | $5,400 | $1,100 | $1,900 | $2,700 |
| Grubbing[c]............. | Acre | 0.25 | $3,800 | $5,200 | $6,600 | $950 | $1,300 | $1,650 |
| General Excavation[d]........... | $Yd^3$ | 372 | $2.10 | $3.70 | $5.30 | $781 | $1,376 | $1,972 |
| Level and Till[e]........ | $Yd^2$ | 1,210 | $0.20 | $0.35 | $0.50 | $242 | $424 | $605 |
| Sites Development | | | | | | | | |
| Salvaged Topsoil Seed, and Mulch[f].. | $Yd^2$ | 1,210 | $0.40 | $1.00 | $1.60 | $484 | $1,210 | $1,936 |
| Sod[g]..................... | $Yd^2$ | 1,210 | $1.20 | $2.40 | $3.60 | $1,452 | $2,904 | $4,356 |
| **Subtotal** | -- | -- | -- | -- | -- | $5,116 | $9,388 | $13,660 |
| Contingencies | Swale | 1 | 25% | 25% | 25% | $1,279 | $2,347 | $3,415 |
| **Total** | -- | -- | -- | -- | -- | $6,395 | $11,735 | $17,075 |

Source: (SEWRPC, 1991)

Note: Mobilization/demobilization refers to the organization and planning involved in establishing a vegetative swale.

[a] Swale has a bottom width of 1.0 foot, a top width of 10 feet with 1:3 side slopes, and a 1,000-foot length.

[b] Area cleared = (top width + 10 feet) x swale length.

[c] Area grubbed = (top width x swale length).

[d] Volume excavated = (0.67 x top width x swale depth) x swale length (parabolic cross-section).

[e] Area tilled = $\left(\text{top width} + \frac{8(\text{swale depth}^2)}{3(\text{top width})}\right)$ x swale length (parabolic cross-section).

[f] Area seeded = area cleared x 0.5.

[g] Area sodded = area cleared x 0.5.

**Table 3 Estimated Maintenance Costs (SEWRPC, 1991)**

| Component | Unit Cost | Swale Size (Depth and Top Width) | | Comment |
|---|---|---|---|---|
| | | 1.5 Foot Depth, One-Foot Bottom Width, 10-Foot Top Width | 3-Foot Depth, 3-Foot Bottom Width, 21-Foot Top Width | |
| Lawn Mowing | $0.85 / 1,000 ft$^2$/ mowing | $0.14 / linear foot | $0.21 / linear foot | Lawn maintenance area=(top width + 10 feet) x length. Mow eight times per year |
| General Lawn Care | $9.00 / 1,000 ft$^2$/ year | $0.18 / linear foot | $0.28 / linear foot | Lawn maintenance area = (top width + 10 feet) x length |
| Swale Debris and Litter Removal | $0.10 / linear foot / year | $0.10 / linear foot | $0.10 / linear foot | – |
| Grass Reseeding with Mulch and Fertilizer | $0.30 / yd$^2$ | $0.01 / linear foot | $0.01 / linear foot | Area revegetated equals 1% of lawn maintenance area per year |
| Program Administration and Swale Inspection | $0.15 / linear foot / year, plus $25 / inspection | $0.15 / linear foot | $0.15 / linear foot | Inspect four times per year |
| **Total** | -- | **$0.58 / linear foot** | **$ 0.75 / linear foot** | – |

***Maintenance Cost***

Caltrans (2002) estimated the expected annual maintenance cost for a swale with a tributary area of approximately 2 ha at approximately $2,700. Since almost all maintenance consists of mowing, the cost is fundamentally a function of the mowing frequency. Unit costs developed by SEWRPC are shown in Table 3. In many cases vegetated channels would be used to convey runoff and would require periodic mowing as well, so there may be little additional cost for the water quality component. Since essentially all the activities are related to vegetation management, no special training is required for maintenance personnel.

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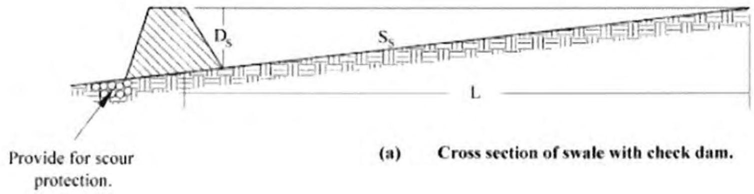
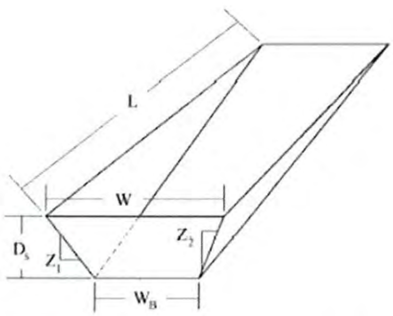



(a) Cross section of swale with check dam.




(b) Dimensional view of swale impoundment area.

**Notation:**

L = Length of swale impoundment area per check dam (ft)
$D_S$ = Depth of check dam (ft)
$S_S$ = Bottom slpe of swale (ft/ft)
W = Top width of check dam (ft)
$W_B$ = Bottom width of check dam (ft)
$Z_{1\&2}$ = Ratio of horizontal to vertical change in swale side slope (ft/ft)

## Design Considerations

- Soil for Infiltration
- Tributary Area
- Slope
- Aesthetics
- Environmental Side-effects

## Description

The bioretention best management practice (BMP) functions as a soil and plant-based filtration device that removes pollutants through a variety of physical, biological, and chemical treatment processes. These facilities normally consist of a grass buffer strip, sand bed, ponding area, organic layer or mulch layer, planting soil, and plants. The runoff's velocity is reduced by passing over or through buffer strip and subsequently distributed evenly along a ponding area. Exfiltration of the stored water in the bioretention area planting soil into the underlying soils occurs over a period of days.

## California Experience

None documented. Bioretention has been used as a stormwater BMP since 1992. In addition to Prince George's County, MD and Alexandria, VA, bioretention has been used successfully at urban and suburban areas in Montgomery County, MD; Baltimore County, MD; Chesterfield County, VA; Prince William County, VA; Smith Mountain Lake State Park, VA; and Cary, NC.

## Advantages

- Bioretention provides stormwater treatment that enhances the quality of downstream water bodies by temporarily storing runoff in the BMP and releasing it over a period of four days to the receiving water (EPA, 1999).
- The vegetation provides shade and wind breaks, absorbs noise, and improves an area's landscape.

## Limitations

- The bioretention BMP is not recommended for areas with slopes greater than 20% or where mature tree removal would

## Targeted Constituents

| | Constituent | Effectiveness |
|---|---|---|
| ☑ | Sediment | ■ |
| ☑ | Nutrients | ▲ |
| ☑ | Trash | ■ |
| ☑ | Metals | ■ |
| ☑ | Bacteria | ■ |
| ☑ | Oil and Grease | ■ |
| ☑ | Organics | ■ |

**Legend *(Removal Effectiveness)***

● Low ■ High

▲ Medium

be required since clogging may result, particularly if the BMP receives runoff with high sediment loads (EPA, 1999).

- Bioretention is not a suitable BMP at locations where the water table is within 6 feet of the ground surface and where the surrounding soil stratum is unstable.
- By design, bioretention BMPs have the potential to create very attractive habitats for mosquitoes and other vectors because of highly organic, often heavily vegetated areas mixed with shallow water.
- In cold climates the soil may freeze, preventing runoff from infiltrating into the planting soil.

## Design and Sizing Guidelines

- The bioretention area should be sized to capture the design storm runoff.
- In areas where the native soil permeability is less than 0.5 in/hr an underdrain should be provided.
- Recommended minimum dimensions are 15 feet by 40 feet, although the preferred width is 25 feet. Excavated depth should be 4 feet.
- Area should drain completely within 72 hours.
- Approximately 1 tree or shrub per 50 $ft^2$ of bioretention area should be included.
- Cover area with about 3 inches of mulch.

### *Construction/Inspection Considerations*

Bioretention area should not be established until contributing watershed is stabilized.

## Performance

Bioretention removes stormwater pollutants through physical and biological processes, including adsorption, filtration, plant uptake, microbial activity, decomposition, sedimentation and volatilization (EPA, 1999). Adsorption is the process whereby particulate pollutants attach to soil (e.g., clay) or vegetation surfaces. Adequate contact time between the surface and pollutant must be provided for in the design of the system for this removal process to occur. Thus, the infiltration rate of the soils must not exceed those specified in the design criteria or pollutant removal may decrease. Pollutants removed by adsorption include metals, phosphorus, and hydrocarbons. Filtration occurs as runoff passes through the bioretention area media, such as the sand bed, ground cover, and planting soil.

Common particulates removed from stormwater include particulate organic matter, phosphorus, and suspended solids. Biological processes that occur in wetlands result in pollutant uptake by plants and microorganisms in the soil. Plant growth is sustained by the uptake of nutrients from the soils, with woody plants locking up these nutrients through the seasons. Microbial activity within the soil also contributes to the removal of nitrogen and organic matter. Nitrogen is removed by nitrifying and denitrifying bacteria, while aerobic bacteria are responsible for the decomposition of the organic matter. Microbial processes require oxygen and can result in depleted oxygen levels if the bioretention area is not adequately aerated. Sedimentation occurs in the swale or ponding area as the velocity slows and solids fall out of suspension.

The removal effectiveness of bioretention has been studied during field and laboratory studies conducted by the University of Maryland (Davis et al, 1998). During these experiments, synthetic stormwater runoff was pumped through several laboratory and field bioretention areas to simulate typical storm events in Prince George's County, MD. Removal rates for heavy metals and nutrients are shown in Table 1.

**Table 1 Laboratory and Estimated Bioretention Davis et al. (1998); PGDER (1993)**

| Pollutant | Removal Rate |
|---|---|
| Total Phosphorus | 70-83% |
| Metals (Cu, Zn, Pb) | 93-98% |
| TKN | 68-80% |
| Total Suspended Solids | 90% |
| Organics | 90% |
| Bacteria | 90% |

Results for both the laboratory and field experiments were similar for each of the pollutants analyzed. Doubling or halving the influent pollutant levels had little effect on the effluent pollutants concentrations (Davis et al, 1998).

The microbial activity and plant uptake occurring in the bioretention area will likely result in higher removal rates than those determined for infiltration BMPs.

## Siting Criteria

Bioretention BMPs are generally used to treat stormwater from impervious surfaces at commercial, residential, and industrial areas (EPA, 1999). Implementation of bioretention for stormwater management is ideal for median strips, parking lot islands, and swales. Moreover, the runoff in these areas can be designed to either divert directly into the bioretention area or convey into the bioretention area by a curb and gutter collection system.

The best location for bioretention areas is upland from inlets that receive sheet flow from graded areas and at areas that will be excavated (EPA, 1999). In order to maximize treatment effectiveness, the site must be graded in such a way that minimizes erosive conditions as sheet flow is conveyed to the treatment area. Locations where a bioretention area can be readily incorporated into the site plan without further environmental damage are preferred. Furthermore, to effectively minimize sediment loading in the treatment area, bioretention only should be used in stabilized drainage areas.

## Additional Design Guidelines

The layout of the bioretention area is determined after site constraints such as location of utilities, underlying soils, existing vegetation, and drainage are considered (EPA, 1999). Sites with loamy sand soils are especially appropriate for bioretention because the excavated soil can be backfilled and used as the planting soil, thus eliminating the cost of importing planting soil.

The use of bioretention may not be feasible given an unstable surrounding soil stratum, soils with clay content greater than 25 percent, a site with slopes greater than 20 percent, and/or a site with mature trees that would be removed during construction of the BMP.

Bioretention can be designed to be off-line or on-line of the existing drainage system (EPA, 1999). The drainage area for a bioretention area should be between 0.1 and 0.4 hectares (0.25 and 1.0 acres). Larger drainage areas may require multiple bioretention areas. Furthermore, the maximum drainage area for a bioretention area is determined by the expected rainfall intensity and runoff rate. Stabilized areas may erode when velocities are greater than 5 feet per second (1.5 meter per second). The designer should determine the potential for erosive conditions at the site.

The size of the bioretention area, which is a function of the drainage area and the runoff generated from the area is sized to capture the water quality volume.

The recommended minimum dimensions of the bioretention area are 15 feet (4.6 meters) wide by 40 feet (12.2 meters) long, where the minimum width allows enough space for a dense, randomly-distributed area of trees and shrubs to become established. Thus replicating a natural forest and creating a microclimate, thereby enabling the bioretention area to tolerate the effects of heat stress, acid rain, runoff pollutants, and insect and disease infestations which landscaped areas in urban settings typically are unable to tolerate. The preferred width is 25 feet (7.6 meters), with a length of twice the width. Essentially, any facilities wider than 20 feet (6.1 meters) should be twice as long as they are wide, which promotes the distribution of flow and decreases the chances of concentrated flow.

In order to provide adequate storage and prevent water from standing for excessive periods of time the ponding depth of the bioretention area should not exceed 6 inches (15 centimeters). Water should not be left to stand for more than 72 hours. A restriction on the type of plants that can be used may be necessary due to some plants' water intolerance. Furthermore, if water is left standing for longer than 72 hours mosquitoes and other insects may start to breed.

The appropriate planting soil should be backfilled into the excavated bioretention area. Planting soils should be sandy loam, loamy sand, or loam texture with a clay content ranging from 10 to 25 percent.

Generally the soil should have infiltration rates greater than 0.5 inches (1.25 centimeters) per hour, which is typical of sandy loams, loamy sands, or loams. The pH of the soil should range between 5.5 and 6.5, where pollutants such as organic nitrogen and phosphorus can be adsorbed by the soil and microbial activity can flourish. Additional requirements for the planting soil include a 1.5 to 3 percent organic content and a maximum 500 ppm concentration of soluble salts.

Soil tests should be performed for every 500 cubic yards (382 cubic meters) of planting soil, with the exception of pH and organic content tests, which are required only once per bioretention area (EPA, 1999). Planting soil should be 4 inches (10.1 centimeters) deeper than the bottom of the largest root ball and 4 feet (1.2 meters) altogether. This depth will provide adequate soil for the plants' root systems to become established, prevent plant damage due to severe wind, and provide adequate moisture capacity. Most sites will require excavation in order to obtain the recommended depth.

Planting soil depths of greater than 4 feet (1.2 meters) may require additional construction practices such as shoring measures (EPA, 1999). Planting soil should be placed in 18 inches or greater lifts and lightly compacted until the desired depth is reached. Since high canopy trees may be destroyed during maintenance the bioretention area should be vegetated to resemble a terrestrial forest community ecosystem that is dominated by understory trees. Three species each of both trees and shrubs are recommended to be planted at a rate of 2500 trees and shrubs per hectare (1000 per acre). For instance, a 15 foot (4.6 meter) by 40 foot (12.2 meter) bioretention area (600 square feet or 55.75 square meters) would require 14 trees and shrubs. The shrub-to-tree ratio should be 2:1 to 3:1.

Trees and shrubs should be planted when conditions are favorable. Vegetation should be watered at the end of each day for fourteen days following its planting. Plant species tolerant of pollutant loads and varying wet and dry conditions should be used in the bioretention area.

The designer should assess aesthetics, site layout, and maintenance requirements when selecting plant species. Adjacent non-native invasive species should be identified and the designer should take measures, such as providing a soil breach to eliminate the threat of these species invading the bioretention area. Regional landscaping manuals should be consulted to ensure that the planting of the bioretention area meets the landscaping requirements established by the local authorities. The designers should evaluate the best placement of vegetation within the bioretention area. Plants should be placed at irregular intervals to replicate a natural forest. Trees should be placed on the perimeter of the area to provide shade and shelter from the wind. Trees and shrubs can be sheltered from damaging flows if they are placed away from the path of the incoming runoff. In cold climates, species that are more tolerant to cold winds, such as evergreens, should be placed in windier areas of the site.

Following placement of the trees and shrubs, the ground cover and/or mulch should be established. Ground cover such as grasses or legumes can be planted at the beginning of the growing season. Mulch should be placed immediately after trees and shrubs are planted. Two to 3 inches (5 to 7.6 cm) of commercially-available fine shredded hardwood mulch or shredded hardwood chips should be applied to the bioretention area to protect from erosion.

### Maintenance

The primary maintenance requirement for bioretention areas is that of inspection and repair or replacement of the treatment area's components. Generally, this involves nothing more than the routine periodic maintenance that is required of any landscaped area. Plants that are appropriate for the site, climatic, and watering conditions should be selected for use in the bioretention cell. Appropriately selected plants will aide in reducing fertilizer, pesticide, water, and overall maintenance requirements. Bioretention system components should blend over time through plant and root growth, organic decomposition, and the development of a natural soil horizon. These biologic and physical processes over time will lengthen the facility's life span and reduce the need for extensive maintenance.

Routine maintenance should include a biannual health evaluation of the trees and shrubs and subsequent removal of any dead or diseased vegetation (EPA, 1999). Diseased vegetation should be treated as needed using preventative and low-toxic measures to the extent possible. BMPs have the potential to create very attractive habitats for mosquitoes and other vectors because of highly organic, often heavily vegetated areas mixed with shallow water. Routine inspections for areas of standing water within the BMP and corrective measures to restore proper infiltration rates are necessary to prevent creating mosquito and other vector habitat. In addition, bioretention BMPs are susceptible to invasion by aggressive plant species such as cattails, which increase the chances of water standing and subsequent vector production if not routinely maintained.

In order to maintain the treatment area's appearance it may be necessary to prune and weed. Furthermore, mulch replacement is suggested when erosion is evident or when the site begins to look unattractive. Specifically, the entire area may require mulch replacement every two to three years, although spot mulching may be sufficient when there are random void areas. Mulch replacement should be done prior to the start of the wet season.

New Jersey's Department of Environmental Protection states in their bioretention systems standards that accumulated sediment and debris removal (especially at the inflow point) will normally be the primary maintenance function. Other potential tasks include replacement of dead vegetation, soil pH regulation, erosion repair at inflow points, mulch replenishment, unclogging the underdrain, and repairing overflow structures. There is also the possibility that the cation exchange capacity of the soils in the cell will be significantly reduced over time. Depending on pollutant loads, soils may need to be replaced within 5-10 years of construction (LID, 2000).

## Cost

### *Construction Cost*

Construction cost estimates for a bioretention area are slightly greater than those for the required landscaping for a new development (EPA, 1999). A general rule of thumb (Coffman, 1999) is that residential bioretention areas average about $3 to $4 per square foot, depending on soil conditions and the density and types of plants used. Commercial, industrial and institutional site costs can range between $10 to $40 per square foot, based on the need for control structures, curbing, storm drains and underdrains.

Retrofitting a site typically costs more, averaging $6,500 per bioretention area. The higher costs are attributed to the demolition of existing concrete, asphalt, and existing structures and the replacement of fill material with planting soil. The costs of retrofitting a commercial site in Maryland, Kettering Development, with 15 bioretention areas were estimated at $111,600.

In any bioretention area design, the cost of plants varies substantially and can account for a significant portion of the expenditures. While these cost estimates are slightly greater than those of typical landscaping treatment (due to the increased number of plantings, additional soil excavation, backfill material, use of underdrains etc.), those landscaping expenses that would be required regardless of the bioretention installation should be subtracted when determining the net cost.

Perhaps of most importance, however, the cost savings compared to the use of traditional structural stormwater conveyance systems makes bioretention areas quite attractive financially. For example, the use of bioretention can decrease the cost required for constructing stormwater conveyance systems at a site. A medical office building in Maryland was able to reduce the amount of storm drain pipe that was needed from 800 to 230 feet - a cost savings of $24,000 (PGDER, 1993). And a new residential development spent a total of approximately $100,000 using bioretention cells on each lot instead of nearly $400,000 for the traditional stormwater ponds that were originally planned (Rappahanock, ). Also, in residential areas, stormwater management controls become a part of each property owner's landscape, reducing the public burden to maintain large centralized facilities.

### *Maintenance Cost*

The operation and maintenance costs for a bioretention facility will be comparable to those of typical landscaping required for a site. Costs beyond the normal landscaping fees will include the cost for testing the soils and may include costs for a sand bed and planting soil.

## References and Sources of Additional Information

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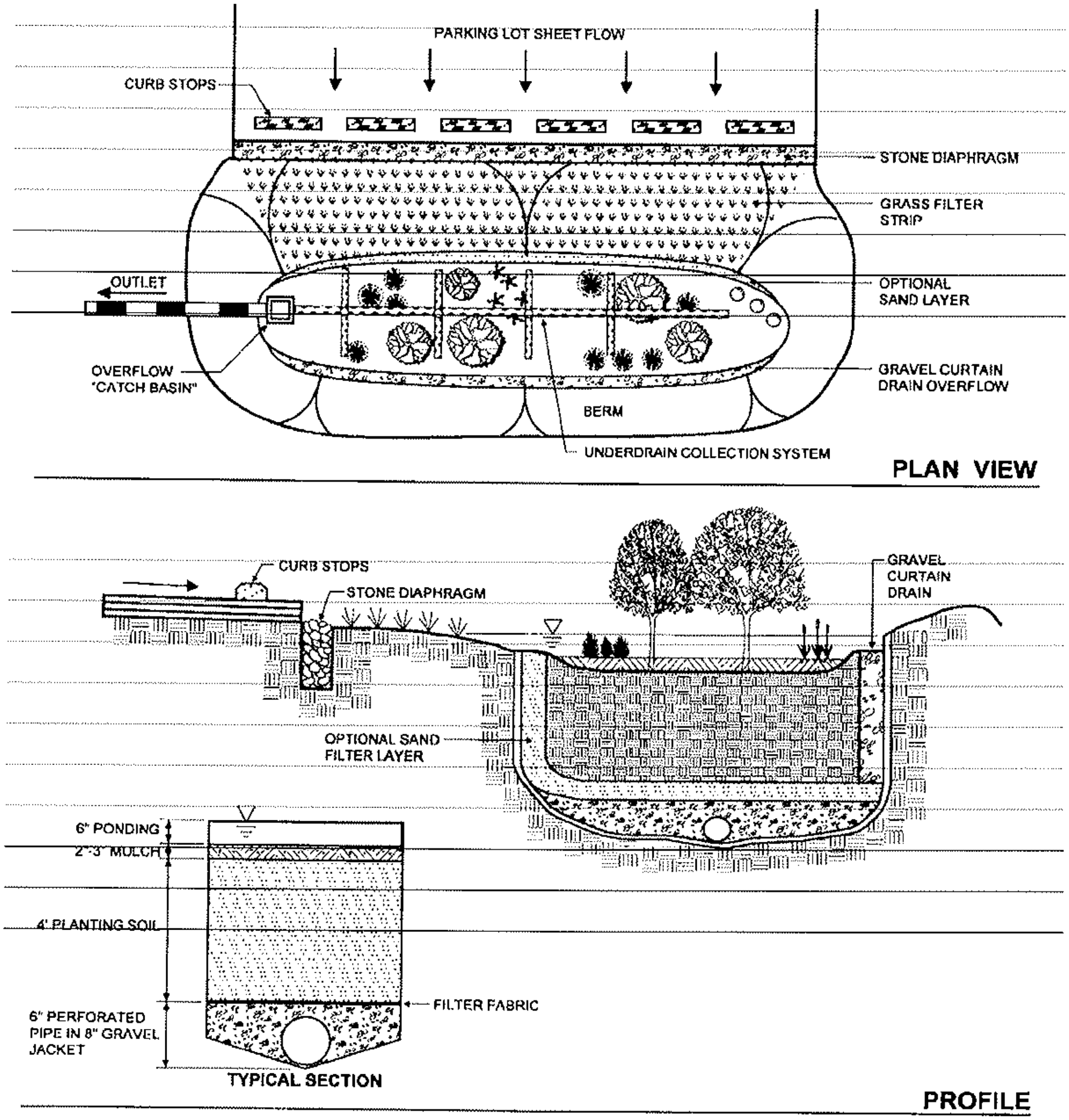


**Schematic of a Bioretention Facility (MDE, 2000)**

# Appendix D
# Stormwater Pollution Prevention Best Management Practices for Homeowner's Associations, Property Managers and Property Owners Manual

# Stormwater Pollution Prevention

*Best Management Practices for Homeowner's Associations, Property Managers and Property Owners*

*Your Guide To Maintaining Water Friendly Standards In Your Community*

**sbcountystormwater.org**

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Redlands • Rialto • San Bernardino • San Bernardino County • San Bernardino County Flood Control District • Upland • Yucaipa

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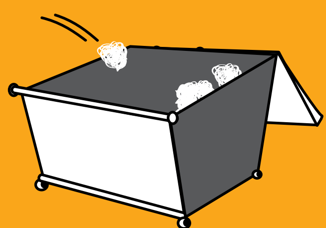
# COMMERCIAL TRASH ENCLOSURES

## FOLLOW THESE **REQUIREMENTS** TO **KEEP OUR WATERWAYS CLEAN**

Trash enclosures, such as those found in commercial and apartment complexes, typically contain materials that are intended to find their way to a landfill or a recycling facility. **These materials are NOT meant to go into our local lakes and rivers.**

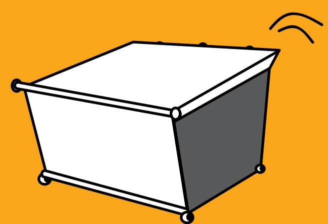
### PROTECT WATER QUALITY BY FOLLOWING THESE SIMPLE STEPS

#### PUT TRASH INSIDE



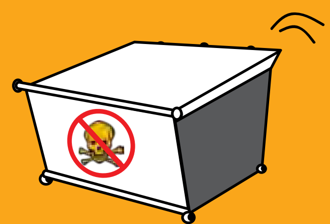
Place trash inside the bin (preferably in sealed bags)

#### CLOSE THE LID



Prevent rain from entering the bin in order to avoid leakage of polluted water runoff

#### KEEP TOXICS OUT



- Paint
- Grease, fats and used oils
- Batteries, electronics and fluorescent lights

### SOME ADDITIONAL GUIDELINES, INCLUDE

✓ **SWEEP FREQUENTLY**
Sweep trash enclosure areas frequently, instead of hosing them down, to prevent polluted water from flowing into the streets and storm drains.

✓ **FIX LEAKS**
Address trash bin leaks immediately by using dry clean up methods and report to your waste hauler to receive a replacement.

✓ **CONSTRUCT ROOF**
Construct a solid cover roof over the existing trash enclosure structure to prevent rainwater from coming into contact with trash and garbage. Check with your local City/County for Building Codes.

In San Bernardino County, stormwater pollution is caused by food waste, landscape waste, chemicals and other debris that are washed into storm drains and end up in our waterways - untreated! You can be part of the solution by maintaining a water-friendly trash enclosure.

**THANK YOU FOR HELPING TO KEEP SAN BERNARDINO COUNTY CLEAN AND HEALTHY!**

San Bernardino County STORMWATER PROGRAM

In the event of a spill or discharge to a storm drain or waterway, contact San Bernadino County Stormwater immediately: (877) WASTE18 | sbcountystormwater.org/report

**sbcountystormwater.org**

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# CESQG PROGRAM

**Conditionally Exempt Small Quantity Generator**

## WHAT IS A CESQG?

Businesses that generate 27 gallons or 220 lbs. of hazardous waste, or 2.2 lbs. of extremely hazardous waste per month are called "Conditionally Exempt Small Quantity Generators," or CESQGs. San Bernardino County Household Hazardous Program provides waste management services to CESQG businesses. The most common CESQGs in San Bernardino County are painters, print shops, auto shops, builders, agricultural operators and property managers, but there are many others. When you call, be ready to describe the types and amounts of waste your business generates in a typical month. If you generate hazardous waste on a regular basis, you must:

- Register with San Bernardino County Fire Department (909) 386-8401 as a hazardous waste generator.
- To obtain an EPA ID# and application form from the State visit www.dtsc.ca.gov.
- Manage hazardous waste in accordance with all applicable local, state and federal laws and regulations.

## HOW DO I GET SERVICE?

To arrange an appointment for the CESQG Program, call 1-800-OILY CAT or 909-382-5401. Be ready to describe the type and amount of hazardous waste your business is ready to dispose of, and the types and size(s) of containers that the waste is in.

### Waste Type and Cost

There is a small handling fee involved in the collection of hazardous waste from your business. Disposal costs depend on the type of waste.

| | |
|---|---|
| Aerosols | $1.29/lb. |
| Automobile motor oil | $.73/gal. |
| Anti-freeze | $1.57/gal. |
| Contaminated oil | $4.48/gal. |
| Car batteries | $.62/ea. |
| Corrosive liquids, solids | $2.80/lb. |
| Flammable solids, liquids | $1.57/lb. |
| Latex Paint | $.73/lb. |
| Mercury | $10.08/lb. |
| NiCad/Alkaline Batteries | $2.13/lb. |
| Oil Base Paints | $1.00/lb. |
| Oil Filters | $.56/ea. |
| Oxidizers | $9.63/lb. |
| PCB Ballasts | $5.94/lb. |
| Pesticides (most) | $2.91/lb. |
| Photofixer, developer | $4.31/gal. |
| Television & Monitors | $11.20/ea. |
| Additional Handling | $138.00/hr. |

*Rates subject to change without notice*

### WE CANNOT ACCEPT

- Radioactives
- Water reactives
- Explosives
- Compressed gas cylinders
- Medical or biohazardous waste
- Asbestos
- Remediation wastes

# HAZARDOUS WASTE

## WHY IS THE FIRE DEPARTMENT COLLECTING HAZARDOUS WASTE?

Small Quantity Generators often have difficulty disposing of small quantities of hazardous waste. Hazardous waste companies usually have a minimum amount of waste that they will pick up, or charge a minimum fee for service. Typically, the minimum fee exceeds the cost of disposal for the hazardous waste. This leaves the small quantity generator in a difficult situation. Some respond by storing hazardous waste until it becomes economical for the hazardous waste transporter to pick it up, putting the business out of compliance by exceeding regulatory accumulation time limits. Other businesses simply store their hazardous wastes indefinitely, creating an unsafe work environment and exceeding accumulation time limits. Yet other businesses attempt to illegally dispose of their waste at household hazardous waste collection facilities. These facilities are not legally permitted to accept commercial wastes, nor are prepared to provide legal documentation for commercial hazardous waste disposal. In answer to the problems identified above, the San Bernardino County Fire Department Household Hazardous Program instituted the Conditionally Exempt Small Quantity Generator Program.

## PAYMENT FOR SERVICES

The CESQG Program will prepare an invoice for your business at the time of service. You can pay at the time of service with cash or a check, or you can mail your payment to the Fire Department within 30 days. Please note that we do not accept credit card payments. The preferred method of payment is to handle payment at time of service. Additional charges may apply for accounts not paid within 30 days.

## ARE THERE ANY OTHER WAYS THAT I CAN SAVE MONEY ON HAZARDOUS WASTE DISPOSAL?

Yes! First, start by reducing the amount of waste that you produce by changing processes or process chemicals, at your business. Next, examine if there is a way that you can recycle your waste back into your processes. Network with similar businesses or trade associations for waste minimization and pollution prevention solutions.

## WHAT IF YOUR BUSINESS DOES NOT QUALIFY?

Call the San Bernardino County Fire Department Field Services Division for assistance with hazardous waste management at 909-386-8401. If you reduce the amount of waste you generate each month to 27 gallons or less, you may qualify in the future.

## WHAT HAPPENS TO YOUR HAZARDOUS WASTE?

Hazardous waste collected by the CESQG Program is transported to a state permitted processing facility in San Bernardino. The waste is further processed at this point and packaged for off-site recycling (oil filters, oil, latex paint, antifreeze, and batteries) or destructive incineration (pesticides, corrosives, flammables, oil based paint).

San Bernardino County Fire Department
CESQG Program
2824 East "W" Street
San Bernardino, CA 92415-0799
Phone: 909-382-5401
Fax: 909-382-5413
www.sbcfire.org/hazmat/hhw.asp
Email: jschwab@sbcfire.org

# WORKING OUTDOORS & HANDLING SPILLS

## WHEN WORKING OUTDOORS USE THE 3Cs

CUANDO TRABAJE AL AIRE LIBRE UTILICE LAS 3Cs

### CONTROL | CONTROL

Locate the nearest storm drain and ensure nothing can enter or be discharged into it.

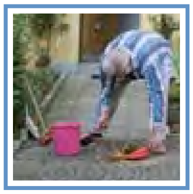
*Ubique el desagüe de aguas pluviales más cercano y asegúrese de que nada pueda ingresar a éste ni descargarse en él.*

### CONTAIN | CONTENER

Isolate your area to prevent material from potentially flowing or being blown away.

*Aísle su área para evitar que el material pueda discurrirse o ser llevado por el viento.*

### CAPTURE | CAPTURAR



Sweep up debris and place it in the trash. Clean up spills with an absorbent material (e.g. kitty litter) or vacuum with a Wet-Vac and dispose of properly.

*Recoja los restos y colóquelos en la basura. Limpie los derrames con un material absorbente (como la arena para gatos) o aspírelos con una Wet-Vac (aspiradora de humedad) y deséchelos correctamente.*

# COMMERCIAL LANDSCAPE

Yard waste, sediments, and toxic lawn/garden chemicals used in commercial landscape maintenance often make their way into the San Bernardino County storm drain system and do not get treated before reaching the Santa Ana River. This pollutes our drinking water and contaminates local waterways, making them unsafe for people and wildlife. Following these best management practices will prevent pollution, comply with regulations and protect public health.

**Recycle Yard Waste**
Recycle leaves, grass clippings and other yard waste. Do not blow, sweep, rake or hose yard waste into the street. Try grasscycling - the natural recycling of grass by leaving clippings on the lawn when mowing. Grass clippings willquickly decompose, returning valuable nutrients to the soil. Further information can be obtained at www.calrecycle.ca.gov/organics.

**Use Fertilizers, Herbicides and Pesticides Safely**
Fertilizers, herbicides and pesticides are often carried into the storm drain system by sprinkler runoff. Use of natural, non-toxic alternatives to the traditional fertilizers, herbicides and pesticides is highly recommended. If you must use chemical fertilizers, herbicides, or pesticides:

- Spot apply pesticides and herbicides, rather than blanketing entire areas.
- Avoid applying near curbs and driveways, and never apply before a rain.
- Apply fertilizers as needed, when plants can best use it, and when the potential for it being carried away by runoff is low.

**Recycle Hazardous Waste**
Pesticides, fertilizers, herbicides and motor oil contaminate landfills and should be disposed of through a Hazardous Waste Facility, which accepts these types of materials. For information on proper disposal call, (909) 386-8401.

**Use Water Wisely**
Conserve water and prevent runoff by controlling the amount of water and direction of sprinklers. Sprinklers should be on long enough to allow water to soak into the ground but not so long as to cause runoff. Periodically inspect, fix leaks and realign sprinkler heads. Plant native vegetation to reduce the need of water, fertilizers, herbicides, and pesticides.

**Prevent Erosion**
Erosion washes sediments, debris and toxic runoff into the storm drain system, polluting waterways.

- Prevent erosion and sediment runoff by using ground cover, berms and vegetation down-slope to capture runoff.
- Avoid excavation or grading during wet weather.

**Store Materials Safely**
Keep landscaping materials and debris away from the street, gutter and storm drains. On-site stockpiles of materials must be covered with plastic sheeting and surrounded with sand bags to protect from rain, wind and runoff.

# SIDEWALK, PLAZA, ENTRY MONUMENT & FOUNTAIN MAINTENANCE

**Pollutants on sidewalks and other pedestrian traffic areas and plazas are typically due to littering and vehicle use. Fountain water containing chlorine and copperbased algaecides is toxic to aquatic life. Proper inspection, cleaning, and repair of pedestrian areas and HOA owned surfaces and structures can reduce pollutant runoff from these areas. Maintaining these areas may involve one or more of the following activities:**

1. **Surface Cleaning**
2. **Graffiti Cleaning**
3. **Sidewalk Repair**
4. **Controlling Litter**
5. **Fountain Maintenance**

## POLLUTION PREVENTION:

Pollution prevention measures have been considered and incorporated in the model procedures. Implementation of these measures may be more effective and reduce or eliminate the need to implement other more complicated or costly procedures. Possible pollution prevention measures for sidewalk, plaza, and fountain maintenance and cleaning include:

- Use dry cleaning methods whenever practical for surface cleaning activities.
- Use the least toxic materials available (e.g. water based paints, gels or sprays for graffiti removal).
- Once per year, educate HOA staff and tenants on pollution prevention measures.

## MODEL PROCEDURES:

### 1. Surface Cleaning

**Discharges of wash water to the storm water drainage system from cleaning or hosing of impervious surfaces is prohibited.**
**Sidewalks, Plazas**

✓ Use dry methods (e.g. sweeping, backpack blowers, vacuuming) whenever practical to clean sidewalks and plazas rather than hosing, pressure washing, or steam cleaning. DO NOT sweep or blow material into curb; use devices that contain the materials.

✓ If water must be used, block storm drain inlets and contain runoff. Discharge wash water to landscaping or contain and dispose of properly.

# SIDEWALK, PLAZA, ENTRY MONUMENT & FOUNTAIN MAINTENANCE

**Parking Areas, Driveways, Drive-thru**

✓ Parking facilities should be swept/vacuumed on a regular basis. Establish frequency of public parking lot sweeping based on usage and field observations of waste accumulation.

✓ If water must be used, block storm drain inlets and contain runoff. Discharge wash water to landscaping or contain and dispose of properly.

✓ Sweep all parking lots at least once before the onset of the wet season.

✓ Use absorbents to pick up oil; then dry sweep.

✓ Appropriately dispose of spilled materials and absorbents.

OPTIONAL:

- Consider increasing sweeping frequency based on factors such as traffic volume, land use, field observations of sediment and trash accumulation, proximity to water courses, etc.

**Building Surfaces, Decks, etc., without loose paint**

✓ Use high-pressure water, no soap.

✓ If water must be used, block storm drain inlets and contain runoff. Discharge wash water to landscaping or contain and dispose of properly.

**Unpainted Building Surfaces, Wood Decks, etc.**

✓ If water must be used, block storm drain inlets and contain runoff. Discharge wash water to landscaping or contain and dispose of properly.

✓ Use biodegradable cleaning agents to remove deposits.

✓ Make sure pH is between 6.5 and 8.5 THEN discharge to landscaping (if cold water without a cleaning agent) otherwise dispose of properly.

## 2. Graffiti Cleaning

**Graffiti Removal**

✓ Avoid graffiti abatement activities during rain events.

✓ When graffiti is removed by painting over, implement the procedures under Painting and Paint Removal in the Roads, Streets, and Highway Operation and Maintenance procedure sheet.

✓ Protect nearby storm drain inlets prior to removing graffiti from walls, signs, sidewalks, or other structures needing graffiti abatement. Clean up afterwards by sweeping or vacuuming thoroughly, and/or by using absorbent and properly disposing of the absorbent.

✓ Note that care should be taken when disposing of waste since it may need to be disposed of as hazardous waste.

OPTIONAL:

• Consider using a waterless and non-toxic chemical cleaning method for graffiti removal (e.g. gels or spray compounds).

## 3. Sidewalk Repair

**Surface Removal and Repair**

✓ Schedule surface removal activities for dry weather if possible.

✓ Avoid creating excess dust when breaking asphalt or concrete.

✓ Take measures to protect nearby storm drain inlets prior to breaking up asphalt or concrete (e.g. place hay bales or sand bags around inlets). Clean afterwards by sweeping up material.

✓ Designate an area for clean up and proper disposal of excess materials.

✓ Remove and recycle as much of the broken pavement as possible.

✓ When making saw cuts in pavement, use as little water as possible. Cover each storm drain inlet with filter fabric during the sawing operation and contain the slurry by placing straw bales, sandbags, or gravel dams around the inlets. After the liquid drains shovel or vacuum the slurry, remove from site and dispose of properly.

✓ Always dry sweep first to clean up tracked dirt. Use a street sweeper or vacuum truck. Do not dump vacuumed liquid in storm drains. Once dry sweeping is complete, the area may be hosed down if needed. Discharge wash water to landscaping, pump to the sanitary sewer if permitted to do so or contain and dispose of properly.

**Concrete Installation and Repair**

✓ Avoid mixing excess amounts of fresh concrete or cement mortar on-site. Only mix what is needed for the job.

✓ Wash concrete trucks off-site or in designated areas on-site, such that there is no discharge of concrete wash water into storm drain inlets, open ditches, streets, or other storm water conveyance structures. (See Concrete Waste Management BMP WM – 8)

✓ Store dry and wet concrete materials under cover, protected from rainfall and runoff and away from drainage areas. After job is complete remove temporary stockpiles (asphalt materials, sand, etc.) and other materials as soon as possible.

✓ Return leftover materials to the transit mixer. Dispose of small amounts of excess concrete, grout, and mortar in the trash.

✓ When washing concrete to remove fine particles and expose the aggregate, contain the wash water for proper disposal.

✓ Do not wash sweepings from exposed aggregate concrete into the street or storm drain. Collect and return sweepings to aggregate base stock pile, or dispose in the trash.

✓ Protect applications of fresh concrete from rainfall and runoff until the material has hardened.

## 4. Litter Control

✓ Enforce anti-litter laws.

✓ Provide litter receptacles in busy, high pedestrian traffic areas of the community, at recreational facilities, and at community events.

✓ Cover litter receptacles and clean out frequently to prevent leaking/spillage or overflow.

OPTIONAL:

• Post "No Littering" signs.

## 5. Fountain Maintenance

✓ Do not use copper-based algaecides. Control algae with chlorine or other alternatives, such as sodium bromide.

✓ Allow chlorine to dissipate for a few days and then recycle/reuse water by draining it gradually onto a landscaped area. Water must be tested prior to discharge to ensure that chlorine is not present (concentration must be less than 0.1 ppm).

✓ Contact local agency for approval to drain into sewer or storm drain.

✓ Avoid mixing excess amounts of fresh concrete or cement mortar on-site. Only mix what is needed for the job.

# EQUIPMENT MAINTENANCE & REPAIR

**Vehicle or equipment maintenance has the potential to be a significant source of stormwater pollution. Engine repair and service (parts cleaning, spilled fuel, oil, etc.), replacement of fluids, and outdoor equipment storage and parking (dripping engines) can all contaminate stormwater. Conducting the following activities in a controlled manner will reduce the potential for stormwater contamination:**

1. **General Maintenance and Repair**
2. **Vehicle and Machine Repair**
3. **Waste Handling/Disposal**

**Related vehicle maintenance activities are covered under the following program headings in this manual: "Vehicle and Equipment Cleaning", "Vehicle and Equipment Storage", and "Vehicle Fueling".**

## POLLUTION PREVENTION:

Pollution prevention measures have been considered and incorporated in the model procedures. Implementation of these measures may be more effective and reduce or eliminate the need to implement other more complicated or costly procedures. Possible pollution prevention measures for equipment maintenance and repair include:

- Review maintenance activities to verify that they minimize the amount of pollutants discharged to receiving waters. Keep accurate maintenance logs to evaluate materials removed and improvements made.

- Switch to non-toxic chemicals for maintenance when possible.

- Choose cleaning agents that can be recycled.

- Minimize use of solvents. Clean parts without using solvents whenever possible. Recycle used motor oil, diesel oil, and other vehicle fluids and parts whenever possible.

- Once per year, educate HOA staff and tenants on pollution prevention measures.

## MODEL PROCEDURES:

### 1. General Maintenance and Repair

**General Guidelines**

> ➔ *Note: Permission must be obtained for any discharge of wash water to the sanitary sewer from the local sewering agency.*

- ✓ Review maintenance activities to verify that they minimize the amount of pollutants discharged to receiving waters. Keep accurate maintenance logs to evaluate materials removed and improvements made.
- ✓ Regularly inspect vehicles and equipment for leaks.
- ✓ Move activity indoors or cover repair area with a permanent roof if feasible.
- ✓ Minimize contact of stormwater with outside operations through berming the local sewering and drainage routing.
- ✓ Place curbs around the immediate boundaries of the process equipment.
- ✓ Clean yard storm drain inlets regularly and stencil them.

**Good Housekeeping**

- ✓ Avoid hosing down work areas. If work areas are washed and if discharge to the sanitary sewer is allowed, treat water with an appropriate treatment device (e.g. clarifier) before discharging. If discharge to the sanitary sewer is not permitted, pump water to a tank and dispose of properly.
- ✓ Collect leaking or dripping fluids in drip pans or container. Fluids are easier to recycle or dispose of properly if kept separate.
- ✓ Keep a drip pan under the vehicle while you unclip hoses, unscrew filters, any discharge of or remove other parts. Place a drip pan under any vehicle that might leak while you work on it to keep splatters or drips off the shop floor.
- ✓ Educate employees on proper handling and disposal of engine fluids.
- ✓ Promptly transfer used fluids to the proper waste or recycling drums. Don't leave full drip pans or other open containers lying around.
- ✓ Do not pour liquid waste to floor drains, sinks, outdoor storm drain inlets, or other storm drains or sewer connections.
- ✓ Post signs at sinks and stencil outdoor storm drain inlets.

### 2. Vehicle Repair

**General Guidelines**

- ✓ Perform vehicle fluid removal or changing inside of a building or in a contained covered area, where feasible, to prevent the run-on of stormwater and the runoff of spills.
- ✓ Regularly inspect vehicles and equipment for leaks, and repair as needed.

- ✓ Use secondary containment, such as a drain pan or drop cloth, to catch spills or leaks when removing or changing fluids.
- ✓ Immediately drain all fluids from wrecked vehicles. Ensure that the drain pan or drip pan is large enough to contain drained fluids (e.g. larger pans are needed to contain antifreeze, which may gush from some vehicles).
- ✓ Promptly transfer used fluids to the proper waste or recycling drums. Don't leave full drip pans or other open containers lying around.
- ✓ Recycle used motor oil, diesel oil, and other vehicle fluids and parts whenever possible.
- ✓ Oil filters disposed of in trash cans or dumpsters can leak oil. Place the oil filter in a funnel over a waste oil recycling drum to drain excess oil before disposal. Oil filters can also be recycled. Ask your oil supplier or recycler about recycling oil filters.
- ✓ Store cracked batteries in a non-leaking secondary container and dispose of properly at recycling facilities or at County hazardous waste disposal site.

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**Vehicle Leak and Spill Control**

- ✓ Use absorbent materials on small spills. Remove the absorbent materials promptly and dispose of properly.
- ✓ Place a stockpile of spill cleanup materials where it will be readily accessible.
- ✓ Sweep floor using dry absorbent material.

## 3. Machine Repair

- ✓ Keep equipment clean; don't allow excessive build-up of oil or grease.
- ✓ Minimize use of solvents.
- ✓ Use secondary containment, such as a drain pan or drop cloth, to catch spills or leaks when removing or changing fluids.
- ✓ Perform major equipment repairs at the corporation yard, when practical.
- ✓ Following good housekeeping measures in Vehicle Repair section.

## 4. Waste Handling/Disposal

**Waste Reduction**

- ✓ Prevent spills and drips of solvents and cleansers to the shop floor.
- ✓ Do liquid cleaning at a centralized station so the solvents and residues stay in one area. Recycle liquid cleaners when feasible.

✓ Locate drip pans, drain boards, and drying racks to direct drips back into a solvent sink or fluid holding tank for reuse.

OPTIONAL:

- If possible, eliminate or reduce the amount of hazardous materials and waste by substituting non-hazardous or less hazardous material:

  -Use non-caustic detergents instead of caustic cleaning for parts cleaning.

  -Use a water-based cleaning service and have tank cleaned. Use detergent-based or water-based cleaning systems in place of organic solvent degreasers.

  -Replace chlorinated organic solvents with non-chlorinated solvents. Non-chlorinated solvents like kerosene or mineral spirits are less toxic and less expensive to dispose of properly. Check list of active ingredients to see whether it contains chlorinated solvents.

  -Choose cleaning agents that can be recycled.

**Recycling**

OPTIONAL:

- Separate wastes for easier recycling. Keep hazardous and non-hazardous wastes separate, do not mix used oil and solvents, and keep chlorinated solvents separate from non-chlorinated solvents.
- Label and track the recycling of waste material (e.g. used oil, spent solvents, batteries).
- Purchase recycled products to support the market for recycled materials.

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## LIMITATIONS:

Space and time limitations may preclude all work being conducted indoors. It may not be possible to contain and clean up spills from vehicles/equipment brought on-site after working hours. Dry floor cleaning methods may not be sufficient for some spills – see spill prevention and control procedures sheet. Identification of engine leaks may require some use of solvents.

# POOL MAINTENANCE

***Pool chemicals and filter solids, when discharged to the City streets, gutters or storm drans, DO NOT GET TREATED before reaching the Santa Ana River. Chlorine, acid cleaning chemicals and metal-based algaecides used in pools can kill beneficial organisms in the food chain and pollute our drinking water.***

**When emptying your swimming pool, spa or fountain, please use one of the following best management practices to prevent water pollution:**

- Reuse the water as landscape irrigation
- Empty the water into the sewer between midnight and 6:00 am
- Remove solids and floating debris and dispose of in the trash, de-chlorinate the water to a chlorine residual = 0, wait 24 hours, then discharge the water to the street or storm drain
- Try not to use metal-based algaecides (i.e. copper sulfate) in your pool or spa. If you have, empty your pool or spa into the sewer. *Prior to discharging pool water into the sanitary sewer system, contact your local agency.*
- If the pool contains algae and mosquito larvae, discharge the water to the sewer

**When acid cleaning or other chemical cleaning:**

- Neutralize the pool water to pH of 6.5 to 8.5, then discharge to the sewer

**For swimming pool and spa filter backwash:**

- Dispose of solids into trash bag, then wash filter into a landscape area
- Settle, dispose of solids in trash and discharge water to the sewer, never to the storm drain

# » For Residents

*The following is a preview of the information we have available to residents. For more fact sheets, visit **sbcountystormwater.org***

**Bear Lake – City Public Service Yard**
42040 Garstin Dr. (cross street: Big Bear Blvd.)
Big Bear Lake, CA 92315
Hours: 2nd & 4th Saturday of each month,
9 am – 12 noon
(800) 645 – 9228

**Chino – Chino City Public Works Services Center**
5050 Schaefer Ave. (cross street: 4th St.)
Chino, CA 91710
Hours: 2nd & 4th Saturday of each month, 8 am – 1 pm
(909) 591 - 9843

**Fontana (For City of Fontana residents only)**
16454 Orange Way (cross street: Cypress Ave.)
Fontana, CA 92335
Hours: Saturdays, 8 am – 12 noon
(909) 350 – 6531

**City of Ontario Household Hazardous Waste Facility**
1430 S. Cucamonga Ave.
Ontario, CA 91761
Hours: Fridays & Saturdays, 9 am – 2 pm
(909) 395 – 2040

**Rancho Cucamonga – Rancho Cucamonga HHW Facility**
12158 Baseline Rd. (cross street: Rochester Ave.)
Rancho Cucamonga, CA 91739
Hours: Saturdays, 8 am – 12 noon
(909) 382 – 5401

**Redlands – Redlands City Yard**
500 Kansas St. (cross street: Park Ave.)
Redlands, CA 92373
Hours: Saturdays, 9:30 am – 12:30 pm
(909) 798 – 7600

**Rialto – City Maintenance Yard**
246 Willow Ave. (cross street: Rialto Ave.)
Rialto, CA 92376
Hours: 2nd & 4th Friday of each month, 2 pm – 4 pm
2nd & 4th Saturday of each month, 10 am – 2 pm
(909) 820 – 2622

**San Bernardino – San Bernardino International Airport**
2824 East "W" St., Building 302
(cross street: Victoria Ave.)
San Bernardino, CA
Hours: Monday – Friday, 9 am – 4 pm
(909) 382 – 5401

**Upland – Upland City Yard**
1370 N. Benson Ave. (cross street: 14th St.)
Upland, CA 91786
Hours: Saturdays, 9 am – 2 pm
(909) 382 – 5401

# WE DID IT OURSELVES AND WE DID IT RIGHT

When painting your home, protect your family and community.

- **PAINTS** that are water-based are less toxic and should be used whenever possible.
- **BRUSHES** with water-based paint should be washed in the sink. Those with oil-based paint should be cleaned with paint thinner.
- **SAFELY** dispose of unwanted paint and paint thinner. The County of San Bernardino offers 9 HHW Centers that accept paint and other household hazardous waste from residents FREE of charge. For a list of acceptable materials, location information, and hours of operation call 1-800-OILY CAT.

# VEHICLE MAINTENANCE

Oil, grease, anti-freeze and other toxic automotive fluids often make their way into the San Bernardino County storm drain system, and do not get treated before reaching the Santa Ana River. This pollutes our drinking water and contaminates waterways, making them unsafe for people and wildlife. Follow these best management practices to prevent pollution and protect public health.

**Cleaning Auto Parts**
Scrape parts with a wire brush or use a bake oven rather than liquid cleaners. Arrange drip pans, drying racks and drain boards so that fluids are directed back into the parts washer or the fluid holding tank. Do not wash parts or equipment in a sink, parking lot, driveway or street.

**Storing Hazardous Waste**
Keep your liquid waste segregated. Many fluids can be recycled via hazardous waste disposal companies if they are not mixed. Store all materials under cover with spill containment or inside to prevent contamination of rainwater runoff.

**Preventing Leaks and Spills**
Conduct all vehicle maintenance inside of a garage. Place drip pans underneath vehicle to capture fluids. Use absorbent materials instead of water to clean work areas.

**Cleaning Spills**
Use dry methods for spill cleanup (sweeping, absorbent materials). To report accidental spills into the street or storm drain call (877) WASTE18 or 911.

**Proper Disposal of Hazardous Waste**
Dispose of household hazardous waste by taking it to your nearest household hazardous waste center. For more information, call 1-800-OILY CAT or check out sbcountystormwater.org/Disposal.html

# FREE

## DOGGIE WASTE BAGS

Remember to pick up after your pet every time to keep San Bernardino County clean and healthy!

# » Get In Touch With Us Online!

**» Website**
*sbcountystormwater.org*

**» eUpdates**
*sbcountystormwater.org/newsletter*

**» Facebook**
*facebook.com/sbcountystormwater*

**» YouTube**
*youtube.com/sbcountystormwater*

**» Report Pollution Violations**
*sbcountystormwater.org/report*

**» Email**
*info@sbcountystormwater.org*

# Appendix E
# Water Quality Calculations

| | | | |
|---|---|---|---|
| Project: RPRP, Prelim Eng Phase | Computed: B.F. | Date: 12-1-12 | |
| Subject: WQ Calcs - total project | Checked: | Date: | |
| Task: Env (Task 9) | Page: 1 | of: 2 | |
| Job #: 43-170063 | No: | | |

HDR | ONE COMPANY *Many Solutions*℠

I. BMP Drainage Area

Project total = 21 ac. (impervious, prop. design)
During PS&E, this area will divided further based on station/parking lot and layover design.

II. NOAA Atlas 14 Precipitation Depth Map

2yr - 1hr. rainfall value ⇒ $I_{2yr} = 0.57$

A. ① Determine $C_{BMP}$ (composite runoff coefficient)

Assume area associated w/ proposed imperviousness are for stations, parking lots, and layover facility.

② BMP Drainage Area Region ⇒ valley

③ Target BMP Flow Rate (AKA WQF)

Per Table D-1

Regression coefficient I = 0.2787

Hence $I_{BMP} = I_{2y} \times$ Reg. Coeff. $\times 2$

$= 0.57 \times 0.2787 \times 2$

$= 0.32$ in/hr.

$WQF = C_{BMP} \times I_{BMP} \times A = 0.90 \times 0.32 \times 21$

WQF = 6 cfs

B. Target BMP volume (AKA WQV)

① watershed impervious ratio
Assume for commercial use, $i = 0.90$

② Composite Runoff coefficient

$$C_{BMP} = 0.858i^3 - 0.78i^2 + 0.774i + 0.04$$
$$= 0.858(0.9)^3 - 0.78(0.9)^2 + 0.774(0.90) + 0.04$$
$$= 0.63 \quad - 0.63 \quad + 0.70 \quad + 0.04$$
$$= 0.74$$

③ Located in Valley Area

④ $P_6 = I_{24} \times$ regression coefficient
$= 0.57 \times 1.4807$
$= 0.84$ in (6 hr. mean storm rainfall)

⑤ Assume drawdown time = 48 hr.
$a = 1.963$

⑥ maximized Detention Volume ($P_o$)
$P_o = a \times C_{BMP} \times P_6 = 1.963 \times 0.74 \times 0.84$
$= 1.22$ in.

$V_o$ = BMP volume (AKA WQV)
$= (P_o \times A)/12$
$= (1.22 \times 21)/12$
$=$ <u>2.1 ac-ft</u>

## INSTRUCTIONS FOR ESTIMATING VOLUME- AND FLOW-BASED BMP DESIGN RUNOFF QUANTITIES[4]

1) Identify the "BMP Drainage Area" that drains to the proposed BMP element. This includes all areas that will drain to the proposed BMP element, including pervious areas, impervious areas, and off-site areas, whether or not they are directly or indirectly connected to the BMP element. Calculate the BMP Drainage Area (A) in acres.

2) Outline the Drainage Area on the NOAA Atlas 14 Precipitation Depths (2-year 1hour Rainfall) map (Figure D-1).

3) Determine the area-averaged 2-year 1-hour rainfall value for the Drainage Area outlined above.

### A. Flow-Based BMP Design

1) Calculate the composite runoff coefficient, CBMP, as defined in part B.2, below.

2) Determine which Region the BMP Drainage Area is located in (Valley, Mountain or Desert).

3) Determine BMP design rainfall intensity, IBMP, by multiplying the area-averaged 2-year 1-hour value from the NOAA Atlas 14 map by the appropriate regression coefficient from Table D-1 ("I"), and then multiplying by the safety factor specified in the criteria—usually a factor of 2.

---

[4] Rainfall analysis to develop regression coefficients in Table D-1 and modifications to the NOAA Atlas 14 map were conducted by:

Hromadka II, T.V., Professor Emeritus, Department of Mathematics, California State University, Fullerton, and Adjunct Professor, Department of Mathematical Sciences, United States Military Academy, West Point, NY

Laton, W.R , Assistant Professor, Department of Geological Sciences, California State University, Fullerton

Picciuto J.A.., Assistant Professor, Department of Mathematical Sciences, United States Military Academy, West Point, NY

With assistance from:

Rene Perez, M.S. Candidate, Department of Geological Sciences, California State University, Fullerton, and

Jim Friel, Ph.D. Professor Emeritus, Department of Mathematics, California State University, Fullerton

Reported as follows:

1. Hromadka II, T.V., Laton, W.R., and Picciuto J.A., 2005. Estimating Runoff Quantities for Flow and Volume-based BMP Design. Final Report to the San Bernardino County Flood Control District.
2. Laton, W.R., Hromadka II, T.V., and Picciuto J.A., 2005. Estimating Runoff Quantities for Flow and Volume-based BMP Design (submitted). Journal of the American Water Resources Association.

4) Calculate the target BMP flow rate, Q, by using the following formula (see Table D-2 below for limitations on the use of this formula):

$$Q = CBMP \cdot IBMP \cdot A$$

where: **Q** = flow in $ft^3/s$

**IBMP** = BMP design rainfall intensity, in inches/hour

**A** = Drainage Area in acres

**CBMP** = composite runoff coefficient

**Table D-1:** Regression Coefficients for Intensity (I) and 6-hour mean storm rainfall (P**6**).

| Quantity | **Valley** 85% upper confidence limit | **Mountain** 85% upper confidence limit | **Desert** 85% upper confidence limit |
|---|---|---|---|
| **I** | **0.2787** | **0.3614** | **0.3250** |
| **P6** | **1.4807** | **1.9090** | **1.2371** |

**Table D-2**: Use of the flow-based formula for BMP Design (CASQA 2003).

| | **Composite Runoff Coefficient, "C"** | | | |
|---|---|---|---|---|
| **BMP Drainage Area (Acres)** | **0.00 to 0.25** | **0.26 to 0.50** | **0.51 to 0.75** | **0.76 to 1.00** |
| **0 to 25** | **Caution** | **Yes** | **Yes** | **Yes** |
| **26 to 50** | **High Caution** | **Caution** | **Yes** | **Yes** |
| **51 to 75** | **Not Recommended** | **High Caution** | **Caution** | **Yes** |
| **76 to 100** | **Not Recommended** | **High Caution** | **Caution** | **Yes** |

If the flow-based BMP formula use case, as determined by Table D-2, shows "Caution," "High Caution," or "Not Recommended," considering the project's characteristics, then he project proponent must calculate the BMP design flow using the unit hydrograph method, as specified in the most current version of the San Bernardino County Hydrology Manual, using the design storm pattern with rainfall return frequency such that the peak one hour rainfall depth equals the 85th-percentile 1-hour rainfall multiplied by two.

## B. Volume-Based BMP Design

1) Calculate the "Watershed Imperviousness Ratio", i, which is equal to the percent of impervious area in the BMP Drainage Area divided by 100.

2) Calculate the composite runoff coefficient CBMP for the Drainage Area above using the following equation:

$$\mathbf{CBMP = 0.858i^3 - 0.78i^2 + 0.774i + 0.04}$$

where: **CBMP** = composite runoff coefficient; and,

**i** = watershed imperviousness ratio.

3) Determine which Region the Drainage Area is located in (Valley, Mountain or Desert).

4) Determine the area-averaged "6-hour Mean Storm Rainfall", P6, for the Drainage Area. This is calculated by multiplying the area averaged 2-year 1-hour value by the appropriate regression coefficient from Table 1.

5) Determine the appropriate drawdown time. Use the regression constant a = 1.582 for 24 hours and a = 1.963 for 48 hours. *Note: Regression constants are provided for both 24 hour and 48 hour drawdown times; however, 48 hour drawdown times should be used in most areas of California. Drawdown times in excess of 48 hours should be used with caution as vector breeding can be a problem after water has stood in excess of 72 hours. (Use of the 24 hour drawdown time should be limited to drainage areas with coarse soils that readily settle and to watersheds where warming may be detrimental to downstream fisheries.)*

6) Calculate the "Maximized Detention Volume", P0, using the following equation:

$$\mathbf{P0 = a \cdot CBMP \cdot P6}$$

where: **P0** = Maximized Detention Volume, in inches

**a** = 1.582 for 24 hour and a = 1.963 for 48 hour drawdown,

**CBMP** = composite runoff coefficient; and,

**P6** = 6-hour Mean Storm Rainfall, in inches

7) Calculate the "Target Capture Volume", V0, using the following equation:

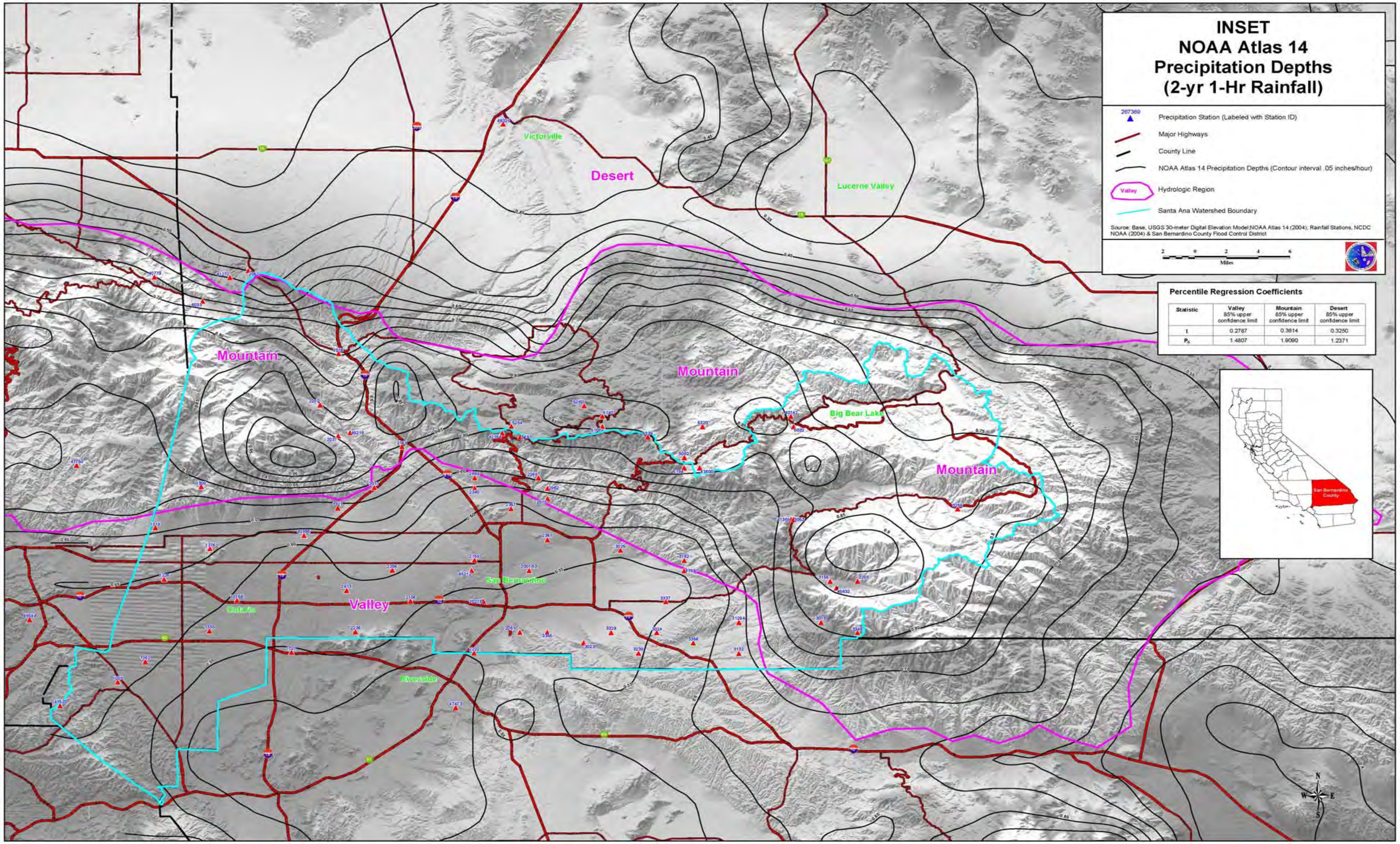
$$\mathbf{V0 = (P0 \cdot A) / 12}$$

where: **V0** = Target Capture Volume, in acre-feet

**P0** = Maximized Detention Volume, in inches; and,

**A** = BMP Drainage Area, in acres

**Figure D-1**: NOAA Atlas 14 Inset Map.




| Statistic | Valley 85% upper confidence limit | Mountain 85% upper confidence limit | Desert 85% upper confidence limit |
|---|---|---|---|
| 1 | 0.2787 | 0.3614 | 0.3250 |
| $P_6$ | 1.4807 | 1.9090 | 1.2371 |

# Appendix F
# Construction Risk Assessment

**Redlands Passenger Rail Project, Preliminary Engineering Phase**
**SWPPP Risk Determination Analysis**

There are two aspects involved in developing a risk determination analysis for a specific project site. The first is to determine the Sediment Risk which involves an R-factor (rainfall erosivity), K-factor (soil erodibility) and LS-factor (topographic). The second is to determine the Receiving Water Risk which involves the impact runoff will have on the receiving water body. The Risk Determination Worksheet provides steps for determining these risk factors. See Attachments.

The following is the methodology used to determine the factors involved to calculate the Risk Level for the Project:

**Sediment Risk**

There are two approaches for determining the sediment risk level according to the Construction General Permit (CGP); GIS Map method or Site-Specific method. This analysis was based on the Site-Specific method. The sediment risk is based upon the RUSLE equation with the three (3) aforementioned factors and is separated into three (3) risk level categories; < 15 tons/acre (low), >15 and <75 tons/acre (medium) and >75 tons/acre (high).

*R-Factor*

The R-factor is based upon the location and duration of construction. The location used to determine the R-factor was done in Google Earth. It is anticipated that the construction schedule will begin 01/01/2015 and end on 12/31/2017. At the time this document was completed, EPA's Rainfall Erosivity Factor Calculator (http://cfpub.epa.gov/npdes/stormwater/LEW/lewcalculator.cfm) was offline. In its place, the USEPA Fact Sheet 3.1 (Storm Water Phase II Final Rule, Construction Rainfall Erosivity Waiver) was utilized. Per associated Figure 1, the Erosivity Index Zone is 25. Per Table 1, the Erosivity Index (EI) from January 1, 2015 to December 31, 2017 is 300%. Per Figure 4, the Isoerodent Value is approximately 40 (see closeup view provided from Google Earth). Hence, the resultant R-factor is 120. See Attachments.

*K-Factor*

Based on site geotechnical data, two general K-Factors were provided; 0.17 and 0.42. The value 0.42 was used as the conservative value. The lower site-specific K-Factor is consistent with the value identified in Google Earth, generally ranging from 0.20 to 0.24. Hence, the resultant K-Factor is 0.42. See Attachments.

*LS-Factor*



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Based on the GIS data available from the SWRCB, Google Earth reflected the LS factors to vary from west to east as 1.19, 1.98, 0.99, and 0.82.

To be conservative, an average LS factor of 1.3 is assumed.

Based on the aforementioned factors, the Project's Sediment Risk is computed to be 65.52 tons/acre and is categorized as *Medium*. See Attachments.

**Receiving Water Risk**

A sediment sensitive watershed drains into a receiving water body (1) listed on EPA's approved CWA 303(d) list for sedimentation/siltation, turbidity with an approved TMDL or (2) designated with beneficial uses of SPAWN, COLD and MIGATORY. The Project discharges to the Santa Ana River Reach 4 and 5. According to the 2006 303(d) List and the 2010 Integrated Report, the Santa Ana River Reach 4 and 5 is not a water body that is impaired by sediment. This was also confirmed by the SWRCB GIS map data on Google Earth. In addition, the receiving water body's designated Beneficial Uses does not include SPAWN, COLD and MIGATORY. Hence, Santa Ana River Reach 4 and 5 are not considered a sediment sensitive watershed, and since both of these criteria do not pertain to the Project the resultant Receiving Water Risk is *Low*. See Attachments.

**Overall Project**

Based on the Sediment Risk and Receiving Water Risk categories, the entire Project is categorized as a combined ***Risk Level 2***. See Attachments.

Sincerely,

Bill Flores, PE, CPESC, CPSWQ, QSD
HDR Engineering, Inc.

| | A | B | C |
|---|---|---|---|
| 1 | **Sediment Risk Factor Worksheet** | | **Entry** |
| 2 | **A) R Factor** | | |
| 3 | Analyses of data indicated that when factors other than rainfall are held constant, soil loss is directly proportional to a rainfall factor composed of total storm kinetic energy (E) times the maximum 30-min intensity (I30) (Wischmeier and Smith, 1958). The numerical value of R is the average annual sum of EI30 for storm events during a rainfall record of at least 22 years. "Isoerodent" maps were developed based on R values calculated for more than 1000 locations in the Western U.S. Refer to the link below to determine the R factor for the project site. | | |
| 4 | http://cfpub.epa.gov/npdes/stormwater/LEW/lewCalculator.cfm | | |
| 5 | **R Factor Value** | | 120 |
| 6 | **B) K Factor (weighted average, by area, for all site soils)** | | |
| 7 | The soil-erodibility factor K represents: (1) susceptibility of soil or surface material to erosion, (2) transportability of the sediment, and (3) the amount and rate of runoff given a particular rainfall input, as measured under a standard condition. Fine-textured soils that are high in clay have low K values (about 0.05 to 0.15) because the particles are resistant to detachment. Coarse-textured soils, such as sandy soils, also have low K values (about 0.05 to 0.2) because of high infiltration resulting in low runoff even though these particles are easily detached. Medium-textured soils, such as a silt loam, have moderate K values (about 0.25 to 0.45) because they are moderately susceptible to particle detachment and they produce runoff at moderate rates. Soils having a high silt content are especially susceptible to erosion and have high K values, which can exceed 0.45 and can be as large as 0.65. Silt-size particles are easily detached and tend to crust, producing high rates and large volumes of runoff. Use Site-specific data must be submitted. | | |
| 8 | Site-specific K factor guidance | | |
| 9 | **K Factor Value** | | 0.42 |
| 10 | **C) LS Factor (weighted average, by area, for all slopes)** | | |
| 11 | The effect of topography on erosion is accounted for by the LS factor, which combines the effects of a hillslope-length factor, L, and a hillslope-gradient factor, S. Generally speaking, as hillslope length and/or hillslope gradient increase, soil loss increases. As hillslope length increases, total soil loss and soil loss per unit area increase due to the progressive accumulation of runoff in the downslope direction. As the hillslope gradient increases, the velocity and erosivity of runoff increases. Use the LS table located in separate tab of this spreadsheet to determine LS factors. Estimate the weighted LS for the site prior to construction. | | |
| 12 | LS Table | | |
| 13 | **LS Factor Value** | | 1.3 |
| 14 | | | |
| 15 | **Watershed Erosion Estimate (=RxKxLS) in tons/acre** | 65.52 | |
| 16 | **Site Sediment Risk Factor** | **Medium** | |
| 17 | Low Sediment Risk: < 15 tons/acre | | |
| 18 | Medium Sediment Risk: >=15 and <75 tons/acre | | |
| 19 | High Sediment Risk: >= 75 tons/acre | | |
| 20 | | | |

**State Water Resources Control Board**

# CONSTRUCTION GENERAL PERMIT
# RISK ASSESSMENT R-FACTOR CALCULATION NOTIFICATION

## NATIONAL POLLUTANT DISCHARGE ELIMINATION SYSTEM (NPDES) GENERAL PERMIT FOR STORM WATER DISCHARGES ASSOCIATED WITH CONSTRUCTION AND LAND DISTURBANCE ACTIVITIES

State Water Resources Control Board Order No. 2009-0009-DWQ, as amended by 2010-0014-DWQ (CGP) requires that dischargers assessing Risk must calculate the Rainfall Erosivity Factor (R-Factor) in the Revised Universal Soil Loss Equation through the Environmental Protection Agency (EPA) Rainfall Erosivity Factor Calculator at: http://cfpub.epa.gov/npdes/stormwater/lew/lewcalculator.cfm

The week of February 13, 2012 the Rainfall Erosivity Factor Calculator became unavailable due to maintenance. EPA has approximated that maintenance may take at least 1 month to complete. Until that time, dischargers shall calculate their project R-factor using the Construction Erosivity Waiver Fact Sheet (Fact Sheet) provided by EPA at http://www.epa.gov/npdes/pubs/fact3-1.pdf (also attached). The Fact Sheet provides the instructions and references needed to calculate R-values for a one year period. Projects active for more than a one year period must calculate the R-factor for year 1, and multiply this value based on the estimated duration.

Please contact the Storm Water Help Desk if you have any questions. 1-866-563-3107 or stormwater@waterboards.ca.gov.

**Examples**:

1. ***Find the R value of a construction project in Sacramento, California with a duration of February 29, 2012 to September 1, 2014 (2.5 years).***

   Figure 1 - Erosivity Index Zone Map:
   The EI distribution zone is 23
   Table 1 – Erosivity Index Table:
   EI percentage February 29 to December 31: 100% – 25.7% = 74.3%
   EI percentage January 1 to February 29: 25.7% - 0.0% = 25.7%
   Total EI percentage for 1 year duration: 74.3% + 25.7% = 100%
   EI percentage February 29 to September 1 (0.5 year): 54.1% - 25.7% = 28.4%
   Figure 4 – Isoerodent Map of California:
   Interpolated annual erosion index for location: 35

R-Factor for 2 year construction: 35 x (100%) x 2 years = 70
R-Factor for 0.5 year construction: 35 x (28.4%) = 9.94
**R-Factor for complete project duration (2.5 years) = 70 + 9.94 = 79.94**

2. ***Find the R value of a construction project in San Diego, California with a duration of June 30, 2012 to November 1, 2013 (1.333 years).***

Figure 1 - Erosivity Index Zone Map:
The EI distribution zone is 25
Table 1 – Erosivity Index Table:
EI percentage June 30 to December 31: 100% – 57.2% = 42.8%
EI percentage January 1 to June 30: 57.2% - 0.0% = 57.2%
Total EI percentage for 1 year duration: 42.8% + 57.2% = 100%
EI percentage June 30 to November 1 (0.333 year): 69.4% - 57.2% = 12.2%
Figure 4 – Isoerodent Map of California:
Interpolated annual erosion index for location: 25

R-Factor for 1 year construction: 25 x (100%) = 25
R-Factor for 0.333 year construction: 25 x (12.2%) = 3.05
**R-Factor for complete project duration (1.333 years) = 25 + 3.05 = 28.05**

United States
Environmental Protection
Agency

Office of Water
(4203)

EPA 833-F-00-014
Revised March 2012
Fact Sheet 3.1[1]

# Stormwater Phase II Final Rule

## Construction Rainfall Erosivity Waiver



The 1972 amendments to the Federal Water Pollution Control Act, later referred to as the Clean Water Act (CWA), prohibit the discharge of any pollutant to navigable waters of the United States unless the discharge is authorized by a National Pollutant Discharge Elimination System (NPDES) permit. Because construction site stormwwater runoff can contribute significantly to water quality problems, the Phase I Stormwater Rule imposed a requirement that all construction sites with a planned land disturbance of 5 acres or more obtain an NPDES permit and implement stormwater runoff control plans. Phase II extends the requirements of the stormwater program to sites of between 1 and 5 acres. The Rainfall erosivity waiver allows permitting authorities to waive those sites that do not have adverse water quality impacts.

### What is Erosivity?

Erosivity is the term used to describe the potential for soil to wash off disturbed, devegetated earth during storms. The potential for erosion is in part determined by the soil type and geology of the site. For instance, dense, clay-like soils on a glacial plain will erode less readily when it rains than will sandy soils on the side of a hill. Another important factor is the amount and force of precipitation expected during the time the earth will be exposed. While it is impossible to predict the weather several months in advance of construction, for many areas of the country, there are definite optimal periods, such as a dry season when rain tends to fall less frequently and with less force. When feasible, this is the time to disturb the earth, so that the site can be stabilized by the time the seasonal wet weather returns. There are many other important factors to consider in determining erosivity, such as freeze/thaw cycles and snow pack.

### How Is Site Erosivity Determined?

The Universal Soil Loss Equation (USLE) was developed by the U.S. Department of Agriculture (USDA) in the 1950s to help farmers conserve their valuable topsoil. The methodology for determining if a site qualifies for the erosivity waiver provided in this guide is based on the *USDA Handbook 703 - Predicting Soil Erosion by Water: A Guide to Conservation Planning With the Revised Universal Soil Loss Equation (RUSLE)*, dated January 1997. (Note that a more updated version of USLE, the Revised USLE, Version 2 (RUSLE2), is available and can be used as an alternative method for determining if a site qualifies for the erosivity waiver. Information about the RUSLE2 computer program is provided later in this fact sheet.)

Using a computer model supported by decades' worth of soil and rainfall data, USDA established estimates of annual erosivity values (R factors) for sites throughout the country. These R factors are used as surrogate measures of the impact that rainfall had on erosion from a particular site. They have been mapped using isoerodent contours, as shown in Figures 2 through 5.

USDA developed the Erosivity Index Table (EI Table, provided here in Table 1), to show how the annual erosivity factor is distributed throughout the year in two-week increments. Table 1 is based on 120 rainfall distribution zones for the continental U.S. Detailed instructions for calculating a project R factor are provided later in this fact sheet.

[1] This revised fact sheet corrects errors identified in calculating the R factor from the 2001 version, and includes updated information about the USLE.

The Stormwater Phase II rule allows permitting authorities to waive NPDES requirements for small construction sites if the value of the rainfall erosivity factor is less than 5 during the period of construction activity (see § 122.26(b)(15)(i)(A)). Note that the permitting authority has the option to not allow waivers for small construction activity.

If the R factor for the period of construction calculates to less than 5, and the permitting authority allows the use of the waiver, the site owner may apply for a waiver under the low rainfall erosivity provision of the applicable EPA or State NPDES regulations. When applying, owners are encouraged to consider other site-specific factors, such as proximity to water resources and the sensitivity of receiving waters to sedimentation impacts. The small construction operator must certify to the permitting authority that the construction activity will take place during a period when the rainfall erosivity factor is less than 5.

The start and end dates used for the construction activity will be the initial date of disturbance and the anticipated date when the site will have achieved final stabilization as defined by the permit, respectively. If the construction continues beyond this period, the operator will need to recalculate the Erosivity Index for the site based on this new ending date (but keeping the old start date) and either resubmit the certification form or apply for NPDES permit coverage.

## What Other Factors Can Affect Waiver Availability and Eligibility?

EPA has established the R factor of less than 5 as the criteria for determining waiver eligibility. However, since the intent is to waive only those construction activities that will not adversely impact water quality, State and Tribal permitting authorities have considerable discretion in determining where, when, and how to offer it. They can establish an R factor threshold lower than 5, or they can suspend the waiver within an area where watersheds are known to be heavily impacted by, or sensitive to, sedimentation. They can also suspend the waiver during certain periods of the year. They may opt not to offer the waiver at all. NOTE: This waiver is not available to sites that will disturb more than 5 acres of land (large construction).

## What if My Site Is Not Eligible?

If your site is not eligible for a waiver, you must submit a Notice of Intent, or whichever type of application is required, to obtain coverage under the applicable NPDES construction stormwater permit, and comply with its requirements. For information about EPA's Construction General Permit (CGP), see http://www.epa.gov/npdes/stormwater/cgp. State program information is available at http://cfpub.epa.gov/npdes/contacts.cfm?program_id=6&type=STATE.

## Examples

### 1. Construction started and completed in one calendar year.

*Find the R factor value of a construction site in Denver, Colorado. Assume the site will be disturbed from March 10 to May 10 of the same year.*

The EI distribution zone is 84 (Figure 1). Referring to Table 1, the project period will span from March 1 (from Table 1, the closest date prior to the actual March 10 start date) to May 15 (from Table 1, the closest date after the actual May 10 end date). The difference in values between these two dates is 9.7% (9.9 - 0.2 = 9.7). Since the annual erosion index for this location is about 45 (interpolated from Figure 2), the R factor for the scheduled construction project is 9.7% of 45, or 4.4.

Because 4.4 is less than 5, the operator of this site would be able to seek a waiver under the low rainfall erosivity provision.

### 2. Construction spanning two calendar years.

*Find the R factor value for a construction site in Pittsburgh, Pennsylvania. Assume the site will be disturbed from August 1 to April 15.*

The EI distribution zone is 111 (Figure 1). Referring to Table 1, the project period will span from July 29 (from Table 1, the closest date prior to the actual August 1 start date) to April 15. The difference in values between July 29 and December 31 is 35% (100 - 65.0 = 35.0). The difference between January 1 and April 15 is 8%. The total percentage EI for this project is 43% (35 + 8 = 43). Since the annual erosion index for this location is 112 (interpolated from Figure 2), the R factor for the scheduled construction is 43% of 112, or 48.

Since 48 is greater than 5, the operator of this site would not be able to seek a waiver under the low rainfall erosivity provision.

## How Do I Compute the R factor for My Project?

1. Estimate the construction start date. This is the day you expect to begin disturbing soils, including grubbing, stockpiling, excavating, and grading activities.
2. Estimate the day you expect to achieve final stabilization, as defined by your permitting authority's regulations or NPDES construction stormwater permit, over all previous disturbed areas. This is your construction end date.
3. Refer to Figure 1 to find your Erosivity Index (EI) Zone based on your geographic location.

4. Refer to Table 1, the Erosivity Index (EI) Table. Find the number of your EI Zone in the left column. Locate the EI values for the dates that correspond to the project start and end dates you identified in Steps 1 and 2. If your specific date is not on the table, either interpolate between dates to obtain your %EI value, or use the closest date prior to your proposed start date and the closest date after your proposed end date. Subtract the start value from the end value to find the % EI for your site. The maximum annual EI value for a project is 100%. NOTE: If your project lasts for one year or more, your EI value is 100%.
5. Refer to the appropriate Isoerodent Map (Figures 2 through 5). Interpolate the annual isoerodent value for your area. This is the annual R factor for your site.
6. Multiply the percent value obtained in Step 4 by the annual isoerodent value obtained in Step 5. This is the R factor for your scheduled project.

## Can I Use a Personal Computer to Calculate the R factor?

The computer program used by USDA to evaluate erosion potential is called the Revised Universal Soil Loss Equation, or RUSLE. The current version of RUSLE (RUSLE2) is a Windows-based model that uses extensive databases that are geographically-linked. RUSLE2 can be used to calculate the R factor for a proposed construction site; however, RUSLE2 can require a large investment of time to set up. RUSLE2 can be downloaded free of charge from the Internet at http://fargo.nserl.purdue.edu/rusle2_dataweb/RUSLE2_Index.htm. Note that RUSLE2 is an upgrade of RUSLE, and contains more detailed data. Therefore, your calculated R factor may differ based on whether you calculate your R factor using the methods specified above, which utilizes data from *USDA Handbook 703 - Predicting Soil Erosion by Water: A Guide to Conservation Planning With the Revised Universal Soil Loss Equation (RUSLE)*, January 1997, or whether you calculate your R factor using the more updated RUSLE2. EPA notes that either method of calculation is acceptable for determining eligibility for the construction rainfall erosivity waiver.

## Where Can I Get Help?

- A copy of "Chapter 2, Rainfall-Runoff Erosivity Factor (R)" from the *USDA Handbook 703 - Predicting Soil Erosion by Water: A Guide to Conservation Planning With the Revised Universal Soil Loss Equation (RUSLE)*, January 1997, is available on EPA's web site at http://www.epa.gov/npdes/pubs/ruslech2.pdf.
- Information about RUSLE2, and a download of the program, is available at http://fargo.nserl.purdue.edu/rusle2_dataweb/.
- Your local USDA Service Center may be able to provide assistance with calculating R factors and other conservation-related issues. To find the office nearest you, go to http://www.nrcs.usda.gov/wps/portal/nrcs/main/national/contact/local.

**For Additional Information**

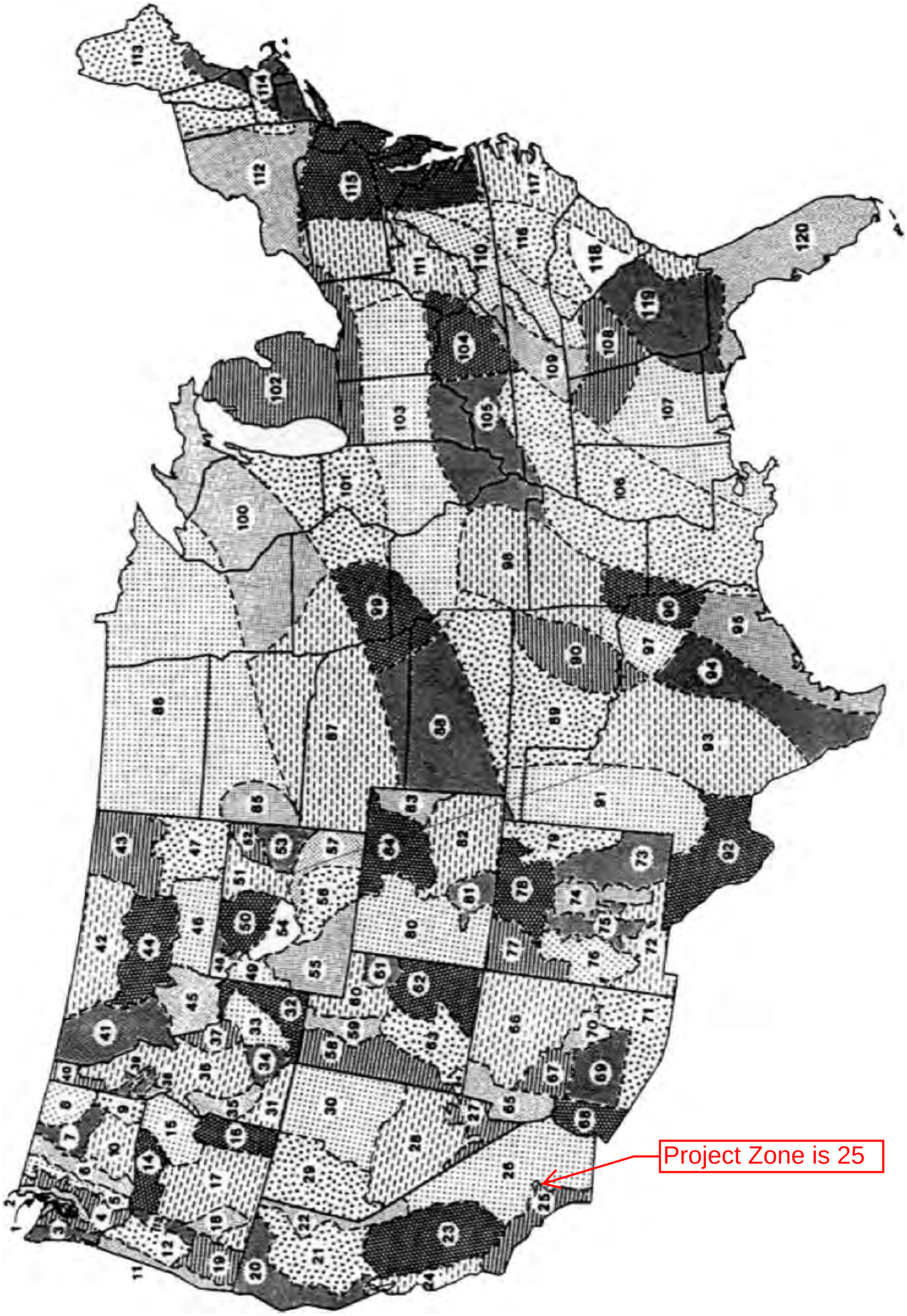
***Reference Documents***

Stormwater Phase II Final Rule Fact Sheet Series
- Internet: cfpub.epa.gov/npdes/stormwater/swfinal.cfm

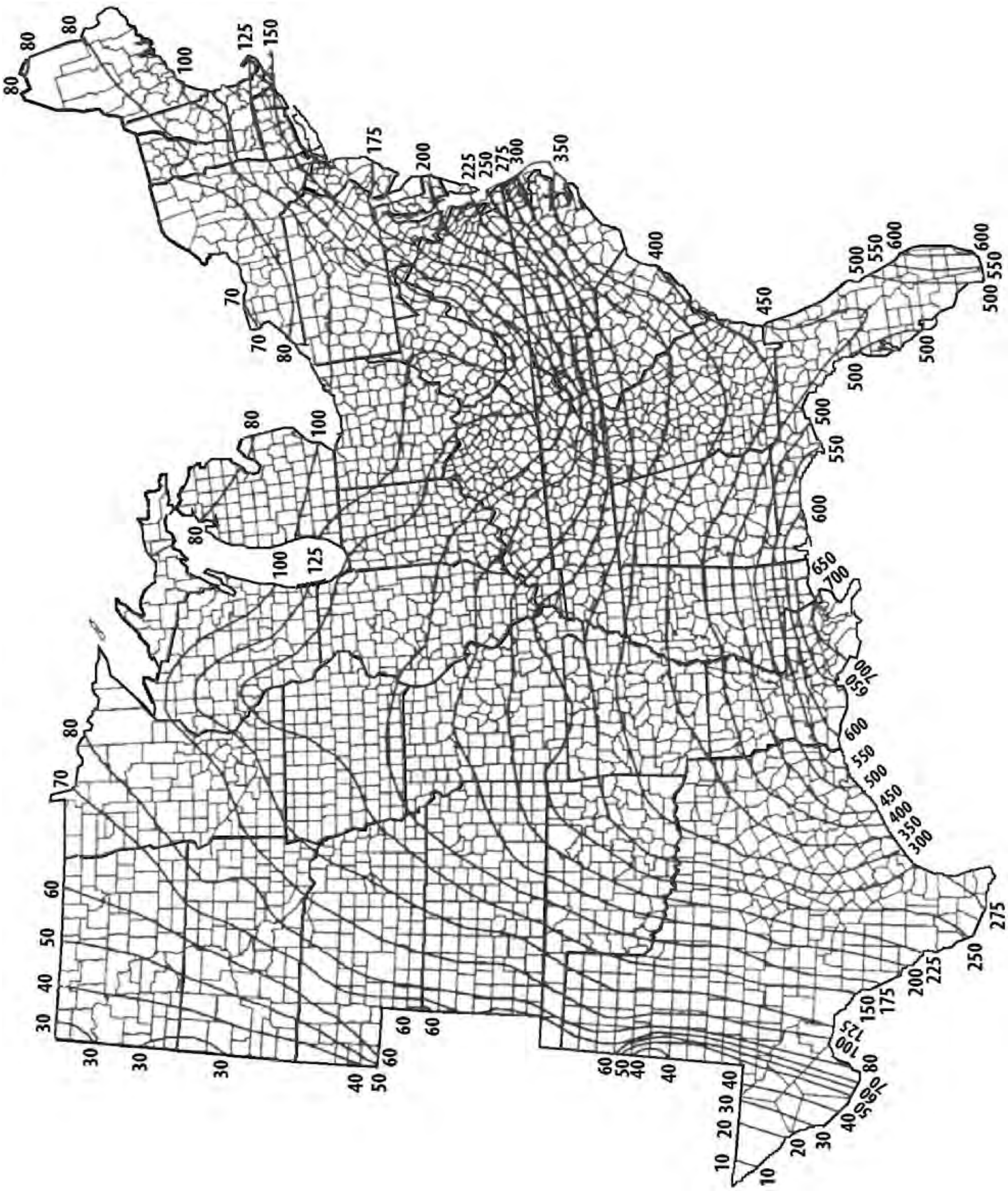
Stormwater Phase II Final Rule (64 *FR* 68722)
- Internet: www.epa.gov/npdes/regulations/phase2.pdf
- Contact the U.S. EPA Water Resource Center (Phone: (202) 564-9545)

*Agricultural Handbook Number 703, Predicting Soil Erosion by Water: A Guide to Conservation Planning With the Revised Universal Soil Loss Equation (RUSLE)*, Chapter 2, pp. 21-64, January 1997.
- Internet: www.epa.gov/npdes/pubs/ruslech2.pdf

# Figure 1. Erosivity Index Zone Map



# Figure 2. Isoerodent Map of the Eastern U.S.

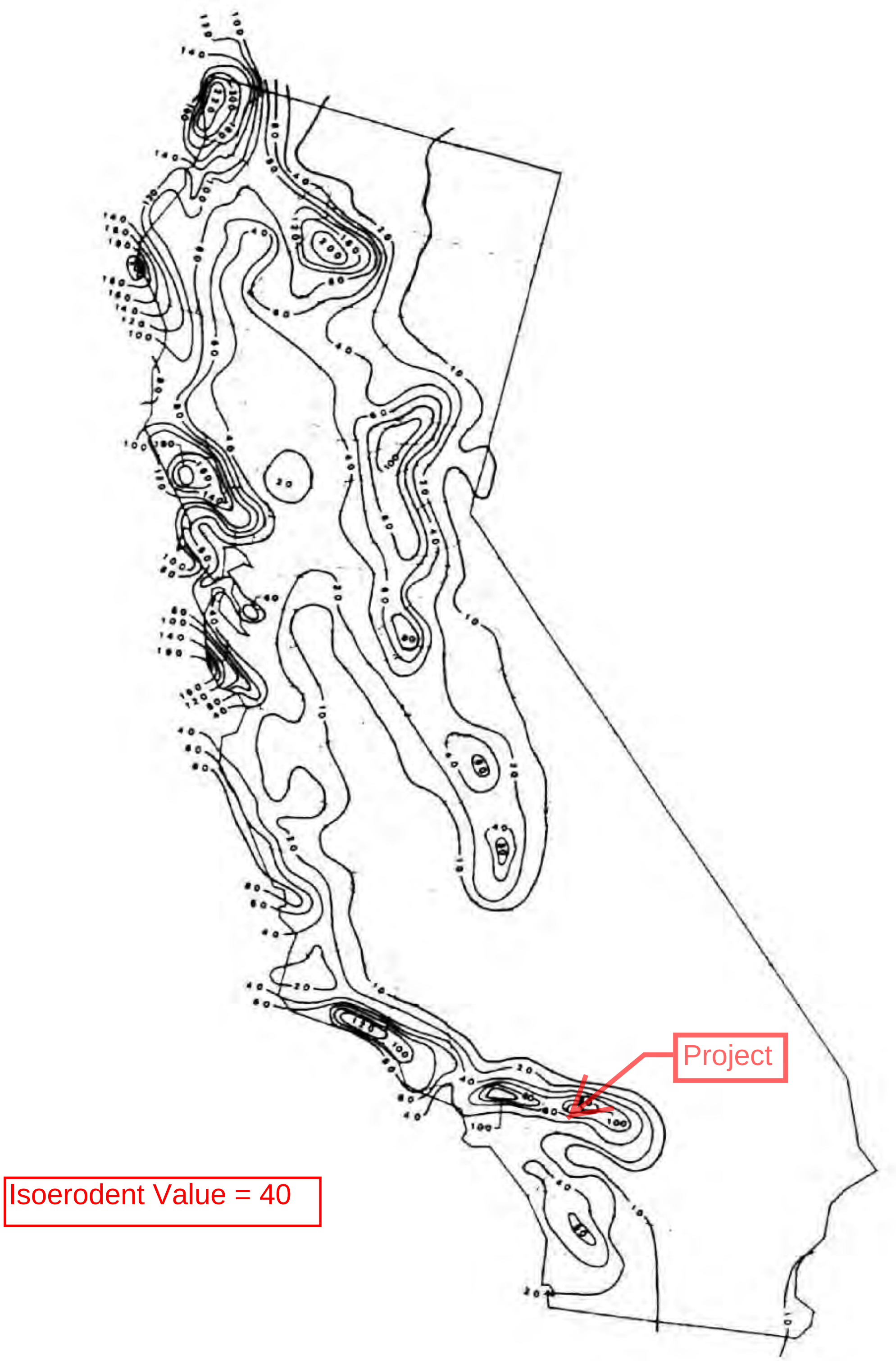


Note: Units for all maps on this page are hundreds ft•tonf•in(ac•h•yr)$^{-1}$

# Figure 3. Isoerodent Map of the Western U.S.

Note: Units for all maps on this page are hundreds ft•tonf•in(ac•h•yr)$^{-1}$

## Figure 4. Isoerodent Map of California




Note: Units for all maps on this page are hundreds ft•tonf•in(ac•h•yr)$^{-1}$

## Figure 5. Isoerodent Map of Oregon and Washington

Note: Units for all maps on this page are hundreds ft•tonf•in(ac•h•yr)$^{-1}$

# Table 1. Erosivity Index (%EI Values extracted from USDA Manual 703)

All values are at the end of the day listed below - Linear interpolation between dates is acceptable.
EI as a percentage of Average Annual R Value Computed for Geographic Areas Shown in Figure 1

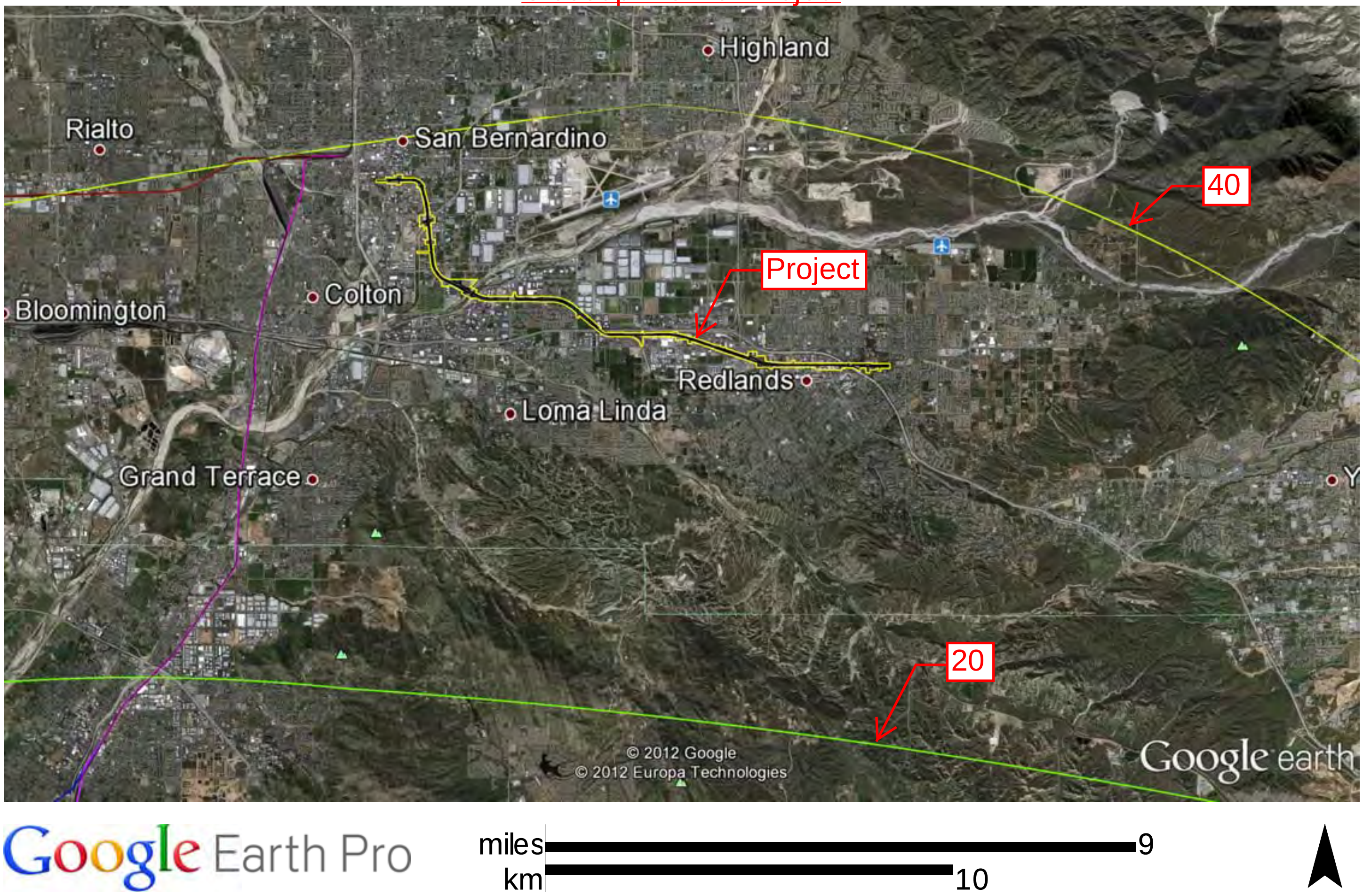
| Month | Jan | Jan | Jan | Feb | Mar | Mar | Mar | Apr | Apr | May | May | Jun | Jun | Jul | Jul | Aug | Aug | Sept | Sept | Oct | Oct | Nov | Nov | Dec | Dec |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Day | 1 | 16 | 31 | 15 | 1 | 16 | 31 | 15 | 30 | 15 | 30 | 14 | 29 | 14 | 29 | 13 | 28 | 12 | 27 | 12 | 27 | 11 | 26 | 11 | 31 |
| EI Zone | | | | | | | | | | | | | | | | | | | | | | | | | |
| 1 | 0 | 4.3 | 8.3 | 12.8 | 17.3 | 21.6 | 25.1 | 28 | 30.9 | 34.9 | 39.1 | 42.6 | 45.4 | 48.2 | 50.8 | 53 | 56 | 60.8 | 66.8 | 71 | 75.7 | 82 | 89.1 | 95.2 | 100 |
| 2 | 0 | 4.3 | 8.3 | 12.8 | 17.3 | 21.6 | 25.1 | 28.0 | 30.9 | 34.9 | 39.1 | 42.6 | 45.4 | 48.2 | 50.8 | 53.0 | 56.0 | 60.8 | 66.8 | 71.0 | 75.7 | 82.0 | 89.1 | 95.2 | 100 |
| 3 | 0 | 7.4 | 13.8 | 20.9 | 26.5 | 31.8 | 35.3 | 38.5 | 40.2 | 41.6 | 42.5 | 43.6 | 44.5 | 45.1 | 45.7 | 46.4 | 47.7 | 49.4 | 52.8 | 57.0 | 64.5 | 73.1 | 83.3 | 92.3 | 100 |
| 4 | 0 | 3.9 | 7.9 | 12.6 | 17.4 | 21.6 | 25.2 | 28.7 | 31.9 | 35.1 | 38.2 | 42.0 | 44.9 | 46.7 | 48.2 | 50.1 | 53.1 | 56.6 | 62.2 | 67.9 | 75.2 | 83.5 | 90.5 | 96.0 | 100 |
| 5 | 0 | 2.3 | 3.6 | 4.7 | 6.0 | 7.7 | 10.7 | 13.9 | 17.8 | 21.2 | 24.5 | 28.1 | 31.1 | 33.1 | 35.3 | 38.2 | 43.2 | 48.7 | 57.3 | 67.8 | 77.9 | 86.0 | 91.3 | 96.9 | 100 |
| 6 | 0 | 0.0 | 0.0 | 0.5 | 2.0 | 4.1 | 8.1 | 12.6 | 17.6 | 21.6 | 25.5 | 29.6 | 34.5 | 40.0 | 45.7 | 50.7 | 55.6 | 60.2 | 66.5 | 75.5 | 85.6 | 95.9 | 99.5 | 99.9 | 100 |
| 7 | 0 | 0.0 | 0.0 | 0.0 | 0.0 | 1.2 | 4.9 | 8.5 | 13.9 | 19.0 | 26.0 | 35.4 | 43.9 | 48.8 | 53.9 | 64.5 | 73.4 | 77.5 | 80.4 | 84.8 | 89.9 | 96.6 | 99.2 | 99.7 | 100 |
| 8 | 0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.9 | 3.6 | 7.8 | 15.0 | 20.2 | 27.4 | 38.1 | 49.8 | 57.9 | 65.0 | 75.6 | 82.7 | 86.8 | 89.4 | 93.4 | 96.3 | 99.1 | 100.0 | 100.0 | 100 |
| 9 | 0 | 0.8 | 3.1 | 4.7 | 7.4 | 11.7 | 17.8 | 22.5 | 27.0 | 31.4 | 36.0 | 41.6 | 46.4 | 50.1 | 53.4 | 57.4 | 61.7 | 64.9 | 69.7 | 79.0 | 89.6 | 97.4 | 100.0 | 100.0 | 100 |
| 10 | 0 | 0.3 | 0.5 | 0.9 | 2.0 | 4.3 | 9.2 | 13.1 | 18.0 | 22.7 | 29.2 | 39.5 | 46.3 | 48.8 | 51.1 | 57.2 | 64.4 | 67.7 | 71.1 | 77.2 | 85.1 | 92.5 | 96.5 | 99.0 | 100 |
| 11 | 0 | 5.4 | 11.3 | 18.8 | 26.3 | 33.2 | 37.4 | 40.7 | 42.5 | 44.3 | 45.4 | 46.5 | 47.1 | 47.4 | 47.8 | 48.3 | 49.4 | 50.7 | 53.6 | 57.5 | 65.5 | 76.2 | 87.4 | 94.8 | 100 |
| 12 | 0 | 3.5 | 7.8 | 14.0 | 21.1 | 27.4 | 31.5 | 35.0 | 37.3 | 39.8 | 41.9 | 44.3 | 45.6 | 46.3 | 46.8 | 47.9 | 50.0 | 52.9 | 57.9 | 62.3 | 69.3 | 81.3 | 91.5 | 96.7 | 100 |
| 13 | 0 | 0.0 | 0.0 | 1.8 | 7.2 | 11.9 | 16.7 | 19.7 | 24.0 | 31.2 | 42.4 | 55.0 | 60.0 | 60.8 | 61.2 | 62.6 | 65.3 | 67.6 | 71.6 | 76.1 | 83.1 | 93.3 | 98.2 | 99.6 | 100 |
| 14 | 0 | 0.7 | 1.8 | 3.3 | 6.9 | 16.5 | 26.6 | 29.9 | 32.0 | 35.4 | 40.2 | 45.1 | 51.9 | 61.1 | 67.5 | 70.7 | 72.8 | 75.4 | 78.6 | 81.9 | 86.4 | 93.6 | 97.7 | 99.3 | 100 |
| 15 | 0 | 0.0 | 0.0 | 0.5 | 2.0 | 4.4 | 8.7 | 12.0 | 16.6 | 21.4 | 29.7 | 44.5 | 56.0 | 60.8 | 63.9 | 69.1 | 74.5 | 79.1 | 83.1 | 87.0 | 90.9 | 96.6 | 99.1 | 99.8 | 100 |
| 16 | 0 | 0.0 | 0.0 | 0.5 | 2.0 | 5.5 | 12.3 | 16.2 | 20.9 | 26.4 | 35.2 | 48.1 | 58.1 | 63.1 | 66.5 | 71.9 | 77.0 | 81.6 | 85.1 | 88.4 | 91.5 | 96.3 | 98.7 | 99.6 | 100 |
| 17 | 0 | 0.0 | 0.0 | 0.7 | 2.8 | 6.1 | 10.7 | 12.9 | 16.1 | 21.9 | 32.8 | 45.9 | 55.5 | 60.3 | 64.0 | 71.2 | 77.2 | 80.3 | 83.1 | 87.7 | 92.6 | 97.2 | 99.1 | 99.8 | 100 |
| 18 | 0 | 0.0 | 0.0 | 0.6 | 2.5 | 6.2 | 12.4 | 16.4 | 20.2 | 23.9 | 29.3 | 37.7 | 45.6 | 49.8 | 53.3 | 58.4 | 64.3 | 69.0 | 75.0 | 86.6 | 93.9 | 96.6 | 98.0 | 100.0 | 100 |
| 19 | 0 | 1.0 | 2.6 | 7.4 | 16.4 | 23.5 | 28.0 | 31.0 | 33.5 | 37.0 | 41.7 | 48.1 | 51.1 | 52.0 | 52.5 | 53.6 | 55.7 | 57.6 | 61.1 | 65.8 | 74.7 | 88.0 | 95.8 | 98.7 | 100 |
| 20 | 0 | 9.8 | 18.5 | 25.4 | 30.2 | 35.6 | 38.9 | 41.5 | 42.9 | 44.0 | 45.2 | 48.2 | 50.8 | 51.7 | 52.5 | 54.6 | 57.4 | 58.5 | 60.1 | 63.2 | 69.6 | 76.7 | 85.4 | 92.4 | 100 |
| 21 | 0 | 7.5 | 13.6 | 18.1 | 21.1 | 24.4 | 27.0 | 29.4 | 31.7 | 34.6 | 37.3 | 39.6 | 41.6 | 43.4 | 45.4 | 48.1 | 51.3 | 53.3 | 56.6 | 62.4 | 72.4 | 81.3 | 88.9 | 94.7 | 100 |
| 22 | 0 | 1.2 | 1.6 | 1.6 | 1.6 | 1.6 | 1.6 | 2.2 | 3.9 | 4.6 | 6.4 | 14.2 | 32.8 | 47.2 | 58.8 | 69.1 | 76.0 | 82.0 | 87.1 | 96.7 | 99.9 | 99.9 | 99.9 | 99.9 | 100 |
| 23 | 0 | 7.9 | 15.0 | 20.9 | 25.7 | 31.1 | 35.7 | 40.2 | 43.2 | 46.2 | 47.7 | 48.8 | 49.4 | 49.9 | 50.7 | 51.8 | 54.1 | 57.7 | 62.8 | 65.9 | 70.1 | 77.3 | 86.8 | 93.5 | 100 |
| 24 | 0 | 12.2 | 23.6 | 33.0 | 39.7 | 47.1 | 51.7 | 55.9 | 57.7 | 58.6 | 58.9 | 59.1 | 59.1 | 59.2 | 59.2 | 59.3 | 59.5 | 60.0 | 61.4 | 63.0 | 66.5 | 71.8 | 81.3 | 89.6 | 100 |
| 25 | 0 | 9.8 | 20.8 | 30.2 | 37.6 | 45.8 | 50.6 | 54.4 | 56.0 | 56.8 | 57.1 | 57.1 | 57.2 | 57.6 | 58.5 | 59.8 | 62.2 | 65.3 | 67.5 | 68.2 | 69.4 | 74.8 | 86.6 | 93.0 | 100 |
| 26 | 0 | 2.0 | 5.4 | 9.8 | 15.6 | 21.5 | 24.7 | 26.6 | 27.4 | 28.0 | 28.7 | 29.8 | 32.5 | 36.6 | 44.9 | 55.4 | 65.7 | 72.6 | 77.8 | 84.4 | 89.5 | 93.9 | 96.5 | 98.4 | 100 |
| 27 | 0 | 0.0 | 0.0 | 1.0 | 4.0 | 5.9 | 8.0 | 11.1 | 13.0 | 14.0 | 14.6 | 15.3 | 17.0 | 23.2 | 39.1 | 60.0 | 76.3 | 86.1 | 89.7 | 90.4 | 90.9 | 93.1 | 96.6 | 99.1 | 100 |
| 28 | 0 | 0.0 | 0.0 | 0.0 | 0.2 | 0.5 | 1.5 | 3.3 | 7.2 | 11.9 | 17.7 | 21.4 | 27.0 | 37.1 | 51.4 | 62.3 | 70.6 | 78.8 | 84.6 | 90.6 | 94.4 | 97.9 | 99.3 | 100.0 | 100 |
| 29 | 0 | 0.6 | 0.7 | 0.7 | 0.7 | 1.5 | 3.9 | 6.0 | 10.5 | 17.9 | 28.8 | 36.6 | 43.8 | 51.5 | 59.3 | 68.0 | 74.8 | 80.3 | 84.3 | 88.8 | 92.7 | 98.0 | 99.8 | 99.9 | 100 |
| 30 | 0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.2 | 0.8 | 2.8 | 7.9 | 14.2 | 24.7 | 35.6 | 45.4 | 52.2 | 58.7 | 68.5 | 77.6 | 84.5 | 88.9 | 93.7 | 96.2 | 97.6 | 98.3 | 99.6 | 100 |
| 31 | 0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.2 | 1.0 | 3.5 | 9.9 | 15.7 | 26.4 | 47.2 | 61.4 | 65.9 | 69.0 | 77.2 | 86.0 | 91.6 | 94.8 | 98.7 | 100.0 | 100.0 | 100.0 | 100.0 | 100 |
| 32 | 0 | 0.1 | 0.1 | 0.1 | 0.1 | 0.6 | 2.2 | 4.3 | 9.0 | 14.2 | 23.3 | 34.6 | 46.3 | 54.2 | 61.7 | 72.9 | 82.5 | 89.6 | 93.7 | 98.2 | 99.7 | 99.9 | 99.9 | 99.9 | 100 |
| 33 | 0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.6 | 2.3 | 4.2 | 8.8 | 16.1 | 30.0 | 46.9 | 57.9 | 62.8 | 66.2 | 72.1 | 79.1 | 85.9 | 91.1 | 97.0 | 98.9 | 98.9 | 98.9 | 98.9 | 100 |
| 34 | 0 | 0.0 | 0.0 | 0.0 | 0.0 | 1.8 | 7.3 | 10.7 | 15.5 | 22.0 | 29.9 | 35.9 | 42.0 | 48.5 | 56.9 | 67.0 | 76.9 | 85.8 | 91.2 | 95.7 | 97.8 | 99.6 | 100.0 | 100.0 | 100 |
| 35 | 0 | 0.0 | 0.0 | 0.0 | 0.0 | 2.5 | 10.2 | 15.9 | 22.2 | 27.9 | 34.7 | 43.9 | 51.9 | 56.9 | 61.3 | 67.3 | 73.9 | 80.1 | 85.1 | 89.6 | 93.2 | 98.2 | 99.8 | 99.8 | 100 |

| Month | Jan | Jan | Jan | Feb | Mar | Mar | Mar | Apr | Apr | May | May | Jun | Jun | Jul | Jul | Aug | Aug | Sept | Sept | Oct | Oct | Nov | Nov | Dec | Dec |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Day | 1 | 16 | 31 | 15 | 1 | 16 | 31 | 15 | 30 | 15 | 30 | 14 | 29 | 14 | 29 | 13 | 28 | 12 | 27 | 12 | 27 | 11 | 26 | 11 | 31 |
| EI Zone | | | | | | | | | | | | | | | | | | | | | | | | | |
| 36 | 0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.9 | 3.4 | 6.7 | 12.7 | 18.5 | 26.6 | 36.3 | 46.0 | 53.5 | 60.2 | 68.3 | 75.8 | 82.6 | 88.3 | 96.3 | 99.3 | 99.9 | 100.0 | 100.0 | 100 |
| 37 | 0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 1.0 | 3.9 | 9.1 | 19.1 | 26.7 | 36.3 | 47.9 | 61.4 | 75.1 | 84.5 | 92.3 | 96.0 | 99.1 | 100.0 | 100.0 | 100.0 | 100.0 | 100 |
| 38 | 0 | 0.0 | 0.0 | 1.1 | 4.3 | 7.2 | 11.0 | 13.9 | 17.9 | 22.3 | 30.3 | 43.1 | 55.1 | 61.3 | 65.7 | 72.1 | 77.9 | 82.6 | 86.3 | 90.3 | 93.8 | 98.4 | 100.0 | 100.0 | 100 |
| 39 | 0 | 0.0 | 0.0 | 0.0 | 0.0 | 1.6 | 6.5 | 11.0 | 17.8 | 24.7 | 33.1 | 42.8 | 50.3 | 54.9 | 59.7 | 68.9 | 78.1 | 83.6 | 87.5 | 93.0 | 96.5 | 99.2 | 100.0 | 100.0 | 100 |
| 40 | 0 | 0.0 | 0.0 | 0.0 | 0.0 | 1.5 | 6.2 | 10.1 | 16.3 | 23.3 | 32.5 | 42.2 | 50.1 | 55.6 | 60.5 | 67.5 | 74.3 | 79.4 | 84.1 | 91.1 | 95.8 | 99.1 | 100.0 | 100.0 | 100 |
| 41 | 0 | 0.1 | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 | 0.4 | 1.1 | 6.8 | 22.9 | 40.1 | 54.9 | 63.8 | 70.7 | 81.5 | 89.8 | 96.3 | 98.7 | 99.2 | 99.3 | 99.4 | 99.4 | 99.7 | 100 |
| 42 | 0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.2 | 0.9 | 5.2 | 17.3 | 33.8 | 53.2 | 66.5 | 75.9 | 87.6 | 93.7 | 97.5 | 99.0 | 99.7 | 100.0 | 100.0 | 100.0 | 100.0 | 100 |
| 43 | 0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.1 | 0.4 | 2.7 | 9.5 | 21.9 | 42.7 | 58.6 | 71.1 | 84.6 | 91.9 | 97.1 | 99.0 | 99.8 | 100.0 | 100.0 | 100.0 | 100.0 | 100 |
| 44 | 0 | 1.7 | 2.3 | 2.4 | 2.4 | 2.4 | 2.4 | 2.7 | 3.5 | 7.6 | 18.5 | 34.3 | 52.5 | 64.0 | 72.3 | 83.3 | 90.0 | 95.1 | 97.3 | 98.5 | 98.9 | 98.9 | 98.9 | 99.2 | 100 |
| 45 | 0 | 0.2 | 0.2 | 0.3 | 0.3 | 0.4 | 0.6 | 0.8 | 1.4 | 3.7 | 10.2 | 22.6 | 41.8 | 54.0 | 64.5 | 78.7 | 88.4 | 96.0 | 98.7 | 99.4 | 99.7 | 99.7 | 99.8 | 99.9 | 100 |
| 46 | 0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.6 | 2.6 | 7.5 | 19.6 | 32.9 | 48.9 | 63.0 | 73.5 | 83.3 | 89.5 | 95.6 | 98.3 | 99.6 | 100.0 | 100.0 | 100.0 | 100.0 | 100 |
| 47 | 0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.4 | 1.6 | 5.8 | 17.0 | 33.0 | 52.5 | 66.4 | 75.7 | 85.5 | 91.3 | 96.5 | 98.8 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100 |
| 48 | 0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 2.0 | 8.1 | 15.4 | 27.8 | 40.7 | 52.6 | 61.1 | 69.3 | 82.6 | 92.0 | 98.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100 |
| 49 | 0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.7 | 2.7 | 8.3 | 20.0 | 27.5 | 35.6 | 44.6 | 46.0 | 70.2 | 81.3 | 89.2 | 93.6 | 98.5 | 100.0 | 100.0 | 100.0 | 100.0 | 100 |
| 50 | 0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.1 | 0.4 | 2.4 | 8.2 | 13.7 | 23.8 | 38.8 | 55.1 | 66.1 | 73.6 | 81.8 | 87.7 | 93.8 | 97.0 | 99.4 | 100.0 | 100.0 | 100.0 | 100.0 | 100 |
| 51 | 0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.3 | 1.0 | 3.1 | 8.7 | 18.8 | 35.8 | 49.6 | 60.4 | 70.2 | 77.0 | 84.0 | 88.8 | 93.8 | 96.6 | 99.1 | 100.0 | 100.0 | 100.0 | 100.0 | 100 |
| 52 | 0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.6 | 2.5 | 6.8 | 17.5 | 29.8 | 46.1 | 60.5 | 72.7 | 86.0 | 92.8 | 96.8 | 98.4 | 99.7 | 100.0 | 100.0 | 100.0 | 100.0 | 100 |
| 53 | 0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.8 | 3.0 | 9.5 | 24.2 | 35.3 | 48.0 | 63.1 | 76.1 | 87.7 | 93.5 | 97.2 | 98.6 | 99.5 | 99.8 | 99.9 | 100.0 | 100.0 | 100 |
| 54 | 0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.2 | 0.7 | 2.4 | 7.2 | 14.7 | 27.2 | 37.2 | 47.3 | 58.8 | 67.6 | 74.0 | 79.2 | 86.7 | 92.6 | 97.9 | 99.8 | 99.9 | 100.0 | 100.0 | 100 |
| 55 | 0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 1.3 | 5.4 | 13.3 | 25.5 | 31.6 | 38.8 | 52.5 | 66.8 | 75.5 | 81.2 | 87.9 | 92.8 | 98.3 | 100.0 | 100.0 | 100.0 | 100.0 | 100 |
| 56 | 0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 1.3 | 5.1 | 11.4 | 22.3 | 29.5 | 38.5 | 51.1 | 65.2 | 77.8 | 85.6 | 91.7 | 95.0 | 98.7 | 100.0 | 100.0 | 100.0 | 100.0 | 100 |
| 57 | 0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.1 | 1.0 | 3.5 | 9.2 | 21.5 | 31.0 | 43.5 | 60.4 | 75.1 | 86.1 | 91.6 | 96.2 | 98.1 | 99.4 | 99.9 | 99.9 | 100.0 | 100.0 | 100 |
| 58 | 0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.2 | 0.9 | 2.9 | 8.0 | 13.2 | 21.0 | 29.1 | 38.0 | 45.9 | 54.5 | 65.4 | 74.8 | 82.1 | 87.5 | 95.4 | 98.8 | 99.7 | 100.0 | 100.0 | 100 |
| 59 | 0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 2.2 | 8.9 | 15.6 | 24.2 | 31.1 | 38.3 | 46.0 | 54.9 | 64.2 | 73.2 | 81.9 | 88.5 | 95.7 | 98.6 | 99.4 | 99.7 | 99.7 | 100 |
| 60 | 0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.4 | 1.5 | 4.0 | 9.5 | 13.3 | 20.5 | 33.6 | 52.8 | 66.5 | 76.7 | 88.1 | 94.2 | 98.6 | 100.0 | 100.0 | 100.0 | 100.0 | 100 |
| 61 | 0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 1.3 | 5.0 | 8.5 | 15.5 | 29.8 | 41.8 | 46.0 | 49.2 | 56.0 | 65.1 | 71.6 | 78.6 | 91.1 | 97.3 | 99.3 | 100.0 | 100.0 | 100 |
| 62 | 0 | 0.0 | 0.0 | 0.1 | 0.3 | 0.8 | 2.1 | 3.6 | 6.5 | 9.7 | 13.7 | 16.5 | 20.8 | 27.3 | 40.1 | 56.9 | 72.6 | 83.4 | 89.4 | 95.5 | 98.1 | 99.6 | 100.0 | 100.0 | 100 |
| 63 | 0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.9 | 3.7 | 7.8 | 13.3 | 15.8 | 19.9 | 29.0 | 46.8 | 64.7 | 78.3 | 88.8 | 93.9 | 98.5 | 100.0 | 100.0 | 100.0 | 100.0 | 100 |
| 64 | 0 | 0.0 | 0.0 | 0.7 | 2.8 | 7.4 | 12.4 | 14.4 | 15.6 | 17.3 | 19.4 | 21.0 | 24.4 | 32.3 | 48.0 | 61.4 | 72.1 | 81.9 | 87.0 | 90.1 | 92.4 | 98.1 | 100.0 | 100.0 | 100 |
| 65 | 0 | 3.6 | 7.0 | 9.6 | 11.4 | 13.0 | 14.4 | 16.3 | 17.7 | 18.4 | 19.3 | 20.5 | 23.6 | 32.0 | 50.0 | 66.2 | 77.2 | 85.4 | 88.8 | 90.4 | 91.3 | 92.7 | 94.8 | 97.0 | 100 |
| 66 | 0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.1 | 0.5 | 1.1 | 2.2 | 3.6 | 6.0 | 7.6 | 11.1 | 19.8 | 38.9 | 59.7 | 74.4 | 83.2 | 88.1 | 94.6 | 97.7 | 99.4 | 100.0 | 100.0 | 100 |
| 67 | 0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.1 | 0.4 | 0.9 | 1.6 | 1.9 | 2.4 | 5.0 | 12.1 | 24.8 | 48.3 | 73.6 | 86.5 | 92.0 | 94.3 | 96.6 | 97.9 | 99.5 | 100.0 | 100.0 | 100 |
| 68 | 0 | 2.3 | 4.5 | 7.8 | 10.4 | 12.0 | 13.3 | 16.3 | 17.7 | 18.1 | 18.2 | 18.3 | 18.4 | 19.9 | 24.5 | 35.0 | 54.4 | 69.4 | 78.6 | 85.7 | 89.2 | 91.9 | 93.9 | 97.0 | 100 |
| 69 | 0 | 2.0 | 3.7 | 5.7 | 7.8 | 10.5 | 12.4 | 13.7 | 14.3 | 14.7 | 15.1 | 15.7 | 17.1 | 22.7 | 36.7 | 50.4 | 63.6 | 75.0 | 81.8 | 87.8 | 90.8 | 93.2 | 94.9 | 97.5 | 100 |
| 70 | 0 | 0.5 | 0.7 | 1.0 | 1.3 | 1.7 | 2.2 | 2.8 | 3.4 | 3.9 | 4.7 | 5.4 | 7.4 | 15.7 | 36.5 | 55.8 | 70.3 | 80.9 | 86.4 | 90.9 | 93.4 | 96.4 | 98.1 | 99.4 | 100 |
| 71 | 0 | 0.7 | 1.2 | 1.6 | 2.1 | 2.8 | 3.3 | 3.6 | 4.0 | 4.5 | 5.6 | 6.5 | 9.1 | 18.5 | 40.6 | 59.7 | 74.0 | 86.3 | 91.7 | 94.7 | 96.0 | 96.7 | 97.3 | 98.8 | 100 |
| 72 | 0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.1 | 0.2 | 0.7 | 0.8 | 1.3 | 3.5 | 9.9 | 24.7 | 51.4 | 71.5 | 83.6 | 93.8 | 97.7 | 99.2 | 99.8 | 99.9 | 99.9 | 100.0 | 100 |
| 73 | 0 | 0.0 | 0.1 | 0.1 | 0.2 | 0.2 | 0.3 | 0.6 | 1.3 | 4.1 | 11.5 | 18.1 | 28.3 | 40.2 | 54.1 | 67.0 | 77.2 | 87.7 | 93.3 | 97.5 | 99.1 | 99.6 | 99.8 | 100.0 | 100 |
| 74 | 0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.1 | 0.2 | 0.5 | 1.2 | 2.7 | 6.4 | 10.2 | 18.4 | 31.0 | 50.7 | 68.7 | 81.2 | 91.6 | 96.1 | 98.4 | 99.2 | 99.8 | 100.0 | 100.0 | 100 |
| 75 | 0 | 0.1 | 0.1 | 0.1 | 0.2 | 0.5 | 1.3 | 1.9 | 3.0 | 4.1 | 6.6 | 10.0 | 17.6 | 28.3 | 44.7 | 59.4 | 71.6 | 83.9 | 90.3 | 94.7 | 96.7 | 98.8 | 99.6 | 99.9 | 100 |

| Month | Jan | Jan | Jan | Feb | Mar | Mar | Mar | Apr | Apr | May | May | Jun | Jun | Jul | Jul | Aug | Aug | Sept | Sept | Oct | Oct | Nov | Nov | Dec | Dec |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Day | 1 | 16 | 31 | 15 | 1 | 16 | 31 | 15 | 30 | 15 | 30 | 14 | 29 | 14 | 29 | 13 | 28 | 12 | 27 | 12 | 27 | 11 | 26 | 11 | 31 |
| EI Zone | | | | | | | | | | | | | | | | | | | | | | | | | |
| 76 | 0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.1 | 0.2 | 0.6 | 1.3 | 2.0 | 3.5 | 4.9 | 8.4 | 17.4 | 37.3 | 57.5 | 72.9 | 83.7 | 89.5 | 95.8 | 98.4 | 99.6 | 100.0 | 100.0 | 100 |
| 77 | 0 | 0.2 | 0.3 | 0.3 | 0.4 | 0.8 | 1.5 | 2.0 | 2.8 | 3.9 | 5.9 | 7.2 | 10.3 | 21.5 | 46.5 | 66.3 | 78.3 | 86.5 | 90.8 | 96.0 | 98.2 | 99.1 | 99.5 | 99.8 | 100 |
| 78 | 0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.2 | 0.5 | 1.6 | 3.8 | 8.9 | 13.2 | 21.8 | 35.8 | 56.6 | 75.4 | 86.0 | 92.9 | 95.9 | 98.2 | 99.2 | 99.8 | 100.0 | 100.0 | 100 |
| 79 | 0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.2 | 0.7 | 1.3 | 2.7 | 5.8 | 12.7 | 18.8 | 28.8 | 41.6 | 58.4 | 75.7 | 86.5 | 94.2 | 97.3 | 98.9 | 99.5 | 99.9 | 100.0 | 100.0 | 100 |
| 80 | 0 | 0.6 | 1.2 | 1.6 | 2.1 | 2.5 | 3.3 | 4.5 | 6.9 | 10.1 | 15.5 | 19.7 | 26.6 | 36.4 | 51.7 | 67.5 | 79.4 | 88.8 | 93.2 | 96.1 | 97.3 | 98.2 | 98.7 | 99.3 | 100 |
| 81 | 0 | 0.1 | 0.1 | 0.2 | 0.4 | 0.5 | 0.8 | 0.9 | 1.5 | 3.9 | 9.9 | 12.8 | 18.2 | 30.7 | 54.1 | 77.1 | 89.0 | 94.9 | 97.2 | 98.7 | 99.3 | 99.6 | 99.7 | 99.9 | 100 |
| 82 | 0 | 0.0 | 0.1 | 0.1 | 0.2 | 0.2 | 0.5 | 1.2 | 3.1 | 6.7 | 14.4 | 20.1 | 29.8 | 44.5 | 64.2 | 83.1 | 92.2 | 96.4 | 98.1 | 99.3 | 99.7 | 99.8 | 99.8 | 99.9 | 100 |
| 83 | 0 | 0.0 | 0.1 | 0.1 | 0.1 | 0.3 | 0.9 | 1.6 | 3.5 | 8.3 | 19.4 | 30.0 | 44.0 | 59.2 | 72.4 | 84.6 | 91.2 | 96.5 | 98.6 | 99.5 | 99.8 | 99.9 | 100.0 | 100.0 | 100 |
| 84 | 0 | 0.0 | 0.1 | 0.1 | 0.2 | 0.3 | 0.6 | 1.7 | 4.9 | 9.9 | 19.5 | 27.2 | 38.3 | 52.8 | 68.8 | 83.9 | 91.6 | 96.4 | 98.2 | 99.2 | 99.6 | 99.8 | 99.8 | 99.9 | 100 |
| 85 | 0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 1.0 | 2.0 | 3.0 | 6.0 | 11.0 | 23.0 | 36.0 | 49.0 | 63.0 | 77.0 | 90.0 | 95.0 | 98.0 | 99.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100 |
| 86 | 0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 1.0 | 2.0 | 3.0 | 6.0 | 11.0 | 23.0 | 36.0 | 49.0 | 63.0 | 77.0 | 90.0 | 95.0 | 98.0 | 99.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100 |
| 87 | 0 | 0.0 | 0.0 | 0.0 | 1.0 | 1.0 | 2.0 | 3.0 | 6.0 | 10.0 | 17.0 | 29.0 | 43.0 | 55.0 | 67.0 | 77.0 | 85.0 | 91.0 | 96.0 | 98.0 | 99.0 | 100.0 | 100.0 | 100.0 | 100 |
| 88 | 0 | 0.0 | 0.0 | 0.0 | 1.0 | 1.0 | 2.0 | 3.0 | 6.0 | 13.0 | 23.0 | 37.0 | 51.0 | 61.0 | 69.0 | 78.0 | 85.0 | 91.0 | 94.0 | 96.0 | 98.0 | 99.0 | 99.0 | 100.0 | 100 |
| 89 | 0 | 1.0 | 1.0 | 2.0 | 3.0 | 4.0 | 7.0 | 12.0 | 18.0 | 27.0 | 38.0 | 48.0 | 55.0 | 62.0 | 69.0 | 76.0 | 83.0 | 90.0 | 94.0 | 97.0 | 98.0 | 99.0 | 100.0 | 100.0 | 100 |
| 90 | 0 | 1.0 | 2.0 | 3.0 | 4.0 | 6.0 | 8.0 | 13.0 | 21.0 | 29.0 | 37.0 | 46.0 | 54.0 | 60.0 | 65.0 | 69.0 | 74.0 | 81.0 | 87.0 | 92.0 | 95.0 | 97.0 | 98.0 | 99.0 | 100 |
| 91 | 0 | 0.0 | 0.0 | 0.0 | 1.0 | 1.0 | 1.0 | 2.0 | 6.0 | 16.0 | 29.0 | 39.0 | 46.0 | 53.0 | 60.0 | 67.0 | 74.0 | 81.0 | 88.0 | 95.0 | 99.0 | 99.0 | 100.0 | 100.0 | 100 |
| 92 | 0 | 0.0 | 0.0 | 0.0 | 1.0 | 1.0 | 1.0 | 2.0 | 6.0 | 16.0 | 29.0 | 39.0 | 46.0 | 53.0 | 60.0 | 67.0 | 74.0 | 81.0 | 88.0 | 95.0 | 99.0 | 99.0 | 100.0 | 100.0 | 100 |
| 93 | 0 | 1.0 | 1.0 | 2.0 | 3.0 | 4.0 | 6.0 | 8.0 | 13.0 | 25.0 | 40.0 | 49.0 | 56.0 | 62.0 | 67.0 | 72.0 | 76.0 | 80.0 | 85.0 | 91.0 | 97.0 | 98.0 | 99.0 | 99.0 | 100 |
| 94 | 0 | 1.0 | 2.0 | 4.0 | 6.0 | 8.0 | 10.0 | 15.0 | 21.0 | 29.0 | 38.0 | 47.0 | 53.0 | 57.0 | 61.0 | 65.0 | 70.0 | 76.0 | 83.0 | 88.0 | 91.0 | 94.0 | 96.0 | 98.0 | 100 |
| 95 | 0 | 1.0 | 3.0 | 5.0 | 7.0 | 9.0 | 11.0 | 14.0 | 18.0 | 27.0 | 35.0 | 41.0 | 46.0 | 51.0 | 57.0 | 62.0 | 68.0 | 73.0 | 79.0 | 84.0 | 89.0 | 93.0 | 96.0 | 98.0 | 100 |
| 96 | 0 | 2.0 | 4.0 | 6.0 | 9.0 | 12.0 | 17.0 | 23.0 | 30.0 | 37.0 | 43.0 | 49.0 | 54.0 | 58.0 | 62.0 | 66.0 | 70.0 | 74.0 | 78.0 | 82.0 | 86.0 | 90.0 | 94.0 | 97.0 | 100 |
| 97 | 0 | 1.0 | 3.0 | 5.0 | 7.0 | 10.0 | 14.0 | 20.0 | 28.0 | 37.0 | 48.0 | 56.0 | 61.0 | 64.0 | 68.0 | 72.0 | 77.0 | 81.0 | 86.0 | 89.0 | 92.0 | 95.0 | 98.0 | 99.0 | 100 |
| 98 | 0 | 1.0 | 2.0 | 4.0 | 6.0 | 8.0 | 10.0 | 13.0 | 19.0 | 26.0 | 34.0 | 42.0 | 50.0 | 58.0 | 63.0 | 68.0 | 74.0 | 79.0 | 84.0 | 89.0 | 93.0 | 95.0 | 97.0 | 99.0 | 100 |
| 99 | 0 | 0.0 | 0.0 | 1.0 | 1.0 | 2.0 | 3.0 | 5.0 | 7.0 | 12.0 | 19.0 | 33.0 | 48.0 | 57.0 | 65.0 | 72.0 | 82.0 | 88.0 | 93.0 | 96.0 | 98.0 | 99.0 | 100.0 | 100.0 | 100 |
| 100 | 0 | 0.0 | 0.0 | 0.0 | 1.0 | 1.0 | 2.0 | 3.0 | 5.0 | 9.0 | 15.0 | 27.0 | 38.0 | 50.0 | 62.0 | 74.0 | 84.0 | 91.0 | 95.0 | 97.0 | 98.0 | 99.0 | 99.0 | 100.0 | 100 |
| 101 | 0 | 0.0 | 0.0 | 1.0 | 2.0 | 3.0 | 4.0 | 6.0 | 9.0 | 14.0 | 20.0 | 28.0 | 39.0 | 52.0 | 63.0 | 72.0 | 80.0 | 87.0 | 91.0 | 94.0 | 97.0 | 98.0 | 99.0 | 100.0 | 100 |
| 102 | 0 | 0.0 | 1.0 | 2.0 | 3.0 | 4.0 | 6.0 | 8.0 | 11.0 | 15.0 | 22.0 | 31.0 | 40.0 | 49.0 | 59.0 | 69.0 | 78.0 | 85.0 | 91.0 | 94.0 | 96.0 | 98.0 | 99.0 | 100.0 | 100 |
| 103 | 0 | 1.0 | 2.0 | 3.0 | 4.0 | 6.0 | 8.0 | 10.0 | 14.0 | 18.0 | 25.0 | 34.0 | 45.0 | 56.0 | 64.0 | 72.0 | 79.0 | 84.0 | 89.0 | 92.0 | 95.0 | 97.0 | 98.0 | 99.0 | 100 |
| 104 | 0 | 2.0 | 3.0 | 5.0 | 7.0 | 10.0 | 13.0 | 16.0 | 19.0 | 23.0 | 27.0 | 34.0 | 44.0 | 54.0 | 63.0 | 72.0 | 80.0 | 85.0 | 89.0 | 91.0 | 93.0 | 95.0 | 96.0 | 98.0 | 100 |
| 105 | 0 | 1.0 | 3.0 | 6.0 | 9.0 | 12.0 | 16.0 | 21.0 | 26.0 | 31.0 | 37.0 | 43.0 | 50.0 | 57.0 | 64.0 | 71.0 | 77.0 | 81.0 | 85.0 | 88.0 | 91.0 | 93.0 | 95.0 | 97.0 | 100 |
| 106 | 0 | 3.0 | 6.0 | 9.0 | 13.0 | 17.0 | 21.0 | 27.0 | 33.0 | 38.0 | 44.0 | 49.0 | 55.0 | 61.0 | 67.0 | 71.0 | 75.0 | 78.0 | 81.0 | 84.0 | 86.0 | 90.0 | 94.0 | 97.0 | 100 |
| 107 | 0 | 3.0 | 5.0 | 7.0 | 10.0 | 14.0 | 18.0 | 23.0 | 27.0 | 31.0 | 35.0 | 39.0 | 45.0 | 53.0 | 60.0 | 67.0 | 74.0 | 80.0 | 84.0 | 86.0 | 88.0 | 90.0 | 93.0 | 95.0 | 100 |
| 108 | 0 | 3.0 | 6.0 | 9.0 | 12.0 | 16.0 | 20.0 | 24.0 | 28.0 | 33.0 | 38.0 | 43.0 | 50.0 | 59.0 | 69.0 | 75.0 | 80.0 | 84.0 | 87.0 | 90.0 | 92.0 | 94.0 | 96.0 | 98.0 | 100 |
| 109 | 0 | 3.0 | 6.0 | 10.0 | 13.0 | 16.0 | 19.0 | 23.0 | 26.0 | 29.0 | 33.0 | 39.0 | 47.0 | 58.0 | 68.0 | 75.0 | 80.0 | 83.0 | 86.0 | 88.0 | 90.0 | 92.0 | 95.0 | 97.0 | 100 |
| 110 | 0 | 1.0 | 3.0 | 5.0 | 7.0 | 9.0 | 12.0 | 15.0 | 18.0 | 21.0 | 25.0 | 29.0 | 36.0 | 45.0 | 56.0 | 68.0 | 77.0 | 83.0 | 88.0 | 91.0 | 93.0 | 95.0 | 97.0 | 99.0 | 100 |
| 111 | 0 | 1.0 | 2.0 | 3.0 | 4.0 | 5.0 | 6.0 | 8.0 | 11.0 | 15.0 | 20.0 | 28.0 | 41.0 | 54.0 | 65.0 | 74.0 | 82.0 | 87.0 | 92.0 | 94.0 | 96.0 | 97.0 | 98.0 | 99.0 | 100 |
| 112 | 0 | 0.0 | 0.0 | 1.0 | 2.0 | 3.0 | 4.0 | 5.0 | 7.0 | 12.0 | 17.0 | 24.0 | 33.0 | 42.0 | 55.0 | 67.0 | 76.0 | 83.0 | 89.0 | 92.0 | 94.0 | 96.0 | 98.0 | 99.0 | 100 |
| 113 | 0 | 1.0 | 2.0 | 3.0 | 4.0 | 5.0 | 6.0 | 8.0 | 10.0 | 13.0 | 17.0 | 22.0 | 31.0 | 42.0 | 52.0 | 60.0 | 68.0 | 75.0 | 80.0 | 85.0 | 89.0 | 92.0 | 96.0 | 98.0 | 100 |
| 114 | 0 | 1.0 | 2.0 | 4.0 | 6.0 | 8.0 | 11.0 | 13.0 | 15.0 | 18.0 | 21.0 | 26.0 | 32.0 | 38.0 | 46.0 | 55.0 | 64.0 | 71.0 | 77.0 | 81.0 | 85.0 | 89.0 | 93.0 | 97.0 | 100 |
| 115 | 0 | 1.0 | 2.0 | 3.0 | 4.0 | 5.0 | 6.0 | 8.0 | 10.0 | 14.0 | 19.0 | 26.0 | 34.0 | 45.0 | 56.0 | 66.0 | 76.0 | 82.0 | 86.0 | 90.0 | 93.0 | 95.0 | 97.0 | 99.0 | 100 |

| Month | Jan | Jan | Jan | Feb | Mar | Mar | Mar | Apr | Apr | May | May | Jun | Jun | Jul | Jul | Aug | Aug | Sept | Sept | Oct | Oct | Nov | Nov | Dec | Dec |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Day | 1 | 16 | 31 | 15 | 1 | 16 | 31 | 15 | 30 | 15 | 30 | 14 | 29 | 14 | 29 | 13 | 28 | 12 | 27 | 12 | 27 | 11 | 26 | 11 | 31 |
| EI Zone | | | | | | | | | | | | | | | | | | | | | | | | | |
| 116 | 0 | 1.0 | 3.0 | 5.0 | 7.0 | 9.0 | 12.0 | 15.0 | 18.0 | 21.0 | 25.0 | 29.0 | 36.0 | 45.0 | 56.0 | 68.0 | 77.0 | 83.0 | 88.0 | 91.0 | 93.0 | 95.0 | 97.0 | 99.0 | 100 |
| 117 | 0 | 1.0 | 2.0 | 3.0 | 4.0 | 5.0 | 7.0 | 9.0 | 11.0 | 14.0 | 17.0 | 22.0 | 31.0 | 42.0 | 54.0 | 65.0 | 74.0 | 83.0 | 89.0 | 92.0 | 95.0 | 97.0 | 98.0 | 99.0 | 100 |
| 118 | 0 | 1.0 | 2.0 | 3.0 | 5.0 | 7.0 | 10.0 | 14.0 | 18.0 | 22.0 | 27.0 | 32.0 | 37.0 | 46.0 | 58.0 | 69.0 | 80.0 | 89.0 | 93.0 | 94.0 | 95.0 | 96.0 | 97.0 | 97.0 | 100 |
| 119 | 0 | 2.0 | 4.0 | 6.0 | 8.0 | 12.0 | 16.0 | 20.0 | 25.0 | 30.0 | 35.0 | 41.0 | 47.0 | 56.0 | 67.0 | 75.0 | 81.0 | 85.0 | 87.0 | 89.0 | 91.0 | 93.0 | 95.0 | 97.0 | 100 |
| 120 | 0 | 1.0 | 2.0 | 4.0 | 6.0 | 7.0 | 9.0 | 12.0 | 15.0 | 18.0 | 23.0 | 31.0 | 40.0 | 48.0 | 57.0 | 63.0 | 72.0 | 78.0 | 88.0 | 92.0 | 96.0 | 97.0 | 98.0 | 99.0 | 100 |
| 121 | 0 | 8.0 | 16.0 | 25.0 | 33.0 | 41.0 | 46.0 | 50.0 | 53.0 | 54.0 | 55.0 | 56.0 | 56.5 | 57.0 | 57.8 | 58.0 | 58.8 | 60.0 | 61.0 | 63.0 | 66.5 | 72.0 | 80.0 | 90.0 | 100 |
| 122 | 0 | 7.0 | 14.0 | 20.0 | 25.5 | 33.5 | 38.0 | 43.0 | 46.0 | 50.0 | 52.5 | 54.5 | 56.0 | 58.0 | 59.0 | 60.0 | 61.5 | 63.0 | 65.0 | 68.0 | 72.0 | 79.0 | 86.0 | 93.0 | 100 |
| 123 | 0 | 4.0 | 8.0 | 12.0 | 17.0 | 23.0 | 29.0 | 34.0 | 38.0 | 44.0 | 49.0 | 53.0 | 56.0 | 59.0 | 62.0 | 65.0 | 69.0 | 72.0 | 75.0 | 79.0 | 83.0 | 88.0 | 93.0 | 96.0 | 100 |
| 124 | 0 | 4.0 | 9.0 | 15.0 | 23.0 | 29.0 | 34.0 | 40.0 | 44.0 | 48.0 | 50.0 | 51.0 | 52.0 | 53.0 | 55.0 | 57.0 | 60.0 | 62.0 | 64.0 | 67.0 | 72.0 | 80.0 | 88.0 | 95.0 | 100 |
| 125 | 0 | 7.0 | 12.0 | 17.0 | 24.0 | 30.0 | 39.0 | 45.0 | 50.0 | 53.0 | 55.0 | 56.0 | 57.0 | 58.0 | 59.0 | 61.0 | 62.0 | 63.0 | 64.0 | 66.0 | 70.0 | 77.0 | 84.0 | 92.0 | 100 |
| 126 | 0 | 9.0 | 16.0 | 23.0 | 30.0 | 37.0 | 43.0 | 47.0 | 50.0 | 52.0 | 54.0 | 55.0 | 56.0 | 57.0 | 58.0 | 59.0 | 60.0 | 62.0 | 64.0 | 67.0 | 71.0 | 77.0 | 86.0 | 93.0 | 100 |
| 127 | 0 | 8.0 | 15.0 | 22.0 | 28.0 | 33.0 | 38.0 | 42.0 | 46.0 | 50.0 | 52.0 | 53.0 | 53.0 | 53.0 | 53.0 | 54.0 | 55.0 | 57.0 | 59.0 | 63.0 | 68.0 | 75.0 | 83.0 | 92.0 | 100 |
| 128 | 0 | 8.0 | 15.0 | 22.0 | 29.0 | 34.0 | 40.0 | 45.0 | 48.0 | 51.0 | 54.0 | 57.0 | 59.0 | 62.0 | 63.0 | 64.0 | 65.0 | 66.0 | 67.0 | 69.0 | 72.0 | 76.0 | 83.0 | 91.0 | 100 |
| 129 | 0 | 9.0 | 16.0 | 22.0 | 27.0 | 32.0 | 37.0 | 41.0 | 45.0 | 48.0 | 51.0 | 53.0 | 55.0 | 56.0 | 57.0 | 57.0 | 58.0 | 59.0 | 61.0 | 64.0 | 68.0 | 73.0 | 79.0 | 89.0 | 100 |
| 130 | 0 | 10.0 | 20.0 | 28.0 | 35.0 | 41.0 | 46.0 | 49.0 | 51.0 | 53.0 | 55.0 | 56.0 | 56.0 | 57.0 | 58.0 | 59.0 | 60.0 | 61.0 | 62.0 | 65.0 | 69.0 | 74.0 | 81.0 | 90.0 | 100 |
| 131 | 0 | 8.0 | 15.0 | 22.0 | 28.0 | 33.0 | 38.0 | 41.0 | 44.0 | 47.0 | 49.0 | 51.0 | 53.0 | 55.0 | 56.0 | 58.0 | 59.0 | 60.0 | 63.0 | 65.0 | 69.0 | 75.0 | 84.0 | 92.0 | 100 |
| 132 | 0 | 10.0 | 18.0 | 25.0 | 29.0 | 33.0 | 36.0 | 39.0 | 41.0 | 42.0 | 44.0 | 45.0 | 46.0 | 47.0 | 48.0 | 49.0 | 51.0 | 53.0 | 56.0 | 59.0 | 64.0 | 70.0 | 80.0 | 90.0 | 100 |
| 133 | 0 | 8.0 | 16.0 | 24.0 | 32.0 | 40.0 | 46.0 | 51.0 | 54.0 | 56.0 | 57.0 | 58.0 | 58.0 | 59.0 | 59.0 | 60.0 | 60.0 | 61.0 | 62.0 | 64.0 | 68.0 | 74.0 | 83.0 | 91.0 | 100 |
| 134 | 0 | 12.0 | 22.0 | 31.0 | 39.0 | 45.0 | 49.0 | 52.0 | 54.0 | 55.0 | 56.0 | 56.0 | 56.0 | 56.0 | 57.0 | 57.0 | 57.0 | 57.0 | 58.0 | 59.0 | 62.0 | 68.0 | 77.0 | 88.0 | 100 |
| 135 | 0 | 7.0 | 15.0 | 22.0 | 30.0 | 37.0 | 43.0 | 49.0 | 53.0 | 55.0 | 57.0 | 58.0 | 59.0 | 60.0 | 61.0 | 62.0 | 63.0 | 65.0 | 67.0 | 70.0 | 74.0 | 79.0 | 85.0 | 92.0 | 100 |
| 136 | 0 | 11.0 | 21.0 | 29.0 | 37.0 | 44.0 | 50.0 | 55.0 | 57.0 | 59.0 | 60.0 | 60.0 | 60.0 | 60.0 | 61.0 | 61.0 | 61.0 | 62.0 | 63.0 | 64.0 | 67.0 | 71.0 | 78.0 | 89.0 | 100 |
| 137 | 0 | 10.0 | 18.0 | 25.0 | 30.0 | 39.0 | 46.0 | 51.0 | 54.0 | 57.0 | 58.0 | 59.0 | 59.0 | 60.0 | 60.0 | 60.0 | 61.0 | 62.0 | 63.0 | 64.0 | 67.0 | 72.0 | 80.0 | 90.0 | 100 |
| 138 | 0 | 11.0 | 22.0 | 31.0 | 39.0 | 46.0 | 52.0 | 56.0 | 58.0 | 59.0 | 60.0 | 61.0 | 61.0 | 61.0 | 61.0 | 62.0 | 62.0 | 62.0 | 63.0 | 64.0 | 66.0 | 71.0 | 78.0 | 89.0 | 100 |
| 139 | 0 | 8.0 | 14.0 | 20.0 | 25.0 | 32.0 | 37.0 | 42.0 | 47.0 | 50.0 | 53.0 | 55.0 | 56.0 | 58.0 | 59.0 | 61.0 | 63.0 | 64.0 | 66.0 | 68.0 | 71.0 | 76.0 | 85.0 | 93.0 | 100 |
| 140 | 0 | 13.0 | 18.0 | 43.0 | 56.0 | 65.0 | 69.0 | 69.4 | 69.7 | 70.1 | 70.4 | 70.8 | 71.1 | 71.5 | 71.9 | 72.2 | 72.6 | 73.0 | 73.3 | 73.6 | 74.0 | 76.0 | 81.0 | 89.0 | 100 |

Figure 4 - Isoerodent Map of California
Closeup View of Project



HDR | ONE COMPANY *Many Solutions*

| | | | |
|---|---|---|---|
| Project: Redlands Passenger Rail | Computed: B.F. | Date: 4/26/12 | |
| Subject: R-Factor | Checked: | Date: | |
| Task: | Page: | of: | |
| Job #: | No: | | |

Assume Const. Schedule

Begin const: Jan 1, 2015

End const: Dec 31, 2017

EI => 2015, from Jan 1 to Dec 31

100 - 0 = 100%

2016, => 100%

2017 => 100%

EI = 3(100) = 300%

R value = Isoerodent value × EI

= 40 × 3.00

= 120

## Flores, Bill

**From:** Kim, Tae
**Sent:** Monday, May 07, 2012 9:57 AM
**To:** Flores, Bill
**Cc:** Goldman, Gary; Molinaro, Joe; Boraks, Michael
**Subject:** RE: Info required for PWQMP (RPRP)

Bill,
As requested, here are the preliminary values of Soil Erodibility and permeability of the alignment.
Please let me know if you have any question.

**Preliminary Permeability and Soil Erodibility – Near Surface Soils**

| Station No | Generalized Soil Type (near surface soils) | Permeability ($10^{-4}$ cm/sec) | Soil Erodibility Factor |
|---|---|---|---|
| 100+00 to 202+00 | Silty Sand | 20 | 0.17 |
| 202+00 to 332+00 | Silt/Sandy Silt | 1-5 (Average 3) | 0.42 |
| 332+00 to 579+00 | Silty Sand | 20 | 0.17 |

**TAE KUK KIM, MS, PE, GE**

**HDR Engineering, Inc.**
Senior Geotechnical Engineer

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o: 714.730.2435| c: 714.296.2891
tae.kim@hdrinc.com | hdrinc.com

Follow Us - Facebook | Twitter | YouTube

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**From:** Flores, Bill
**Sent:** Friday, April 27, 2012 10:52 AM
**To:** Kim, Tae
**Cc:** Goldman, Gary
**Subject:** RE: Info required for PWQMP (RPRP)

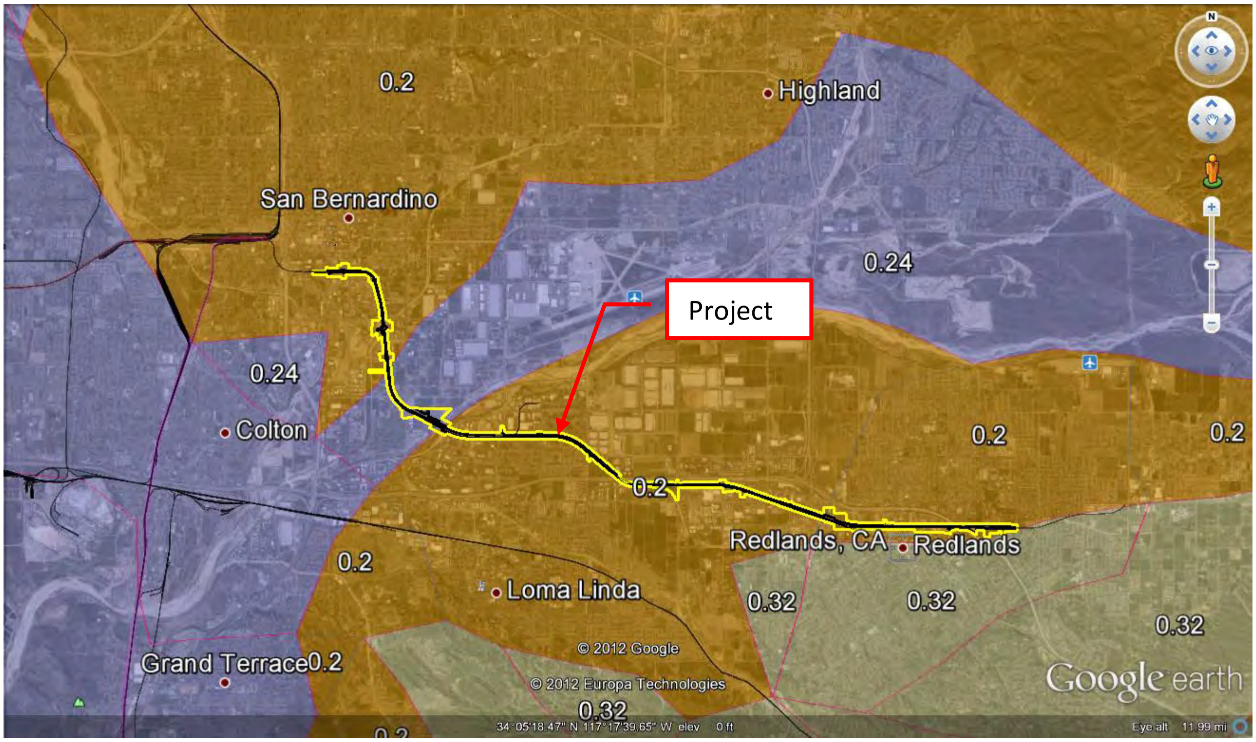
When you get a chance please provide K value on State provide triangle nomograph. I got a prelim number from Google Earth. This minimal effort should be included already in your scope. Please call with questions.

Bill Flores

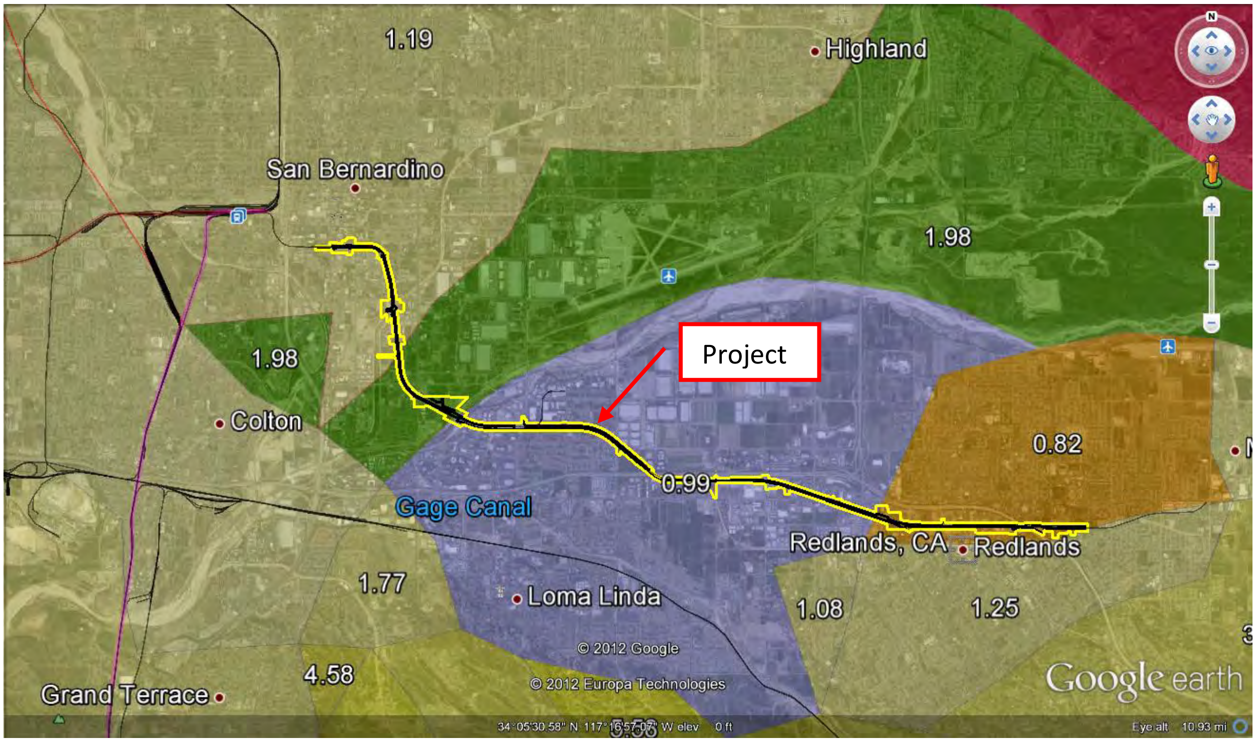
---

**From:** Kim, Tae
**Sent:** Wednesday, April 25, 2012 1:10 PM
**To:** Flores, Bill

## K Factor from Google Earth



## LS Factor from Google Earth



| Sheet Flow Length (ft) | Average Watershed Slope (%) | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **0.2** | **0.5** | **1.0** | **2.0** | **3.0** | **4.0** | **5.0** | **6.0** | **8.0** | **10.0** | **12.0** | **14.0** | **16.0** | **20.0** | **25.0** | **30.0** | **40.0** | **50.0** | **60.0** |
| **<3** | 0.05 | 0.07 | 0.09 | 0.13 | 0.17 | 0.20 | 0.23 | 0.26 | 0.32 | 0.35 | 0.36 | 0.38 | 0.39 | 0.41 | 0.45 | 0.48 | 0.53 | 0.58 | 0.63 |
| **6** | 0.05 | 0.07 | 0.09 | 0.13 | 0.17 | 0.20 | 0.23 | 0.26 | 0.32 | 0.37 | 0.41 | 0.45 | 0.49 | 0.56 | 0.64 | 0.72 | 0.85 | 0.97 | 1.07 |
| **9** | 0.05 | 0.07 | 0.09 | 0.13 | 0.17 | 0.20 | 0.23 | 0.26 | 0.32 | 0.38 | 0.45 | 0.51 | 0.56 | 0.67 | 0.80 | 0.91 | 1.13 | 1.31 | 1.47 |
| **12** | 0.05 | 0.07 | 0.09 | 0.13 | 0.17 | 0.20 | 0.23 | 0.26 | 0.32 | 0.39 | 0.47 | 0.55 | 0.62 | 0.76 | 0.93 | 1.08 | 1.37 | 1.62 | 1.84 |
| **15** | 0.05 | 0.07 | 0.09 | 0.13 | 0.17 | 0.20 | 0.23 | 0.26 | 0.32 | 0.40 | 0.49 | 0.58 | 0.67 | 0.84 | 1.04 | 1.24 | 1.59 | 1.91 | 2.19 |
| **25** | 0.05 | 0.07 | 0.10 | 0.16 | 0.21 | 0.26 | 0.31 | 0.36 | 0.45 | 0.57 | 0.71 | 0.85 | 0.98 | 1.24 | 1.56 | 1.86 | 2.41 | 2.91 | 3.36 |
| **50** | 0.05 | 0.08 | 0.13 | 0.21 | 0.30 | 0.38 | 0.46 | 0.54 | 0.70 | 0.91 | 1.15 | 1.40 | 1.64 | 2.10 | 2.67 | 3.22 | 4.24 | 5.16 | 5.97 |
| **75** | 0.05 | 0.08 | 0.14 | 0.25 | 0.36 | 0.47 | 0.58 | 0.69 | 0.91 | 1.20 | 1.54 | 1.87 | 2.21 | 2.86 | 3.67 | 4.44 | 5.89 | 7.20 | 8.37 |
| **100** | 0.05 | 0.09 | 0.15 | 0.28 | 0.41 | 0.55 | 0.68 | 0.82 | 1.10 | 1.46 | 1.88 | 2.31 | 2.73 | 3.57 | 4.59 | 5.58 | 7.44 | 9.13 | 10.63 |
| **150** | 0.05 | 0.09 | 0.17 | 0.33 | 0.50 | 0.68 | 0.86 | 1.05 | 1.43 | 1.92 | 2.51 | 3.09 | 3.68 | 4.85 | 6.30 | 7.70 | 10.35 | 12.75 | 14.89 |
| **200** | 0.06 | 0.10 | 0.18 | 0.37 | 0.57 | 0.79 | 1.02 | 1.25 | 1.72 | 2.34 | 3.07 | 3.81 | 4.56 | 6.04 | 7.88 | 9.67 | 13.07 | 16.16 | 18.92 |
| **250** | 0.06 | 0.10 | 0.19 | 0.40 | 0.64 | 0.89 | 1.16 | 1.43 | 1.99 | 2.72 | 3.60 | 4.48 | 5.37 | 7.16 | 9.38 | 11.55 | 15.67 | 19.42 | 22.78 |
| **300** | 0.06 | 0.10 | 0.20 | 0.43 | 0.69 | 0.98 | 1.28 | 1.60 | 2.24 | 3.09 | 4.09 | 5.11 | 6.15 | 8.23 | 10.81 | 13.35 | 18.17 | 22.57 | 26.51 |
| **400** | 0.06 | 0.11 | 0.22 | 0.48 | 0.80 | 1.14 | 1.51 | 1.90 | 2.70 | 3.75 | 5.01 | 6.30 | 7.60 | 10.24 | 13.53 | 16.77 | 22.95 | 28.60 | 33.67 |
| **600** | 0.06 | 0.12 | 0.24 | 0.56 | 0.96 | 1.42 | 1.91 | 2.43 | 3.52 | 4.95 | 6.67 | 8.45 | 10.26 | 13.94 | 18.57 | 23.14 | 31.89 | 39.95 | 47.18 |
| **800** | 0.06 | 0.12 | 0.26 | 0.63 | 1.10 | 1.65 | 2.25 | 2.89 | 4.24 | 6.03 | 8.17 | 10.40 | 12.69 | 17.35 | 23.24 | 29.07 | 40.29 | 50.63 | 59.93 |
| **1000** | 0.06 | 0.13 | 0.27 | 0.69 | 1.23 | 1.86 | 2.55 | 3.30 | 4.91 | 7.02 | 9.57 | 12.23 | 14.96 | 20.57 | 27.66 | 34.71 | 48.29 | 60.84 | 72.15 |

LS Factors for Construction Sites. *Table from Renard et. al., 1997.*

As applicable, a more refined LS factor should be determined using cross sections at specific spacings. Refer to Caltrans LS Factor method.

| Receiving Water (RW) Risk Factor Worksheet | Entry | Score |
|---|---|---|
| **A. Watershed Characteristics** | yes/no | |
| A.1. Does the disturbed area discharge (either directly or indirectly) to a **303(d)-listed waterbody impaired by sediment** (For help with impaired waterbodies please visit the link below) or has a **USEPA approved TMDL implementation plan for sediment**?:<br>http://www.waterboards.ca.gov/water_issues/programs/tmdl/integrated2010.shtml<br>**OR**<br>A.2. Does the disturbed area discharge to a waterbody with designated beneficial uses of SPAWN & COLD & MIGRATORY? (For help please review the appropriate Regional Board Basin Plan)<br>http://www.waterboards.ca.gov/waterboards_map.shtml | **no** | **Low** |

# 2006 CWA SECTION 303(d) LIST OF WATER QUALITY LIMITED SEGMENTS REQUIRING TMDLS

**SANTA ANA REGIONAL WATER QUALITY CONTROL BOARD**

**USEPA APPROVAL DATE: JUNE 28, 2007**

| REGION | TYPE | NAME | CALWATER WATERSHED | POLLUTANT/STRESSOR | POTENTIAL SOURCES | ESTIMATED SIZE AFFECTED | PROPOSED TMDL COMPLETION |
|---|---|---|---|---|---|---|---|
| 8 | R | San Diego Creek Reach 2 | 80111000 | | | | |
| | | | | Metals | | 6.3 Miles | 2007 |
| | | | | | Urban Runoff/Storm Sewers | | |
| 8 | R | Santa Ana River, Reach 4 | 80127000 | | | | |
| | | | | Pathogens | | 14 Miles | 2019 |
| | | | | | Nonpoint Source | | |
| 8 | R | Santiago Creek, Reach 4 | 80112000 | | | | |
| | | | | Salinity/TDS/Chlorides | | 9.8 Miles | 2019 |
| | | | | | Source Unknown | | |
| 8 | C | Seal Beach | 80111000 | | | | |
| | | | | Enterococcus | | 0.53 Miles | 2019 |
| | | | | *Impaired 50 yards around drain at 1st Street.* | | | |
| | | | | | Source Unknown | | |
| | | | | PCBs (Polychlorinated biphenyls) | | 0.53 Miles | 2019 |
| | | | | | Source Unknown | | |
| 8 | R | Silverado Creek | 80112000 | | | | |
| | | | | Pathogens | | 11 Miles | 2019 |
| | | | | | Unknown Nonpoint Source | | |
| | | | | Salinity/TDS/Chlorides | | 11 Miles | 2019 |
| | | | | | Unknown Nonpoint Source | | |
| 8 | R | Summit Creek | 80171000 | | | | |
| | | | | Nutrients | | 1.5 Miles | 2008 |
| | | | | | Construction/Land Development | | |

## ABBREVIATIONS

**REGIONAL WATER QUALITY CONTROL BOARDS**

| | |
|---|---|
| 1 | North Coast |
| 2 | San Francisco Bay |
| 3 | Central Coast |
| 4 | Los Angeles |
| 5 | Central Valley |
| 6 | Lahontan |
| 7 | Colorado River Basin |
| 8 | Santa Ana |
| 9 | San Diego |

**WATER BODY TYPE**

| | |
|---|---|
| B = | Bays and Harbors |
| C = | Coastal Shorelines/Beaches |
| E = | Estuaries |
| L = | Lakes/Reserviors |
| R = | Rivers and Streams |
| S = | Saline Lakes |
| T = | Wetlands, Tidal |
| W= | Wetlands, Freshwater |

**CALWATER WATERSHED**

**"Calwater Watershed" is the State Water Resources Control Board hydrological subunit area or an even smaller area delineation.**

**GROUP A PESTICIDES OR CHEM A**

**aldrin, dieldrin, chlordane, endrin, heptachlor, heptachlor epoxide, hexachlorocyclohexane (including lindane), endosulfan, and toxaphene**

**2010 California 303(d) List of Water Quality Limited Segments***

Water quality limited segments requiring a TMDL(5A), being addressed by TMDL(5B), and/or being addressed by an action other than TMDL(5C).

| REGION | REGION NAME | WATER BODY NAME | WBID | WATER BODY TYPE | WATER BODY TYPE CODE | INTEGRATED REPORT CATEGORY | USGS CATALOGING UNIT | CALWATER WATERSHED | ESTIMATED SIZE AFFECTED | UNIT | POLLUTANT | POLLUTANT CATEGORY | FINAL LISTING DECISION | TMDL REQUIREMENT STATUS** | EXPECTED TMDL COMPLETION DATE*** | EXPECTED ATTAINMENT DATE*** | USEPA TMDL APPROVED DATE*** | COMMENTS INCLUDED ON 303(d) LIST | POTENTIAL SOURCES | SOURCE CATEGORY |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 8 | Regional Board 8 - Santa Ana Region | Santa Ana River, Reach 4 | CAR8012700019990211142130 | River & Stream | R | 5 | 18070203 | 80127000 | 14 | Miles | Pathogens | Pathogens | List on 303(d) list (TMDL required list) | 5A | 2019 | | | | Nonpoint Source | Unspecified Nonpoint Source |

***Meaning that the tables include listings still requiring the development of a TMDL, those that have a completed TMDL approved by USEPA, and those that are being addressed by actions other than a TMDL.***

***** USGS HUC = US Geological Survey Hydrologic Unit Code. Calwater = State Water Resources Control Board hydrological subunit area or even smaller planning watershed.

****** TMDL requirement status definitions for listed pollutants are: A= TMDL still required, B= being addressed by USEPA approved TMDL, C= being addressed by action other than a TMDL

******* Dates relate to the TMDL requirement status, so there will only be one applicable date for each listing.

## Table 3-1 BENEFICIAL USES - Continued

| INLAND SURFACE STREAMS | BENEFICIAL USE | | | | | | | | | | | | | | | | | | Hydrologic Unit | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | MUN | AGR | IND | PROC | GWR | NAV | POW | REC1 | REC2 | COMM | WARM | LWRM | COLD | BIOL | WILD | RARE | SPWN | EST | Primary | Secondary |
| **UPPER SANTA ANA RIVER BASIN** | | | | | | | | | | | | | | | | | | | | |
| Santa Ana River | | | | | | | | | | | | | | | | | | | | |
| Reach 3 – Prado Dam to Mission Blvd. in Riverside | + | X | | | X | | | X | X | | X | | | | X | X | | | 801.21 | 801.21, 801.25 |
| Reach 4 – Mission Blvd. in Riverside to San Jacinto Fault in San Bernardino | + | | | | X | | | X[3] | X | | X | | | | X | | | | 801.27 | 801.44 |
| Reach 5 – San Jacinto Fault in Bernardino to Seven Oaks Dam[t] | X* | X | | | X | | | X[3] | X | | X | | | | X | X | | | 801.52 | 801.57 |
| Reach 6 – Seven Oaks Dam to Headwaters (see also Individual Tributary Streams) | X | X | | | X | | X | X | X | | | | X | | X | | X | | 801.72 | |
| San Bernardino Mountain Streams | | | | | | | | | | | | | | | | | | | | |
| Mill Creek Drainage: | | | | | | | | | | | | | | | | | | | | |
| Reach 1 – Confluence with Santa Ana River to Bridge Crossing Route 38 at Upper Powerhouse | I | I | | | I | | | I | I | | | | I | | I | I | | | 801.58 | |
| Reach 2 – Bridge Crossing Route 38 at Upper Powerhouse Headwaters | X | X | | | X | | X | X | X | | | | X | | X | | | | 801.58 | |

X Present or Potential Beneficial Use
I Intermittent Beneficial Use
+ Excepted from MUN (see text)

* **MUN** applies upstream of Orange Avenue (Redlands); downstream, water is excepted from **MUN**
[t] Reach 5 uses are intermittent upstream of Waterman Avenue
[3] Access prohibited in some portions by San Bernardino County Flood Control

# Combined Risk Level Matrix

| Receiving Water Risk | Sediment Risk: Low | Sediment Risk: Medium | Sediment Risk: High |
|---|---|---|---|
| Low | Level 1 | Level 2 | Level 2 |
| High | Level 2 | Level 2 | Level 3 |

**Project Sediment Risk:** **Medium**
**Project RW Risk:** **Low**
**Project Combined Risk:** **Level 2**