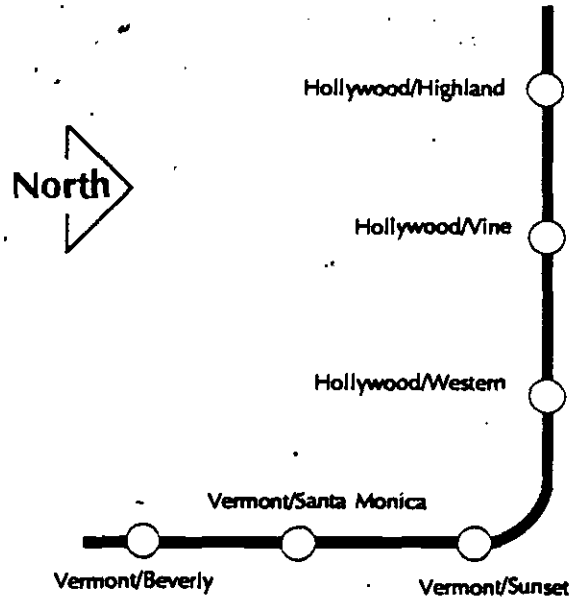
SOUTHERN CALIFORNIA RAPID TRANSIT DISTRICT

METRO RAIL PROJECT



FINAL REPORT
Volume 1

VALUE ENGINEERING STUDIES MOS II

SUMMARY AND FINAL REVIEW

December 1989

Prepared by:

FOSTER ENGINEERING, INC.
ENGINEERING • ARCHITECTURE • CONSTRUCTION
SAN FRANCISCO ○ SACRAMENTO SAN DIEGO

in association with

CONSULTING VALUE SPECIALISTS, INC.
Value Engineers

28689447

FOSTER ENGINEERING, INC.
ENGINEERING AND ARCHITECTURE
SAN FRANCISCO SACRAMENTO SAN DIEGO

December 15. 1989

Mr. J. E. Crawley
Southern California Rapid Transit District
425 South Main Street
Los Angeles. CA 90013

Dear Mr. Crawley:

Subject: Metro Rail Project
Value Engineering For MOS-II. Final Report

We are pleased to transmit for your record and use three (3) copies of the Final Report. comprised of four (4) volumes. which documents the Value Engineering Studies and final disposition of Value Engineering Proposals.

We appreciate this opportunity to be of service in furthering the planning for the MOS-II extension of the Metro Rail Project. We would like to thank you and others at SCRTD and MRTC for their help and cooperation. Special thanks to Al Levy. Ramesh Thakarar. and Douglas Low for their helpful comments and assistance during the course of the Value Engineering Study Workshops.

Sincerely.

FOSTER ENGINEERING. INC.

Johnson W. Yee for

H. A. Foster
President

File 453-A01. Chron

847 Howard Street, San Francisco, CA 94103 (415) 543-1193

SOUTHERN CALIFORNIA RAPID TRANSIT DISTRICT
METRO RAIL PROJECT
VALUE ENGINEERING FOR MOS II

FINAL REPORT

TABLE OF CONTENTS

SUMMARY

SCRTD has retained Foster Engineering, Inc. of San Francisco and CVS, Inc. of Portland, Oregon to undertake Value Engineering Studies of the second Minimum Operating Segment (MOS-2) extension of the heavy rail Metro Rail Project from downtown Los Angeles into Hollywood. This extension will provide a branch line extending from the current MOS-1 terminal at the Wilshire/Alvarado Station along a subway alignment within Vermont Avenue and Hollywood Boulevard to the intersection of Hollywood and Highland, a distance of about six (6) miles. Also included in the scope are six (6) proposed stations located along the alignment.

The scope of the project necessitated the separation of the Value Engineering effort into three (3) separate Value Engineering, namely:

Value Engineering Study #1:	Design Criteria and Directives
Value Engineering Study #2:	Line Structures
Value Engineering Study #3:	Stations.

These studies were completed between the months of July 1989 and September 1989 and draft issue was made to the District in October 1989. Review was undertaken by the District and its general engineering consultant immediately thereafter and comments were issued to Foster Engineering, Inc. for response on November 29, 1989.

A letter was issued to the District by Foster Engineering, Inc. on December 8, 1989 responding to specific comments and suggesting a Final Review Meeting for December 13, 1989. This meeting was convened on the appointed date and a final disposition of Value Engineering Proposals was decided upon during the course of the meeting.

Of the four (4) Proposals developed during VE Study #1, all were accepted by the District for implementation or further study. Of the ten (10) Proposals developed during VE Study #2, four (4) were accepted for implementation or further study, two (2) were deferred to VE Study #3, two (2) were withdrawn by the VE Team, and two (2) were rejected. Of the seventeen (17) Proposals developed during VE Study #3, fifteen (15) were accepted for implementation or further study and two (2) were rejected.

Table 1 following is the summary tabulation of the Proposals and the decisions concerning the District's actions. Of a total of thirty-one (31) Proposals developed during this study effort, only four (4) were rejected. The potential VE savings resulting from acceptance of the Proposals is estimated to be on the order of $110 Million. Excluded from consideration is potential latent cost savings on the order of $80 Million, which would be measured against cost overruns. Therefore, based on a present design cost of $640 Million, the minimum savings potential would be on the order of 110/640 or 17.1 percent.

SOUTHERN CALIFORNIA RAPID TRANSIT DISTRICT METRO RAIL PROJECT
VALUE ENGINEERING FOR MOS-II
TABLE 1 - FINAL REVIEW (Page 1 of 4)

VALUE ENGINEERING PROPOSAL (VEP) DECISION MATRIX

VE STUDY #1 - MOS-II CRITERIA AND STANDARDS						FINAL SCRTD ACTION		
VEP No.	Description	Potential VE Savings	SCRTD Comments CC	SCRTD Comments HS	MRTC Comments	Accepted	Accepted w/ Reservation	Rejected
1	Contract Packaging	$ 13,171,000	--	--	C w/E		●	
2	Change Orders, Claims and Disputes Resolution	$ 50,000,000*	C w/E	NC	--	●		
3	Design Quality Control	$ 30,000,000*	--	NC	--	●		
4	Field Management	---------	--	NC	--	●		

* Latent Cost Savings

LEGEND

C	Concur
C w/E	Concur with Exception
NC	Not Concur
Study	Further Study Required

SOUTHERN CALIFORNIA RAPID TRANSIT DISTRICT METRO RAIL PROJECT
VALUE ENGINEERING FOR MOS-II
TABLE 1 - FINAL REVIEW (Page 2 of 4)

VALUE ENGINEERING PROPOSAL (VEP) DECISION MATRIX

VE STUDY #2 - MOS-II LINE STRUCTURES						FINAL SCRTD ACTION		
VEP No.	Description	Potential VE Savings	SCRTD Comments RT	SCRTD Comments HS	MRTC Comments	Accepted	Accepted w/ Reservation	Rejected
1	Reduce Tunnel Diameter	$ 8,073,000	--	C	NC			●
2	Change Tunnel Lining from 12" Reinforced Concrete to 8" Unreinforced Concrete	$ 13,500,000	C	NC	NC	WITHDRAWN BY VE TEAM		
3	Substitute Double Track Tunnel For Twin Tunnel	$ 26,378,000	--	--	NC	WITHDRAWN BY VE TEAM		
4	Modify Tunnel Invert	$ 2,541,000	C	NC	NC		●	
5	Modify Tunnel Walkway	$ 2,591,000	C	--	Study			●
6	Reduce Size of Tunnel Cross Passages	$ 6,798,000	C	C w/E	NC		●	
7	Modify and Reduce Size of Cut-and-Cover Crossover Structure	See VE Study #3	--	--	--			
8	Substitute Double Crossover For Pocket Track At Hollywood/Vine Station	See VE Study #3	--	--	--			
	Relocate Pocket Track To Coincide With Hollywood/Vine Station	See VE Study #3	--	--	--			
9	Raise System Profile	$ 3,541,000	--	--	C w/E	●		
10	Modify Wet Standpipe	$ 483,000	--	C	C w/E	●		

SOUTHERN CALIFORNIA RAPID TRANSIT DISTRICT METRO RAIL PROJECT
VALUE ENGINEERING FOR MOS-II
TABLE 1 - FINAL REVIEW (Page 3 of 4)

VALUE ENGINEERING PROPOSAL (VEP) DECISION MATRIX

VE STUDY #3 - MOS-II STATIONS						FINAL SCRTD ACTION		
VEP No.	Description	Potential VE Savings	SCRTD Comments RT	SCRTD Comments HS	MRTC Comments	Accepted	Accepted w/ Reservation	Rejected
1	Reduce Station Depth	$ 4,150,000	C	--	NC		●	
2	Eliminate Station Columns	$ 3,995,000	C	--	Study		●	
3	Reduce Station Platform Length	$ 2,622,000	C	--	Study		●	
4	Station Foundation	$ 1,859,000	C	--	NC		●	
5	Relocate BRS Outlets	$ 9,910,000	C	C	C	●		
6	Provide Noise Control by Restricting Emergency Fan Activation To Emergency Events Only	$ 12,030,000	C	--	NC	●		
7	Relocate UPE Outlets	$ 2,562,000	C	--	C	●		
8	Modify Smoke Exhaust System Design	$ 432,000	NC	NC	NC			●
9	Delete Dedicated Underground Space For Future Air Conditioning	$ 10,314,000	C	--	Study	●		
10	Delete Fresh Air Supply Shafts and Fans	$ 7,706,000	C	NC	NC		●	

SOUTHERN CALIFORNIA RAPID TRANSIT DISTRICT METRO RAIL PROJECT
VALUE ENGINEERING FOR MOS-II
TABLE 1 - FINAL REVIEW (Page 4 of 4)

VALUE ENGINEERING PROPOSAL (VEP) DECISION MATRIX

VE STUDY #3 - MOS-II STATIONS						FINAL SCRTD ACTION		
VEP No.	Description	Potential VE Savings	SCRTD Comments DL	SCRTD Comments HS	MRTC Comments	Accepted	Accepted w/ Reservation	Rejected
11	Extend Mezzanine Throughout Station and Provide Open Space Over Platform Center	$ 557,000	C	--	C w/E	●		
12	Reduce Size of Major Entrances and Provide Secondary Entrance	Not Quantified	C w/E	C	NC		●	
13	Open Station Entrances To Atmosphere with Approach Concourses	$ 1,027,000	C	--	Study		●	
14	Rearrange Emergency Exits and Eliminate Sidewalk Appendages and Hatches	$ 3,509,000	C	C	Study		●	
15	Modify Crossover Configuration At Vermont/Beverly and Vermont/Sunset, Narrow Track To 13'-0" Centers, and Change Station Platforms To Side Configuration	$ 13,833,000	C	C w/E	Study		●	
16	Substitute Two Double Crossovers For Pocket Track At Hollywood/Vine Station and Change Station Platforms To Side Configuration	$ 16,961,000	NC	--	NC			●
17	Relocate Pocket Track To Point North of Highland Station By Modifying Dwell Time Criteria. Add Double Crossover In Front of Hollywood/Vine Station For Interim Terminal Operations In Side Platform Configuration	$ 9,707,000	C w/E	--	NC		●	

RTD

JAMES E. CRAWLEY, P.E.
Director of Engineering
Rail Facilities

November 29, 1989

Mr. Harry Foster
Foster Engineering, Inc.
847 Howard Street
San Francisco, CA 94103

Dear Mr. Foster:

Subject: Contract No. 5085
Value Engineering Consulting Services

Attached is a set of comments on Value Engineering Studies No. 1 through No. 3 from District staff and consultants for your consideration. After you have reviewed these comments, a working meeting should be set up to discuss them and finalize the Value Engineering Reports.

If your schedule permits, it would be desirable to hold the meeting in Los Angeles during the week of December 11. Let me know the exact date that would be convenient for you.

I would appreciate it if you would prepare an agenda for this meeting and send me an advanced copy.

Sincerely,

James E. Crawley, P.E.

Attachment

PHASE II VALUE ENGINEERING STUDY

CONFIGURATION CONTROL (CC) COMMENTS: VE PROPOSAL #2 - CHANGE ORDERS, CLAIMS, AND DISPUTE RESOLUTION

GENERAL:

THIS IS THE SECOND REVIEW OF THIS SECTION. I DON'T SEE ANY EVIDENCE OF RESPONSE TO PREVIOUS COMMENTS.

PROPOSED ALTERNATIVE CONCEPTS (PAGE 22)

FOSTER RECOMMENDATION #1:

"Establish Dispute Review Board to project image of fairness and expeditiousness."

CC RESPONSE:

Agree. This recommendation has been made by every consultant we've had review the claim resolution process and should be seriously considered. An internal "Dispute Review Board" was written into the first draft of the Claims Management Procudures but was deleted on direction of OCPM. As a side note, the phrase "project and image of fairness...." is unfortunate since it sounds like the Board is being established for public relation purposes only.

FOSTER RECOMMENDATION #2:

"Enhance authority of the Resident Engineer to match Contractor's Representative on a one-to-one basis. The Resident Engineer therefore should be a District employee acting as deputy to the Contracting Officer, with authority to negotiate field changes up to $100,000 or more, subject to review and approval by the Contracting Officer.

CC RESPONSE:

Agree that the Resident Engineers should be given change approval and execution authority. However, I do not agree with the suggested $100,000 level. $25,000 is the typical authority level allocated to the field (WMATA, LACTC). Above $25,000 FAR regulations (FAR 36.203) require greater documentation (independent estimates, etc.) and changes above this level are subject to more stringent audit.

FOSTER RECOMMENDATION #3:

"Keep number of inspectors and clerical staff to a minimum required for proper supervision in the District's interest."

CC RESPONSE:

Agree (of course). Foster does not present any finding or backup indicating that this is not already the case.

FOSTER RECOMMENDATION #4:

"Avoid duplication of effort"

"Duplication of supervision by PDCD and District must necessarily lead to PDCD RE to defer to the District PE, even though the contractor has to report to the RE. If the District feels that [the] RE is not able to function alone, the PE should replace him.

CC RESPONSE

Agree. Organizational structure and responsibilities need to be reviewed.

FOSTER RECOMMENDATION #5:

"District should establish well-qualified and well-trained construction supervisory force necessary for the conclusion of its construction program."

Agree. Foster recommendations concerning ongoing training for RE's/PE's related to specialized areas (Claims, Schedules, etc) as well as training and orientation to District procedures should be considered.

OTHER:

1. Foster does not appear to understand the role of the RE vis-a-vis the CCB related to change negotiation. The CCB does not place a limit on negotations at the time of change approval. Under the current procedures the PE has authority to negotiate and execute up to $10,000 (exclusive of time extensions), and the CA has authority to negotiate up to any amount - although the agreed amounts are subject to approval by whoever is authorized to execute the change order. Increases in costs during negotiations after change approval are reported to the CCB for acknowledgement - not approval. The CCB does sometimes set a limit to initial not-to-exceed costs for force account work; however if increases are required specific CCB approval is only necessary if the *scope* of the change is revised.

   It is true that RE's do not currently have specific negotiating power since they do not have change execution authority.

   If Foster picked this impression up from RE's or PE's, we need to clarify negotiation responsibilities and authority.

2. Foster states that the volume of changes is unusually high but does not provide any support for this statement. Who are we being compared to?

M E M O R A N D U M

SOUTHERN CALIFORNIA RAPID TRANSIT DISTRICT
TRANSIT SYSTEMS DEVELOPMENT DEPARTMENT
SYSTEMS AND CONSTRUCTION SAFETY

****

DATE: November 7, 1989

TO: James E. Crawley

FROM: Harold E. Storey

SUBJECT: Phase II Value Engineering Study

****

The Systems and Construction Safety Department and the Fire/Life Safety Committee have reviewed the subject study. Our comments are indicated on the attached 11 pages of review comment forms.

In addition, I have enclosed a copy of a memorandum dated August 29, 1989, to Mr. Rhine from Byron Ishkanian denoting a number of cost saving ideas that may fit with the Value Engineering Study.

Attachments

cc: F/LSC
L. Boyden
M. Ingram

RTD 81-1
EFF 3/84

SOUTHERN CALIFORNIA RAPID TRANSIT DISTRICT

METRO RAIL PROJECT
REVIEW / COMMENT SHEET

Reviewer H.E. Storey File No. Value Engr Date 6/7/1989

Dept. / Section SCS Submittal No. and/or Date _____ Sheet 1 of 11

Design Review / Submittal Title Study #1 - Design Criteria Matrix

REF NO.	PAGE NO.	DRAWING NO. / DOCUMENT SECT	COMMENT	RESPONSE / ACTION
1	3	General	It is difficult to give identification to the report areas since no line or paragraph numbers are indicated. I suggest that Final report have paragraph numbers.	
2	3	Suggestions/ Recommended Comment	Many of the items listed have been previously considered by the District. The verbs used by Foster should indicate this such as: o Implement proposed contract repackaging concepts o [redacted] Implement proposed Disputes Review Board. Otherwise report gives misleading insight into the work and evaluation of existing District policy and direction.	
3	4	Definitions General Comment	Need to define "Quality." Present report interpretation okay to build a system that lasts only 30 years, anything better is GOLD PLATING!	

RTD 81-1
EFF 3/84

SOUTHERN CALIFORNIA RAPID TRANSIT DISTRICT

METRO RAIL PROJECT
REVIEW / COMMENT SHEET

Reviewer H. E Stacy File No. Value Engineering Date Oct. 3, 1989

Dept. / Section SCS Submittal No. and/or Date _____ Sheet 2 of 11

Design Review / Submittal Title Study #1 Design Criteria MOS-II

REF NO.	PAGE NO.	DRAWING NO. / DOCUMENT SECT	COMMENT	RESPONSE / ACTION
4	6	Achieving Econ Value General comment	None of the suggested Tests for Economic Value address "quality or "durability ah Important ingredients of Value Engineering. The item must be of a good quality & durability nature so as to last the design life of the system — 50 to 100 years. This aspect is different than maintainability and reliability.	Agree Must do
5	10	VE Proposal #2 General comment	Description of Change Order proposal in first paragraph is very misleading. The RE, PE and Director CM Resp up to $25,000 with no input by CEC. Better solutions are often more than limits However; to just state increase RE authority is too vague	

RTD 81-1
EFF 3/84

SOUTHERN CALIFORNIA RAPID TRANSIT DISTRICT

METRO RAIL PROJECT
REVIEW / COMMENT SHEET

RTD

Reviewer H.E. Stacey File No. Value Eng'r Date Oct 3 1989

Dept. / Section SCS Submittal No. and/or Date ________ Sheet 3 of 11

Design Review / Submittal Title Study #7 Design Criteria MOS II

REF NO.	PAGE NO.	DRAWING NO. / DOCUMENT SECT	COMMENT	RESPONSE / ACTION
5	10	VE #2 Construc	DO NOT CONCUR — I question the $50 Million dollar savings estimated for this change. The number of MCO inspectors & clerical help is at a minimum now	
6	11	VE #3	DO NOT CONCUR — Combining the Design groups with Construction Mgm't is the needed change. As of now the Designers believe that the Contractor & CM will take care of items as part of the required submittal process whereas the CM believe the Designers did not do an adequate job of detailing needs. This problem will also remain on a Two-Team set up	
7	11	VE #4	DO NOT CONCUR — The Submittal review is in the hands of the RE and for FLS items. Putting reviewers in each Field Office versus a central office and saving time and money is questionable. Workload in the	

RTD 81-1
EFF 3/84

SOUTHERN CALIFORNIA RAPID TRANSIT DISTRICT

METRO RAIL PROJECT
REVIEW / COMMENT SHEET

Reviewer H E Story File No. Value Eng Date Oct 198

Dept. / Section SCS Submittal No. and/or Date _____ Sheet 1 of 11

Design Review / Submittal Title Study #1 / Design Criteria Mod II

REF NO.	PAGE NO.	DRAWING NO. / DOCUMENT SECT	COMMENT	RESPONSE / ACTION
8	26	VE #2	DO NOT CONCUR The last paragraph statement that the District accepts no obligation to do business with the Contractor in a timely manner is untrue and needs to be deleted	
9	28 9.29	VE #3	Very redundant study	
10	31	VE #4	DO NOT CONCUR This submittal proves is not the problem. The problem is contractor ability to request many "RFI's" which create in the contractor mind many field changes and more money. Today computer oriented contractors serve the limited ability of the CM Owner to respond and keep on top of the construction thus enhancing the contractors chances for claim awards.	

RTD 81-1
EFF 3/84

SOUTHERN CALIFORNIA RAPID TRANSIT DISTRICT

METRO RAIL PROJECT
REVIEW / COMMENT SHEET

Reviewer H. E. Story File No. Value Eng'g Date OCT 1987

Dept. / Section SCS Submittal No. and/or Date _____ Sheet 5 of 11

Design Review / Submittal Title Study #7 Design Criteria Mod II

REF NO.	PAGE NO.	DRAWING NO. / DOCUMENT SECT	COMMENT	RESPONSE / ACTION
			DO NOT CONCUR —	
11	35	Potential Vs Prop. Tunnel	Elimination of Rebar would not be prudent in earthquake prone Ls. If any thing occured claims would exceed the savings. This concept needs to be a well established proven idea in the properties before it is tried in L.A. There are TOO MANY unknowns The VE Teams BELIEFS are not good enough to stand on in this case	
			CAN CONCUR IN — However	
12	37	Tunnels continued	Walkway width of 2'6" is State Law. Patron Safety is from human Factors Engineering, An inches SAFE Condition is possible. CAN NOT CONCUR IN 1000' FOOT 750 ft X passage distance IS NFPA existing criteria based on distance to get to safe refuge. We are putting exits at 1000 ft when they exit to the STREET. Reasoning is NOT on our feelings like the VE Team	

RTD 81-1
EFF 3/84

SOUTHERN CALIFORNIA RAPID TRANSIT DISTRICT

METRO RAIL PROJECT
REVIEW / COMMENT SHEET

Reviewer H. E. Stacy File No. Value Engr Date Oct 1989

Dept. / Section SC Submittal No. and/or Date _____ Sheet 6 of 11

Design Review / Submittal Title Study #1 Design Criteria MOS II

REF NO.	PAGE NO.	DRAWING NO. / DOCUMENT SECT	COMMENT	RESPONSE / ACTION
			CAN CONCUR, HOWEVER	
13	39	Towers & Stations	Station work is more expensive because of utility work, shoring adjacent building, etc. Again, the VE team is stating their BELIEF of which 5 ft apart is okay for short distances. Also side platform stations added other requirements. ie more elevators, stairs, bigger mezzanines.	
			CAN CONCUR, HOWEVER	
14	40	Towers & Stations	Center platforms are a plus in rush hours because crowds make use of the platform space allocated for other directional travel. Side platforms are a waste of space with persons crowding on one platform while the other side remains empty.	
15	41	"	Shortening platforms by 10' to just fit car door leaves no margin of error for train setting / automatically in Manual Mode	

RTD 81-1
EFF 3/84

SOUTHERN CALIFORNIA RAPID TRANSIT DISTRICT

METRO RAIL PROJECT
REVIEW / COMMENT SHEET

Reviewer H E Stacy File No. Value Engr Date 10/3/89

Dept. / Section CSE Submittal No. and/or Date _____ Sheet 7 of 11

Design Review / Submittal Title Study #1 & 2 STATIONS MOS II

REF NO.	PAGE NO.	DRAWING NO. / DOCUMENT SECT	COMMENT	RESPONSE / ACTION
			Study #1 Cont.	
16	43	Cost Savings	DO NOT CONCUR — I do not believe that the cost savings are realistic. As the report states they are not quantifiable.	
			Study #3 STATIONS MOS II	
			CAN CONCUR —	
1	7	Emergency Vent Shafts #5	If design can collect by mist spills it would be acceptable as long as spills do not reach Trackways.	
			DO NOT CONCUR —	
2	57	VEP-3	Do not believe the V.E. Team has properly evaluated station smoke exhaust. Smoke in Tramway goes to each end of platform & under platform — not adequate.	

RTD 81-1
EFF 3/84

SOUTHERN CALIFORNIA RAPID TRANSIT DISTRICT

METRO RAIL PROJECT
REVIEW / COMMENT SHEET

Reviewer W E. Story File No. Value Engr Date Oct 18 1989

Dept. / Section SCS Submittal No. and/or Date _____ Sheet 8 of 11

Design Review / Submittal Title Study #3 Stations NW II

REF NO.	PAGE NO.	DRAWING NO. / DOCUMENT SECT	COMMENT	RESPONSE / ACTION
			Do NOT CONCUR —	
3	75	VE #10	Do not believe that the VE Team has proper knowledge of Station Vent System.	
			CAN CONCUR —	
4	86	VE #12	The suggested two or more station entrances is okay as long as total NFPA 130 egress requirements are maintained	
			CAN CONCUR —	
5	103	VE #14	Number of Emergency Exits is based upon NFPA 130 criteria. A long car criteria is met with larger main entrances or more of them and less emergency exits. Solutions are numerous.	
			DO NOT CONCUR —	
6	Gen. Comment		I doubt cost savings as discussed. Particularly when stations entrances then could be problem and for a LA	

RTD 81-1
EFF 3/84

SOUTHERN CALIFORNIA RAPID TRANSIT DISTRICT

METRO RAIL PROJECT
REVIEW / COMMENT SHEET

Reviewer H. E. Stacy File No. Value Eng'r Date 8/22 1989

Dept. / Section TSD Submittal No. and/or Date _____ Sheet 9 of 11

Design Review / Submittal Title Study #2 - Line Structures Most

REF NO.	PAGE NO.	DRAWING NO. / DOCUMENT SECT	COMMENT	RESPONSE / ACTION
			CAN CONCUR - HOWEVER	
1	8	VE #1	Small Tunnel size has merit but tighter ROW means tighter tolerance which will cost more. Therefore savings will be less than estimated	
			DO NOT CONCUR —	
2	18	VE #2	Do not believe that LA with its earthquake fault lines and seismic activity is ready to begin the idea of unreinforced concrete Tunnel lining. One maintenance problem or accident involving this design will triple claim awards since its not the transit industry does not design its Tunnels in this manner. Also don't its engineering wisdom and company to surface highways	

RTD 81-1
EFF 3/84

SOUTHERN CALIFORNIA RAPID TRANSIT DISTRICT

METRO RAIL PROJECT
REVIEW / COMMENT SHEET

Reviewer H. E. Storey File No. Value Eng'r Date Feb 1987

Dept. / Section SCS Submittal No. and/or Date _____ Sheet 10 of 11

Design Review / Submittal Title Study #2 - Line Structures Mod II

REF NO.	PAGE NO.	DRAWING NO. / DOCUMENT SECT	COMMENT	RESPONSE / ACTION
			DO NOT CONCUR -	
3	30	VE #4	Unreinforced invert questionable for L.A. Seismic effects	
			CAN CONCUR - HOWEVER	
4	42	VE #6	Gas pumps are required as rooms for Train Control electrical and valves for wet standpipe. Space for them will have to be found somewhere if design changed. Savings questionable. 800 foot spacing does not fit exiting to safe refuge area in required time.	
			DO NOT CONCUR	
5	45	VE #6	Firemen & Company cargo not counted. EXIT will not comply with firemen as described Paragraphs 1 & 2 need to be rewritten.	

RTD 81-1
EFF 3/84

SOUTHERN CALIFORNIA RAPID TRANSIT DISTRICT

METRO RAIL PROJECT
REVIEW / COMMENT SHEET

Reviewer HE Storey File No. Value Engr Date 6/3/1987

Dept. / Section SCS Submittal No. and/or Date _____ Sheet 4 of 11

Design Review / Submittal Title Study #2 - Line Structures MOW

REF NO.	PAGE NO.	DRAWING NO. / DOCUMENT SECT	COMMENT	RESPONSE / ACTION
			CAN CONCUR	
6	52	VE #78	Wet standpipe change okay as long as not damage prone by derailed vehicle or maint-of-way equipment	

MEMORANDUM

SOUTHERN CALIFORNIA RAPID TRANSIT DISTRICT
TRANSIT SYSTEMS DEVELOPMENT DEPARTMENT
SYSTEMS AND CONSTRUCTION SAFETY

****

DATE: August 29, 1989

TO: William Rhine

FROM: Byron M. Ishkanian BMI

SUBJECT: Phase II Cost Reduction Suggestions and Proposal

****

The following is submitted in the interest of providing cost cutting ideas for the construction of Phase II of the Metro Rail Project.

Items presented can be considered starting points for discussions in attempting to get as much mileage or "bang for the buck", so to speak, from monies appropriated for the Phase II portion of the Metro Rail.

Subjects discussed are the result of experience accumulated during the construction of MOS-1, knowledge and experience from other tunneling projects and discussions with others in the discipline of underground construction.

If the ideas prove to be of value, the savings generated could allow the Phase II portion to reach the Universal City Station location rather than stalling out at Hollywood and Highland Station.

Completion of the system to the north side of the Hollywood Hills would allow greater ridership and materially drain traffic from the Hollywood Freeway from Cahuenga Pass to the Civic Center.

Ideas presented fall into three large categories which will be discussed in greater detail on the following pages, and are as follows:

1. Extend each tunnel drive excavation sequence.

2. Mine the stations from the tunnel alignment or from two shafts to the surface.

3. Materially reduce the number of primary excavation contracts.

Illustrations of the ideas presented in this memo are included.

1. Extend each tunnel drive sequence.

In MOS-1, tunnel drives were short dual tunneled sections between large cut and cover station excavations. I propose to drive tunnels in Phase II greater lengths, and right through the proposed station locations.

This would save time and money in setting up the tunneling sequence, since fewer setups would be needed; and a partial excavation of the station location would be made by the tunneling machine passing through the length of the station.

Removal of two cylinders of earth, by the tunneling sequence, 22' in diameter the length of the station would lessen excavation cost of the station.

Since this proposal provides for "mined" stations(discussed later), the extensive ground control and support and extensive excavation of a cut and cover station would be eliminated and thus a saving realized, in earth movement and backfill.

Only the earth needed for the station would be removed by the tunnel excavation mechanisms and no backfilling would be necessary. If shafts were needed at the station locations for ventilation, one could use these for muck removal if that mode was deemed appropriate.

Since, in this modus operandi, the station construction could not start until the tunneling was through the station, it would be absolutely necessary that the dual tunnel drives start almost simultaneously. We prepared for this in MOS-1, but none of the contractors elected to run parallel tunneling operations and we were not able to force them to do it. As a result, tunneling operations in dual tunnels were done sequentially rather than simultaneously.

This luxury would not be allowed in this proposal. If necessary, parallel tunnel contracts could be split with one contractor building the AR and the other the AL, to make sure both tunnels progress at a pace to allow station construction to start. Crosspassage and intermediate construction between the tunnels would have to be designated to be done by one or the other of the contractors in this case.

In our present alinement for Phase II, tunnel drives would consist of continuous excavation by one machine as allowed by the rock to be cut. For example, from the present geotechnical information the drives could be distributed for contracts in the following manner.

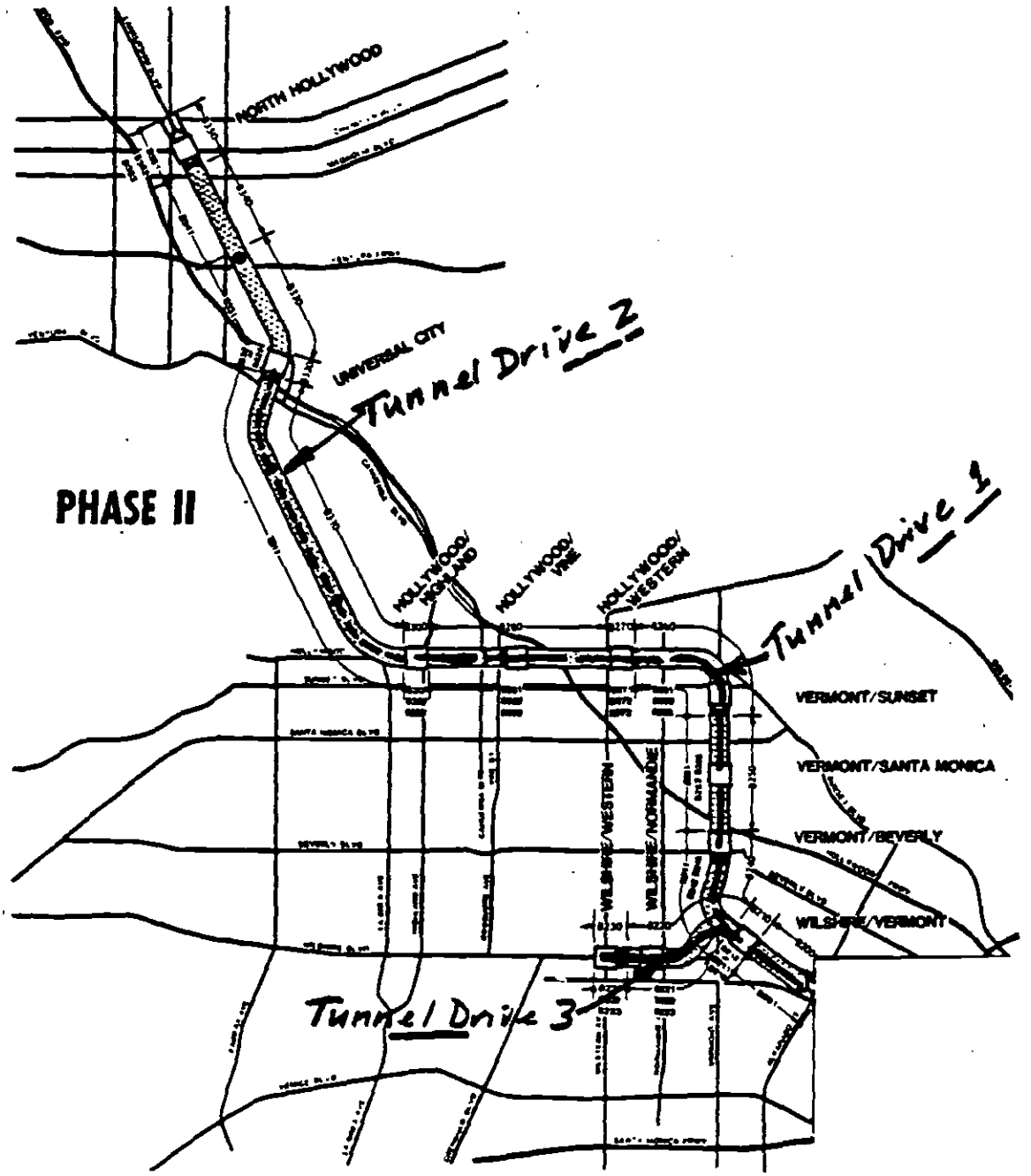
a. One tunnel drive from MacArthur Park to Wilshire and Western or veering off at Vermont, from Mac Arthur Park to Vermont and Beverly Blvd. Either way, this could result in two tunnel drives.

b. There appears to be a possible stratigraphic change just north of Beverly on Vermont, wherein massive sandstones in the middle and lower Puente Formation might necessitate a full face cutter head boring machine to cut the rock.

c. If an excavator type machine could work in this area, then the tunnel drive could be extended all the way to Hollywood and Highland Ave.

c. (Continued)
Obviously, an excavator type machine could not be used to cut through the basalts and heavy conglomerates of the Topanga Formation making up the Hollywood Hills.

d. Thus, from MacArthur Park to Western Ave. and up Vermont and Hollywood Blvd. through the Cahuenga Pass to Universal City, we would have three or possible four tunnel drives, at the most.

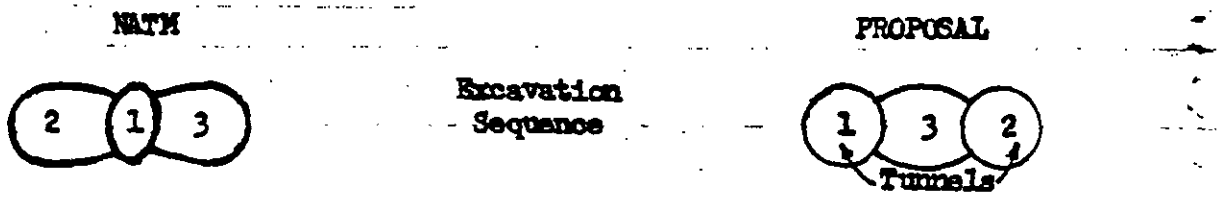


2. Mine the stations from the tunnel alignment or from two shafts to the surface.

Underground mining of the stations would necessitate mining and supporting the area between the tunnel drives, and mining the mezzanine area above the tunnels and the intermediate ground between tunnels.

If the area between tunnels at the stations did not need to be 20', tunnel drives could be angled slightly upon approach to the stations to lessen this distance.

Otherwise, the mined portion of the station would resemble a modified reverse NATM(New Austrian Tunneling Method) sequence. Rather than the central portion (between tunnels) being mined out first, supported and then the tunnel extensions mined, in this case the tunnel drives would already be in place and the central portion remain to be mined and supported.

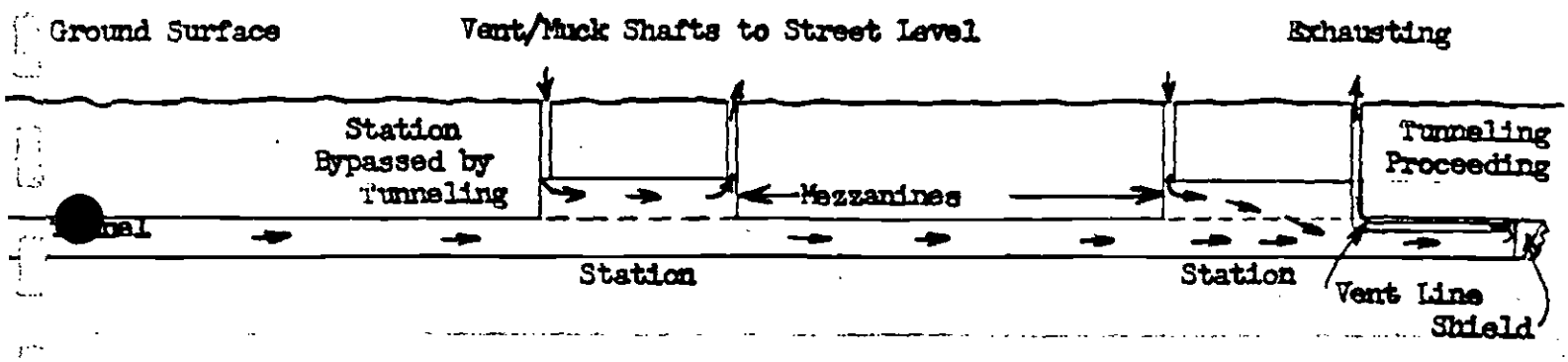


The mezzanine would then be mined similarly, only the sequence would revert to the central oval mined first and the parallel ovals mined secondarily. For these excavations, muck could be moved out with the same system as the tunneling muck. An additional California Switch could be installed at the Station excavation location for muck trains. In this manner, forward tunnel excavation would not be interrupted by work at the Station.

If this muck removal system proved to be impractical, two dual purpose shafts could be sunk(of minimum diameter) at each end of the station. These shafts would be constructed to handle the extrication of muck and also ventilation for the station and forward tunnel construction. Since the tunnel and Station construction would probably be classified Gassy, the exhaust mode of ventilation would be required. As the tunnel construction progressed past one Station to another, the main exhaust fan location could be moved along accordingly to the station nearest the primary tunnel excavation location.

Fans on blow and exhaust would then be used on the bypassed Station to purge those locations while construction was progressing. Detailed diagrams are presented at the conclusion of the memo, with elementary drawings presented on this and the excavation method described above on this page.

Ventilation While Tunneling is Proceeding



Station construction contracts, by this method, would consist of the mezzanine area primarily. These could be made a part of the tunnel drive contracts if the tunneling contractor had the mining expertise for this type of work.

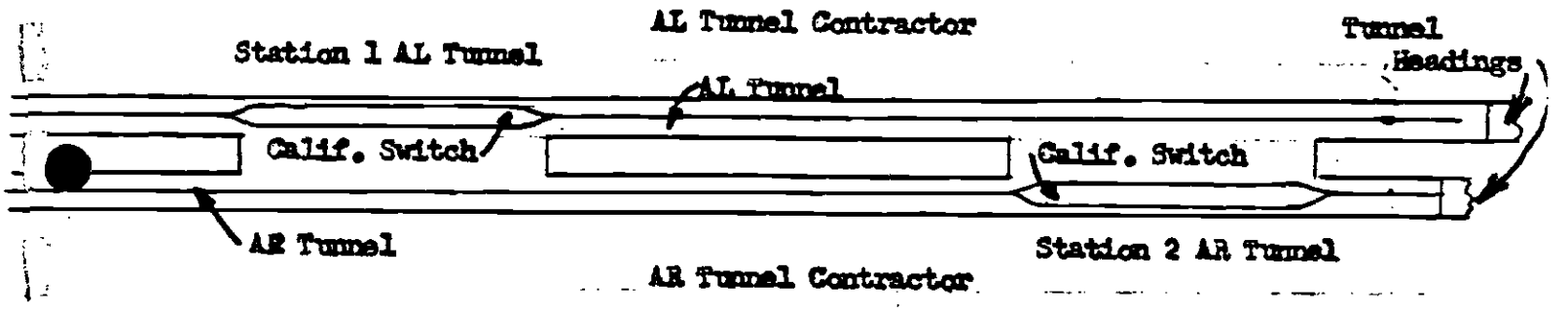
If otherwise, they would have to be designated as separate contracts and/or all the station-mezzanine contracts grouped as one contract, with the specialty contractor doing all the mining portions of the Stations.

With this procedure we could limit the number of Station contracts to three or four, and possibly as few as two.

If separate contractors were selected for parallel tunnel drives, one tunnel drive and the first station encountered could be in one contract and the next station in the contract for the other tunnel drive.

An example of the configuration for excavation of a station proceeding while the tunnel drive was working ahead is shown in the illustration as follows.

Plan View of Separate Tunnel(Parallel) Contracts Operation



If station construction could not proceed in this manner because of conflict with tunnel construction, shafts could be sunk at the end of the stations as shown in the diagram on the previous page, and the plan view below.

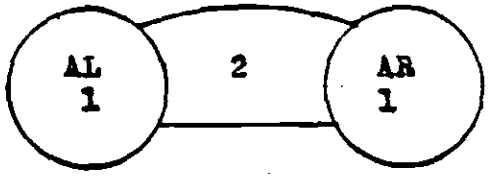
Scale 1" equals 100'

STAGES OF STATION EXCAVATION AND CONSTRUCTION USING THIS PROPOSAL IDEA

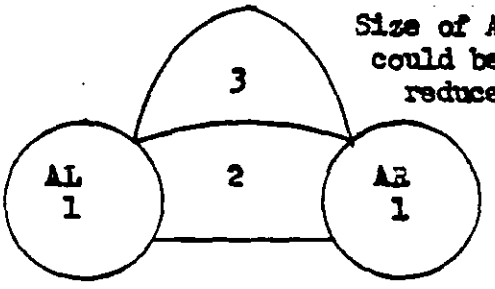
Step 1

AL and AR Tunnels Excavated Through the Station

Step 2
Excavate and Support Area 2

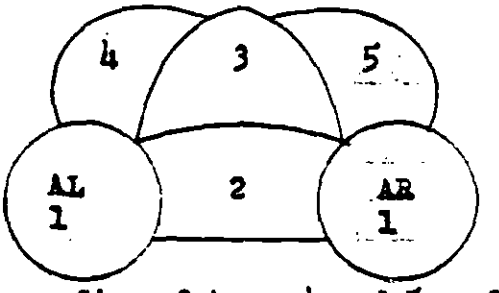


Step 3
Excavate and Support Area 3

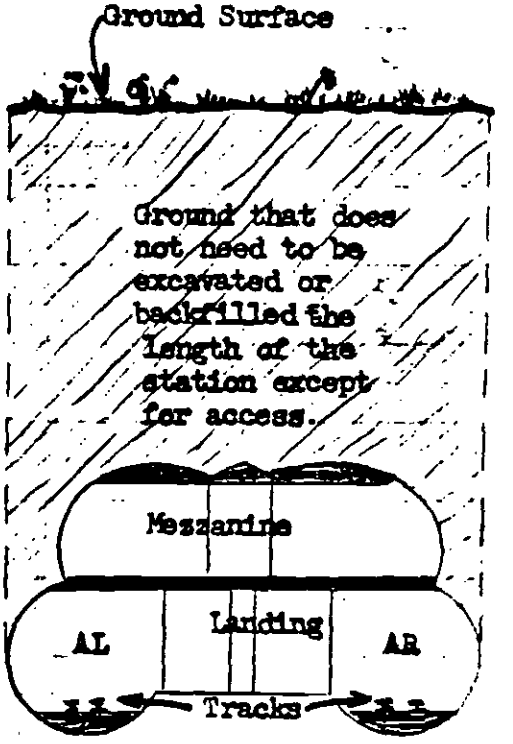


Size of Area 3 could be further reduced

Step 4 and 5
Excavate and Support Areas 4 &



Size of Areas 4 and 5 could be further reduced



Scale 1" equals 25'

Volumes of earth removed by this method from a rectangular station box 80'x60'x600' minus the area under the landing is as follows:

Station Box minus underlanding is 4775 sq.ft. x 600ft. is 2,865,000cu.ft. or 106,111cu.yd

Area removed by through tunneling of the station(assumed 20' diam. tunnels) is 314.16sq. ft. x 600ft. is 188,496cu.ft. or 6981cu.yds. per tunnel.

Balance of the earth removed by the station excavation proposal is 1,026,504cu.ft. or 38,018cu.yds.

A total of 51,980 cu.yds. would be removed from the rectangular box station by the station mining and tunneling excavation(tunnels 13,962cu.yd.and station-38018cu.yds.)

Note: Further reductions in earth removed from the stations could be made in reducing the size and/or configuration of excavation steps 3,4 and 5.

Final savings in ground that need not be excavated or backfilled is 106,111cu.yds minus 51,980 cu.yds or 54,131 cu.yds

BMI-489

3. Materially reduce the number of primary excavation contracts.

Reduction of the number of contracts would bring reduced costs from an administrative standpoint, both for the District, Construction Manager and the Contractor.

Since contractors would be doing repetetive operations, ideally, their efficiency would improve. Preparation time for tunnel drives would be dramatically reduced, since, as previously mentioned, the number of drives would be fewer.

Station excavations would assume a pattern which would create a more efficient operation. Coordination of the tunneling sequence and the Station excavation would be important for separate contractors and also if one contractor handled both operations on one contract.

Surface disruption of the city would be far less, which could result in reduced liability claims, traffic accidents, guard services and transient invasion of the work site problems and the attendant exposures that are created.

Conclusions: Against

1. Mining type construction may not be practical.
2. Intermingling of parallel contracts might not work.
3. Seismic requirements might not be met.
4. Building settlement might result if mining is not done properly.
5. Inability to find contractors experienced in this type of station construction.
6. The possibility of changing tunneling machines on drives, if geotech reports are not complete.

For

1. Reductions of at least 20% cost in station excavations and 10% in tunnel drives could be realized.
2. Faster construction of Phase II.
3. Fewer contracts and entities to deal with.
4. Less disruption of the city in general.
5. No large street support "I" beams or street plates required.
6. No major strut support across excavations needed
7. Use of the natural strata bridging effect.
8. Less utility disruption and hazardous material mitigation.

Ideas presented here are submitted to provide a radical solution to the problem of extending the Metro Rail Project to the north flank of the Hollywood Hills with the limited funds available.

cc Harold E. Storey
James Crawley
Sam Louis
Fernando Quesada
Mel Polacek
Jim Monsees
Nadeem Tahir

A. Levy

M E M O R A N D U M

SOUTHERN CALIFORNIA RAPID TRANSIT DISTRICT
TRANSIT SYSTEMS DEVELOPMENT
RAIL FACILITIES

****

TO: James E. Crawley

FROM: Ramesh Thakarar

DATE: October 13, 1989

SUBJECT: Value Engineering Study #2 -
Line Structures

****

I have reviewed the subject report and below are my recommendations:

(1) Value Engineering Proposal (VEP) #2.

The recommendation is for the District to install 8" unreinforced concrete lining. This recommendation has merit and needs further evaluation. I quote from Guidelines for Tunnel Lining Design, prepared by the Technical Committee on Tunnel Lining Design of the Underground Technology Research Council, published by American Society of Civil Engineers, Section 3.3.3. Lining Capacity, page 21:

"There is considerable divergence of opinion on the necessity and utility of reinforcing steel in cast-in-place concrete linings. If it is accepted that the initial support system absorbs the ground deformation and redistributes unequal pressures before the concrete lining is installed, the possibility of outward bending that could overcome passive pressure is virtually nil. This indicates that an outer ring of reinforcing steel is not required. Nevertheless, inward bending, particularly in the crown, can result from gravity loading. If it is considered that this may exceed the capacity of embedded initial support members, an interior ring of reinforcing steel will be needed. Consideration may be given to an inner layer of longitudinal reinforcing bars to resist shrinkage and temperature cracking that occurs preferentially over embedded steel ribs, combined with sufficient circumferential rebar to hold the longitudinal steel in place against the pressure of wet concrete sliding down the forms from the slick line.

It should be recognized that many unreinforced concrete linings have given long satisfactory service in rock tunnels tunnels, and it is not clear that the investment in reinforcing steel is cost-effective. High quality grouting between the lining and excavated ground can promote favorable conditions for lining response to loads. Reinforcing steel will increase lining costs by adding materials and impeding lining construction."

The present design requires two layers of reinforcing steel (#5 @ 12" transverse) and #5 @ 18" longitudinally, with a minimum lining thickness of 12 inches. I believe that a more careful analysis would reduce the thickness of the lining and the amount of reinforcing specified. Perhaps a lining design based on the geotechnical conditions encountered in the field may be more appropriate.

(2) VEP #4 - Tunnel Invert.

The recommendation is for the District to delete reinforcing steel in the concrete of the tunnel invert. This recommendation has merit and warrants further evaluation.

The current design may be the result of the structural engineer's tendency to always reinforce the surfaces of concrete. I also realize that ACI Code requires reinforcing for shrinkage, temperature and load distribution purposes. Since most codes have been written for above ground structures, a special review and analysis of tunnel inverts may show that no such steel is necessary.

(3) VEP #5 - Tunnel Walkway
VEP #6 - Cross-passages

The sketches presented in the Report eliminate many of the complexities of current design and warrant serious consideration by the District.

Overcoming resistance to changes in Standard designs that have been in existence for several years is always difficult. Concerns about Professional Liability may also be raised. But, despite these obstacles, an opportunity exists for some significant cost reductions.

A. Levy

M E M O R A N D U M

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TRANSIT SYSTEMS DEVELOPMENT
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A. Levy
re V.E.

MEMORANDUM

SOUTHERN CALIFORNIA RAPID TRANSIT DISTRICT
TRANSIT SYSTEMS DEVELOPMENT DEPARTMENT
RAIL TRANSIT FACILITIES

TO: James E. Crawley

FROM: Douglas A. Low

DATE: October 17, 1989

SUBJECT: Evaluation of Phase II
Value Engineering Study #3 Proposals

My analysis of Subject VE proposals is as follows:

VEP # 1 Reduce Station Depth

Generally agree with the concept of limiting clearance to 10'-0". Implementation is tied to VEP #9 and #10, which defer initial air conditioning provisions and eliminate station fresh air supply. These elements, as presently designed, require added clearance.

VEP # 2 Station Columns

Strongly concur with recommendation to eliminate columns. Will require investigation of satisfactory methods to achieve ceiling lighting and sound control.

VEP # 3 Station Length

Concur with recommendation to reduce platform length by 10 feet, if reduced train overrun is acceptable to Operations.

VEP # 4 Station Foundation

Concur with recommendation to provide eccentric continuous one-way footings, if soils under foundation can support loads over reduced area.

VEP # 5 BRS Outlets

Strongly concur with recommendation to place BRS outlets in streets, if Fire/Life Safety Committee and City of Los Angeles can be pursuaded to accept gratings.

VEP # 6 Noise Control

Concur in principal that attenuators should be eliminated, because this potentially reduces length of station. Will require investigation to determine configuration and cost of required auxiliary ventilation system.

VEP # 7 UPE Outlets

Strongly concur with recommendation to place UPE outlets in streets. See comment on VEP #5.

VEP # 8 Smoke Exhaust System

Question logic of recommendation to eliminate present system. Smoke pushed out of the station at track level will not necessarily remove smoke from upper portion of mezzanine, which could be serious evacuation problem.

VEP # 9 Future Air Conditioning

Concur with recommendation to defer all air conditioning requirements, unless it can be shown that some or all of the present provisions cannot be implemented later.

VEP #10 Fresh Air Supply

Concur with recommendation to eliminate fresh air supply, which does not presently service most of the station, unless it can be shown that it is required for the future air conditioning system.

VEP #11 Mezzanine Configuration

Strongly concur that proposed horizontal beam configuration in open mezzanine areas should be adopted, even if cost reduction estimate is incorrect and there is a modest increase in cost.

VEP #12 Secondary Station Entrances

Concur in principal that second entrance is preferable to emergency exit. Need to investigate their functions and relative costs before making final judgement. Disagree that primary entrance should be downgraded in capacity.

VEP #13 Open Plaza Entrances

Concur that plaza type station entrances should be encouraged, with determination made on a site-specific basis. Question whether ancillary space needs to be substantially relocated.

VEP #14 Emergency Exit Location

Concur that emergency exits located at the ends of platforms should be incorporated within the platform length, where possible. Also agree that sidewalk hatches for exits have disadvantages, and should provide alternative exiting method where possible.

VEP #15 Crossover Length/Width Reduction- Side Platform Stations

Concur in principal with narrowing of tracks to reduce crossover length and thus cost, requiring side platform stations at Vermont/ Beverly and Vermont/Sunset. Requires additional investigation to verify all functional requirements and true cost savings.

VEP #16 Pocket Track in Station

Disagree with this recommendation, which provides a double crossover on narrow track centers at each end of a side platform station, and creates pockets in the berthed train positions. It is doubtful whether Operations would consider this arrangement satisfactory. Unless absolutely necessary because of considerable cost savings, a side platform station at Hollywood/Vine is not acceptable. Utilizing a center platform with widened double crossovers would not appreciably save cut-and-cover length.

VEP #17 Relocated Pocket Track

Strongly favor this proposal in lieu of VEP #16. This alternative provides the pocket track in a location west of Hollywood/Highland Station under the Santa Monica mountains. While the proposal shows a side platform station with one double crossover at Hollywood/Vine, a center platform configuration with wider crossover could be utilized and still substantially reduce the overall cut-and-cover length.

cc: J. Ball
A. Levy
K. Murthy

8931538

METRO RAIL TRANSIT CONSULTANTS
DMJM / PBQD / KE / HWA

September 08, 1989

Mr. James E. Crawley, P.E.
Director of Transit Facilities
Southern California Rapid Transit District
425 South Main Street
Los Angeles, California 90014

Subject: Metro Rail Project
Value Engineering Proposal Comments

Purpose: Information Transmittal

File No. P050X004

Dear Mr. Crawley:

Per your request, here are some general observations on the draft proposals.

VEP No. 1 Tunnel/Station Excavation contracts in lieu of present concept.

- The Value Engineering team has considered the time savings in the tunnels only. The station structural contracts will be delayed due to the excavation duration. This has not been considered in their analysis.

- Repackaging provides some definite benefits in longer tunnel drives and in reducing the number of shields but it also creates new interfaces such as the responsibility for the excavation support system, utility maintenance and protection, decking, limits of restoration, entrance structure limits and sequence of construction, etc.

Reduction of tunnel diameter from 17'-10" to 16'-6" I.D.

- We understand and concur that the vehicle design will not be altered at this time.

- We also point out the possibility of shaving inches from the re-rail procedure and gaining inches in the reconfiguration of tunnel electrical and mechanical hardware. However, the envelope should be protected for future vehicle purchases and other unforseen conditions such as liner repairs.

Reduction of tunnel lining thickness.

- We have stated our position with respect to reducing the cast-in-place lining thickness and are opposed to reducing this dimension since misalignment of the tunnel primary support could reduce the nominal dimension of 12 inches to 9 inches.

- Reduction of the free annulus between the vehicle and the tunnel wall will increase local air velocities, increase the piston effect of the train and increase power requirements in O & M costs.

Removal of reinforcing steel in liner and invert.

- We believe that the dowel inserts for the walkway are potential for forming cost reductions in the tunnel. This could be changed, if studies indicate economy, to female inserts to eliminate forming and stripping delays. The experience on other projects indicate female inserts are either plugged or misaligned during concrete placement and require redrilling for placement of new inserts.

- The re-steel in the tunnel is less than the amount required for temperature steel but is designed to create a blanket protection for the concrete liner should there be a failure of the liner integrity.

- The invert steel is minimal and serves to support the stirrup steel dowels for the trackwork plinths.

- We do not consider either of the above to be a major cost item or a deletion item.

VECP No. 3 Design Quality Control

- We concur with the alternative concept of one design entity preparing all the tunnel design.

- A Peer Review of design documents was included in our current work plan and approved by RTD. The first review will occur this month with the pre-final documents for A136, A147 and A157. Budgetary and schedule considerations shall be reviewed to include this.

We are attaching an internal memo from Mr. Bill Armento dated September 6, 1989 which discusses in detail the pros and cons of V.E.P. No. 01.

We recommend a thorough review of all the VEP items together as interrelationship of many of the considered items play an important role in cost reduction consideration.

METRO RAIL TRANSIT CONSULTANTS

K.N. Murthy
Project Director

KNM:gr

Attachments

cc: W. Rhine, SCRTD
A. Levy, SCRTD
TSD-DCC (2)

METRO RAIL TRANSIT CONSULTANTS
DMJM/PBQD/KE/HWA

MEMORANDUM

TO: K. N. Murthy

FROM: W. J. Armento

DATE: September 6, 1989

SUBJECT: Interim Draft, Value Engineering Study No. 1

FILE NO: T700X004.00

Review was made of VEP No. 1 - Contract Packaging dated July 27, 1989 and my comments follow.

The concept of providing a separate contract for decking, excavation and shoring for the cut-and-cover work followed by another contract for the concrete and finish work of stations, crossovers and pocket track is questioned in regard to practicality, time efficiency and cost savings.

For subway projects there is a large group of contractors who are quite familiar with the requirements of the full range of activities that go into the construction of a cut-and-cover project. Underground construction, or "heavy construction" for an urban transit system involves the planning and execution of decking arrangements, sheeting and bracing installations and removals, excavation procedures, underpinning and protection of adjacent structures, and dewatering as these relate to the actual construction of the subway structure. A contract that embodies the excavation work together with the concrete shell construction is certainly more practical than dividing the responsibilities into two separate contracts. With separate contracts the design office would have to cope with trying to direct the excavation contractor in many aspects of the work to accommodate the follow-up structure contractor. The excavation work will not necessarily be free from cross-lot bracing, as the VEP assumes, since there is the likelihood of the presence of deep basements adjacent to the excavation or the inability to attain easements for tiebacks under adjacent properties. Then, of course, the structure contractor would have to be given all the as-built data of decking, sheeting and bracing so that he would be aware of conditions under which he would be conducting his work.

Two separate contracts would be more time consuming than a single contract that combines the excavation work with the structure construction. A separate excavation contract contemplates the full length of trench excavation to virtually subgrade and then leaving the area for the second contractor to start work. Under a single contract the excavation is not usually carried down to subgrade for the full length of the trench before concrete work can start. Instead, the excavation proceeds down to subgrade in a longitudinal sequence with concrete work installed in similar order as the excavation work reaches completion.

There are cost penalties in two separate contracts. Decking materials, the deck beams and timber decking panels, are very often re-usable materials by subway contractors. If the second contractor removes these and keeps them then the full charge for these materials will be assessed to the District by the excavation contractor. Also, of what use will a so-called "building contractor" have for the deck beams and timber panels? Likewise the cross-lot bracing, wales and particularly struts are re-usable. What would a "building contractor" do with a lot full of pipe struts? Not to be overlooked is the assortment of claims that a second contractor would make because of changed cnditions; i.e., sheeting intruding in the neat line of his work, wales interfering with rebar installation, dewatering not functioning properly, difficulties in removing internal bracing, etc.

WJA/ca

cc: G. M. Cofer
DCC (2)

A. Levy

MRTC COMMENTS

TO

VALUE ENGINEERING STUDY #2 AND #3

METRO RAIL TRANSIT CONSULTANTS
DMJM/PBQD/KE/HWA

METRO RAIL TRANSIT CONSULTANTS
DMJM / PBQD / KE / HWA

November 20, 1989

Mr. James E. Crawley, P.E.
Director of Transit Facilities
Southern California Rapid Transit District
425 South Main Street
Los Angeles, California 90014

Subject: Value Engineering Study #2 and #3

File #: P001 X004.00

Purpose: Information Transmittal

Dear Mr. Crawley:

Per your request, we have reviewed the Value Engineering studies performed by Foster Engineering and C V S Inc. We had previously, forwarded to you, comments on Study #1. Hence, these comments are directed to the other two reports only.

MRTC's comments on each proposal, in the study, are in the following three categories:

* Concurrence with suggested proposal.
* Concur with reservations pending further detailed analysis and costing.
* Disagree with the proposal.

As expressed in the meetings, with the Value Engineering Team and the District staff, we have great difficulty in acknowledging the method and the value of the dollar savings projected by the Value Engineering Team. Therefore our comments concerning cost savings against each proposal are very general in nature. It is our recommendation that upon finalization of the VE study a detailed cost estimate of the accpeted proposals should be done.

Attached for your information, review, and comments are:

* Summary of the response to each of the proposals.
* An Appendix that includes more detailed discipline responses for the proposals.

891086gb.ltr

548 S. Spring Street, Seventh Floor, Los Angeles, CA 90013 · (213) 612-7000

Should you require further technical evaluation, clarification, and/or discussion concerning this response please advise us.

Very truly yours,

K.N. Murthy

KNM:mgb

cc: W. J. Rhine, SCRTD
A. Levy, SCRTD
SCRTD-TSD/DCC
DCC (2)

Attachment

STUDY #2 - VALUE ENGINEERING PROPOSAL

Proposal No. 1 -Reduce Tunnel Diameter

- MRTC concurs that there may be an opportunity to reduce rerailing clearances.
- We suggest that the District carefully consider the proposal to use the Breda vehicle envelope in lieu of the composite one. Future vehicle procurement competition could be impacted.
- One of the parameters considered in the determination of the standard 17'-10" diameter was a clearance annulus to permit a steel liner repair of the tunnel should the membrane and/or concrete lining be damaged by an earthquake or should gas leaks develop. We recommend that this space remain.
- We consider the estimated savings to be about half of what is shown in the proposal.

Proposal No. 2 - Change Tunnel Lining From 12-in. Reinforced to 8-in. Unreinforced Concrete.

- MRTC does not agree that the reinforcing steel can be eliminated. Earthquake design and the requirements of ACI-318 dispute the removal of longitudinal reinforcing steel.
- For tunnel traveller-type forms, reinforcing steel setting is never a critical path activity. The cure,

strip, move, and set sequence always is the schedule controller.

- o We do not agree with some unit prices used which in turn overstate the potential savings.

Proposal No. 3 -Double Track Tunnel

- o Current tunneling history on MOS-1 has supported the fact that soil stability in the L.A. area approaches the point of limiting equilibrium at the present diameter. To go to a non-circular, and/or larger cross-section would require a major re-evaluation of methods and stabilization procedures.
- o We might consider the double track circular tunnel in sound rock but not in the study segment. Further, Fire/Life Safety requirements must also be considered.
- o MRTC does not recommend this proposal. Any material cost savings for the alignment under consideration is for the removal of cross passages and reduction of crossover structures. What is not considered is the increase in schedule due to the reduced heading progress which would be in the order of 6-15 feet per day compared to 30-40 feet per day per single tunnel.

Proposal No. 4 -Remove Reinforcing from Tunnel Invert Concrete.

- o Our design follows design concepts used in Washington, Baltimore and Atlanta and uses minimum reinforcing steel in the invert slab. The savings realized due to

elimination of this steel, in our opinion, is far less than projected.

- Reinforcing steel stirrups for the second pour trackwork plinths must be supported and secured for concrete placement. The temperature steel permits this as well as to reinforce the invert concrete and provide a negative return bond continuity within the invert to mitigate any stray current. We do not recommend eliminating the invert reinforcing steel.

Proposal No. 5 -Modify Tunnel Walkway

- Although the proposed alternative has merit, all aspects of the walkway configuration in tangent and curved tunnel require further design study.
- MRTC concludes that a fabricated steel and non-ferrous walkway could be designed and constructed to satisfy criteria and Fire/Life Safety requirements and potentially reduce the capital cost of the current cast-in-place design.
- Several factors must be considered before we would concur that this alternative design is better in the long term. Deterioration of bolts and structural steel will require higher maintenance costs and could result in a shorter life than reinforced concrete.
- In addition, the possible damage of, or failure of the walkway could create a serious contact with a train.
- We do not concur with the estimated cost savings of the alternative design.

Proposal No. 6 -Tunnel Cross Passages

- MRTC suggests that further study of a horseshoe tunnel design be done which could reduce the amount of fill concrete in the structure.
- Fire/Life Safety requirement of clear passage width and height as well as fire rated doors cannot be altered.

Proposal No. 7 and No. 8

(See Study #3)

Proposal No. 9 - System Profile

- Profiles shown on the Phase II Preliminary Engineering drawings are approximate and subject to revision. Station profiles have been selected based upon the existing information of utility depths, surface elevations, entrance locations, and station vault conceptual layout. The final positioning of each station and adjacent line will be determined in the continuing preliminary engineering or early final design. MRTC will consider all the parameters such as invert elevation(s) and grade of the stations to assure that the final alignment sets the structures at the optimum design depth.
- MRTC does not see the proposal as a savings but only as a statement of fact which will be carried out.

Proposal No. 10 -Wet Standpipe Redesign

- Relocation of the wet standpipe is contingent upon acceptance of Proposal No. 5 -Tunnel Walkway Modification.
- We do not have any concerns with the functional aspects of the proposal. However, we recommend that the issue of cooking or burning of joint gaskets in a tunnel fire situation be studied. We understand that high temperature gasket material is available and should be specified if this proposal is accepted.

STUDY #3 VALUE ENGINEERING PROPOSAL

Proposal No. 1 -Station Depth

This proposal suggests that the station structure be reduced in overall depth by reducing floor to ceiling heights.

- Platform to underside of mezzanine is controlled by vehicle envelope height and the top of rail to platform height. The ceiling area above the platform requires a space of 3.5 feet for the air supply duct system. Lowering this clearance would impact the vehicle envelope in mezzanine areas.
- The vault ceiling height is controlled by the clearance requirements above the handicapped elevator shaft or by the space requirement for the smoke exhaust duct and the minimum head clearance of 10 feet at the exterior wall line.
- This proposal does not have merit.

Proposal No. 2 -Station Columns

- Considerable discussion took place during the system definition period as to the merits and negative impacts of station center columns. It was shown at that time that by reducing the span length of the vault roof proportionate reductions in the thickness of the roof slab occurred. Although we generally concur that column free stations are architecturally more pleasing, the

previous V.E. analysis identified the cost-effectiveness of the center column design.

- The design requirement to mitigate buoyancy may add concrete to the invert and walls of the stations where the aquifer is above or has the potential to introduce hydrostatic pressures.
- There are no considerations or discussion in the proposal text as to the design connection problems of precast beams to cast-in-place exterior walls or the logistical and virtually impossible task of trying to thread 55 foot precast beams through the maze of decking support beams and supported utilities.
- MRTC does not agree with the estimate cost savings shown. The figures are based upon erroneous assumptions and contradict earlier evaluations of the cost-effective center column station design.

Proposal No. 3 -Station Length

- Although we forsee no difficulties from an exiting or platform capacity point of view, the stopping accuracy of the ATO system would require further study to assess the merits of the proposed 10 foot reduction. Train berthing interlocks currently require that all doors of a train be within the platform confines. The proposed 10 foot reduction in platform would result in more frequent overshoot if the berthing boundries with resultant operational delays.

Proposal No. 4 -Station Foundation

- The proposed design of one-way footings is based upon a false assumption of no hydrostatic uplift pressure.
- We do not concur with the estimated cost reduction; it is based upon quantity reductions which are not achievable.

Proposal No. 5 -Emergency Vent Shaft

- MRTC concurs that cost reductions are possible, if the City of Los Angeles agrees to the change. Space availability and safety concerns have dictated the current sidewalk location of these structures.
- If the District can convince the City to reconsider their position, recording the positioning of the vent structures within the cut-and-cover limits, the structures could be reconfigured to reduce concrete and improve ventilation efficiencies.
- We are presently studying this concept for the Wilshire Corridor Stations in Phase II.

Proposal No. 6 -Emergency Vent Shaft Noise

- The vent shaft fans are all automatically controlled and can be operated day or night. Current noise reduction measures, such as sprayed-on acoustic material in the shafts, does not sufficiently attentuate the noise from the fans. This must be done at the source. Therefore, attenuators cannot be eliminated.

Proposal No. 7 -Under Platform Exhaust Outlet

- MRTC concurs that a redesign of the vent structures to the middle of the street could save costs. However, we suggest that this is a "standards" change which must be carried forward to the City by RTD for their approval.
- Typical rearrangements showing the mid-street design, require further study supported by order-of-magnitude savings and safety risk analyses. It appears that the City's major concern is the release of the surface easement which limits the space in the street for utilities.

Proposal No. 8 -Smoke Exhaust System

- The smoke exhaust system cannot be deleted for the following reasons:
    1. It will be used to expell smoke from the mezzanine area after a fire in the system.
    2. The smoke exhaust system will be used in conjunction with the Underplatform Exhaust System and Supply Air System to ventilate the tunnels in the purging of methane gas during non-train operating periods.
- The functional concept of the Smoke Exhaust System in the V.E. Proposal is misunderstood. The Smoke Exhaust System will be off when the emergency fans are activated. The system will be activated to expell smoke and hot gases which accumulate at the mezzanine ceiling after the emergency fans are turned off.

Proposal No. 9 -Station Ventilation (Provisions for future A.C.)

- o MRTC recognizes the proposal to eliminate the chiller room within the station complex as a potential deferring of capital costs. However, to locate the facility on the surface at a later date would generate premimum costs.
- o In addition, chases or conduits for future piping would have to be included in the station design and the future cost of connecting the chiller plant to the station A.C. system would be increased considerably.

Proposal No. 10 -Station Ventilation (Supply Air System)

- o The environmental Control System Report (August 1985) concluded that the station temperature will exceed 90 F at peak hour operation when outside air is at 84 F and the station supply air system is not used.
- o To overcome unacceptable environment conditions in the station, based on LRDS perameters, it is not recommended to delete the Station Air Supply System.
- o Station Supply Air System will be required in conjunction with the Underplatform Exhaust and Smoke Exhaust Systems to purge the line and stations of methane gas when trains are not in operation.

Proposal No. 11 -Mezzanine Confirguration

- o MRTC supports the concept of continuous mezzanines from the point of view of simplifying structural design and improving the functional characteristics of the stations for current and future development.

- MRTC does not concur with the proposed alternative design of cantilevered walkways since the structure would add additional bending stresses and strain to the exterior walls.
- We conclude that the additional mezzanine reinforced concrete would be more than offset by the savings in exterior wall thickness and overall structure width savings of a full mezzanine but not with the cantilever concept.

Proposal No. 12 -Station Entrances

- MRTC considered the concept of upgrading the emergency exits to standard entrances. The idea was rejected for the following reasons:
    1. Emergency exits are typically in public space. This is not the case with standard entrances.
    2. Emergency exits can be combined with vent shafts to minimize costs.
    3. Patronage figures for many of the Phase II stations do not justify the capital and operating costs of a second entrance.

Proposal No. 13 -Station Entrance Concept

- MRTC supports any recommendation to reduce the cost of structures. However, the concept of open entrance designs, which may have merit at some locations, generally restricts the potential sale of aerial rights generally.

- The open concept may have merit at some sites where a plaza-type design is permissible.
- Open entrance structures have two disadvantages which must be considered. They generate additional maintenance costs and security costs.
- The cost savings projected do not address or include the additional operating and maintenance costs. In addition, the loss of potential real estate revenues is not accounted for.

Proposal No. 14 -Emergency Exits

- MRTC notes a number of functional drawbacks which must be considered.
- The alternative design does not provide for stair width dimensions which meet design criteria for evaluation.
- The building code requires a maximum 20 foot distance between the end of platform and the exit door. Meeting the code would create headroom clearance problems over the trainway.
- Circulation conflicts at the entrances would not permit this alternative in a double end mezzanine station.
- Cost savings appear to be exaggerated.

Proposal No. 15 -Crossover Length/Width Reduction

- MRTC supports the concept of reducing the cut and cover special structures length and width where practical. Our concern is that this cannot be done without the complete

reconfiguration of the Vermont/Beverly and Vermont/Sunset Stations from center platform to side platform.

- MRTC is concerned that the line tunnels can be converged to a safe column separation of one (1) foot in the oxidized Puente soils as proposed. We can safely predict that a ten foot column could be achieved.
- To-date we have not experienced tunneling in this material which, due to its fine grain size cannot be grouted.
- The horizontal alignment adjustments to effect the transition from wide centers to narrow (13'-0") centers requires approximately 250 feet of tunnel. Therefore, shield position control becomes the critical task and impedes advance rates in tracking the curve geometry. MOS-1 tunneling contractors experienced difficulties in maintaining alignment through the curves.
- The anticipated savings in construction cost of the cut-and-cover special structure must be offset by the additional costs of the side platform station, the transition structures at each end of the station and the tunneling production rate in the transitions.

Proposal No. 16 -Pocket Track in Station

- The alternative concept generates a major cost reduction due to the elimination of the pocket track by replacing the Hollywood/Vine center platform station with a side platform configuration and double crossovers at each end of the station.

- o MRTC is concerned that Hollywood/Vine Station is a interim terminal station as well as a key tourist ridership station. The center platform configuration should be maintained for the operational advantages as well as passenger safety and convenience.
- o This proposal only has merit with Hollywood/Vine Station a side platform configuration. MRTC does not support the side platform design for this station and thus does not concur with this proposal.

Proposal No. 17 -Relocate Pocket Track and Add Crossover

- o This proposal is similar to No. 16 and our comments against No. 16 are consistent for this proposal with respect to the Hollywood/Vine Station.
- o We cannot respond with any assurance at this time that relocating the pocket track to sound rock in the Santa Monica Mountains can fulfill all the operational and safety criteria and in fact be built for less than the present cut-and-cover concept.
- o Comparitive costs of the current concept of the proposed rock tunnel pocket track cannot be evaluated using existing order-of-magnitude costs per foot. The complexities of openning up a wide area transition vault between parallel tunnels must be studied and evaluated to assess the costs of rock excavation.
- o The triple track tunnel segment must be positioned and horizontal and vertical alignments would most likely be affected.

- Methodologies analysis and additional geotechnical information would be required to properly assess the merits of the proposal.

APPENDIX

METRO RAIL TRANSIT CONSULTANTS
DMJM/PBQD/KE/HWA

MEMORANDUM

TO: K. N. Murthy

FROM: W. J. Armento Wm. J. Armento

DATE: October 27, 1989

SUBJECT: FOSTER'S VALUE ENGINEERING STUDY

FILE NO: P001X004.0

Per your request I have reviewed Study #2 and Study #3 and offer the following comments related to my area of discipline/expertise.

Study #2 deals primarily with tunnelled line structures and I yield to others to comment on the specifics of the tunnel proper. However, I find I can and should comment on VEP No. 5, Tunnel Walkway, since this has implications also for cut-and-cover line structures.

The proposed prefabricated wireway supported on steel brackets does not have merit because:

1. The prefabricated wireways would not permit flexibility in the horizontal location of the edge of walkway which might be required to provide the proper distance from the centerline of track to the clearance location of the walkway.

2. Positioning of steel bracket in the horizontal plane is problematical to assure proper alignment and a smooth walking surface.

3. Proposed attachment of steel bracket to tunnel lining apparently assumes a cast-in-place concrete lining. However, contractor has the option of using precast concrete segmented liner which would make attachments not only difficult but also variable due to the configuration of ribs and recesses inherent in precast liners.

4. Exposed steel bracket not fireproof so that in the event of a fire would be subject to buckling and possible collapse of the walkway system.

5. The steel brackets are subject to corrosion unless galvanized, or otherwise treated.

6. Construction might take longer than present design of concrete walkway since phasing in of another trade

person, ironworker, would be required to handle the steel bracket; also to match the bolt holes of the cable tray with the steel brackets.

7. To contain the grout, formwork might be required particularly if precast concrete segmented liners are used.

I do not concur with the estimated cost reduction since the preparation of the materials that would be used, along with the multiplicity of operations involved, coupled with the diverse trades required, all magnified by the uncertainties of the installation processes would lead one to feel that the real cost of the proposed prefabricated wireway supported on steel brackets would cost more than a conventional cast-in-place concrete walkway.

Study #3 deals with cut-and-cover structures for which comments related to structural items are as follows:

VEP #2 Station Columns

This proposal to eliminate center columns as a cost reduction proposal has no merit. The center support cuts the slab spans to half the length of the clear span thus reducing the thicknesses of the slabs to half; since slab thicknesses automatically are proportional to span lengths. Reductions in slab thicknesses result in decreases in station depth, excavation depth and sheeting and bracing requirements.

On Page 18 the statement is made "there does not appear to be any need for resistance to hydrostatic pressures as the existing water table appears to be below invert level." This statement is not borne out by the Geotechnical Reports. The report for Vermont/Beverly Station shows ground water level approximately 35 feet above subgrade. Preliminary Geotechnical Investigation indicates that along the Vermont Avenue alignment the ground-water levels vary from about 10 to 30 feet below the ground surface. In MOS-I station designs the existing water levels were high necessitating added concrete weight in one case and hold-down piles in another case.

The sketch of proposed design shows the base slab with a thickness of ± 3'-0 (should have been correctly shown as 3'-0±) for the trackway portion, same as shown in the sketch of present design, and only ± 1'-6" (more correctly 1'-6"±) for the portion under the platform area, or one-half the thickness indicated for the present design. The thicknesses shown for the base slab for the proposed design, compared to those for the present design, are absolutely wrong. Regardless of assumed distribution of subgrade reaction the thickness would be dictated by shear and with comparable design should be twice that of the present design. The 1'-6" shown under the

platform area is woefully inadequate regardless of subgrade reaction assumptions and certainly vulnerable to failure due to hydrostatic pressures.

The sketch of proposed design shows the mezzanine slab thickness (graphically, and confirmed by the cost estimate table) to be the same value as that shown for the present design. This is obviously incorrect since basic mechanics of materials and fundamental concrete design would expect the thickness of the mezzanine slab of the proposed design to be twice that of the present design due to the relative span lengths. Deflection might also be a problem since it varies with the fourth power of the span.

In the proposed design, precast prestressed clear span beams and a poured-in-place slab structure is used for the roof. No mention is made of the connection problems between the precast beams and the poured-in-place exterior concrete walls, nor of the loss of beneficial continuity that a monolithic cast-in place concrete frame structure would obtain. The problems of transporting 55-foot plus beams and lowering them through the decking level and threading them past the interior bracing to set them on the walls are not even mentioned in the proposal.

Page 20 describes the proposed design of column free stations and concludes with the statement "The cost of the complex column finishing in stainless steel is eliminated." This is a misleading assertion. The columns can certainly be left with concrete surface finish without any architectural adornment!

I disagree completely with the estimated cost reduction since it is based on erroneous assumptions of the relative designs, as described above. Correct designs would in general show greater quantities and more operations required for the clear span approach than for the center column design and the results would indicate that clear span would be more costly than a center column station.

<u>VEP #4 Station Foundation</u>

The proposed design consisting of eccentric one-way footings does not have merit because it is based on the false assumption that there is no hydrostatic uplift pressure, and because even in the absence of hydrostatic pressure it would lead to much thicker invert slabs than the present design stiff mat requires. Thicker invert slabs mean deeper excavation with resulting increases in sheeting and bracing requirements and quite likely increases in concrete and reinforcement.

Hydrostatic uplift pressure would generate upward bending

moments in the clear span creating maximum moment at the center and thus requiring a considerably thicker slab than the proposed design assumes, at least twice the value than would be required by the present design of center column whereby the slab spans are cut in half.

Slab thicknesses are generally dictated by shear. In the clear span proposed design there would be only two resisting shear sections whereas in the center column present design there are four resisting shear sections. Regardless of the upward soil pressure distribution assumed for either design, and even in the absence of hydrostatic pressure, the proposed design would have twice the shear force acting at each shear resisting section than is the case for the center column design, hence the slab thickness for the former case would of necessity be twice that of the latter case.

Let us now consider the matter of bending moment in each design case. Page 33 of the VE Study assigns a width of 8'-0" to the eccentric footing which is expected to behave as a cantilever. With a total uniform upward load of W acting on this cantilever the maximum bending moment at the wall section would be 4W. In the center column case the total uniform load acting on each half span would be the same W value, the span would be, say 24 feet, but the bending moment would be no more than 1/12 W x Span, or 2W. Thus the bending moment for the clear span base slab is twice that of the center column slab. Since depth of concrete required varies as the square root of the moment it is seen that the clear span cantilever slab would have to be about 1 1/2 times the thickness of the center column slab, with accompanying increases in rebar requirement.

Disadvantage of proposal: deeper excavation, increases in sheeting and bracing, increases in concrete and reinforcement.

I do not concur with the estimated cost reduction because it is based on completely erroneous quantities for the comparative study. The quantities for the V.E. proposed design should be greater than those for the original design, thus resulting in an increase in cost with the proposed design.

<u>VEP #11 Station Mezzanine Configuration</u>

Continuous mezzanine, however of the full width type not with side cantilevers, has structural and functional merit and should be given serious consideration because:

1. Full width mezzanine slab serves as a diaphragm support for the exterior walls thus reducing substantially the required thicknesses of the walls.

2. A full width mezzanine slab serves to brace the station columns thus helping to reduce their cross-sections by making them more efficient due to lesser unsupported height.

3. Full width mezzanine slab simplifies internal bracing removal which is a major consideration where tie-backs are not feasible for installation.

4. In the absence of the mezzanine slab and where tie-backs cannot be employed, the sizes of soldier piles would be greater than at mezzanine locations to permit the soldier piles to span greater lengths as internal bracing is removed to facilitate HDPE installation and the exterior wall pours.

5. Continuous mezzanines makes possible more opportunities for private entrance which can be accommodated in the initial station design or for which knock-out panels can be provided at very nominal costs.

6. The dispersal and horizontal movement of passengers along a mezzanine level rather than on a platform level is more efficient and less irksome to the transit users.

7. Full length mezzanines can provide for more points of vertical circulation rather than having concentrations of travel at only one or two locations.

8. Full length mezzanines provide more flexibility for the locations of handicap elevators from street level to mezzanine level, and more flexibility for the locations of emergency exits.

9. Full length mezzanines make easier the passage from ancillary spaces of one end of the station to ancillary spaces at the other end of the station.

10. Full length, full width mezzanine provide areas for installation of miscellaneous facilities, such as telephones, change machines, ticket vending machines, maps, concessions,

11. Full length, full width mezzanines facilitate the installation of lighting and signage required at the platform level.

It must be pointed out that the proposed concept of providing cantilever mezzanines is not acceptable from a structural point of view. The 12' wide walkway would not act as a "horizontal beam" as the Sketch of Proposed Design on Page 84 indicates, but rather as a cantilever

supported by the exterior wall due to its length. Cross struts--and only one is shown at mid-length of the walkways--would not provide the necessary vertical support to the walkway to relieve it of its cantilever action. Cantilever walkway would add more bending stresses and strains to the exterior walls. As a matter of actual occurrence, in a Caracas Metro Subway station where similar walkways as those proposed by the V.E. were installed, the thick 5-foot exterior walls developed diagonal cracks at the ends of the walkways. The effects of the cantilever walkway would also be of concern where openings for private entrances are contemplated to the extent that perhaps such openings might be precluded.

I concur with the conclusion that there would be a cost savings of station construction with full length mezzanines, but with full width area and though not necessarily with the takeoff items shown in the cost model Sheet No. 85. The savings would come from reductions in concrete and rebars for exterior walls and columns, reductions in excavation volume, decreases in decking area, and benefits in sheeting design with internal bracing. These overall reductions plus those derived from simplifications of architectural and electrical items will more than offset the cost of adding more mezzanine area.

Study #3 - Conclusion and Recommendations - Page 5

I take exception to the statement "The preparation of DIRECTIVE drawings delineating both the structural system and architectural treatment for the District's stations, and the use of these drawings by section architects and engineers, would not work in the District's interest." The purpose of Directive Drawings is to give useful guidance to the section designer that enables him to arrange and detail his work in the directions that satisfy the needs of the project. They are as valid as criteria and codes that apply to the design work.

A general indictment of Directive Drawings is not valid. There is always room for improvement and suggestions are welcomed. If the Value Engineering Study results in the adoption of new concepts for arrangement and details then the benefits of the study obviously should be reflected in updated Directive Drawings, as well as criteria, otherwise the V.E. exercise would be lost by freeing the designer to express his "imagination and creativity" toward costly products.

WJA/kcr

cc: J. Ball
G. Cofer
DCC (2)

METRO RAIL TRANSIT CONSULTANTS
DMIM/PBQD/KE/HWA

MEMORANDUM

TO: K. N. Murthy

FROM: Ralph Desimone RD

DATE: November 2, 1989

SUBJECT: Foster's Value Engineering Study

FILE NO: T100X004.00

Per your request, we have reviewed Foster's Value Engineering Study. The following are our comments related to planning and architectural issues based on our expertise.

PROPOSAL #1

The proposal erroneously suggests a reduction in headroom requirements. SCRTD Criteria is based on the following calculations:

1. Train dynamic envelope requires 14'-0".
2. Clearance required for mechanical air supply register -2'-6" min. and framing and finish grille clearance - 6" min.
3. Structural Slab 2'-0"
4. Thickness of floor finish 4-1/2"
5. Top of rail to platform 3'-8"
6. Structural beam depth 3'-0"

12'-8 1/2" from top of platform to underside of beam is the result of the above minimum requirements, not like the suggested 10'-0".

Not included in this exercise is a modification to exit stair configuration per UBC 1985. Exit stair headroom requirements, the stair crossing over the trainway min. 14'-0" from T.O.R. requires locating the mezzanine slab at 16'-3" to 17'-0" above platform, as previously recommended by design directives.

Proposal #11

The proposal suggests a continuous mezzanine configuration offering connections between the two end mezzanines. Architectural design emanates from special considerations for the user of the space which includes wayfinding, defensible space, traffic flow and ease of orientation amongst others.

Although this proposal suggests savings due to a more efficient structure and reduced construction costs, it does not satisfy basic functional directives. The purpose of building the entire system could be affected if we did not have adequate organized functional passenger traffic flow.

* This proposal disorganizes traffic flow and will increase the duration required for orientation cueing, etc., within the station.

* It increases ongoing security problems as monitoring would be difficult.

* When faregates are added to the system, the "free areas" would be connected by two 12"-0" wide corridors which are 390' long.

* Savings in structural costs would be offset to a degree by additional costs resulting from increased finishes and public areas and their on-going maintenance costs.

* It is possible to achieve similar structural improvement by the use of bracing elements, without changing existing architectural functional layouts.

Proposal #12

The proposal suggest upgrading the emergency exit to a full entrance. We had considered this option in the past and rejected it for the following reasons.

1. Emergency exits surface within the public right-of-way resulting in major land acquisition savings.

2. Emergency exits can be combined with ancillary shafts and construct at minimal additional costs.

3. The design for each station provides for future entrances but currently projected patronage numbers do not support the need for a complete second entrance.

4. Acquiring additional real estate includes tenant relocation, demolition, and additional construction cost.

Premium price is paid for the street frontage of any property. The proposal impacts this aspect more than the current design. SCRTD is currently resolving a similar situation with a property owner on the SE corner of 5th & Hill Streets.

Proposal #13

The proposals suggests entrances that are open to the sky and not covered as currently designed.

There are disadvantages in the proposal when studied on a macro level which more than offset any potential savings:

* Future joint development options are restricted due to a loss of street level space.

* Proposal #13 seems to contradict proposal #12 which suggest minimizing entrance areas on any one location.

* Concept is feasible if integrated into a major urban plaza with commercial and other pedestrian activities like shopping, food court, entertainment center etc.

* Passageway ancillary spaces, currently located on the mezzanine will need to be relocated to accommodate this option, resulting increased excavation and construction costs.

* Concept would increase on-going maintenance costs and raise security concerns. There is also the likelihood of these spaces turning into congregation spots for anti-social elements conducting unhealthy activities.

Proposal #14

The proposal suggests relocating exit stairs within the 450' length of the platform. While it may result in a construction cost savings, it has the following functional drawbacks that need consideration:

1. The concept allows for a 12' width for a combination of the UPE shaft, stairs and the structure walls. This leaves only 5'-6" for stair widths, which is not sufficient in several cases (stair widths being determined by occupant loads, ridership and exit times by FLSC).

2. The concept shows a 25' dead end condition, measured from the end of platform to the door opening. Building code requires that this distance not exceed 20'. If the proposed stair/UPE structure would be revised to meet code, there would be headroom problems over the trainway (see answer to #3).

3. The concept is not feasible in the double-end mezzanine stations due to entrances and public circulation conflicts. This figure should be excluded from the resultant savings suggested in the proposal.

4. The condition caused by a constriction in the platform width is unsafe for station patronage.

5. Disregards FLSC resolutions.

RD:kcr

cc: J. Ball
G. M. Cofer
DCC (2)

VALUE ENGINEERING PROPOSALS
8-25-89

VEP #9 | STUDY #2 | SYSTEM PROFILE

CONCEPT BEFORE VE

Subway profile as described on plan and profile sheets for Phase II of the LPA. Specifically, average depths to top of rail of cross-over structure are as follows:

Vermont/Beverly	48'
Vermont/Sunset	45'
Hollywood/Vine	52'

RESPONSE

Profiles shown on LPA PHASE II drawings are preliminary in nature and reflect the best thinking at the time. Recent drawings done as part of "6 Stations + Line Segment" work show slightly different configurations wherein the profile was modified to accommodate the station structure.

During continuing design profiles will be reviewed and revised as required.

We agree that a shallower structure results in a lesser cost; but it is also necessary to have sufficient cover over a station structure to provide for supporting utilities, etc.

Basic Cost	$45,746,000
Mark-up 17%	7,776,820
TOTAL	$53,522,820

PROPOSED ALTERNATIVE CONCEPT

Proposed profile would be raised to reduce depth of cross-overs as follows:

Vermont/Beverly	40'
Vermont/Sunset	40'
Hollywood/Vine	46'

RESPONSE

Do not agree that estimate can be reduced to extent shown. Basically each structure was estimated at 25,700/L.F. regardless of depth. They were not estimated on the basis of amounts of excavation backfill, etc.; therefore it is not accurate to estimate a cost for differences in depth and then subtract this cost from a total that was not inclusive of this cost as a separate item initially.

Basic Cost	$42,720,000
Mark-up 17%	7,262,400
TOTAL	$49,982,400

VEP #9 (cont.)

SUMMARY

Estimated Cost	$49,982,000
Est. Gross Savings	3,541,000
Est. Implementation Cost	-0-
Est. Net Initial Savings	3,541,000
Est. Life Cycle Savings	3,541,000

DESCRIPTION OF PRESENT DESIGN

Present design consists of a graphical solution of the subway profile as generally described on Phase II LPA plan and profile sheets.

Profile is developed consistent with tunnelling requirements and location of existing utilities.

DESCRIPTION OF PROPOSED DESIGN

Generally follows present design but top of rail is raised throughout consistent with existing constraints at freeways and existing utilities. Criterion for single tunnel diameter clearances over tunnels is maintained with similar exception contained in present design.

Low points in profiles are relocated so that sumps can be incorporated in cut and cover construction, thereby eliminating the need for sump/cross-passage structures.

RESPONSE

Where depths shown seem excessive at stations it is quite often the result of a street at a grade steeper than the rail can be. (For example the grade of Vermont Avenue at Beverly goes up at an average of 5% whereas the top of rail is descending at 0.3%) (Similarly @ Vermont/Sta Monica Vermont rises @ 4%+ and the station grade is set @ 0.7% [1.0% would be maximum]). In these locations the minimum cover is set @ the low end and the difference in depth of cover at a station of 560' length could be as much as 18' to 20' from one end to the other.

Agree: That some low points may be shifted; but there are some that cannot be taken out of the line section between stations.

VEP #17 | STUDY #3 | STATIONS RELOCATE POCKET TRACK & ADD CLOSURE

CONCEPT BEFORE VE

West of Hollywood/Vine station, the present design provides on combination double crossover/bidirectional pocket track to permit transit operations to recover from equipment failures and other disruptions. This facility is housed in a long cut-and-cover structure approximately 57 feet wide. By virtue of this construction, 65,000 square feet of space is created above the trackway, of which 31,000 square feet is allocated to adjacent station ancillary functions.

RESPONSE

Location of specific pocket track was placed on w/side of H/Vine Sta. - by Operations. They would actually prefer w/of H/Highland. Too much more westerly reduces efficiency of turnback operations.

Train north of pocket track would have to return to universal city or advance to H/Highland to discharge passengers before being stored. Then have to be pushed back to the pocket track for storage.

Pocket track works most efficiently adjacent to a passenger station.

Estimated Cost $18,041,000

PROPOSED ALTERNATIVE CONCEPT

This proposal relocates the pocket track function and its separate structure to a point within the Santa Monica mountains. A double crossover is provided at the west end of Hollywood/Vine station. The station is changed from center platform to side platform to permit closer track spacing and thereby minimize cut-and-cover structure length. Width is also reduced.

The proposed concept creates 17,000 square feet of space above the trackway. This space is consistent with that required for crossover stations.

Advantages:

1. Substantially less surface disruption.
2. Enhances failure recovery.
3. Permits maintenance vehicle staging.
4. Reduces construction time.

Disadvantages:

1. Requires Revenue Service stop to pick up failed equipment train operator.
2. Requires passengers to be directed between platforms occasionally.

Estimated Cost	$71,334,000
Est. Gross Savings	9,707,000
Est. Implem. Cost	-0-
Est. Net Initial Svngs	9,707,000
Est. Life Cycle Svngs	9,707,000

VEP 17 (Cont.)

DESCRIPTION OF PRESENT DESIGN

In addition, a reduction in width is made possible by narrowing the tracks approaching the crossover area form 38.3' CL to 13' CL. (See Response 1) The space available for ancillary functions is about 17,000 ft2. This amount of space is comparable to that required for the crossover functions proposed for this station.

Because the track spacing narrows to 13', the Hollywood/Vine station becomes a side platform station having 15 foot wide platforms through the vertical circulation area at mid-station and 12 foot wide platforms elsewhere. Mezzanine configurations are similar to the present design, with vertical circulation elements corresponding to that provided for the center platform designs.

The pocket track/crossover functions are comparable to or better than that of the present design and unneeded space is saved with less costly construction for a narrow box. Although somewhat inconveniencing patrons when they have to change platforms, the advantages of the proposed design lie in its substantial savings in construction costs, reduced surface disruption and reduced construction time. The savings estimated is the combined total for MOS-II and MOS-III changes. The reduction in MOS-II construction scope is almost $20 million; the increase in MOS-III scope is just under $10 million.

RESPONSE

1. *This would require revision to criteria re: centerline to centerline spacing. (Vol. II Section 1 Paragraphs 1.4.2B shows minimum distance of 14'0".)*

2. *Reverse curves necessary to go from tunnel certerline spacing to station centerline spacing have an effect on the operating speeds.*

3. *Criteria requires 600' target track through station (450' platform + 75' @ each end.)*

4. *Previous attempt at placing double x-over @ 14' track centers was ruled out by systems. (We ended up providing two single crossovers to maintain operational advantages of turnback. This however, required more length of cut and cover construction.) - (#10 double x-overs produce a long gap in traction power of 200' ±) (Break of 12')*

5. *Do not agree with sizes estimated for reduced structure. Based on reverse curves needed to provide required speeds of 45 mph. (See sketch attached)*

PROJECT Metro Rail VE #3 - Stations
LOCATION Los Angeles, California
SYSTEM Relocate Pocket Track & Add X-over

Value Engineering Study
Cost Model

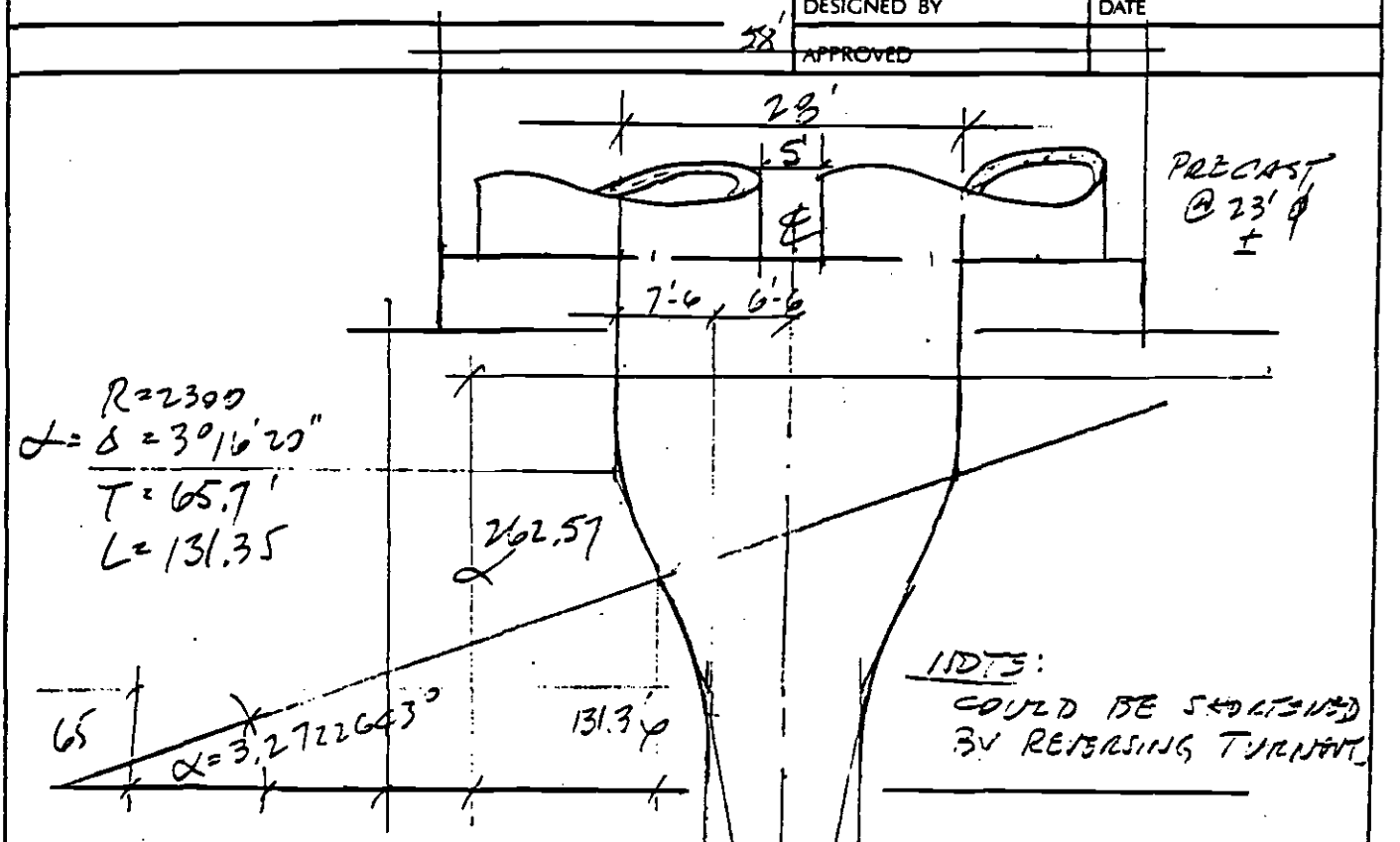
CLIENT SCRTD
DATE 9/13/89
PAGE 2 OF 4

ITEM NO.	DESCRIPTION	ORIGINAL DESIGN				VE PROPOSED DESIGN			
	MOS II	UNITS	NO. UNITS	UNIT COST	($1000's) TOTAL	UNITS	NO. UNITS	UNIT COST	($1000's) TOTAL
B281	Hollywood/Western to Highland								
	Tunnel	RF	4860	$4760	$23,134	RF	5469	$4760	$26,028
	Station - Hollywood Vine	LF	560	48,570	27,199	SF	④ 23,040	① 946	21,796
	Station, mezzanine only	-	-	-	-	SF	⑤ 5,760	② 631	3,635
	X-over	LF	-	-	-	SF	⑥ 17,367	③ 303	5,262
	Pocket Track	LF	1010	25,700	25,957	-	-	-	-
	Facilities Subtotals		6430		$76,290				$56,721
	① Uft Price = ($48,570/LF) ÷ 51.33 FT WIDE = $946/SF								
	② Uft Price = ($946/SF) x 2/3 DEPTH = $631/SF.								
	③ Uft Price = ($25,700/LF) ÷ 56.5 FT WIDE = $455/SF x 2/3 = $303/SF								
	④ 51×210 (TYP) 18×105 (TYP) 150' Platform 12×240 (TYP) ⑤	⑥ 41 177 213 31 17,975 SF					122 31 41 4392 SF		
	DO NOT AGREE WITH SIZES! SEE ATTACHED SKETCHES								

Reference: _____

3/5

	JOB No.	SHEET No.
	DESIGNED BY	DATE
	APPROVED	



R = 2300

$E_u = 3.5"$

$V = \sqrt{\frac{3.5 \times 2300}{4.011}}$

= 44.7 MPH MIN SPEED ACCEPTABLE ON MAIN LINE

@ 40 MPH R = 1833.6'

THEN $\Delta = 3.665027$

T = 58.66

L = 117.288

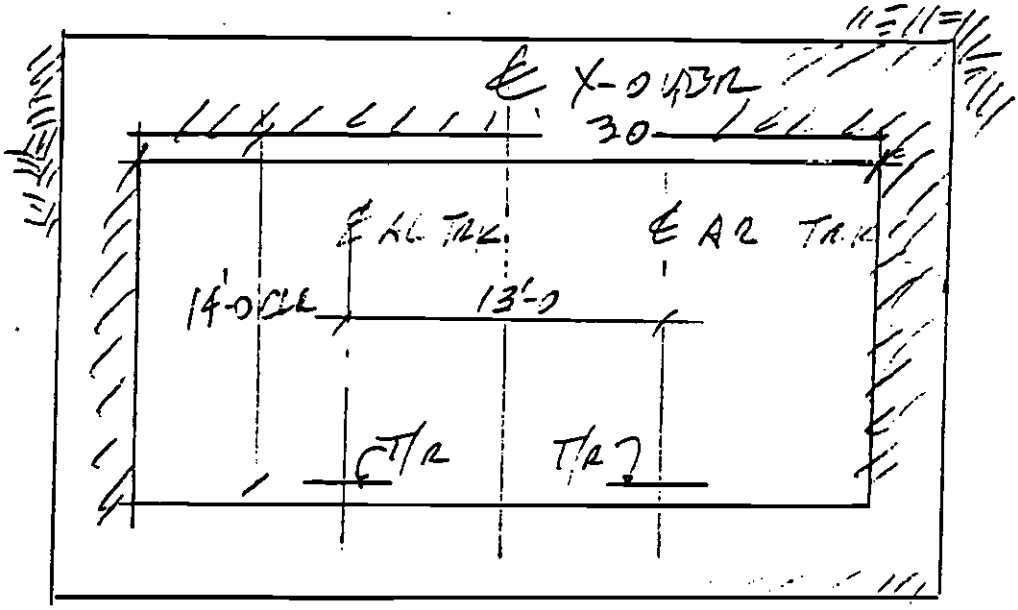
DISTANCE FROM PC TO PCC TO E.T. =

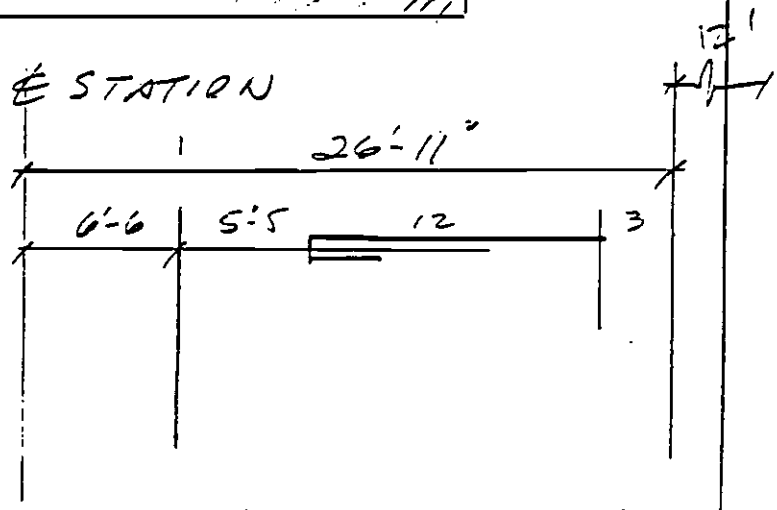
= 117.21 x 2 = 234.42 ≠ 262.57

METRO RAIL TRANSIT CONSULTANTS
DMJM / PBQD / KE / HWA

5/5

VEP # 3 STATIONS H/VINE REPLACE POCKET TRACK W/ DBL X-OVER	JOB No.	SHEET No.
	DESIGNED BY	DATE 10/25/89
	APPROVED	





26'-11" X 2 = 53'10" + 24 = 77'-10" USED

cf = 51.33'

#10 DBL X-OVER PS TO PS = 202.5' (14' c.c.)

METRO RAIL TRANSIT CONSULTANTS
DMJM/PBQD/KE/HWA

MEMORANDUM

TO: K. N. Murthy

FROM: K. V. Sain KVS

DATE: November 15, 1989

SUBJECT: **FOSTER'S VALUE ENGINEERING STUDY**

FILE NO.: T430X004.00

Per your request I have reviewed Study #2 and Study #3. Following are my comments related to my area of expertise/discipline:

Value Engineering Proposal #1 (Study No. 3):

Reduction in space above the platform from (9'-7") + (4'-3-1/2") = 13'-10-1/2" to (9'-7") + (2'-3-1/2" = 11'-10-1/2" will not work. 3'-6' is required for installation of the supply air duct, therefore, a minimum 9'-7"+3'-6" = 13'-1" is required above the platform. This dimension will encroach on 14'-0" clearance above the top of rail.

Reduction in space above mezzanine will not affect the mechanical.

VALUE ENGINEERING PROPOSAL #6 (Study No. 3):

In the present design sound attenuators on both sides of the emergency fans and acoustical lining in the ventilation shafts are provided to control noise generated by the emergency fans. These fans will be tested periodically in the non-reserve period, at night, when the background noise is lowest. Noise and vibration control as mandated by the E.I.S. and set forth in SCRTD criteria Vol. IV Section 7.1.B. will be violated by removing these sound attenuators. Our acoustical consultants have established that acoustical lining alone without the sound attenuators will not be sufficient to reduce noise to acceptable levels.

VALUE ENGINEERING PROPOSAL #8 (Study No. 3):

Smoke exhaust system cannot be deleted for the following reasons:

1. It will be used to expel smoke from the mezzanine area after a fire in the system.

2. Smoke exhaust system will be used in conjunction with the underplatform exhaust system and supply air system to ventilate the tunnels for purging methane gas in the non-revenue period.

3. The functional concept of the smoke exhaust system in the proposal is incorrect. Smoke exhaust system will be off when the emergency fans are activated. This system will be activated to expel smoke and hot gases, which will accumulate at the mezzanine ceiling in the fire incident after the emergency fans are turned off. Therefore, partial vacuum and different air pressure is irrelevant. The system is safe and has a very useful function to perform.

4. The function and use of this system for purging methane gas from the tunnels have been analyzed in the August 1985 Environmental Control System Report.

VALUE ENGINEERING PROPOSAL #9 (Study No. 3):

1. Above grade property for the chiller room, when the air conditioning is needed, may not be available near the station.

2. The cost of such property is not shown in this proposal.

VALUE ENGINEERING PROPOSAL #10 (Study No. 2):

1. I disagree with the proposal to use grooved piping with non-metallic gaskets (victaulic type). A recent fire in a mine burnt out the gaskets and the fire piping failed. It is unsafe to use grooved piping in the tunnels.

2. The new valve arrangement will not work. The proposed arrangement is an undimensioned sketch. Pipe cannot be relocated as shown on the sketch and there is no cost savings in this rearrangement. See attached dimensioned sketch for location of fire line in the tunnel.

VALUE ENGINEERING PROPOSAL #10 (Study No. 3):

The Environmental Control System Report (August 1985) addressed the elimination of station Supply Air System, and concluded that station temperature will exceed 90 F when the outside air is 84 F at three minute headway, LRDS, if station supply air system is deleted. There are many days in a year when the outdoor temperature exceeds 84 F, which will result in even higher system temperature if the station supply air system is not installed. When the headway is further reduced it is predicted that the station temperature will range from 92 F to 104 F. At that time mechanical cooling will be required to maintain reasonable station environment, which is expected in a modern transit system. The station environment prediction is based on many assumptions including the effectiveness of the underplatform exhaust system,

which may not be as effective as assumed resulting in higher temperature, and requiring mechanical refrigeration at longer headways.

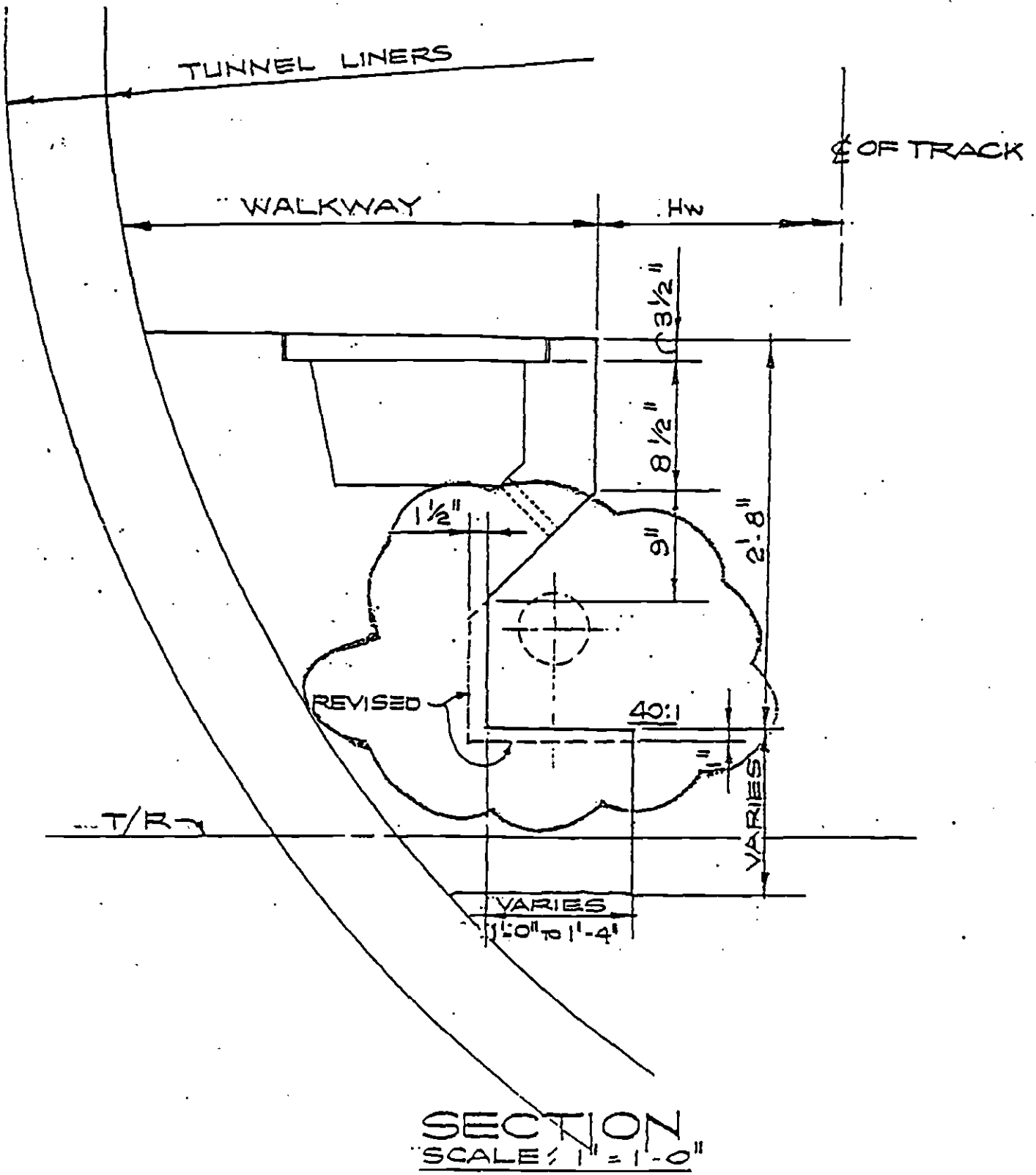
The station supply air system in conjunction with underplatform exhaust and smoke exhaust systems will be used to purge methane gas from the tunnels in the non-revenue period, in a push concept.

KS/ca

cc: J. Ball
G. M. Cofer
DCC (2)

AT TUNNEL WALKWAY SHEET NO. 1 OF 1

MADE BY JPM DATE 8-30-89 CHECKED BY _____ DATE _____



SECTION
SCALE: 1" = 1'-0"

METRO RAIL TRANSIT CONSULTANTS
DMJM/PBQD/KE/HWA

MEMORANDUM

November 1, 1989

TO: K. N. Murthy

FROM: A. Dale

SUBJECT: Foster's Value Engineering Studies

FILE: W001X004.00

In accordance with your request attached are our comments on Value Engineering Studies Nos. 2 and 3.

AD/NB/srt

cc: J. Ball
N. Brown
R. Harvey
M. Ingram

891065NB

Systems Division
Review Comments

A. Value Engineering Study #2

1. VEP No. 1 - Tunnel Diameter

This proposal does not take into consideration antennae,lights conduit and other fixtures. Plus it does not allow 11" for jacking. Also it may not be advisable to limit design to the Breda car dynamic envelope.

2. VEP No. 5 - Tunnel Walkway

1. This proposal does not address how and where the wet standpipe is to be located.

2. It does not address possible interferences with the communications system, specifically the FTELS.

3. In as much as NEMA VE-1 prohibits the use of cable trays as walkways, these specially constructed wireways may require considerable testing.

4. The structure group will have to verify that the proposed structure will handle loads imposed during emergency conditions. (See SDC & S VOL II. 2.12.3).

5. Verification will have to be made to determine if there is sufficient protection for vital circuits in the event of a tunnel fire.

3. VEP No. 6 - Tunnel Cross Passages

1. 1 1/2 hour rated doors are required at cross passages to provide safe refuge in the event of a fire in one of the tunnels. Also doors are required by ventilation demands (See SDC&S 2.3.4.1.4)

2. The opposite tunnel is considered as a smokeproof enclosure in the event of a fire. The crosspassage therefore serves as a required vestibule. As such it must have a ceiling at least 20 inches above the door to serve as a smoke trap. (See UBC 3309-4 1988 addenda.)

3. No consideration has been given for fire protection equipment. The proposed change fails to consider many equipment items that must be located in the crosspassages

for supervisory functions relative to air flow, air quality, fire management and suppression, emergency communications and fluid ejection.

4. Exit calculations are based on 44" clear width openings. Also see UBC 3310-2 for minimum size of vestibule.

5. Communication equipment may be too sensitive to the tunnel environment. If combined with smaller tunnel clearance problems may exist.

4. VEP No. 10 - Tunnel Wet Standpipe Stage II (Exposed)

1. Acceptable from functional and F/LS code stand point. Possible mechanical & structural design considerations eg. adequate support of piping and walkway.

B. Value Engineering Study #3

1. VEP No. 3 - Station Length

No apparent difficulties from exiting or platform capacity point of view. However, as proposed a perfect stop would leave the rear door within 5' of end of platform. Further study is required to determine if this is within the ATO berthing accuracy. The ATO system prevents the doors from being opened if berthing accuracy is out of tolerance. The change from about 15' to 5' accuracy requires further study.

2. VEP No. 5 - Engineering Vent Shaft/Blast Relief Outlets

1. The emergency vent/BRS serves as an air intake under certain emergency conditions. Toxic and other noxious fumes could be drawn into the air supply even with a sump below the opening.

3. VEP No. 6 - Emergency Ventilation - Noise Control

1. There may be local noise abatement requirements which apply even under emergency conditions.

2. Note auxiliary ventilation systems already are used to control NO_2 and CH_4.

4. VEP No. 7 - Under Platform Exhaust Outlet

1. Sumps will accumulate debris which will have to be cleaned out causing disruption of traffic. THEY DO ON THE SIDE WALK TOO.

2. Hazardous material can not be discharged into the City sewer system; therefore a disposal problem exists. NOT IF PROPERLY DESIGNED.

5. VEP No. 12 - Station Entrances

1. This proposal appears acceptable from a F/S standpoint, provided the following:

-Sufficient exit lanes are provided to evacuate station within 6 minutes. (See SDC&S Volume I 2.2.5.3.2)

-Entrances are separated by a minimum of 40 feet. (See SDC&S Volume I 2.2.5.3.7)

-No point on the mezzanine is more than 300 ft. from an exit. (See SDC&S Volume I 2.2.5.3.8)

6. VEP No. 14 - Emergency Exits

1. This proposal seems acceptable as long as the minimum required clear width of emergency exit is maintained and adequate space is provided for the UPE shaft.

2. Please note that the Emergency Exit stairway must be separated from all other occupancies by a two-hour rated separation. (See wall rating schedule DCC No. 84-12050)
3. The current concept of exiting has been carefully reviewed and analyzed by fire service and other safety professionals and is considered acceptable.

7. VEP No. 16 - Pocket Track in Station

1. There does not appear to be any adverse safety implications with this proposal.
2. Further consideration needs to be given to operational aspects. Note that the third track storage capacity of the pocket track is lost in the proposed side platform substitution.

8. VEP No. 17 - Relocate Pocket Track

A computer simulation should be performed by SCRTD, similar to those performed for the recent Pocket Track Study, to determine if this pocket track location is acceptable from our operations standpoint.

METRO RAIL TRANSIT CONSULTANTS
DMJM/PBQD/KE/HWA

MEMORANDUM

DATE: November 6, 1989

To: J. G. Ball

From: J. E. Monsees

Subject: Comments on VE Study #2

File No.: P097

These comments pertain to study #2 only.

1. Reduce Tunnel Diameter

1.a. Provide clearance for Breda car, not for composite car.

Ans.: Not my area of expertise, but a call that should be made by the District. May restrict competition for future car contracts.

1.b. Reduce re-railing clearance

Ans.: Seems like a reasonable suggestion to me. In the very infrequent event of a rerailing, additional clearance can be gained (as a last resort) by lowering the suspension.

1.c. Reduce space above walkway.

Ans.: Call comes from Fire-Life Safety.

1.d. Modify traction power conductor

Ans.: VE teams's proposal is unclear. They should clarify.

Comments on VE Study #2

1.e. Remove annular repair space on inside.

Ans.: My confidence in the membrane is higher now than when we started. However, we do not know how its properties hold up for 50-100 years. Also, in spite of our best efforts, earthquakes do strange things to structures. MWD experience shows that the steel skin can be installed at a later date --- granted service would be disrupted, but probably not as much as it would if a gas leak developed. I am not confident that the technology exists to use interior membranes. I recommend we leave the repair space in as insurance.

Closure:

1) Give strong consideration to saving 5"-6" by reducing rerailing space.

2) Cost savings are unrealistic.

- Incremental excavation is probably closer to $20/yd (disposal cost) than to $50

- Incremental lining is also far cheaper since we need pay only for slightly more concrete -- say $60/yd instead of $150/yd by VE team. (Al to check my costs.)

2. Modify Final Lining Design

2. a. Eliminate reinforcing

Ans.: No. I would agree for similar tunnels anywhere else, i.e., <u>NOT in earthquake country.</u> Circumferential cracking potential (from longitudinal strain) is up to five inches per 100 feet of tunnel. To argue that minimum resteel does not distribute cracking is to dispute long-standing wisdom reflected in ACI318 requirements. If nominal longitudinal steel distributes cracks on 10 ft centers, the average

width becomes 0. 5in.; if on one ft centers the width becomes 0.05 in.. Granted the membrane is quite ductile and will span some cracking. However, we don't know its long term properties (50-100 years) and must do what we can to reduce the potential cracks to be spanned.

Nominal circumferential steel provides added ductibility especially for the believed most likely deformation of the tunnel, horizontal ovalling.

For the record, experts may not fully agree as to earthquake reinforcing for normally stable tunnels, but I will remove my name from a design that contains no reinforcing.

Closure:

1) I must insist that reinforcing stays. We have reached my limit for minimizing it.

2) Al should comment on costs:

- o Cost for concrete must be material cost only.
- o Membrane cost appears high by factor of approx. 3.
- o Excavation cost must (basically) be disposal cost only.

3) I seriously question that eliminating steel will reduce construction time. Tunnel pour times are very seldom governed by time for setting steel.

3. Double Track Tunnel

This proposal requires that SCRTD pioneer in several areas:

- o I am not aware of a tunnel by shield of this cross/section ever being driven in the U.S. Thus a whole new shield concept must be designed, built, and debugged.

- o All shields tend to roll. Should this one roll it critically impacts the vertical track alignment.

- o Face stability will surely be a problem. This shape and size are far less stable than a 20 ft (+) circular tunnel. In my judgment Shank's work has shown that we are near the point of limiting equilibrium for LA alluvium. A larger, flatter opening can only be less stable, I would not be surprised if the VE proposal pushed us over the edge on face stability.

- o Possible problems are probably reduced should the tunnel be well-buried in the "bedrock".

I suggest AL comment on costs. If VE team is correct, perhaps we could consider alternative bids provided RTD pays for considerable extra design and accepts full liability for pioneering design/construction.

4. Tunnel Invert

Our design follows practice (I believe in WMATA, Balt., Atlanta, etc.) I do not know where reinforcement requirement first came from; I suspect experience may show deterioration with age due to train pounding (just as has been found for highways). I recommend we take two steps:

- o Check requirement with other systems.

- o Consider reinforcement without bonding.

In either case (or both) $2.4m seems a small premium for additional insurance. With regard to costs:

- o VE does not make it clear how invert concrete is reduced. Plus, reduced concrete should be priced at material cost only.

- o Rebar cost ($0.60) is too high. VE team used $0.38 in other estimates.

5. Tunnel Walkway

I recommend we consider this suggestion. The only item that occurs to me is that the steel brackets present a long-term maintenance question. Can (or will) they be cleaned and painted on a scheduled basis so that they do not suffer extensive rusting and corresponding short life.

I assume VE'S assertion is true that the prefabricated wireways exist and that they are acceptable to electrical, Fire Life Safety, operations, etc.

6. Tunnel Crosspassages

These designs/construction follow successful applications in Baltimore. If VE's cost projections are accurate, we probably should revisit the design. This would include an update regarding experience elsewhere, construction experience (and cost) here, and then a re-look at the design approach/assumptions. NOTE that others (e.g., electrical, systems, Fire Life Safety,) should also address these crosspassages.

7. System Profile

Response to be provided by Don Logan.

JEM/bp

STUDY NO. 3

Proposal No. 15

These tunnels are primary in oxidized (weathered) Puente. This leads to several points not considered by the VE team:

- o We do not have experience with tunnels in this material.
- o I would have confidence in a 10 foot pillar. Without experience my confidence would fade with a 5-foot one, and I would have no confidence in contractors driving up to 300 feet of adjacent tunnels (i.e., tunnels one foot or less apart).
- o Tunnel stability is also complicated by converging tunnels - contractors consistently have problems with ground control on curves. (Granted VE's curves are long radii.)
- o Ground cannot be grouted (too fine).
- o Close tunnels at BART were by necessity, not by choice.
- o Vertical braces and horizontal ties can be used, but they are expensive; a cost not reflected in VE numbers.
- o Additional exploration and design costs would be necessary to develop VE proposed alignment

Estimating should take a detailed look at VE's costs (assuming operations et al want to pursue this VE).

Cost for narrower station are obtained by VE by scaling linearly from design station. This ignores the fact that many items are constants (or nearly so):

- o Shoring and bracing
- o Station walls
- o Traffic control
- o Utilities
- o Lost business and other intangibles

Operations, fire life safety, and others should review and evaluate operations of having curves on each an dof the station (by choice, not by necessity).

Proposal No. 17

VE proposal apparently is based on the assumption that the new

pocket track will be built in hard rock that is self supporting. We should make several borings into that location and then study all the data to verify that assumption and to perform the design.

VE apparently assumes double-wide crossover can be built in hard rock for $4000/foot. I doubt that, suspect it may be closer to $8000/foot. I strongly suggest estimating take good look at this cost.

Note also that this estimate apparently assumes good rock conditions, which we would have to verify (per first paragraph). Operations should take a good look at having the crossover removed from the station (by 1000 feet or so), as should safety et al.

PDCD

600 SOUTH SPRING STREET
SUITE 1200
LOS ANGELES, CALIFORNIA 90014
(213) 489-6950

REF. CONTRACT NO. 3369
CM-MR-5048

November 27, 1989

Southern California Rapid Transit District
425 South Main Street
Los Angeles, California 90013

Attention: Mr. Samuel K. Louis, P.E.
Director, Construction Management

Subject: Phase II Value Engineering Study

Gentlemen:

Herewith are PDCD's comments on the following Phase II Value Engineering studies:

- o Study No. 1 - Design Criteria and Directives
- o Study No. 2 - Line Structures
- o Study No. 3 - Stations

V. E. Study No. 1 - Design Criteria and Directives/MOS II

PDCD has no comments

V. E. Study No. 2, Line Structures/MOS II

Item 1. Reduce Tunnel Diameter
Present diameter = 17'-10", reduce to 16'-10".
VE Proposal indicates less cost, faster construction.
The estimated saving of $230/LF has been determined on a volume basis.
Excav. Cy/LF
Support Cy/LF
Concrete Cy/LF
Membrane Cy/LF

Muck disposal and material costs do vary with a reduction, however, affect on labor, equipment and plant is questionable.

As a matter of fact, by reducing diameter the clearance tolerances become more rigid and may slow down progress to maintain line and grade. There have been three projects

equipped to excavate and line a 17'-10" diameter tunnel. Three excavators, trailing gear, etc., and at least two sets of forms. A change in diameter may eliminate the benefits for utilizing existing equipment.

Reduction in tunnel diameter would eliminate any future changes to the rolling stock.

Item 2. Change the tunnel lining from 12" to 8" unreinforced concrete.

Elimination of reinforcing steel is recommended if structurally satisfactory. Elimination of reinforcing steel and reduction in the wall thickness together is questionable. Placing concrete in an 8" thick lining with resteel would slow operations.

Reduction in lining thickness would reduce material cost but it is doubtful if labor and equipment costs would be affected.

A reduction in lining thickness would probably change finish diameter and thus would not benefit future costs with reuse of existing forms.

Item 3. Substitute Double Track Tunnel for Twin Tunnel

This item would be influenced by competency of the ground. It would cause heavier supports and thicker lining for the 32'+ vs 17'-10"+ opening. It would require a redesigned excavator and shield.

Item 4. Modify Tunnel Invert

Agree. Elimination of resteel would be advantageous. Concrete volume would be unchanged.

Item 5. Modify Tunnel Walkway

No comment except that there are currently two sets of forms in existence.

Item 6. Reduce Cross Passage Size

This is a design consideration.

Item 9. Raise System Profile

Raising the profile may put tunnels in less competent ground.

Item 10. Modify Wet Standpipe

This is a design consideration.

V.E. Study No. 3, Stations/MOS II

All stations should be identical in layout within a common footprint. Site adapt the entrances.

Better utilization of the area within the body of the station would be to eliminate ancillary items outside the body of the station and utilize the area above the station.

Architectural, electrical, mechanical layout, etc., should be the same in every station. Modify the interior finish within those parameters if a different or a variety in appearance is desirable.

Very truly yours,

Melvin L. Polacek
Construction Manager

Attachments
as noted

cc: S. K. Louis (w/o att.)
W. J. Rhine (w/o att.)
TSD/DCC (w/o att.)

453A01

FOSTER ENGINEERING, INC.
ENGINEERING AND ARCHITECTURE
SAN FRANCISCO SACRAMENTO SAN DIEGO

December 8, 1989

Mr. J. E. Crawley
SOUTHERN CALIFORNIA RAPID TRANSIT DISTRICT
425 South Main Street
Los Angeles, CA 90013

Dear Mr. Crawley:

Subject: VALUE ENGINEERING STUDIES MOS II

We have received your letter dated November 29 together with comments and discussions originating from within SCRTD and from your consultants.

We appreciate the timely handling of this phase of our work with you and were very pleased to note that, for the most part, the VE Proposals were well received.

The comments made in response to Value Engineering Studies 1, 2 and 3 show that there are diverse opinions even among the respondents. These opinions reflect the backgrounds of those making the comments and their special fields of interest. During the course of preparing the reports, the Value Engineering Team sought to take all relevant matters into account, giving each consideration its relevant weight. The reports therefore present what we consider to be a balanced position, which does not give undue weight to tradition or criteria just because they exist. We are pleased with the amount of positive comments.

Many of the negative comments focus on the amounts of the cost savings forecast to be achievable. The cost data used was that provided by SCRTD, supplemented by current data from contractors and others. In recognition of the inherent unreliability of cost projections based on unit prices, the forecasts of cost savings have been kept on the conservative side where possible. It has always been assumed that much more detailed analysis of costs would be made for any VEP accepted for system use. In addition, it is recognized and stated in the reports that some of the proposals are mutually exclusive.

In general, we find nothing in the comments made which would cause us to revise the proposals made in the three Value Engineering Reports. This does not mean that the comments are without merit - only that they are details rather than an overview; or that they represent differences in expert opinion;

847 Howard Street, San Francisco, CA 94103 (415) 541-1193

or that they are written versions of verbal comments already made at review meetings and taken into account in formulating the published reports.

In order to assist you and other District staff to reach a conclusion with respect to the final disposition of each of the VEP proposals presented, we are preparing a summary tabulation of the proposals concerning the VE Team's recommendations and the Team's understanding of staff and consultants comments.

We would propose that this tabulation be completed during the course of the meeting on December 13th by indicating thereon the final actions required by the District. This tabulation will eventually be included in the VE Reports for final distribution.

Copies of comments received will also be included as an appendix.

In the meantime, attached herewith for your consideration is a brief response to some of the comments received. We hope this will set the stage for our discussions next week.

An agenda along the following lines may be appropriate for this meeting:

1. **Opening statement by SCRTD Management outlining purpose of meeting and the need to finalize the disposition of the VE Proposals.**

   Our approach to this matter would be to establish three specific categories for action that would be taken by SCRTD for each of the VE Proposals presented. These would be:

   - Accepted for Implementation with appropriate directions to those concerned.
   - Accepted with reservations pending further study and/or refined design and cost estimates.
   - Rejected.

2. **A summary review of each VE Proposal presented by the VE Team.**

   Each VE Proposal will be briefly presented followed by a discussion concerning the merits of the proposal by all concerned. At the conclusion of the discussion, a decision would be taken by SCRTD management concerning the final action to be taken.

In view of the fact that there are thirty-one VE Proposals to be presented, it may be advisable to limit individual discussion on each VE Proposal to five minutes.

3. **Any concluding remarks by SCRTD staff.**

If you have any questions, please call.

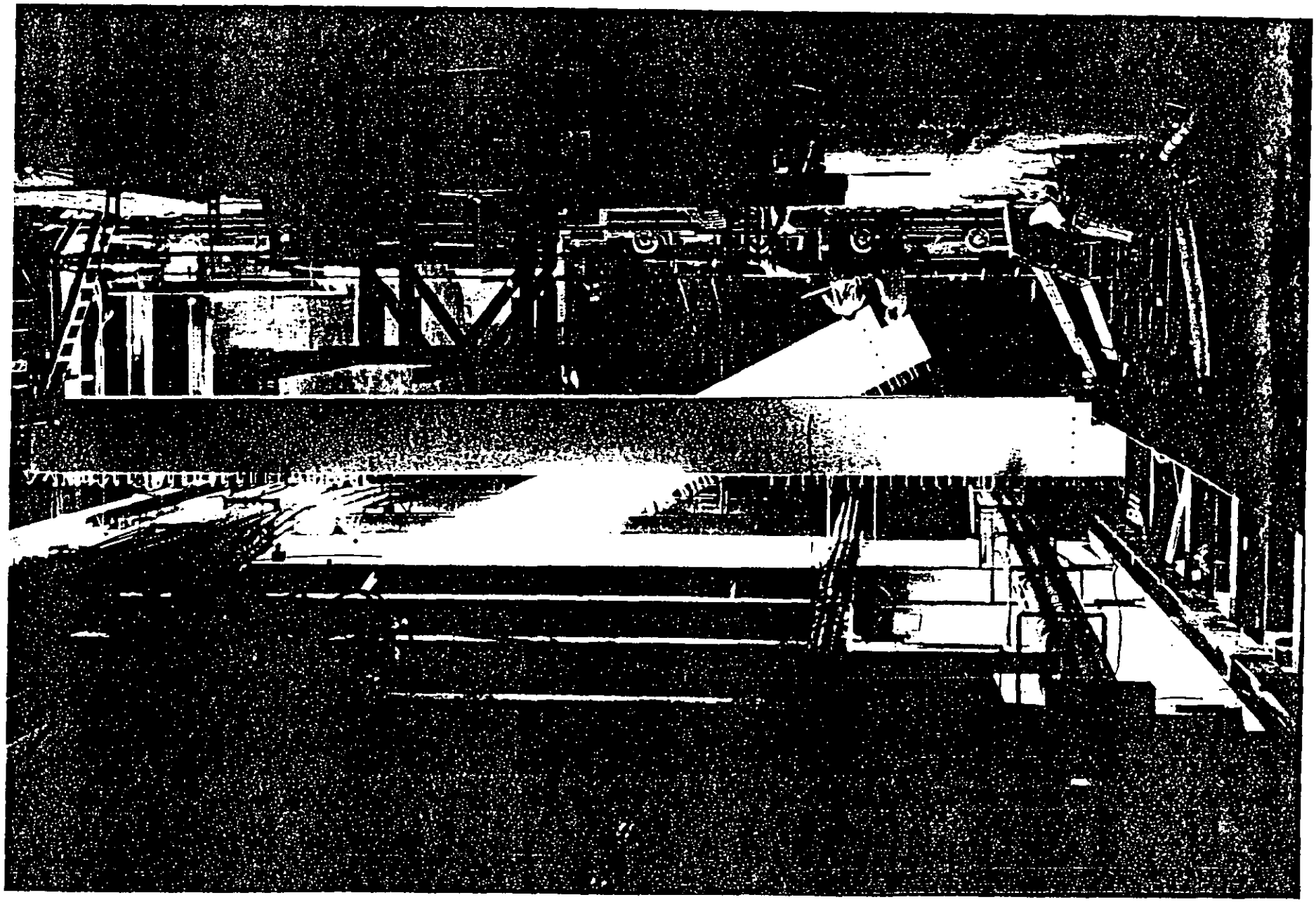
Sincerely,

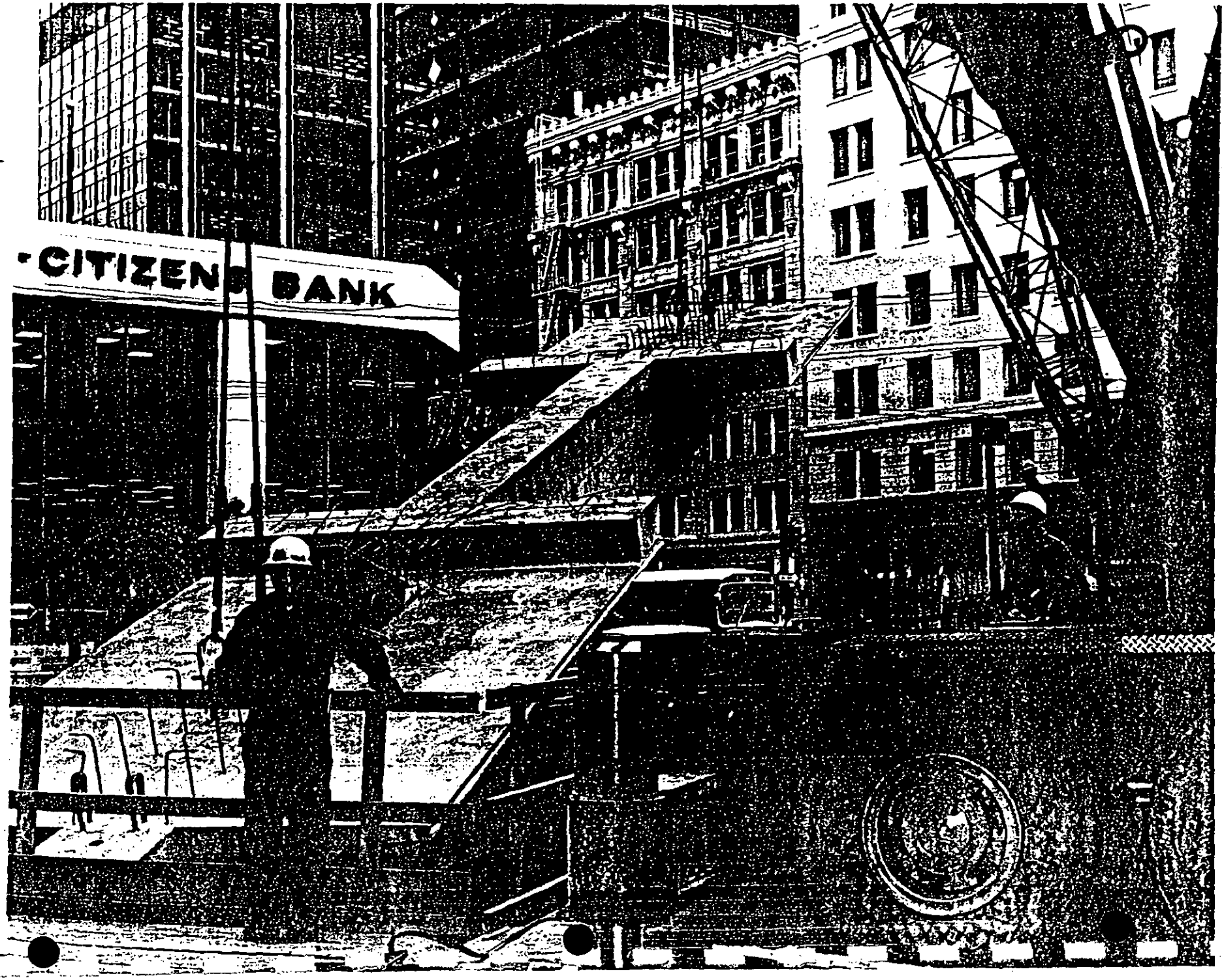
FOSTER ENGINEERING, INC.

H. A. Foster
President

HAF/peh

c: 453-A01
Chron.




CITIZEN
BANK

RESPONSE TO COMMENTS ON VE STUDIES

December 7, 1989

VEP STUDY #1

RE: MRTC letter dated September 8, 1989 - Contract Packaging

The VE Team did in fact consider the time relationship between tunnel and station contracts and considered that from the standpoint of construction duration, there would be no delay to station contracts. Naturally, the start of construction would have to be coordinated with the tunnel works.

In the team's opinion, there is no cost penalty involved for a later start on the station work, particularly when design time is taken into consideration noting that tunnel contracts will require far less design time than station contracts.

The attached memo from Mr. Armento seemed to indicate that a separate contract would be let for station excavation whereas the VEP proposal suggests that station excavation be included in the tunneling contract.

We did not find any compelling arguments in MRTC's response to this matter and continue to believe that the contract packaging suggested would have far reaching benefits to the District.

Certainly there is work to be done to clearly identify interfaces and to prepare, "prior to bid", for normal construction difficulties and to take "positive steps" to mitigate potential claims. These matters are of a routine nature and would be provided for in the various construction packages under preparation.

RE: Mr. Storey's Comment

We have nothing additional to add at this time concerning the comments on VE Study #1.

VEP STUDY #2

The VE Team has no further comments on VEP's # 1, 2, 3, 5, 6, 9, and 10.

We disagree with MRTC concerning the rebar issue and continue to believe in the statement made in the VE Proposal #4 text.

RE: Mr. Storey's Comments

We have no further comment on Mr. Storey's comments.

RE: Mr. Ishkanaian's Comments

We note the general agreement concerning the tunneling contracts. The notes concerning the tunneling methods proposed for the station work are interesting and naturally would need to be studied further.

VEP STUDY #3

RE: MRTC Comments

VEP #1 MRTC arguments not compelling.

VEP #2 The team continues to believe in the economies and advantages of a no-column station. Economies do not come from the "structural" issues. Obviously more concrete and rebar are needed in the roof. Cost savings come from speed and simplicity of construction. Recommend strongly that columns be deleted once and for all.

- Adding concrete to invert to mitigate buoyancy is rarely economical.

- Beam to wall connection is routine when you know how.

- The "virtually impossible" task of threading P-C beams through decking and utilities was performed with great success and economy is San Francisco. See attached pictures. Beams were installed at a rate of 11 per day on average.

VEP #3 No comment.

VEP #4 Strongly disagree. Concept of one way footing has nothing to do with hydrostatic pressure.

If water pressure exists, then this would be dealt with accordingly. Water loads would be superimposed on overburden loads. Discussion regarding statics of design is full of errors. Slab thickness is indeed determined by shear in the present design, but certainly not in the proposed design. Water pressures have to be dealt with and we concur that without columns, the slab thickness would be increased somewhat. The essence of the proposal has nevertheless been misunderstood. The VEP proposal notes the competency of the Puente soils formation and suggests that in lieu of uniform distribution of the loads over a rigid mat, a one-way type of foundation be substituted. If the District elects to use columns, the suggestion is still valid.

Strongly disagree with comment re-estimated cost. VE team considers estimates to be very conservative.

VEP #5 See later comments by Mr. McCutchen.

VEP #6 Do not agree. See comments by Mr. McCutchen.

VEP #7 See comments by Mr. McCutchen.

VEP #8 See later response re ventilation and smoke control.

VEP #9 No further comment.

VEP #10 No further comment.

VEP #11 No comment on first paragraph, but disagree entirely with second and third paragraphs. Introducing the mezzanine configured in the proposal manner would reduce the wall thickness not increase it. A full mezzanine will create a confined space at platform level and does not add to the structural capacity of the station.

VEP #12 No further comment.

VEP #13 The team believes that everything possible should be pursued to implement the concept of plazas and open spaces in the station. The MRTC arguments against such a proposal are not compelling.

VEP #14 No further comment.

VEP #15 VE team recommends side platform stations to precipitate major cost savings.

The VE team considers that the reservations concerning the reduction in tunnel spacing for a short distance are exaggerated. In practice a 5'-0" separation would be readily achievable at no extra cost. The estimated cost savings take into consideration the factors noted. We do not expect any change in the overall tunneling production.

VEP #16 The VE team continues to believe that in general there is little difference between side and center platforms, even for the "so called" busy station. The cost savings are enormous.

VEP #17 The VE team has no doubt whatsoever that the additional space required for the pocket track constructed by rock tunneling methods will be far less than constructing it

at Hollywood and Vine. Naturally, the details must be worked out and we strongly suggest that studies be conducted to examine this proposal further.

* * * * * *

The following additional response has been prepared by Mr. McCutchen.

RE: Mr. Storey

1. Concurs with vent shaft relocation, VEP #5.

2. Does not concur with smoke exhaust VEP #8. Says "smoke in trainways goes to each end of platforms and under platform - not mezzanine".

   Comment: Smoke exhaust system has exhaust ducts in ceiling of mezzanine. Operation of this system will draw smoke from platform area through mezzanine area to ceiling of mezzanine. VEP #8 still stands.

3. Does not concur with Station Vent Proposal VEP #10. Says "Do not believe VE team has proper knowledge of station vent system".

   Comment: VE team has studied station vent system and lack thereof carefully based on design information supplied. Our conclusions and recommendations stand on VEP #10.

RE: Mr. Low

1. Strongly concur with VEP #5.

2. Concur with VEP #6.

3. Strongly concur with VEP #7.

4. Questions logic of VEP #8. "Smoke pushed out of station at track level will not necessarily remove smoke from upper portion of mezzanine, which could be serious evacuation problem".

   Comment: Smoke is exhausted at track level (1) to prevent intrusion into mezzanine space and (2) to draw away any smoke that does intrude into the mezzanine. Smoke should be exhausted by a fan draft as close to the source as possible and strong enough to exhaust all the smoke at platform and mezzanine levels. VEP #8 stands.

5. VEP #10 - concur.

6. Prefer relocated pocket track.

RE: MRTC

1. Proposal No. 1. Station Depth. "Proposal does not have merit," [because]

   (a) "ceiling area above platform requires a space of 3.5 feet for the air supply duct system".

   Comment: Air supply duct system is non-existent, therefore, VEP #1 valid.

   (b) "Vault ceiling height controlled by space requirement for the smoke exhaust duct..."

   Comment: Recommended in VEP #8 that smoke exhaust system be eliminated. VEP #1 OK.

2. VEP #5. Agrees.

3. VEP #6. "Attenuator cannot be eliminated".

   Comment: Does not address criteria that emergency fans should be used for emergency use only. If this criteria is followed, attenuators not necessary, as recommended by FEI in VEP #6. Savings in underground construction enormous.

4. Concurs with VEP #7.

5. VEP #8. "Smoke exhaust system cannot be deleted for following reasons".

   1. Use to expel smoke from mezzanine area after a fire in system.

   2. Used in conjunction with UPE and supply air system to ventilate the tunnels in the purging of methane gas during non-train operating periods.

      Functional concept of smoke exhaust system in VEP misunderstood. Smoke exhaust off when emergency fans activated. System activated to expel smoke and hot gases which accumulate at the mezzanine ceiling after the emergency fans turned off.

      Comment: Reason #2 is a normal, not emergency function. Seems an inefficient way to ventilate tunnels. Reason #2 not stated at District briefings; emergency fans stated as being used to purge methane. Reason #1 not stated at District briefing. Emergency fans should be designed with capacity to do smoke evacuation in tunnels and stations, including mezzanines. VEP #8 still valid.

6. VEP #10. Does not concur in deletion. Used in conjunction with UPE and SES to purge methane.

   Comment: Supply air system not presently functional since no ducts are provided to distribute supply air. VEP #10 still valid.

RE: Memo to K.N. Murphy

1. VEP #6. Night testing of fans makes attenuators needed.

   Comment: Testing can be minimal with reliable fans and can be done at other than night time. Noise can be reduced to acceptable levels if fans are used only in emergencies or training for emergencies. VEP #6. OK.

2. VEP #8. See comments in MRTC report.

3. VEP #10. "Need station supply system".

   Comment: Then put it in, with proper intakes and ductwork.

RE: A. Dale memo to K.N. Murphy

   Comment: Seems to be against everything. No reasons carried over into main MRTC report to change any VEP.

* * * * * *

The following additional response has been prepared by Mr. Bob Miller.

VEP STUDY #3

VEP #3 Station Length

The proposal will not compromise operation in the manual mode because the train must be aligned with the stopping antenna for the doors to open. Since the antenna length has not been changed, the stopping tolerance remains exactly the same as in the present design. The same is true for automatic operation as well. The proposal does not provide for automatic stopping in the reverse traffic direction because the Design Criteria specifically directs that manual berthing will be used for abnormal traffic conditions. We strongly recommend this proposal be seriously considered for adoption.

VEP #16 Relocate Pocket Track at Hollywood/Vine

This proposal does not eliminate the pocket track as inferred by the comment writer's change in title. The double crossovers at both ends of the stations will not inhibit short turning trains. It will provide greater flexibility as more locations are available at which a train can turn. These locations are even

available while a train is stored in one station platform. This proposal allows the simultaneous use of the facility as a storage location and a x-over and a short turn location. The pocket track in the present design can be used for only one of the three functions at a time. We strongly recommend SDA seriously review the proposal. The reasons given for strongly opposing it are not consistent with the facts.

VEP #17 Relocate Pocket Track and Add X-over

This proposal will not add to dead head time for short turning trains because a x-over at Hollywood/Vine has been included in the proposal for this purpose. Similarly, the proposal will not significantly reduce ability to recover service disruptions by increasing single track run times because the x-over at Hollywood/Vine maintains exactly the same single times as the present design. The requirements for fire department and RTD personnel access to stored trains can be provided in the proposed location from the surface in a manner equivalent to the present design's access from the station. We recommend this proposal be seriously reviewed. The reasons given for strongly opposing it are not consistent with the facts.

① A. Levy
② File Value Engineering Phase II

M E M O R A N D U M

SOUTHERN CALIFORNIA RAPID TRANSIT DISTRICT
TRANSIT SYSTEMS DEVELOPMENT DEPARTMENT
SYSTEMS DESIGN AND ANALYSIS

********** 1975

DATE: November 6, 1989

TO: James E. Crawley

FROM: Joel J. Sandberg

SUBJECT: Phase II Value Engineering Study (3 Volumes)

RECEIVED
NOV 10 1989
SCRTD
TRANSIT SYSTEMS DEVELOPMENT
RAIL FACILITIES

****

In response to your memo dated October 19, 1989, Systems Design and Analysis (SDA) has performed a preliminary review of the subject study and identified those Value Engineering Proposals (VEPs) for which there is an apparent adverse systems or operations impact. Please incorporate the following comments into your transmittal to Foster Engineering, Inc. The absence of comments regarding a particular VEP is not intended to imply SDA endorsement.

VALUE ENGINEERING STUDY #2

VEP #1 - Reduce Tunnel Diameter: Reduction in tunnel diameter could inhibit rerailing of derailed trains, as well as performance of certain maintenance activities, particularly those requiring the use of a crane. Therefore, reduction of diameter is only acceptable to the extent that adequate provision for such activities can be maintained.

VEP #9 - [Raise] System Profile: For any ~~revision of~~ system profile, consideration must be given to gradient both in terms of compliance with Criteria and affect on train performance in terms of trip times and energy consumption. SDA requires adequate train performance simulation be performed on the proposed profiles before endorsing any specific configuration.

RECEIVED
FOSTER ENGINEERING, INC.
NOV 13 1989

VALUE ENGINEERING STUDY #3

VEP #1 [Reduce] Station Depth: See comment for Value Engineering Study #2, VEP #6, [Raise] System Profile.

VEP #3 - [Reduce] Station Length: SDA has serious reservations about this proposal as reduction of station platform length by ten feet would significantly compromise

operation in the manual mode and would require additional capabilities for multiple location train berthing be added to the B620 contract for Automatic Train Control equipment. Alternatively, SDA suggests that station cut and cover structures could be shortened by moving some of the systems rooms from the ends of the station box to a mezzanine over the platform and trackways, similar to the configuration discussed in Value Engineering Study #3, VEP #11, Station Mezzanine Configuration. Regarding station costs generally, single mezzanine stations should be considered.

VEP #16 - [Eliminate] Pocket Track at Hollywood/Vine station: Elimination of the pocket track would have several adverse effects on operation. It would inhibit short turning of trains and would eliminate the only location between Westlake/MacArthur Park and North Hollywood where trains or maintenance vehicles could be set out or stored. SDA strongly opposes this proposal.

VEP #17 - Relocate Pocket Track: Relocation of the pocket track from Hollywood/Vine to a point north of the Hollywood/Highland station would have several adverse effects on operations. These include adding considerably deadhead time to short turning of trains; inhibiting fire department and RTD personnel access to stored maintenance equipment and/or stored revenue or bad-order trains in the pocket track; and, significantly reducing the ability to recover from a service disruption by increasing single-tracking rum times. SDA strongly opposes this proposal.

We look forward to the conference which you are planning to facilitate discussion of the Value Engineering Study. Until then, if there are any questions regarding the comments, please contact Tom Frawley (x3985).

cc: E. B. Pollan

T. E. Frawley

METRO RAIL TRANSIT CONSULTANTS
DMJM PBQD/KE HWA

December 11, 1989

Mr. James E. Crawley, P.E.
Director of Transit Facilities
Transit Systems Development
Southern California Rapid Transit District
425 South Main Street
Los Angeles, California 90014

PURPOSE: Information Transmittal

SUBJECT: Value Engineering Study #2 & #3 - Phase II

FILE NO.: P001 (Phase II)

Dear Mr. Crawley:

Further to our meeting of November 22, 1989 and in addition to the letter transmittal of our comments on November 20, 1989, we offer the attached additional comments for your consideration.

To respond to your request we had to develop sufficient levels of engineering details and conduct analysis in order to establish definitive estimates of the individual proposal costs.

You will note, however, that in almost every proposal reviewed we substantiated, by detailed estimate, that the V. E. team predictions of cost savings were greatly overstated. In fact, in Study #3, Proposals No. 15 and 16, MRTC estimates a significant increase in cost as opposed to a reduction. Study #2 proposals with merit amount to two of eight for a savings of $460,000 in our estimation.

We hope the additional details will assist you in your evaluation of potential cost reductions for the Phase II Study segment.

89106gb.ltr

548 S. Spring Street, Seventh Floor, Los Angeles, CA 90013 (213)612-7000

If we can be of further assistance to you in this regard please advise.

METRO RAIL TRANSIT CONSULTANTS

K. N. Murthy
Project Director

KNM:mgb
Attachments

cc: R. J. Murray - SCRTD
A. Levy - SCRTD
SCRTD-TSD/DCC
DCC (2)

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ADDITIONAL COMMENTS.

V. E. STUDY #2.

SOUTHERN CALIFORNIA RAPID TRANSIT DISTRICT METRO RAIL PROJECT
VALUE ENGINEERING STUDY #2 - LINE STRUCTURES - MOS-II
EXHIBIT B

SUMMARY OF VALUE ENGINEERING PROPOSALS (VEP's)

	No.	Description	Remarks	Potential VE Savings	MRTC EST. SAVINGS
	1	Reduce Tunnel Diameter	It appears that a reduction to 16'-10" I.D. is feasible. Suggest further studies to make final determination.	$ 8,073,000	∅ Reduction 12" $1.91M, 6" 0.94M
	2	Change Tunnel Lining from 12" Reinforced Concrete to 8" Unreinforced Concrete	Unreinforced lining is possible and practical.	$ 13,500,000	—
	3	Substitute Double Track Tunnel For Twin Tunnel	Potential for double track tunnel is present. Ground conditions are favorable and tunnel equipment is available. Suggest further study.	$ 26,378,000*	—
*	4	Modify Tunnel Invert	Plain concrete invert serves same function.	$ 2,541,000	$0.203 M
	5	Modify Tunnel Walkway	Prefabricated walkway will simplify and speed up construction.	$ 2,591,000	$.046 M
	6	Reduce Size of Tunnel Cross Passages	Present design very elaborate.	$ 6,798,000	$0.130M
	7	Modify and Reduce Size of Cut-and-Cover Crossover Structure	Refer to VE Study #3.	---------	—
	8	Substitute Double Crossover For Pocket Track At Hollywood/Vine Station	Refer to VE Study #3.	---------	—
	9	Raise System Profile	Refinement in profile can substantially reduce cost of crossover structures.	$ 3,541,000	—
*	10	Modify Wet Standpipe	Use of Vitaulic couplings will simplify and speed construction.	$ 483,000	$0.256M

VE Study #2 Total	**$ 37,527,000***

*** (Does Not Include VEP #3)**

MRTC EVALUATION OF MERIT PROPOSALS (*) $459,000

DESCRIPTIONS OF

VALUE ENGINEERING PROPOSAL
STUDY NO. 2 COMMENTS

SUPPLEMENT TO THE INITIAL REPORT

Proposal No.1 - Reduce Tunnel Diameter

- Further study of the proposal to reduce the finish diameter of the tunnel from 17'-10" to 16'-10" identifies the following negative impacts. Present vehicle envelope, the safety walk envelope and utility systems supported on the interior wall do not permit a reduction in diameter. (See memo N. Brown to J. Ball dated December 1, 1989.)

- If a 12 inch reduction was possible our estimate of the cost savings is $1.9 million compared to F.E.I's $8.1 million.
- A hypothetical 6-inch reduction yielded a $0.94 million saving.
- The proposal is not possible given that the vehicle envelope remains constant.

Proposal No. 2 & 3

(No further comments.)

Proposal No. 4 - Remove Reinforcing Steel From Tunnel Invert

- A more detailed check of the length of single tunnels reveals that the total length of the study area is approximately 46,000 lineal feet not 60,000 lineal feet.

- We estimate the net savings of removing the design re-steel to be $302,000 as compared to $2.54 million by F.E.I.

- We have no strong objections to removing the reinforcing steel recognizing the magnitude of the savings.

Proposal No. 5 - Modify Tunnel Walkway

- We have prepared a detailed estimate of the structural steel supported walkway as described in F.E.I.'s proposal. Our estimate for the capital cost only is a net increase of $46,000. In addition, O&M costs would be considerably higher for the steel supported walkway.

- MRTC recommends that the current design remain as the system standard.

Proposal No. 6 - Tunnel Cross Passages

- We have further studied the "horseshoe" versus the "circular" standard detail for driving the crosspassages and find that the two standard methods are close in cost.

- o F.E.I.'s proposal of a mine-type of rectangular tunnel is not compatible with the finished internal dimensions of the crosspassage to satisfy F/LS and mechanical and electrical inclusions.

- o MRTC does not concur with the cost savings projected and does not support a change in concept.

Proposal No. 7, 8 and 9

(No comment).

Proposal No. 10 - Wet Standpipe Redesign

- o Further investigation of the victaulic coupling design substantiates our initial comments that the U.L. acceptance of a fire resistant gasket.

- o A more detailed estimate of the alternative design indicates a potential savings of $265,000 as opposed to the F.E.I estimate of $483,000.

- o MRTC supports this change provided the victaulic gasket is UL approved.

ADDITIONAL COMMENTS.

V. E. STUDY #3

SOUTHERN CALIFORNIA RAPID TRANSIT DISTRICT METRO RAIL PROJECT
VALUE ENGINEERING STUDY #3 - STATIONS - MOS-II
EXHIBIT B, Page 1 of 4

SUMMARY OF VALUE ENGINEERING PROPOSALS (VEP's)

No.	Description	Remarks	Potential VE Savings	MRTC Estim Savings
1	Station Depth		$ 4,150,000	—
	This proposal suggests reducing headroom clearance in stations to 10'-0"	Has potential to reduce overall station depth by over 5'-0".		
2	Station Columns		$ 3,995,000	—
	This proposal suggests eliminating interior station columns.	Introduces clear span concept with prestressed concrete long-span beams.		
3	Station Length		$ 2,622,000	$1.50 M
	This proposal reduces the length of the platform by 10'-0" but maintains program stop antenna length of 450'-0".	All doors on trains will open on to platform while 10'-0" of train at trailing end will stop beyond platform.		
4	Station Foundation		$ 1,859,000	($1.128 M)
	This proposal is additive to VEP #2 and suggests utilization of eccentric strip footings instead of stiff mat.	Considerably less concrete and rebar needed and capitalizes on good bearing capacity of Puente formation.		
5	Emergency Vent Shaft (BRS Outlet)		$ 9,910,000	$3.48 M
	This proposal suggests locating BRS shaft in the middle of the street directly over tracks and providing system for collecting hazardous spills.	Deletes sidewalk vent shafts and extensive associated underground passages connecting to station.		
6	Emergency Vent Shaft (Noise Control)		$ 12,030,000	$.995 M
	This proposal deletes requirement for attentuation of emergency fans by substituting an auxiliary vent system for methane detection. This proposal is additive to VEP #5.	Reduces considerably space requirements for emergency fans. Complies with noise control criteria.		

Continued Next Page

SUMMARY OF VALUE ENGINEERING PROPOSALS (VEP's)

No.	Description	Remarks	Potential VE Savings	
7	Under Platform Exhaust (UPE) Outlets		$ 2,562,000	MRTC ESTIM SAVINGS $0.96M
	This proposal suggests locating UPE outlets in center of street in lieu of sidewalk placement. This proposal is additive to VEP's #5 & #6.	Delete sidewalk outlets.		
8	Smoke Exhaust System		$ 432,000	—
	This proposal modifies present design for smoke exhaust.	Insures best possible ventilation for passenger and fire fighter safety.		
9	Station Ventilation (Provision For Future Air Conditioning)		$ 10,314,000	$0.792M
	This proposal deletes underground spaces for future system chillers. Suggest installing chillers at surface with cooling tower when and if air conditioning is required.	Deletes air conditioning requirement from current program and suggests construction of facilities when and if required at surface. This proposal does not preclude provision of future air conditioning.		
10	Station Ventilation (Fresh Air Supply)		$ 7,706,000	—
	This proposal suggests deleting sidewalk shafts and fans providing "fresh air" to the station because, as presented, system is not adequate and therefore not functional.	As presented, ventilation and fresh air supply is adequately provided by train piston action.		
11	Station Mezzanine Configuration		$ 557,000	
	This proposal suggests extending mezzanine throughout station and providing open space over platform center.	Has major structural advantages and provides access for future entrances throughout entire length of station.		

Continued Next Page

DESCRIPTIONS OF VE PROPOSALS

VEP #2 STATION COLUMNS

VEP #1 STATION DEPTH

SUMMARY OF VALUE ENGINEERING PROPOSALS (VEP's)

No.	Description	Remarks	Potential VE Savings	MRTC ESTIM SAVING
12	Station Entrances This proposal suggests reducing size of major entrances and providing secondary entrance off sidewalk.	Right-of-way implications are complex but proposal is considered to add value to the stations. Cost of proposed alternate is comparable.	Not Quantified	—
13	Station Entrances This proposal suggests opening station entrances with approach concourses to atmosphere.	Will create open space feeling for station and create plaza entrance for each station.	$ 1,027,000	—
14	Emergency Exits This proposal suggests rearrangement of emergency exits and elimination of sidewalk appendages and hatches.	Reduces cut-and-cover construction and makes exiting safer and more accessible.	$ 3,509,000	—
15	Crossover/Station Width This proposal modifies crossover configuration at Vermont/Beverly and Vermont/Sunset by narrowing track to 13'-0" centers. Stations are side platform configuration.	Major reduction of cut-and-cover construction.	$ 13,833,000	($10.09 M)
16	Pocket Track At Hollywood/Vine Station This proposal substitutes two double crossovers for pocket track at Hollywood/Vine Station and introduces side platform configuration.	Substantial reduction in cut-and-cover construction. Disadvantage is that pocket track is maintained on main line.	$ 16,961,000	($2.529 M)

Continued Next Page

VALUE ENGINEERING PROPOSAL
STUDY #3 COMMENTS.

Proposal No. 1 - Station Depth

- o A sketch of the control dimensions of the station box has been developed to indicate the current limiting critical dimensions. (See page 2).

- o Reduction of the overall box depth is only possible if a number of standard design features which address, air handling, methane gas venting, elevator clearances, etc., are reconsidered in the Phase II Design.

- o MRTC will consider the minimal structure depth in each station. However, such factors as negative buoyancy can add additional structure depth and wall thickness.

Proposal No. 2 - Station Columns

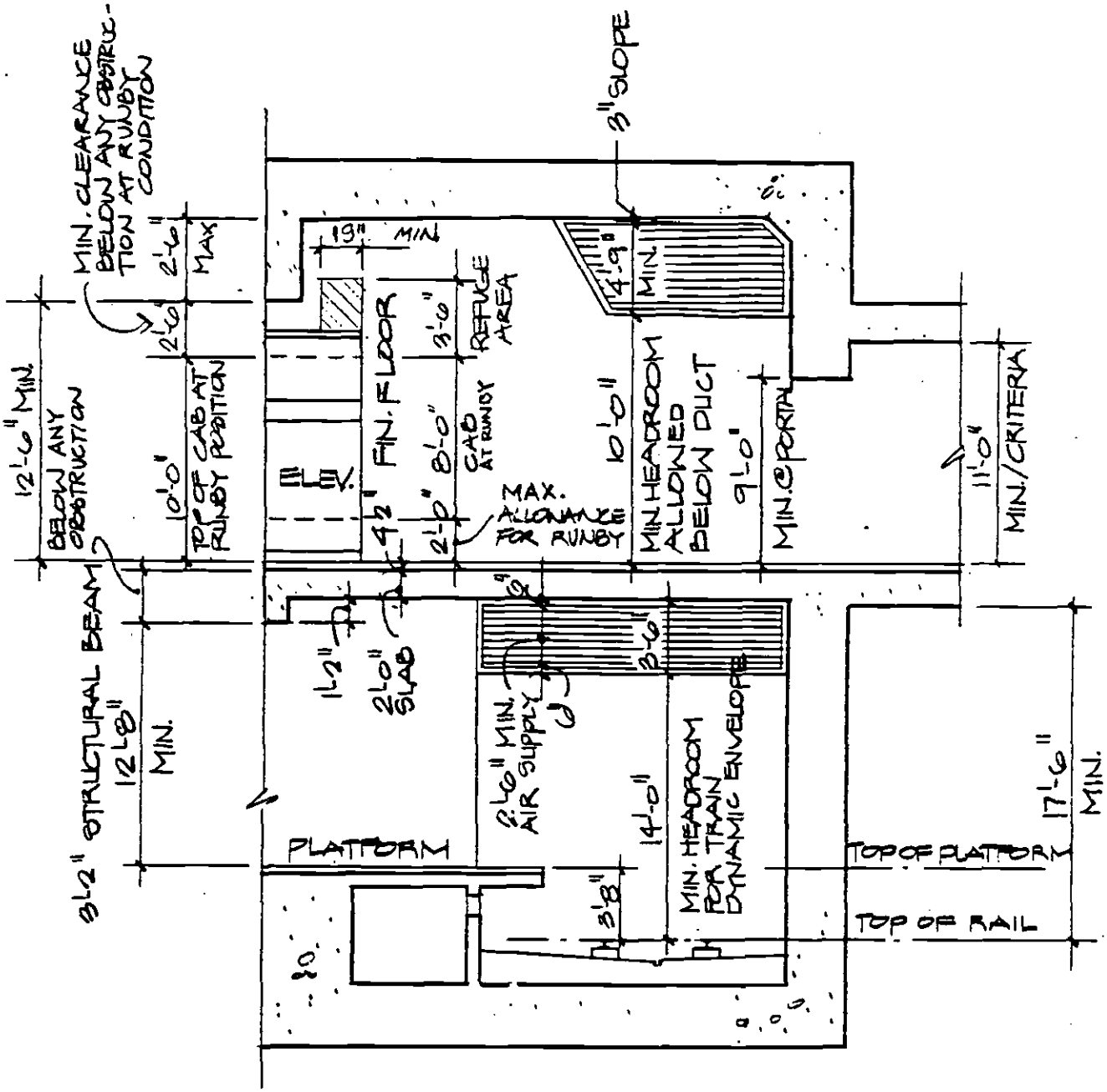
- o MRTC additionally notes that the suggested savings in the proposed column free concept includes a reduction in concrete invert thickness which is not possible.

- o This proposal violates general design principles and constructibility logistics and has no merit. (See page 3).

Proposal No. 3 - Station Length

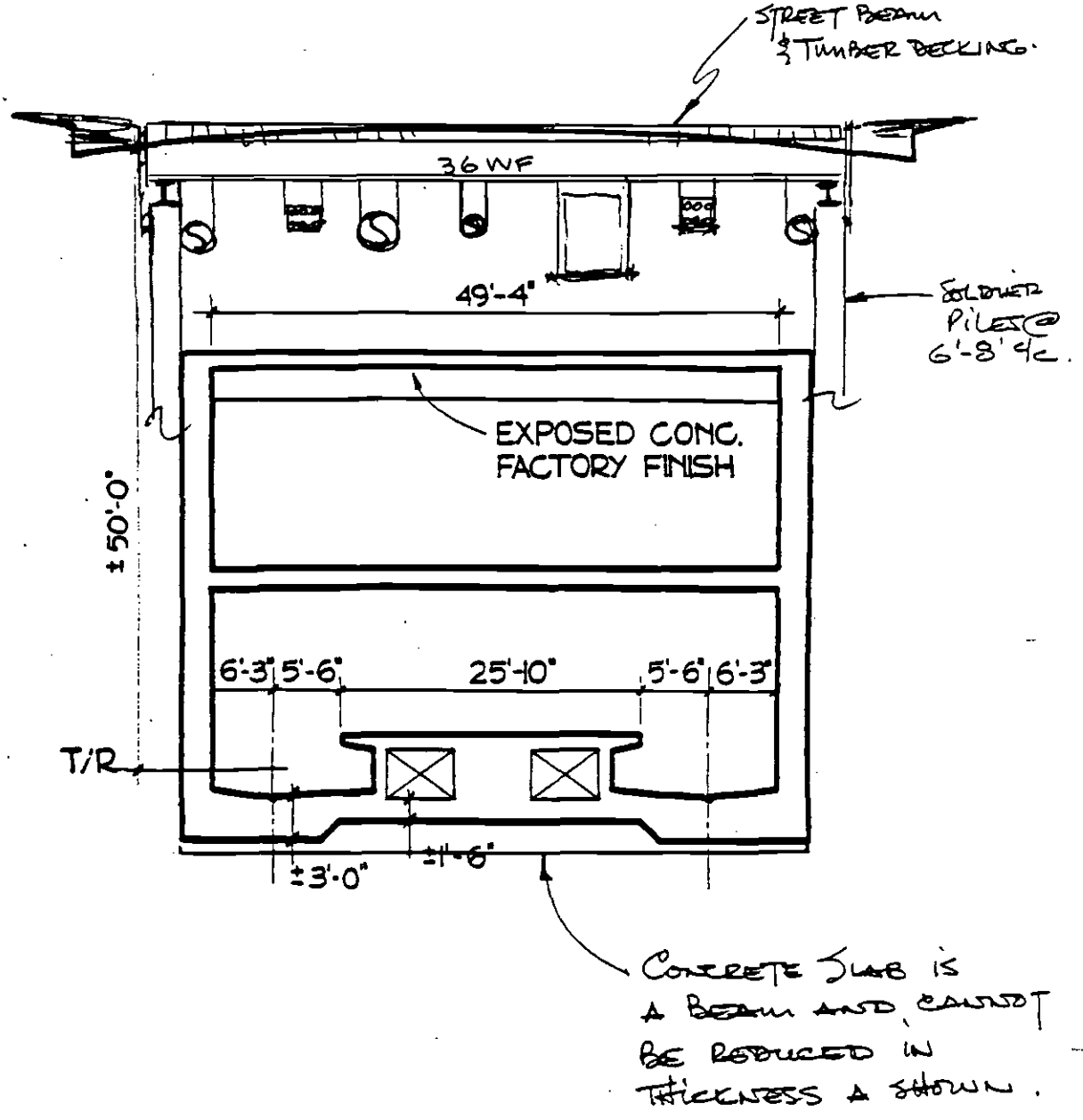
- o MRTC's estimate of potential savings is $1.5 million as compared to F.E.I.'s $2.6 million.

Station #3 Proposal No 1	JOB No.	SHEET No.
	DESIGNED BY	DATE
	APPROVED	



STUDY TITLE **SOUTHERN CALIFORNIA RAPID TRANSIT DISTRICT METRO RAIL PROJECT - MOS-II**
VALUE ENGINEERING STUDY #3 - STATIONS

SKETCH OF PROPOSED DESIGN



STATION COLUMNS

- MRTC suggests that the focus to reduce station length should be on the ancillary areas. Such possibilities, as vertically mounting the emergency fans, are being considered for Phase II Stations.

Proposal No. 4 - Station Foundation

- MRTC further notes that the three stations on Vermont Avenue will be designed to a final water table elevation above the roof of the station vault. The Hollywood corridor stations will encounter a hydraulic head from invert elevation to mezzanine elevation. In each case hydrostatic uplift forces are considered uniform across the underside of structure.

- The attached station foundations - proposed design sketch (page #5) is marked up to show the shortcoming of the proposed station vault cross-section.

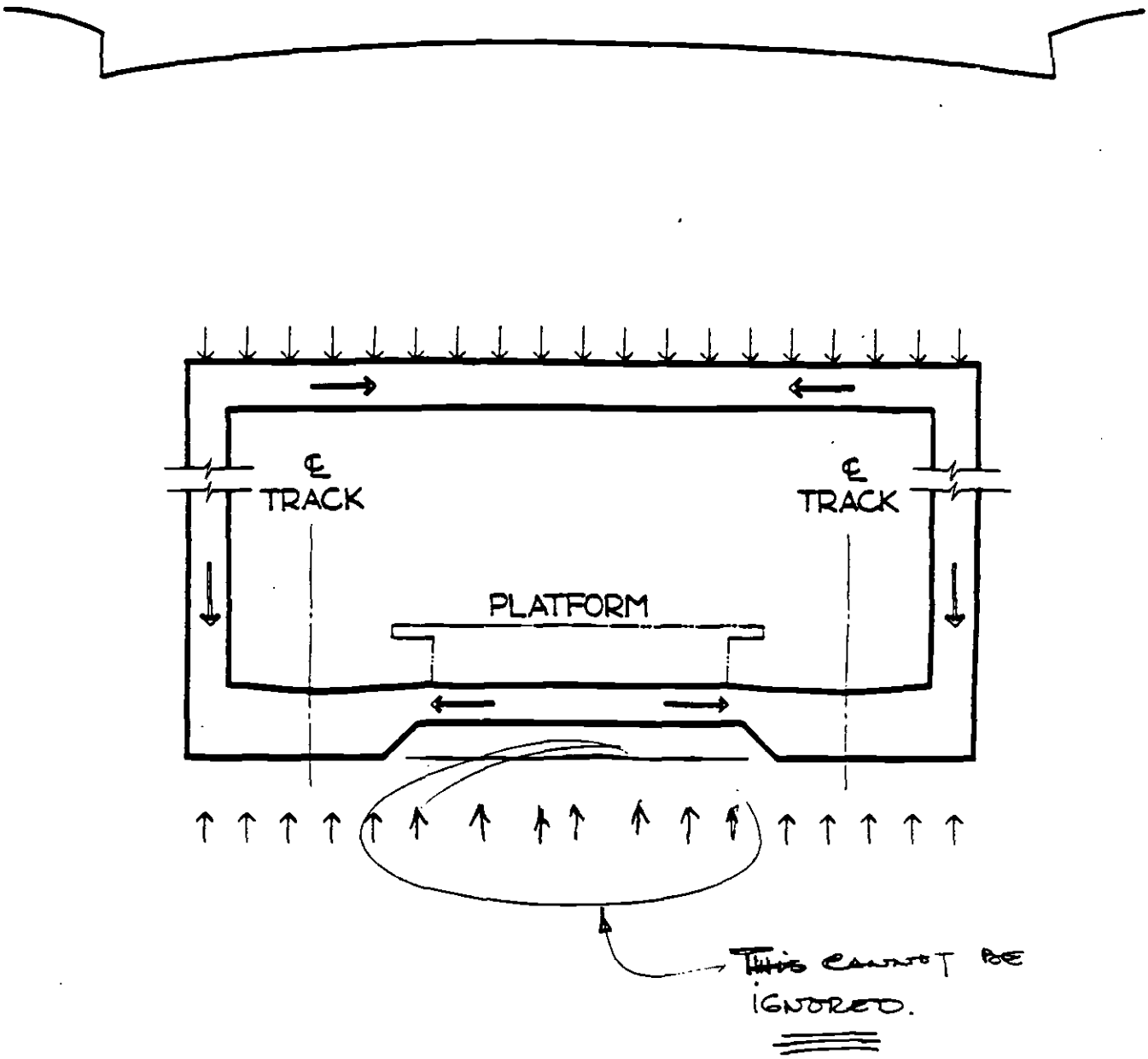
- We estimate that the projected savings is, in fact, an additional cost of $2. to $3 million for the column - free roof design.

Proposal No. 5 - Emergency Vent Shaft Location

- A more detailed estimate of the cost savings of placing the Blast Relief Shafts in the street and within the cut and cover area is $3.48 million as opposed to F.E.I.'s $9.91 million.

- We encourage the District to open discussions with the City to place the vents in the street. MRTC will support these discussions with design detail and cost estimates, as directed by the District.

SKETCH OF PROPOSED DESIGN



STATION FOUNDATIONS

Proposal No. 6 - Noise Control of Emergency Vent Shafts

- MRTC reiterates that fan attenuators cannot be removed without creating two major impacts.
  1) Increases the platform and interior noise adjacent to the fan rooms to levels in excess of design standards when fans are operating.

  2) Noise attenuation can only be attained by increasing the length of the shafts, by creating bends or baffles, and by application of spray-on acoustical treatment.

- The attenuators at the fans provide a 30 to 40 dB noise reduction. For example, the bends and spray-on treatment to accomplish the equivalent noise attentuaion of the fan attenuators is as follows:

Noise Attenuation	Requires
30 dB	2 bends, 40 feet shaft
40 dB	3 bends, 60 feet shaft
30 dB	150 feet shaft
40 dB	200 feet shaft
30 dB	1000 feet shaft (No acoustic treatment).

- Lengthening and bending the shaft can only be accomplished by lowering the station vault or extending the cut and cover construction.

- MRTC does not concur with the proposal estimate of $12.0 million savings. If the attenuators could be removed (MRTC does not agree that they can) we estimate the savings to be $1.0 million or less.

Proposal No. 7 - Under Platform Exhaust Outlets

- We support the concept of placing the outlet vents in the street and within the cut and cover area. However, we estimate the net savings to be in the order of $1.0 million as compared to F.E.I.'s estimate of $2.56 million.

Proposal No. 8 - Smoke Exhaust System

- The proposal has no merit.

Proposal No. 9 - Station Ventilation (Provisions for future A.C.)

- MRTC estimates the savings of removing the chiller plant spaces within the station ancillary areas to be in the order of $0.8 million as opposed to F.E.I.'s estimate of $10.3 million.

- MRTC cautions the District on the concept of placing chiller plants on the surfaces. This should be considered on a site by site basis so that a contingency plan for locating the plants is resolved in the early planning and design of each station site.

Proposal No. 10 - Station Ventilation (Supply Air System)

- MRTC inquired of the status of station A.C. on the MARTA system and the following information was transmitted:
  - In the summers of 1988 and 1989 the A.C. was operating in the six North Line Stations.
  - The conditioned stations maintained a comfortable temperature and humidity at approximately 10°F below ambient at peak afternoon rush hour.

- MARTA plans to operate the A.C. systems for all underground stations in the summer of 1990.
- In general, when condition air is not required, the air handling units supply outside air to the stations and heat from the trains is removed by the under platform exhaust system.

Proposal No. 11 - Mezzanine Configuration

- MRTC notes that in order to accomplish a strut supported design for a continuous walkway over the track bed the entire station vault would have to be deepened by 1'-2" to 2'-4". Exterior wall thicknesses could be reduced in these areas.

- The proposed V.E. cantilever design would add concrete and reinforcing steel to the exterior walls and connection point and therefore add costs.

- Some future savings would be recognized but we conclude that additional current costs would be required to modify the station.

- MRTC does not recommend this proposal due to the additional cost.

Proposal No. 12 - Station Entrances

- This is not so much a design concern as it is an RTD policy direction. However, the merits and concerns of doubling entrance structures to provide alternative emergency exits must be looked at on a station by station basis. Where emergency exits cannot be reasonably positioned without creating excessive costs then the alternative entrance may be the solution.

- MRTC predicts an increase in capital costs by adding an entrance; not a reduction.

Proposal No. 13 - Station Entrance Concept

(No further comments).

Proposal No. 14 - Emergency Exits

- Please refer to the memo in the Appendix, Ralph Desimone to K. N. Murthy, dated November 2, 1989. Page 4 of the memo addresses the concerns MRTC has with the concept. (A copy of the memo page is reproduced as page 10).

Proposal No. 15 - Crossover Length/Width Reduction

- MRTC has done some further investigation of the transition geometry from wide track centers to narrow track centers. We note the following impacts of this proposal.
  1) The minimum track center dimension is 15'-0" for a No. 10 double crossover due to the askewness of the crossing diamond.
  2) The length of the cut and cover transition and crossover is approximately 700 feet long as compared to the modified standard double crossover of 300 to 320 feet.

- Based on the Trial 1 arrangement (page 11) we estimate an increase in the cost due, in majority, to the increase in the length of the cut and cover construction.

Proposal #14

The proposal suggests relocating exit stairs within the 450' length of the platform. While it may result in a construction cost savings, it has the following functional drawbacks that need consideration:

1. The concept allows for a 12' width for a combination of the UPE shaft, stairs and the structure walls. This leaves only 5'-6" for stair widths, which is not sufficient in several cases (stair widths being determined by occupant loads, ridership and exit times by FLSC).

2. The concept shows a 25' dead end condition, measured from the end of platform to the door opening. Building code requires that this distance not exceed 20'. If the proposed stair/UPE structure would be revised to meet code, there would be headroom problems over the trainway (see answer to #3).

3. The concept is not feasible in the double-end mezzanine stations due to entrances and public circulation conflicts. This figure should be excluded from the resultant savings suggested in the proposal.

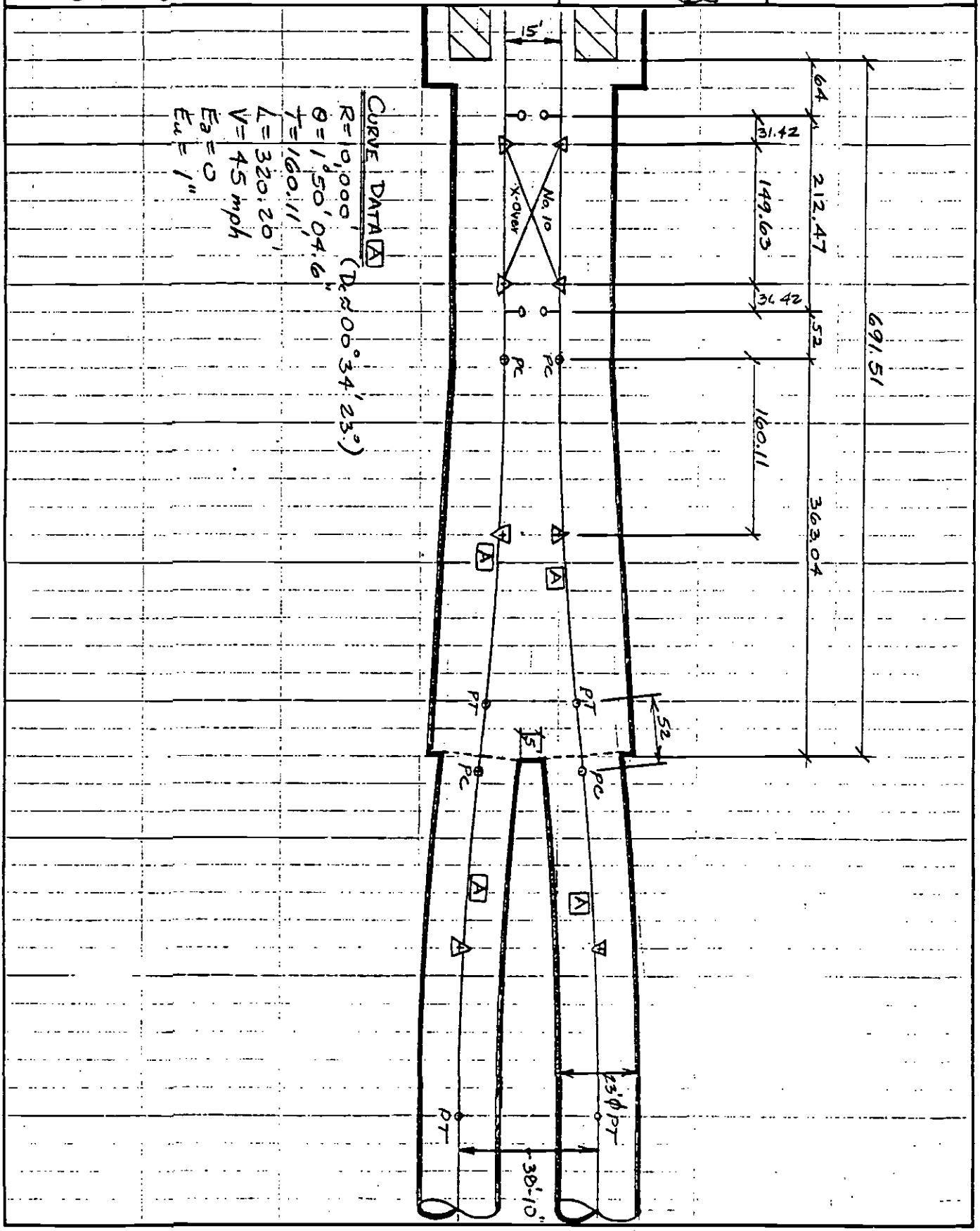
4. The condition caused by a constriction in the platform width is unsafe for station patronage.

5. Disregards FLSC resolutions.

RD:kcr

cc: J. Ball
G. M. Cofer
DCC (2)

TRIAL 1 - SKETCH OF TUNNEL TO NARROW T.C. CROSSOVER	JOB No.	SHEET No. 15 - 1
	DESIGNED BY S.J	DATE Dec 1984
	APPROVED	



Proposal No. 16 - Pocket Track at Hollywood/Vine Station

- From the alignment analysis done for Proposal No. 15, we estimate a net increase in cost for this proposal. The increased cost is attributed to an overall increase in cut and cover special structures from approximately 1200 feet to 1400 feet for the two double crossovers at either end of the station.

- MRTC does not recommend this proposal.

METRO RAIL TRANSIT CONSULTANTS
DMJM/PBQD/KE/HWA

MEMORANDUM

DATE: December 1, 1989

TO: J. Ball

FROM: N. Brown

SUBJECT: Passenger Vehicle Requirements Relating to Tunnel Diameter

REFERENCE:
1) Value Engineering Study #2 - VEP #1 - Tunnel Diameter
2) Tunnel Maintenance and Rerailment Study prepared by MRTC dated April, 1984.

In accordance with your request we have examined the dimensional parameters related to operating the passenger vehicle in the tunnel to determine if, as far as the passenger vehicle is concerned, the tunnel diameter could be reduced. The proposed tunnel diameter reduction is discussed in reference (1).

In reference (2) clearances required for rerailing are identified. Tables from this report are attached showing vehicle 1 tunnel clearances for a 17' 6" diameter tunnel and the results of a survey of related tunnel clearance dimensions on other transit properties.

The Breda vehicle static and dynamic outlines fit closely within the SCRTD static and dynamic outlines assuming that the tunnel diameter is reduced from 17'- 4" down to 16'- 4", the vehicle will no longer fit inside the tunnel due to significant dynamic interference with the construction tolerance zone. Other items that will no longer be able to be maintained are the 11 inches of jacking clearance identified for rerailing; the clearance envelope above the walkway as dictated by the design criteria; the walkway width, and adequate space for overhead gas sensors, conduits, antenna, lights, blue lights and signage.

The 11" rerailing requirement could probably be reduced if this were the only impediment to going to a smaller tunnel.

In addition to the interference being critical there are other negative impacts such as increased operating costs due to greater energy consumption for the train to overcome the piston effect, redesign of the ventilation system to handle the greater air pressures caused by a higher blockage ratio, and possible redesign of maintenance equipment to be able to access the smaller diameter tunnel.

891095gb.mem

To fully evaluate a reduction in the tunnel diameter redesigns would be required to shrink the tunnel around the vehicle while still maintaining dynamic clearances; the operating cost increase would have to be calculated along with any ventilation system cost increases; and then a trade off analysis would have to be performed based on a realistic expected reduction in bid prices for tunnel contracts.

If we can provide further assistance on this VEP please advise.

NB:mgb

Attachments (2)

cc: G. Wasz
A. Dale
DCC (2)

NOTE: 17'6" Tunnel diameter	VEHICLE/TUNNEL CLEARANCES					
	CRITICAL CASES				TANGENT TRACK	
	1000' Radius, 4" Superelevation Floating Slab (6.3% System Trackage)		900' Radius, 4" Superelevation Floating Slab (0.6% System Trackage)		0" Superevelvation (70% System Trackage)	
CLEARANCE REQUIREMENTS (See Paragraph 1.3)	OUTSIDE WALKWAY	INSIDE WALKWAY	OUTSIDE WALKWAY	INSIDE WALKWAY	FLOATING SLAB	RIGID INVERT
Tunnel walkway width Requirement: Floor width of 30"	29" (worst case tolerance)	29"	29" (worst case tolerance)	29"	30"	30"
Minimum vertical clearance above static outline to tunnel face Objective: 12"	11" *	11" *	9-3/4" *	11" *	13-11/16"	18"
Minimum clearance between vehicle dynamic outline and tunnel face Requirement: 2" to any fixed installation	4-3/16"	5-5/8"	3-1/4"	5-5/16"	7-1/2"	10-1/2"
Vertical distance between vehicle floor and tunnel walkway Requirement: 0" to 7" below vehicle floor	4-3/16"	13/16"	4-3/16"	13/16"	5-1/2"	5-1/2"
Passenger clearance envelope above walkway maintained clear of vehicle static outline Requirement: As stated	Yes (minor construction tolerance infringement)	Yes	Yes (minor construction tolerance infringement)	Yes	Yes	Yes
Maintenance personnel walkway clearance envelope maintained clear of vehicle dynamic outline Objective: as stated	Yes (minor construction tolerance infringement)	No (operational limitations required)	Yes (minor construction tolerance infringement)	No (operational limitations required)	Yes (minor construction tolerance infringement)	Yes
Construction tolerance Requirement: ±4" (±3" on curves of radius 1000' or smaller)	Yes (±3")	Yes (±3")	Yes (±3")	Yes (±3")	Yes (±4")	Yes (±4")

Note: Clearances and dimensions are current at the time of this report. Any future changes (if any) are expected to be minor. Remaining 23.1% of trackage represents curves with a radius greater than 1000 feet, and also spiral segments associated with all curves. Only circular curves (having constant radius) are included in the listed track percentages for the two critical cases.

* Vehicle/tunnel clearances are based on composite vehicle outlines. Actual clearances relative to any one specific candidate vehicle will be slightly greater.

VEHICLES/TUNNEL CLEARANCES
TABLE 1-2

Property / Clearance or Dimension	BART	MARTA	MBTA	MTA/ BRRT	WMATA	RANGE OF FIVE PROPERTIES	PLANNED SCRTD
Length of Circular bore tunnel[b]	Apprx. 10 mi.	½ mi.	2 mi.	Apprx. 4 mi.	N/A	½-10 mi.	Apprx.[c] 16 mi.
CLEARANCES STANDARDS/-TOLERANCES[d]							
• Tunnel Constr. Tolerance	See Note[e]	---	±2½"	±3½"	±2"	0 - ±3½"	±3 - ±4"[f]
• Track construction/ maintenance tolerance	±1½"	---	±2½"	---	---	0 - ±2½	---[g]
• Allowance for acoustical treatment	1½[h]	2"	2"	---	---	0 - 2	2"
• Allowance for installation	2"	6"	---	4"	2"	0 - 6	2"
• Clearance envelope[i]	5"[d]	---	3"	2"	2"	0 - 5	2"
• Additional clearance specified	---	---	---	---	4"	0 - 4	---
ACTUAL VERTICAL DIMENSIONS							
• Tunnel Diameter	16'6"-[j] 17'0"	18'6"	18'0"	17'0"	16'6"	16'6"-18'6"	17'6"
• Top of rail to tunnel ceiling	13'2"-[j] 14'2"	14'0"	14'6"	NA	12'0"	12'0"-14'6"	13'6"
• Car height (static outline)[k]	10'6"	11'10"	12'5"	12'5"	10'10"	10'6"-12'5"	12'3/4"[l]

--- Not Applicable
NA Not Available

Source: Phone and document survey conducted August, 1983

[a] Reflects most recent availabl standards and newest construc tion, e.g. MBTA

[b] Right-of-way miles. For additional comparison: TCC has 5.4 miles, PATH approx. 6

[c] Approximately 3 right-of-way miles of Metro Rail are through rock tunnel (Santa Monica Mountains) and are not expected to have clearance problems. No precast tunnel liner is required.

[d] Vertical and horizontal unles: otherwise noted; These figur are not necessarily additive.

[e] BART clearance envelope includes running clearance and construction tolerance.

[f] 3" in minimum radius curves; 4" otherwise.

[g] Included in vehicle dynamic envelope; max. lateral rail near = ½' wheel gauge/rail gauge differential = 0.4 maximum rail construction tolerance of + 1/8" laterally, 1/8" cross level tolerance, plus ½" top of rail tolerance.

[h] Can be omitted where clearance is critical.

[i] Beyond car's dynamic outline.

[j] Low figures are for tangent track and gentle curves. High figures for curves of less than 1500' radius.

[k] Top of rail to top of roof.

[l] Composite vehicle height to top of vehicle antenna is 12' - 4 2/3".

TRANSIT SYSTEM SURVEY
CIRCULAR BORE TUNNEL CLEARANCES AND DIMENSIONS[a]

TABLE 2-1