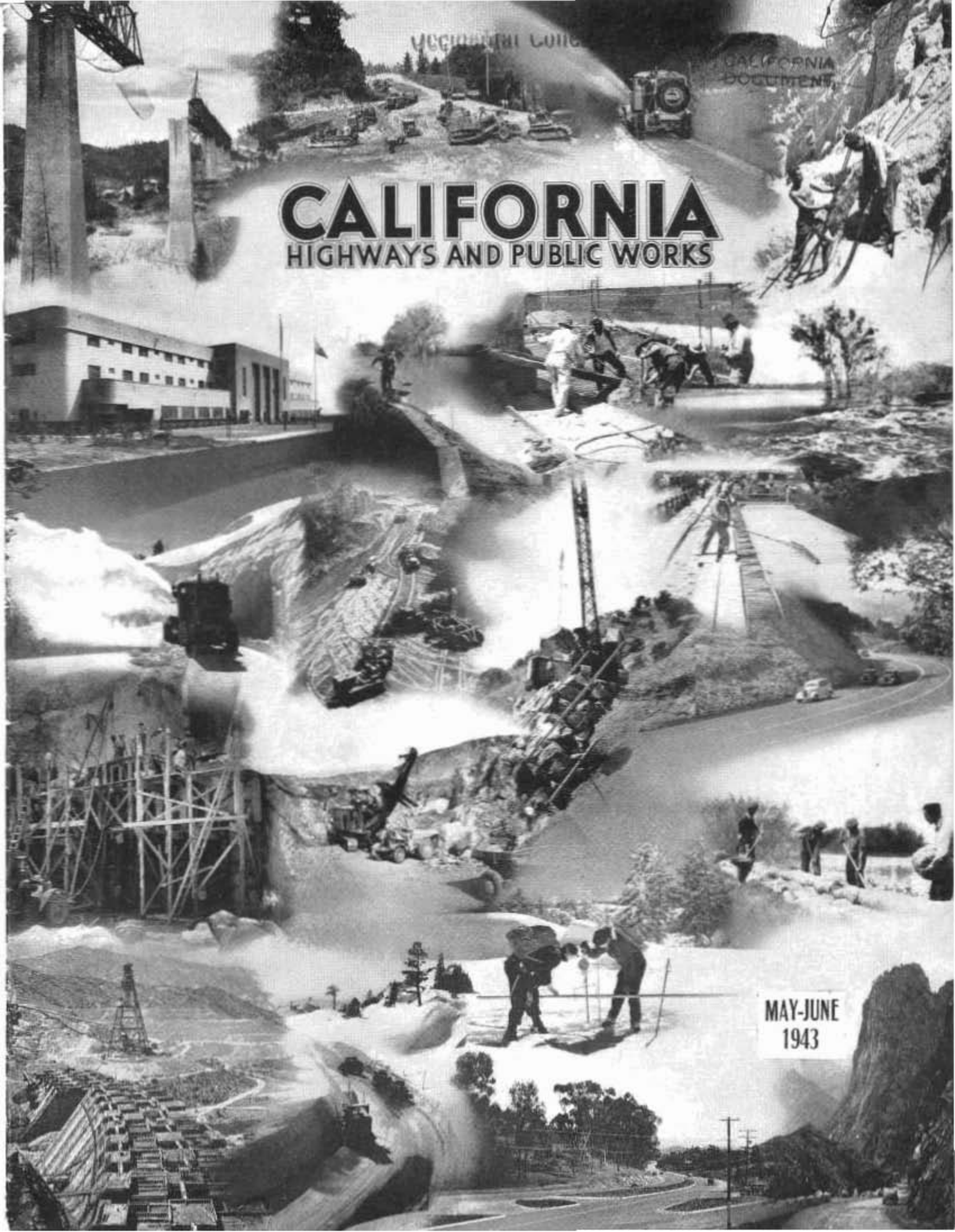
CALIFORNIA
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CALIFORNIA HIGHWAYS AND PUBLIC WORKS

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Gov. Warren's Appeal to President Wins Approval for Central Valley Project Food Crop Features

A CONCERTED drive by public and private agencies, organizations and individuals from California has finally broken the Washington deadlock which for months has threatened to leave the Central Valley Project in a partially completed and unproductive state.

First break in the deadlock came in the form of a letter from President Roosevelt in reply to a personal plea by Governor Earl Warren that the President intercede on behalf of the project. As result of the Governor's plea, President Roosevelt ordered the War Production Board and the Federal Power Commission to reexamine the status of the project and its relation to war production. This led to a revision of the WPB stop work orders permitting installation of control gates on Friant Dam, the completion of the Madera Canal and finishing concrete work on Keswick Dam. That approval of work on other features may be made by the WPB is indicated by the President's letter.

BUDGET BILL INCREASED

Second break for the project came when the budget bill which previously had carried no funds for continuation of work on the project after July 1 was revised to include a $16,500,000 item to finance completion of Shasta Dam. The House Interior Appropriations Subcommittee subsequently reduced this amount to $11,500,000 and the bill as reported by the committee was passed by the House. It is now pending before the Senate and there is a possibility additional funds will be provided for work on the irrigation features approved by the WPB.

Governor Warren has followed the development of the Central Valley Project closely. In his previous post as Attorney General he served four years on the Water Project Authority which represents the State's interest in the project. He thus has an intimate knowledge of the project and the enormous part it can play in increasing the production of critical war crops in California, protecting lands already under cultivation from flood and drought and producing additional hydroelectric power. His letter to President Roosevelt reviewed in detail the present status of the project and what completion of various units of the project would accomplish. He wrote in part:

WARREN LETTER TO ROOSEVELT

"The action of the War Production Board in cancelling priorities on all features of the Central Valley Project except the Shasta Dam and certain attendant power facilities, coupled with the fact that no funds for the project are included in the budget for the 1944 fiscal year, has caused great concern to the people of California.

"I am well aware of your intimate knowledge of and personal interest in this project, exemplified by your allocating $20,000,000 from the Emergency Relief Appropriation on September 10, 1935, making possible commencement of work, and your continued support since that time. Therefore, I am addressing this letter to you to solicit your personal assistance in securing the necessary funds and priorities for the completion of this project, which will yield large values in the prosecution of the war from the standpoint of production of needed food, fiber, and electric power.

"I well recognize that the war has caused many drastic changes in the construction program of the Federal Government, and am heartily in accord with the concept that anything not directly related to winning the war should be postponed for the duration. It is my firm conviction, however, that the production of food, in view of the growing shortage throughout the world, is second only to the production of the materials of war.

"The adaptability of California's soils and the wide range of its climate particularly fit this State for the production of all types of food necessary to the war effort. Many crops are produced on a year-around basis and, compared to other states, the yield per acre is much higher. Lands which the Central Valley Project will serve are heavy producers of beans, potatoes, sugar beets, vegetables, forage crops for beef and dairy production, flax, cotton, and both deciduous and citrus fruits.

VAST CROP POTENTIALITIES

"There are also large acreages in grains and other less essential crops which, if provided with an adequate water supply, could easily be converted to the production of needed war foods. In addition, there is a large acreage, not now in use, which the Department of Agriculture has classified as highly desirable for the production of guayule and which is needed immediately if the Department's present planting program is carried to fruition.

"California agriculture is bending every effort to meet the mounting demands for food within its own borders. A great influx of population to man the war plants has taken place in the last two years. Growing military establishments in every section of the State, with a population that is difficult to estimate, are producing an additional heavy drain on the food resources of California. Valuable shipping space needed for the transportation of war materials is now being used for the importation of food products that could be grown on lands in California. In-

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Control of Roadside Vegetation to Reduce Fire Hazards

By E. S. WHITAKER, Assistant Landscape Engineer

SOME years ago, the agricultural interests of this State figuratively leaned on their collective fences and gazed with ever increasing trepidation across the narrow strip of land separating their properties from the paved roadways that carried the ebb and flow of traffic on the State Highway System. They feared for the safety of their fields of grain, or their pasture lands; their interests also lay directly and indirectly in timber and watershed lands.

Along the highways flowed traffic that yearly became more dense and included local traffic that well knew the dangers of fire; city dwellers and out of State people who did not realize the hazards along the roads' edges throughout a six months' dry season; careless travelers who did not think of the possible havoc to be wrought by an accidental fire.

RESPONSIBILITY OF STATE

Between the fence lines and the traveled way extended a narrow strip of untended land, growing a full complement of grass and weeds that, as part of the right of way, came under the jurisdiction of the State Division of Highways. So far as the owners of the lands beyond the fences were concerned, the hazards caused by the traffic on the highways and existing in the matured growth on the rights of way were the responsibility of the State.

The Division of Highways recognized the benefit of a cooperative program of fire hazard control and in the 1920's began an active program to that end. Portions of the right of way bearing the worst fire hazards and fronting valuable dry crop or timber and watershed lands were treated for such control.

A large amount of the work in the first years consisted of hand removal of brush, hand hoeing around posts and of dry burning. From this start an annual program developed.

It was found that dry burning, alone, was a risky proposition. In order to burn an area clean it was necessary that the growth pass maturity and dry out sufficiently to burn well. By that time, growth in the adjoining fields was also so dry that the danger from spread of fire was constantly at hand.

SPRAYING EQUIPMENT DEVELOPED

There was also the damage resulting from scorching or burning trees on the right of way, and hand labor for their protection became a large item of the yearly roadside charges. Spraying equipment was accordingly devised that could spray a strip well out on the right of way and, wherever possible, directly next to the right of way line.

EXPERIMENTS WITH CHEMICALS

Experiments with chemicals and oils were undertaken to determine what agent would kill the growth quickly and as cheaply as possible. An experiment with large hooded burners and one with live steam was carried out, trying to find a method of destroying green growth so that the hazard of burning during the dry season would be done away with.

DIESEL OIL EFFECTIVE

With the possible exception of a proper chemical used under optimum conditions, no experiment has as yet produced results equal to that obtained through the use of diesel oil. By applying a spray under sufficient pressure to insure penetration of heavy growth, between 30-50 pounds pressure per square inch, and by using from one-twentieth to one-tenth of a gallon application per square yard according to the denseness of the growth, a strip of grass and weeds could be treated and killed while the surrounding growth was green.

After allowing from 10 to 15 days interim for as complete a kill as possible, the sprayed strip could then be burned with little danger of fire spreading outside of the sprayed area. Under favorable moisture conditions, if spraying could be under way while the vegetation growth was still small, a complete kill was secured and burning was not necessary.

With the expansion of the program it was obvious that, while a fire hazard could be said to exist wherever dry grass existed on the right of way, it was necessary to keep the work to a minimum from an economic point of view. A policy was therefore adopted as to selection of areas to be treated. Under this policy work was restricted to areas adjacent to grain, grazing and watershed lands, and in some cases for the protection of timber lands.

SELECTION POLICY ADOPTED

In the selection of areas for protection of grain and grazing lands, the traffic density on the affected portions of each route was a determining factor, for where low count traffic of predominantly local origin constitutes the main portion of the traffic, hazard control is not as necessary as along roads carrying a high volume of mixed type traffic.

Along the coast where climatic conditions are favorable, many miles of roadsides have been fireproofed and improved in appearance by planting ice plant. The two best varieties for this purpose apparently are Mesembryanthemum edule and croceum. Both act not only as soil binders, but crowd out all other grass and weed growth as well. Through their clean green foliage and bright flowers they add greatly to the beauty of the roadsides.

The width of shoulders and of the portions graded for their maintenance also determines whether the roadside should be treated. Wide shoulders, clean of growth—no treatment; narrow shoulders with a fire hazard close to the pavement edge—treatment

At top—Spraying roadside slope with diesel oil preparatory to burning. Simplified adjustable boom equipment is operated by one man from front of tank truck. Bottom—Mowing tall dry growth reducing fire hazard

necessary. The area and type of development on private property is still another factor in determining where firebreaks should be established. A few acres of grain or pasture surrounded by orchards or fields of green crops need not be given the same protection as several hundred acres of grain or grazing land that stretches away from the right of way line unbroken by any kind of a firebreak.

DISKING FOR FIREBREAKS

With the addition of county roads to the State Highway System and the general increase of traffic, it became necessary to include more and more roadside mileage in the program. In order to cut the total cost of the work, farm type disks were used to form the firebreak whenever possible. To spray once and then burn a strip nine feet in width costs, by state-wide 1942 average, $53 a roadside mile; to disk a comparable strip costs $15 a mile. While the immediate answer to the difference in costs is apparently "disk everything," such work cannot be done due to the inaccessibility of a large portion of the roadsides to disking equipment on steep cut slopes.

However, the mileage of the disking for the establishment of firebreaks has increased from nothing in 1928 to 537 roadside miles in 1942. In valley sections with wide right of way, disking equipment is put in action as soon as the ground dries out sufficiently to carry the weight of the disk and tractor. On this type of roadside, a heavy disk with retractable rubber tired wheels can be used. With the wheels lowered the disk can be towed behind a truck for rapid transfer from one portion of a roadside to another as conditions require.

RESTRICTIONS ON DISKING

Disking is restricted to the area beyond the gutter or ditch line. No shoulder or slope areas inside this line are disked except under unusual conditions, as the soil loosening action of the disk blades disturbs the desired compaction of the slope or shoulder and its early displacement and dissipation by wind and rain follow. On the other hand, grading equipment can be used to good advantage inside the ditch line. Where space is available, one blade width placed directly next to the portion normally bladed for the maintenance of improved shoulders establishes a satisfactory firebreak.

In 1942, the strip to be sprayed was moved in from the area adjacent the right of way to the first nine feet directly next the improved shoulder. There were a number of advantages gained by making this change. It allowed for more rapid progress of the work, as the innumerable pauses to swing the boom or the spray bar to clear posts and trees were reduced. Equipment could be kept on the traveled way or on the improved shoulder, and it was not necessary to wait for the ground to dry out and become solid enough to hold up equipment in order to place the spray strip near to or directly next the right of way line. Other conditions being favorable spraying could be started at an earlier date.

PRESERVING GREEN ROADSIDES

The sprayed and burned strip in this new location later appeared to be a part of the roadway and did not leave an unsightly and esthetically objectionable scar through the wild flowers and green growth of the roadside. This in itself is no small feature, the Division having received a number of letters, from mildly critical to condemnatory, decrying the destruction of green growth right at the season when the roadsides appeared at their best.

But most of all, the firebreak was placed at the point where the greatest number of fires started. If the fire incidence was the direct result of traffic, then the hazard nearest to the traffic should be controlled. Whereas, with an intervening strip of dry grass between the road edge and the firebreak in which a fire could start and finally gain size enough to jump the break, with a fireproofed area at the point of occurrence the probability of a fire ever getting started is minimized.

It is still necessary, of course, to provide a firebreak by spraying or disking around trees or other plantings before burning can be undertaken. All of this type of work applies only to accidental fires, no work being attempted to anticipate fires of incendiary origin.

Another change put in effect in 1942 was the development of simplified

Disking roadside areas beyond ditch line establishes firebreaks

Burning oil-sprayed roadside growth. Fire is kept in control with water hose connections from truck tanks

spraying equipment. One new development consisted of a folding swivel-toggle boom, which is mounted between the cab and the tank on a tank truck with a pressure pump located either at the side or at the rear of the truck. The boom is operated by one man sitting on the right side of the driver's seat. In this position he can look head and see what to spray and can also coordinate the movements of the driver of the truck.

The unit is particularly adaptable to spraying next to the shoulder edge, and, whereas the rear end heavy boom units needed a crew of three and even four men for operation, this equipment is operated by two men. It was first designed and used by maintenance forces in the San Diego area.

A further development was built in the Equipment Department Shop at Redding using a single pipe toggled in sections for the boom and for supplying the oil to the spray heads as well. This does away with the use of hose. When not in use in moving from point to point the boom is folded away behind the cab, and when the spraying is completed for the season it is easily dismantled and stored. Through the use of improved methods of work and improved types of equipment as described, costs in normal times should be reduced for the spraying operations.

MOWING REDUCES HAZARD

On portions of routes where spraying and burning has previously been done but has been discontinued this year, roadside mowing is now done where necessary, cutting one swath in width. This work, while not fireproofing the mowed strip, does reduce the hazard that exists in standing tall dry growth.

In 1928, some 661 roadside miles were treated for control of fire hazards at a cost of $37,752. By 1942, this program had expanded to nearly 2,600 roadside miles with a total expenditure of $118,179. Due to conditions imposed by the war, the program for 1943 has been reduced to treatment of 1,980 roadside miles of spraying and burning and of disking at a total anticipated expenditure of $86,000.

The amounts shown do not include expenditures by the State Division of Forestry nor the United States Forest Service. The State Forester has cooperated in the program by supervising the maintenance forces, in many cases in burning operations. The Forest Service has carried on control work in certain timber areas with their own forces.

While the program for 1943 is being carried out in the normal way with the exception of reduction in volume of work, it is to be expected that changes will be necessary for 1944.

LIMITED BY WAR RESTRICTIONS

Looking ahead, when diesel oil will not be available due to war restrictions, it may be necessary to, in part, return to dry or flash burning operations. It will be necessary also to limit the use of equipment for discing and blading because of tire shortage and inability to replace equipment.

Through the use of high pressure spray rigs designed for use as tree spraying equipment, it is possible to place two spray guns in operation. This equipment will throw a spray of water at the rate of 25 to 30 gallons a minute up to a distance of 100 feet. Strip burning started with pressure torches, when protected by the use of such equipment, can be safely accomplished.

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California Adopts Waterway Ratings for Large Drainage Culverts

By R. ROBINSON ROWE, Assistant Engineer, Bridge Department

FOREWORD

This is the eighth of a series of technical abstracts from a joint departmental review of culvert practice of the California Division of Highways, by a committee composed of G. A. Tilton, Jr., Assistant Construction Engineer; R. L. Thomas, Assistant Engineer, Surveys and Plans; Clarence F. Woodin, Assistant Maintenance Engineer, and the writer.

A "large culvert," for the purpose of this article, may be any section from a 54-inch pipe to a small bridge. Design in this range should include a hydraulic analysis. The empirical rules offered in the text must not be interpreted as safe substitutes for analysis, but, rather, expedients for preliminary or budget estimates. Giving a first approximation, the rules will show need for and simplify the application of hydraulic principles.

THE effect of modern standards of highway alignment and grade on culvert design has been noted, in part, before.[1] In addition to the longer and stronger conduits required by high embankments, the same trend has increased the size of waterway for which a culvert is more economical than a bridge.

For this premise and the discussion to follow, the term "large culvert" includes structures classed as bridges for administration purposes but which are actually culverts on a large scale. Without attempting too fine a division line, any waterway under a highway may be considered a culvert if its entire perimeter is functionally streamlined from end to end.

Objectively, the culvert so confines a stream laterally (to shorten spans) that depth is materially increased. Crown elevation is usually determined as the minimum consistent with the waterway requirement, so that confinement may be vertical as well as lateral. Hence the crown must be streamlined to pass floods without entrapment of drift or generation of major turbulence.

FACTORS OF COST

The longer the waterway the more the saving in structure cost if the stream is narrowly confined. This follows in part from the cost of end transitions (headwalls, endwalls, debris racks and energy dissipators) which are disproportionately expensive for short culverts. Consequently, if a reconstructed highway is multilane or on a high grade over a minor stream, a large culvert may be more economical than a small bridge. For example, a channel 50 feet wide by 4 feet deep formerly spanned by a 40-foot 2-lane bridge might be replaced economically by a triple 8 x 6 box culvert when the highway is widened to 4 lanes.

Such replacements may be made at widely differing sites. In our experience, old bridges have been replaced by pipes as small as 18 inches in diameter and by arch culverts as large as 285 square feet in section. For the small sections, determinant of size is mostly a matter of hydrology, but for those over 15 square feet in section, hydraulic principles become more and more important.

Extrapolation of Formulae

Whether the basic culvert formula leads first to a design discharge or directly to a waterway area, the shape of the waterway under the highway is not taken into consideration. In a particular case, if the required area is 16 square feet, the designer may choose a 54-inch pipe or a 4 x 4 box. The formula would be satisfied if he selected an 8 x 2[2] box or a 2 x 8 box. The latter would be a hydraulic absurdity and also expensive. Up to this size, the cheapest section should be satisfactory hydraulically.

In another case, suppose the required area is 100 square feet. Hydrology will be satisfied by a 135-inch pipe or a 10 x 10 box or a D-19 arch culvert (10.08-foot span by 12.33-foot depth). But if the outfall is free, any of these flowing full will discharge at high, probably damaging, velocity. This outfall velocity would be much less if the designer chose a double 10 x 5 box or a battery of five 60-inch pipes.

The area equivalence of these sections governs only at the culvert entrance. Once flood water has entered the culvert at a certain rate, velocity through the conduit will depend upon roughness of walls, shape of section, gradient of flow line and freedom of outlet. This is apparent at once by examining the Manning formula:

$$V = \frac{1.486}{n} R^{2/3} S^{1/2}$$

For sections of similar shape, the hydraulic radius, R, increases directly with the size ratio, and velocity as the two-thirds power. Hence doubling the diameter of a pipe adds 59 per cent to the velocity at full capacity.

Since velocity also varies as the square root of the slope and inversely as the roughness, the effect of doubling the diameter will be worse for steep, smooth conduits than for rough ones on mild gradients. In fact, the disadvantage of high velocity in large

[1] California Highways and Public Works, November, 1942.

[2] Box dimensions are "span times depth" in that order.

culverts can be offset in many cases by roughening the walls or stepping the grade.[3]

Most important, however, is the freedom of outlet. If the outlet is submerged, the large culvert will flow full to the outlet, then outfall in a decelerating transition through the wider channel. But if the outlet is free, the culvert will outfall in an accelerating transition, as illustrated in **Fig. 29 c, e, g** [4] and estimated for typical cases in **Fig. 30.**[4]

From these general considerations, it may be concluded that cross-section area of large culverts should not be computed from formulae devised for small culverts, unless there is assurance that the outlet will be submerged.

Shape of Section

If the outlet is free, it is most important that the shape of the culvert section be selected with careful regard for the natural cross-section of the stream. Natural channels in rocky canyons may have width and depth nearly equal, but stable channels through softer materials are 5 to 50 times as wide as deep.

Economy demands some reduction of channel width at highway crossings. For bridges the reduction of main channel is seldom as much as 40 per cent, but greater reduction is practical for culverts, because of protection built into the structures. The greater the reduction, the more costly the protective appurtenances, so that there is, for each site, an economic limit to span reduction. This limit may be as great as 50 per cent of main channel.

In selecting the shape of wetted section, it is obvious that a circular section is the most economical for prefabricated conduits and a rectangular section (nearly square) the simplest to form on the job. This latter is economical up to a certain combination of span and earth load, beyond which it is cheaper to form a thin arch than to cast a thick top slab.

Now the natural section of most streams is a concave bed (varying from trapezoidal to parabolic) under a level water surface. Deforming the upper surface to the crown of a pipe or an arch is not natural and should not be attempted without weighing the consequences. At the culvert entrance, the consequences are not severe—backwater, reduced velocity of approach, moderate eddy action, debris entrapment. But at a free outfall the consequences are usually damaging—draw-down flow, increased velocity of retreat, erosion of banks by direct or eddy currents, scour by high bed velocities in supercritical flow.

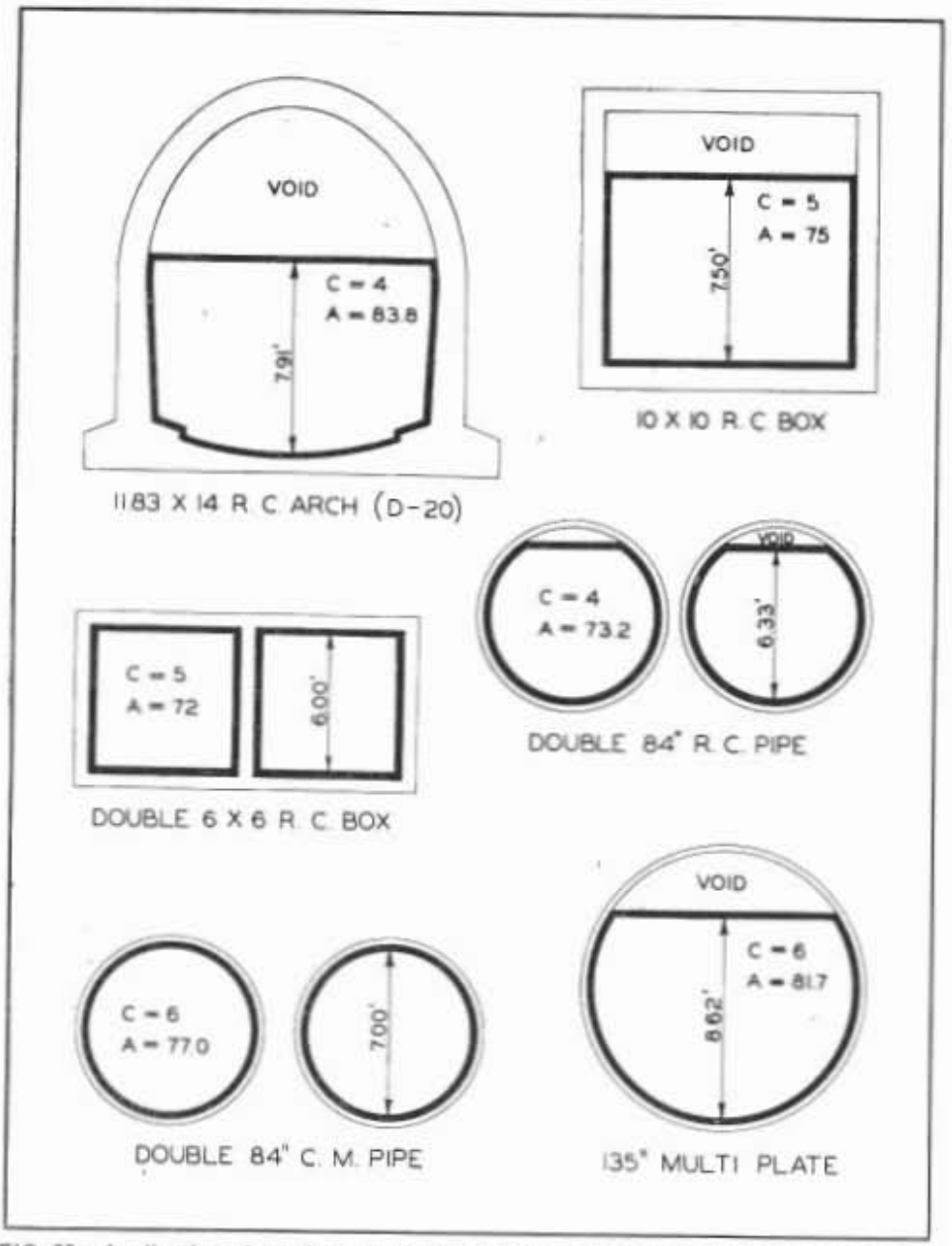


FIG. 53. Application of rated waterway limitation to typical free-outlet culvert sections

Structural Voids

The answer, of course, is that the archway of a free culvert is primarily a structural void instead of a waterway. Part of it may be usable for waterway or driftway, but it is careless practice to determine waterway area requirement from, say, the Talbot formula, then select an arch culvert with barely that requirement.

Structural voids are not limited to arch culverts. The upper portion of a large pipe culvert is similar in shape and primary function. Even for rectangular sections, the crown slab may be elevated to serve as roadway deck, leaving a structural void.

As thus defined, the structural void is readily apparent, but determination of the boundary between usable waterway and the void is more difficult. The committee proposes two steps—first, an arbitrary boundary for preliminary studies and estimates and, second, a method of analysis for final design.

[3] *Loc. cit.* p. 8.
[4] California Highways and Public Works, January, 1942, p. 6.

Rated Waterway

The first step is to define a "rated waterway" for each large culvert with free outlet as the equivalent usable waterway (exclusive of structural void) for the culvert under the most favorable conditions. If the culvert is laid on sub-critical gradient and if the downstream channel is reasonably secure against erosion and scour, then the tentative selection of a section by its rated waterway may be confirmed by the hydraulic analysis.

The rated waterway of any culvert section is determined arbitrarily by the formula:

$$D_{rw} = \frac{b + c\sqrt{n}}{2}$$

Where D_{rw} is the depth of rated waterway above the flow line, **b** is the culvert span, **n** the number of spans (usually one) and **c** depends on type, as follows:

c = 4 ft. for R. C. arches and pipe
c = 5 ft. for R. C. boxes and C. M. arches
c = 6 ft. for C. M. pipe

Tables 4-7 show the application of this arbitrary formula to standard large culverts. In these tables it will be noted that the reduction of working area is greatest for high and narrow sections and that it diminishes for rough-wall or multiple conduits. **Figure 53** compares the shapes of waterway and extent of voids of six sections which are nearly equivalent.

Effect on Arch Design

The reduction is properly severe for the standard concrete arches **(Table 4)**. The high and narrow sections with smooth walls, for which a low value of C is applicable, are rated at 62 to 84 per cent of gross area, the percentage rating being less for the larger sections.

These sections were designed to give gross area at least cost. Redesign to obtain rated waterway at least cost would result in flatter arches—especially under low or moderate fills. This could be accomplished by decreasing the rise-to-span ratio of the arch (requiring a heavier arch ring) or lowering the spring line.

The Myers Creek Culvert **(Figure 54)** illustrates the use of such proportions to obtain structural and hydraulic efficiency at the same time. Its rated waterway (last item of **Table 4)** is 93.6 per cent of its gross area. Compare this with the item above it, the Salt Creek Culvert **(Fig. 35a)**,[5] for which the rated waterway is only 53 per cent of the gross area.

Table 4

Rated Waterway for Free Outlet
R. C. Arch Culverts (c = 4, n = 1)

Standard No.	Span ft. =b	Gross depth ft.	Rated depth =Drw	Gross area Sq. ft.	Rated waterway Sq. ft.
D13	4.36	5.44	4.18	20.0	16.9
D14	5.38	6.42	4.69	29.9	24.5
(1)	5.88	7.21	4.94	35.8	28.0
D15	6.55	8.00	5.27	44.1	33.1
D16	7.55	9.25	5.77	59.1	40.5
D17	8.46	10.33	6.23	73.8	48.8
D18	9.32	11.42	6.66	89.9	57.8
D19	10.08	12.33	7.04	105.0	66.0
D20	11.83	14.00	7.91	134.6	83.8
D21	14.00	14.97	9.00	171.6	119.1
(2)	16.25	20.58	10.12	285.3	151.2
(3)	21.00	14.42	12.50	250.7	234.7

(1) Drawing C-1018-2, I-Men-1-B; (2) Bridge 6-23, Salt Creek; (3) Bridges 58-261-8, Myers Creek.

For each of these special designs, shape was determined entirely by height of embankment above the arch, being 73 feet above flow line at Salt Creek and 23 feet at Myers Creek. The ideal shape of the latter would not have been practical under a high embankment.

Table 6

Rated Waterway for Free Outlet
R. C. Box Culverts (C = 5, n = 1, 2, 3)

Size	Single box		Double box		Triple box	
	Gross area	Rated waterway	Gross area	Rated waterway	Gross area	Rated waterway
6x 6	36	33	72		108	
7x 7	49	42	98		147	
8x 7	56	52	112		168	
8x 8	64	52	128	120.6	192	
9x 8	72	63	144		216	
9x 9	81	63	162	144.6	243	238.4
10x 8	80	75	160		240	
10x 9	90	75	180	170.7	270	
10x10	100	75	200	170.7	300	280
12x 9	108	102	216		324	
12x10	120	102	240	228.9	360	
12x12	144	102	288	228.9	432	372

The conflict between hydraulic and structural arch shapes under moderate-to-high fills should be compromised. **Figure 55** compares the standard arch (a) with other general shapes which may prove more economical for free-outlet culverts. The flat arch (c) for low fills is essentially the shape of the Myers Creek culvert. Some intermediate design (b) should be most economical for moderate fills.

Table 5

Rated Waterway for Free Outlet
R. C. Pipe Culverts (C = 4, n = 1, 2)

Diameter inches	Single pipe (n=1)		Double pipe (n=2)	
	Gross area	Rated waterway	Gross area	Rated waterway
51	14.2	14.1	28.4	
54	15.9	15.6	31.8	
57	17.7	17.1	35.4	
60	19.6	18.6	39.3	
63	21.6	20.2	43.3	
66	23.8	21.9	47.5	
69	26.0	23.5	51.9	51.8
72	28.3	25.2	56.5	56.0
75	30.7	27.0	61.4	60.4
78	33.2	28.8	66.4	64.6
81	35.8	30.6	71.6	68.9
84	38.5	32.5	77.0	73.2

Adaptability of the multiple arch (d) for fills of any height should be tested. Use is not uncommon for low fills **(Figures 56 and 57)** where clearance is limited.

Table 7

Rated Waterway for Free Outlet
C. M. Pipe Culvert
(c = 6, n = 1, 2, 3)

Diameter In.	Single pipe (n=1)		Double pipe (n=2)		Triple pipe (n=3)	
	Gross area	Rated waterway	Gross area	Rated waterway	Gross area	Rated waterway
75	30.7	30.6	61.4		92.0	
78	33.2	32.9	66.4		99.5	
84	38.5	37.3	77.0		115.5	
90	44.2	42.0	88.4		132.5	
96	50.3	46.7	100.5		150.8	
102	56.7	51.5	113.5		170.2	
105	60.1	54.1	120.3	120.1	180.4	
108	63.6	56.6	127.2	126.2	190.9	
114	70.9	61.9	141.8	139.0	212.6	
120	78.5	67.3	157.1	151.7	235.6	
135	99.4	81.7	198.8	184.9	298.2	294.5
150	122.7	97.3	245.4	219.9	368.2	353.3
165	148.5	114.2	297.0	257.3	445.5	414.4
180	176.7	132.2	353.4	297.1	530.1	478.5

Adaptability of the multiple arch (d) for fills of any height should be tested. Use is not uncommon for low fills **(Figures 56 and 57)** where clearance is limited.

One definite start has been made. Culvert standard sheets D23 and D24 for plain concrete arch culverts each include tabulated columns showing gross and rated waterways for each standard section. The D23 and D24 sections were not modified to improve

[5] California Highways and Public Works, January, 1943, p. 10.

the rating, but the evaluation shown on these standards will point the way for modifications in the future.

Method of Hydraulic Analysis

It must be emphasized again that the "rated waterway" is a first approximation to design, which should be confirmed or corrected by hydraulic analysis. The objective is to determine stage and velocity at outlet, anticipating, as the next step in design, either (1) modification of section until velocity is tolerable or (2) protecting the culvert and roadway structure against intolerable velocity.

The general problem is that of accelerated flow in an open channel—controlled at inlet and free at outlet. The analysis should start with the assumption that flow will be critical just inside the culvert entrance. Using the design discharge, compute the critical stage, for which velocity head is half the mean depth. For this purpose, mean depth is the wetted area divided by the width of the free water surface.

Working upstream from the critical section, the entrance stage (including head of approach velocity) will be the energy head at critical see-

FIG. 54. Myers Creek culvert on State Highway in Imperial County, a flat arch under a low fill

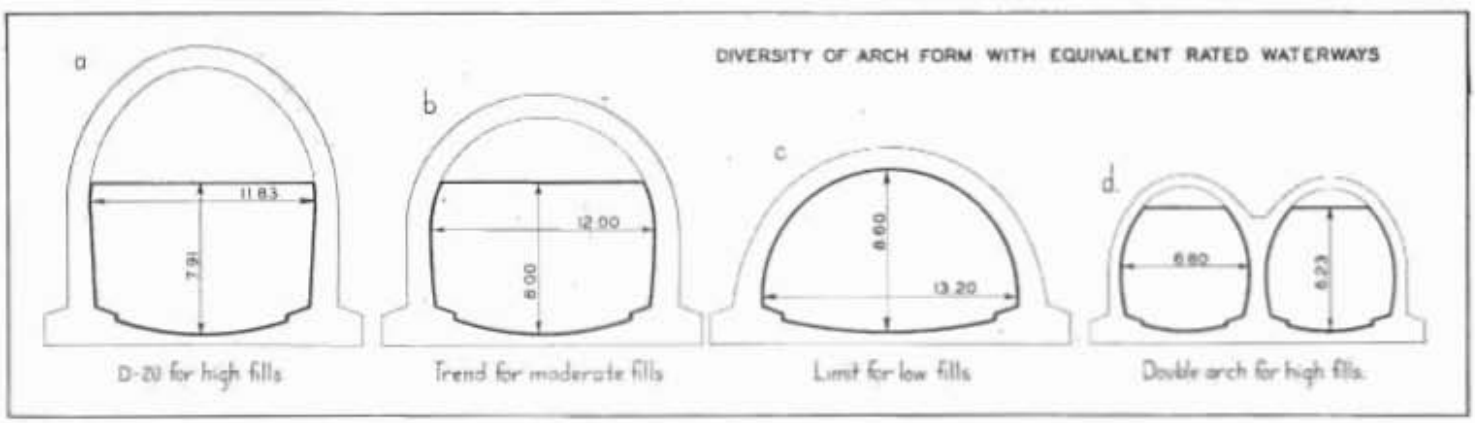


FIG. 55. Trend of arch design for least cost of rated waterway

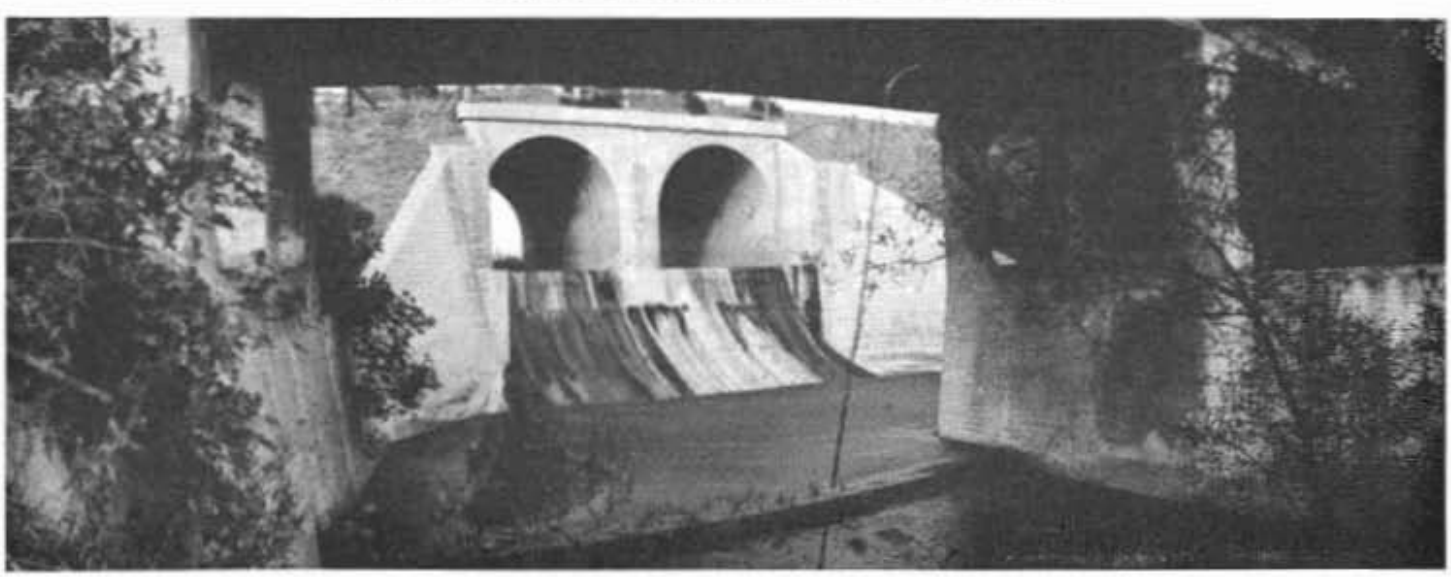


FIG. 56. Las Flores Creek. Looking under bridge at double arch culvert of A. T. & S. F. Railway

FIG. 57. Quintuple culvert of rubble masonry and metal arches, Moosa Canyon on State Highway in San Diego County

tion plus an allowance for entrance loss.

Working downstream, the easiest procedure is to calculate the distance L_1 to a section somewhat smaller than the critical section, assuming that the mean slope of the energy line between two sections is the mean of the slopes at those sections. The method will be illustrated for a circular section, using **Table 8,** a chart (such as Scobey's) (1)[6] for Kutter's formula and the approximation

$$L = \frac{h_{e1} - h_{e2}}{S_1 - S_m}$$

For an example, assume a 72-inch R. C. pipe culvert 200 feet long on a slope of 0.02 and with free outlet—proposed to carry 252 second-feet (= 10 ft. per sec. through 25.2 sq. ft. of its rated waterway, see **Table 5).** Dividing Q (= 252) by $D^{2.5}$ (= 88.2), the quotient, 2.86, may be used to interpolate the critical elements from **Table 8,** viz:

Critical velocity, $V_c = 4.70\sqrt{6} = 11.5$ ft. per sec.,
Least energy, $h_e = 1.067 \times 6 = 6.40$ ft.,
Critical depth, $d_c = .726 \times 6 = 4.35$ ft., and
Hydraulic radius, $R = .300 \times 6 = 1.80$ ft.

Using Kutter's n = .013 and these values for V and R, find the slope (S = 0.0043) of the energy line at this point. Since the culvert slope ($S_1 = 0.02$) is steeper, flow will accelerate and downstream sections will be smaller than the critical.

Take some smaller section for which elements are given in **Table 8**—e.g. that for which d = .604 D = 3.62 ft. In **Table 8** (shown in the third column, this page) the first 3 columns are computed for critical flow, but the last 3 columns are geometric relations independent of flow. Hence for the supercritical flow at this second section, R = .279 D = 1.67 ft., A = .495 D^2 = 17.82 sq. ft. and V = 252 ÷ 17.82 = 14.14 ft. per sec. Again using a Kutter chart, find $S_2 = 0.0072$.

Application of the approximation to find $L_1 = 23$ ft. is now obvious, with the detail shown on **Figure 58.** The figure is a profile summarizing a series of steps like the first. The steps continue until the sum of L_1, L_2, etc. exceeds the length of culvert, then the depth of flow at outlet can be interpolated and outfall velocity (V = 18.6 ft. per sec.) computed.

Justification for an analysis for such a design is now apparent. Assumption that the pipe flowed full at outlet would have given an outfall

(Continued on page 17)

Table 8
Critical Elements of Circular Sections

$\frac{Q}{D^{2.5}}$	$\frac{V_c}{\sqrt{D}}$	$\frac{h_e}{D}$	$\frac{d}{D}$	$\frac{R}{D}$	$\frac{A}{D^2}$
1.0	3.20	.579	.420	.222	.312
1.2	3.38	.640	.462	.237	.355
1.4	3.55	.698	.501	.250	.395
1.6	3.72	.752	.537	.261	.430
1.8	3.88	.805	.571	.270	.463
2.0	4.04	.857	.604	.279	.495
2.2	4.19	.907	.634	.285	.525
2.4	4.34	.956	.663	.291	.553
2.581	4.47	1.000	.6887	.295	.577
2.6	4.49	1.005	.691	.295	.579
2.8	4.65	1.053	.718	.299	.602
3.0	4.80	1.100	.743	.301	.625
3.5	5.20	1.220	.800	.304	.673
4.0	5.64	1.342	.848	.303	.710
4.5	6.12	1.468	.887	.300	.735
5	6.64	1.600	.918	.294	.753
5.5	7.18	1.740	.939	.289	.767
6	7.76	1.892	.956	.284	.773

[6] Numbers in parenthesis refer to bibliography at end of article.

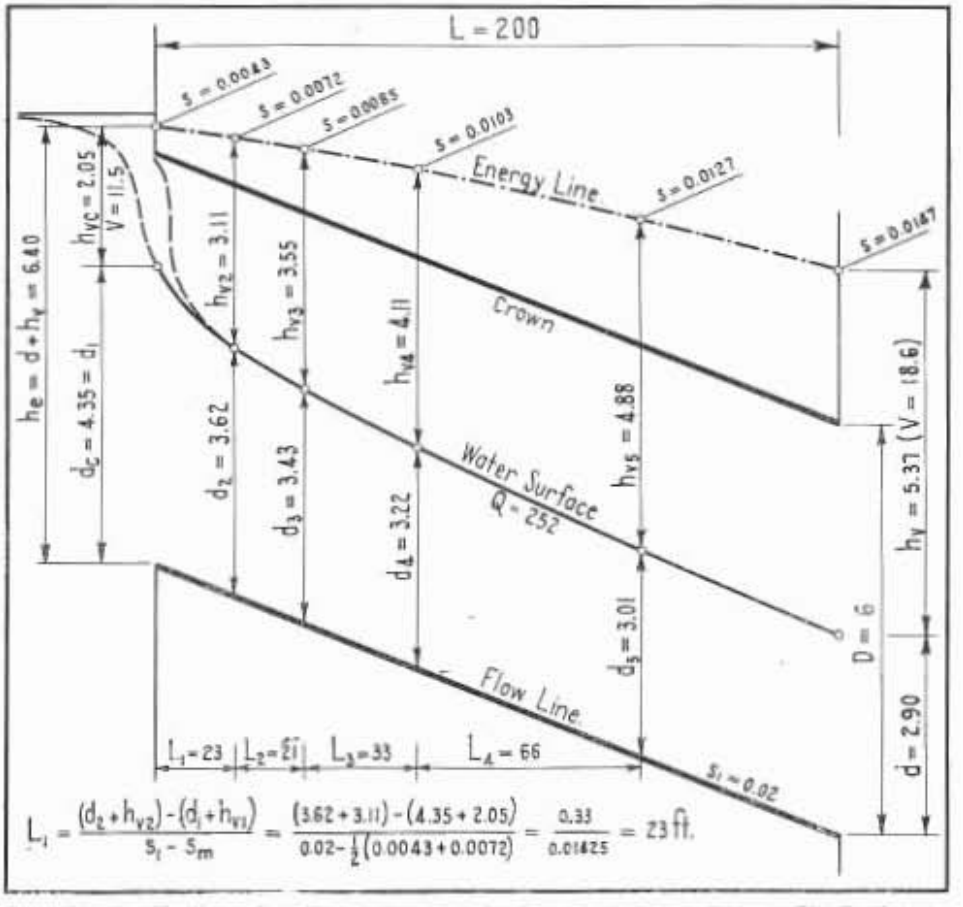


FIG. 58. Application of Table 8 and formula for non-uniform flow to 72" R. C. pipe (Kutter's N = .013) culvert with free outlet

Bay Bridge Shows Low Accident Record Despite High Traffic Peaks

STUDIES of accident reports, traffic movement and physical conditions on the San Francisco-Oakland Bay bridge during 1942, which have been completed by the Division of Highways, reveal that in terms of vehicle miles traveled last year, the bridge shows four fatalities per hundred million vehicle miles as compared with eleven on the rural State highway system.

For the entire time the bridge has been opened, in the same terms, the bridge record is six compared with the rural State highway average during the last five years of 12.5.

Accident reports show that wilful disregard of fundamental rules of the road regarding proper speed, passing movements and adherence to designated lanes of travel and the astoundingly high percentage of drunken or had-been-drinking drivers, are the greatest contributing causes. Accidents resulting simply from confusion or mere inadvertence on the part of drivers make up only a small part of the total.

HAZARD POINT STUDY

During times of peak traffic movement, each lane on the upper deck of the span in one direction carries from 1,000 to 1,500 cars, and with traffic in this amount there is great need for the most complete control of its movement to assure a steady uninterrupted flow and to reduce the accident rate.

The record on the lower deck of the bridge shows a concentration of accidents at the Treasure Island entrance. This situation is under study at the present time in an endeavor to provide some method of traffic control that will alleviate the hazard at that point at least to some extent.

During the past two years, much thought has been given to improving the center marking on the upper deck and several trial installations have been made. All except one of the methods tried thus far have been discarded. The raised painted line now on a section of the bridge, or some modification of that design, seems to have some possibility of improving the visibility of the center marking particularly during rain storms. Light shields required by military authority to shield the bridge lights as a protection measure are now being installed.

Hope for betterment of the accident record would seem to lie in some more complete control of traffic, which would be accomplished by other than purely physical means.

HIGH SPEED CAUSE

Sixteen accidents, or 30 per cent of the lower deck total, occurred at the intersection of the Treasure Island roadway. A large part of these are the result of vehicles entering the danger zone at too high a speed. The use of traffic signals to reduce the hazard at this point is being studied by the Traffic and Safety Department of the Division of Highways.

Three fatal accidents with four deaths occurred during 1942, as compared to seven in 1941 with a death toll of ten. There was an increase in the number of personal injury accidents from 82 to 119, but the number of persons injured was only slightly greater, increasing from 169 to 189. It is evident that although the accident rate may have increased, the severity rate has decreased sharply.

The following tabulations of traffic accidents on the bridge during 1942 show the types of accidents and the contributing causes:

TRAFFIC ACCIDENTS

January 1 to December 31, 1942

UPPER DECK

	Crossed center line	Rear end	Hit bridge right side	Other	Total	Per cent
Total accidents	50	162	3	27	242	100
Driver drinking	17	26		3	46	19
Driver asleep	6	4	1	2	13	5
Curved roadway	2	1		6	9	4
Wet pavement	2	4		4	10	4
Fatal accidents	1	1		1	3	1
Injury accidents	25	55	3	6	90	37
Property damage only	24	105		20	149	62
Daylight accidents	22	81	3	14	120	50
Night accidents	28	81		13	122	50

LOWER DECK

	Crossed center line	Rear end	Hit bridge right side	Other	Total	Per cent
Total accidents	5	29	6	14	54	100
Driver drinking		1			1	2
Driver asleep						0
Curved roadway	1	2		2	5	9
Wet pavement	2	6		3	11	20
Fatal accidents						0
Injury accidents	1	11	1	6	19	35
Property damage only	4	18	5	8	35	65
Daylight accidents	3	24	4	14	45	83
Night accidents	2	5	2		9	17

TRAFFIC ACCIDENTS

January 1 to December 31, 1942

UPPER DECK

20.7% of all accidents were head-on.
66.9% of all accidents were rear-end.
1.2% of all accidents were hit bridge right side.
11.2% of all accidents were miscellaneous types.

LOWER DECK

9.3% of all accidents were head-on.
53.7% of all accidents were rear-end.
11.1% of all accidents were hit bridge right side.
25.9% of all accidents were miscellaneous types.

UPPER DECK

19.0% of all accidents involved drinking drivers.
34.0% of all head-on accidents involved drinking drivers.
16.0% of all rear-end accidents involved drinking drivers.
0.0% of all hit bridge right side accidents involved drinking drivers.
11.1% of all miscellaneous accidents involved drinking drivers.

UPPER DECK

24.4% of all accidents involved drinking or asleep drivers.
46.0% of all head-on accidents involved drinking or asleep drivers.
18.5% of all rear-end accidents involved drinking or asleep drivers.
33.3% of all hit bridge right side accidents involved drinking or asleep drivers.
16.5% of all miscellaneous accidents involved drinking or asleep drivers.

It was during the impanelling of a jury that the following colloquy occurred:

Judge: You are a property owner?

Prospective Juror: Yes, Your Honor.

Judge: Married or single?

Prospective Juror: I have been married five years, Your Honor.

Judge: Have you formed or expressed an opinion?

Prospective Juror: Not in five years, Your Honor.

"Young man," said the old one, severely, "when I was your age, I, too, thought I knew all. Now I have reached the conclusion that I know very little."

"Great Scot!" exclaimed the lad in astonishment; "has it taken you this long to find that out? Why, I knew it the minute I saw you!"

$1,000,000 Winter Highway Damage

By W. A. SMITH, Assistant Maintenance Engineer

U. S. 66 blocked by flood debris at railroad underpass near Gish, San Bernardino County. Railroad was also washed out

DAMAGE to State highway structures and facilities in excess of $1,000,000 occurred during the winter season just past. Nearly three quarters of this damage was in the Los Angeles and San Bernardino areas.

A large portion resulted from the single three-day storm January 21 to 23, when 5.58 inches of rain fell in the Los Angeles area and 7.23 inches in San Bernardino. It was reported that 28 inches of rain fell at Camp Baldy and 21 inches at Big Bear.

A second storm in April caused about $80,000 damage in the same area.

With such a heavy rainfall in the short period, it is not surprising that nearly every section of highway and, in fact, other types of transportation systems were closed to traffic for longer or shorter periods.

DEBRIS CHOKED SUBWAY

At Cajon Pass on U. S. 66, for example, the Gish subway was choked with debris due to scouring out of the highway well in advance of opening of the railroad.

The most extensive damage occurred nearby drainage structure. The embankment under the railroad tracks west of the subway was completely washed out.

Highway maintenance forces were able to start traffic moving over the

on State Highway Route 62 in San Gabriel Canyon, and the cost of restoration of channel paving in the Arroyo Seco will be the largest single item. Long sections of other routes were covered with mud and debris up to several feet in depth.

State Highway 188 washed out; temporary detour near Crestline, San Bernardino County

OCEAN SCOURED EMBANKMENT

At Camarillo on U. S. 101, the highway was blocked by eucalyptus trees. At El Morro Bay on State Highway Route 60, the ocean scoured out the highway embankment to the shoulder line and only prompt action by highway maintenance forces in placing heavy riprap prevented entire loss of the section of highway.

U. S. 99 was closed to traffic for several days due to washing out of approach to the Castaic Creek bridge.

Floods occurred at intervals in the southern part of the San Joaquin Valley, and most of the highways in parts of Tulare and Kern Counties were under water at one point or another. The most serious storm was on March 9 and 10, when one bridge was destroyed and eight damaged in this area. The most serious damage from a traffic viewpoint was at Poso Creek on U. S. 99, near Famoso Junction. Traffic must detour at this point for a period of three months while repairs are made.

MANY BRIDGES DESTROYED

During the several storms, other bridges were destroyed or damaged, including structures across Little Cow Creek and Oak Run Creek at Mile 20 in Shasta County; five spans of the Santa Ynez River bridge on Route 56 in Santa Barbara County; the detour bridge over the Salinas River on Route 56 in Monterey County; and complete loss of the bridge across Matilija Creek on Route 138 in Ventura County.

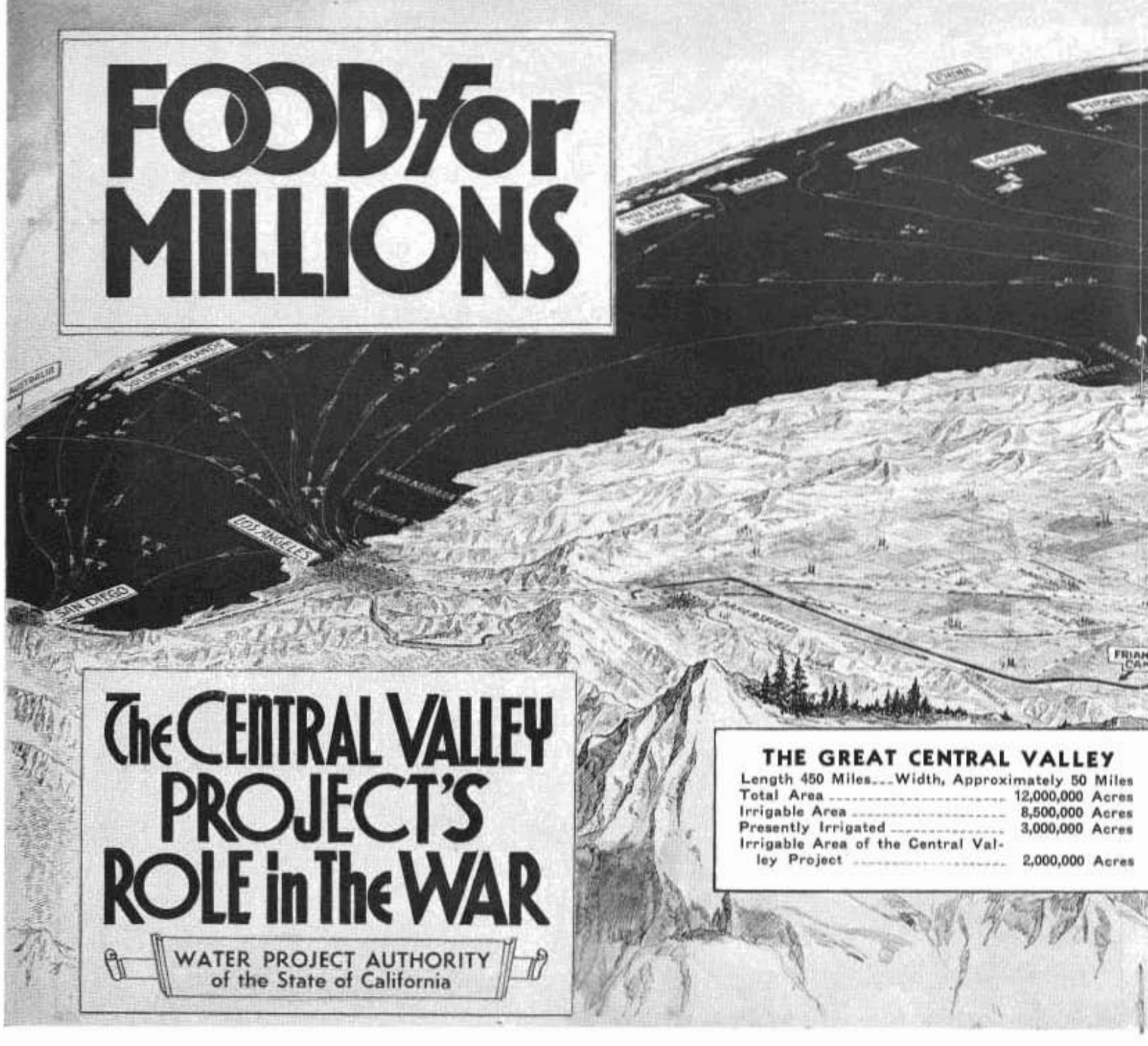
The damage as outlined does not include such work as repair of pavement which has been damaged by flooding. This work is usually done as part of regular maintenance operations and is not included in the estimate, although the total cost will add up to a considerable item.

Funds are not available for complete restoration of the highways at this time. Only sufficient work is being done to make them safe for travel at many points. The heavy damage placed a severe strain on the limited personnel and equipment, but on the whole the organization was fortunate that the damage was not more widespread.

Approach to Castaic Creek Bridge on U. S. 99 in Los Angeles County washed away

Roadway between bridges washed out in San Gabriel Canyon

One lane of approach to bridge over Santa Clara River on U. S. 6 damaged



Governor's Appeal Wins Approval

(Continued from page 1)

creased food production in California will ease this transportation problem.

FRIANT CONTROL GATES NEEDED

"Certain features of the project could be completed within a year, and others within two years, which would be of incalculable aid to California agriculture. For example, the Friant Dam on the San Joaquin River is now complete with the exception of control gates. Some $16,500,000 has been expended on this structure, yet today it is not capable of even serving the purpose of controlling floods. In its present status no water can be impounded. Installation of control gates in the dam would make possible the regulation of the water supply for 200,000 acres of fertile irrigated lands now planted to many war crops, and also a full dependable irrigation supply for 65,000 acres of land potentially capable of producing such crops.

"The Madera Canal, extending northward from Friant Dam, has been completed through eight miles of the only difficult terrain it must traverse. I am informed that the remainder of the canal could be completed for the most part as an unlined ditch in one year, using only a minimum amount of critical materials. This canal would serve 175,000 acres of lands within the Madera Irrigation District of which 83,000 acres are presently irrigated for the most part from wells.

CANAL WORK STOPPED

"Construction work on the Friant-Kern Canal, extending southward from Friant Dam, has not been started because of a stop-order of the War Production Board. The Bureau of Reclamation has stated that with a green light on priorities for

materials and equipment, this canal could be completed in a two-year period. This canal would bring a supplemental water supply to about 1,000,000 acres of irrigated land in an area where a severe deficiency in water exists.

"That the agricultural area to be served by the Friant-Kern Canal is highly important in the production of war crops, is shown by the fact that two of the counties it will serve—Tulare and Fresno—rank second and third in the value of food production among the counties in the entire United States.

"However, the effective operation of Friant Reservoir and the Friant-Kern and Madera canals is dependent upon construction of the Delta Cross-channel and the Delta-Mendota Canal, which will link the Sacramento Valley features of the project to those of the San Joaquin Valley. These two features of the project are essential for importation of water to replace water which will be impounded in Friant Reservoir and transported in the Madera and Friant-Kern canals.

"The Contra Costa Canal is completed except for an eleven-mile section to its proposed terminus near the city of Martinez. It is the only feature of the project at present actually in operation, and is supplying water to cities, war industries, and lands along the south shore of Suisun Bay. Its operation during a dry year, when water would be most needed, is dependent upon a supply from Shasta Reservoir furnished through the Delta Cross-channel. This canal could be completed within a year and would be capable of serving some 20,000 acres of agricultural land, as well as many important war industries.

FLOOD CONTROL IMPERATIVE

"Completion of the Shasta and Friant dams would aid in the control of floods on the Sacramento and San Joaquin rivers. Valuable crop lands adjacent to both rivers, and perhaps more important, main rail and highway systems, are subject to damage from flood waters of these streams.

"California is recognized as the main base for operations in the War of the Pacific. Any possible steps that can be

taken to protect her rail and highway systems, so vital to the movement of troops and supplies, should be of foremost importance and merit serious consideration by the agencies which now control priority ratings and by their rulings the appropriations from the Congress.

"On the other hand, in a dry year such as occurred in 1931, 1934, and 1939, water impounded behind the Shasta Dam would protect from the menace of salt water some 400,000 acres of lands in the Sacramento-San Joaquin Delta largely devoted to the growing of sugar beets, potatoes, asparagus, celery, and other vegetable crops. In dry years, crop losses in this area due to salt water invasion from San Francisco Bay have run into several millions of dollars.

POWER POSSIBILITIES AVAILABLE

"Also, lands in the San Joaquin Valley have suffered from inadequate water supply and the use of electricity for pumping in these dry years has increased tremendously. While consumption of electric energy mounts rapidly in dry years, hydro-electric production of necessity drops off due to depleted reservoirs. With California's expanding war industries and increased use of electricity, the margin of safety between production and consumption of electricity at this time is little more than adequate. If the present margin should be further reduced through expanded consumption, installation of the additional generating units at Shasta and Keswick dams would provide the logical solution of the problem.

"At this time, only two of the five generating units planned for Shasta are being installed and the three units originally planned for Keswick have been held up by War Production Board orders. When additional electric power is required in California, it should be pointed out that the additional power facilities which are an integral part of the project should be the first installed to meet such increased demands.

LAND REVERTING TO DESERT

"There is still another phase of this entire problem which merits consideration. I refer to the continued necessity of deepening wells used for irrigation, particularly in the Southern San Joaquin Valley where the overdraft on underground water supplies yearly grows more acute. Critical materials that could well be used for other purposes are required in the deepening of these wells and the attendant replacement of pumping equipment. Also, as the water level recedes, cost of electricity mounts in some cases to the point where it becomes uneconomic to farm the lands. Already some 60,000 acres of land that once were producing have reverted to desert.

"In view of the foregoing facts, I am firmly convinced the completion of the Central Valley Project is so essential to the war effort that I feel it incumbent upon myself as Governor of California to call these matters to your personal attention. I am certain that with your assistance the necessary priorities and appropriations can be obtained to make possible the use of this great project in California's endeavor to increase its production of foodstuffs vital to the Nation."

PRESIDENT ROOSEVELT'S REPLY

President Roosevelt wrote in reply:

"The most careful consideration has been given to your letter of March twentieth, in which you urge completion of the Central Valley development. The matter has been taken up with the War Production Board and the Federal Power Commission, and these agencies have thoroughly re-examined the project after consultation with the other interested Federal departments.

"The deferment of work on the Central Valley project, along with many others throughout the country, was found necessary by the War Production Board to meet a critical materials situation toward the end of 1942. While the problem of balancing our war budget in terms of materials and manpower is still an extremely difficult one, the current review of the irrigation, power and flood control features of the Central Valley development has led to the conclusion that further work can and should be authorized to the following extent:

"1. Completion of the Friant Dam with installations of the valves required for storing water but with continued postponement of the spillway gates;

"2. Completion of the Madera Canal;

"3. Completion of the concrete work on Keswick Dam.

STEEL SUPPLY CRITICAL

"The principal critical material required for this work is steel. The War Production Board hopes to be able to supply a majority of the necessary items from distress stocks, and in that way avoid interference with other urgent war production. The concrete work on Keswick Dam will make it possible to continue the contractor on the job for some months to come and will facilitate the ultimate completion of the project whenever it can be authorized. The completion of Friant Dam and Madera Canal should increase food production to some extent as early as 1944, with still greater benefits in 1945.

"Serious consideration is being given to the question of restoring the halted Shasta unit and the two Keswick units in terms of the fuel oil supply situation in the Pacific Coast. In view of the fact that this is a direct concern of the Petroleum Administrator for War, the matter has been placed before him. If he advises that the units are essential as an oil 'conversion' measure, we are hopeful that the necessary materials for their completion can be found.

"At the moment there are serious obstacles to authorizing the remaining irrigation features of the Central Valley development. They would require considerable amounts of critical materials and it would require a much longer period to make their benefits available than in the case of Friant Dam and Madera Canal.

"I fully share your view that this great public work in which we have already invested so much in money, material, and labor should be brought to completion as soon as feasible. The additional work which is now being authorized will permit the project to make important and reasonably prompt contributions to the war program, and I am hopeful that the matter can be reconsidered again at an early date so that still further work may be authorized."

GOVERNOR CLOSELY ASSOCIATED

Since his inauguration as Chief Executive of the State, Governor Warren has continued his close association with the activities of the Water Project Authority, attending its meetings and giving the newly appointed members the benefit of his experience on the Authority. The membership of the Authority now comprises, C. H. Purcell, Director of Public Works, Chairman; Attorney General Robert W. Kenny, Director of Finance John F. Hassler, State Controller Harry B. Riley and State Treasurer Charles G. Johnson. State Engineer Edward Hyatt is the Executive Officer and Deputy State Engineer A. D. Edmonston, Acting Secretary.

The Water Project Authority adopted resolutions urging completion of major irrigation features of the project and construction of the transmission line from Shasta to Oroville. Resolutions also were adopted by the California Farm Production Council and California State Board of Agriculture urging completion of the Central Valley Project to assist in the production of food and fiber in California.

These resolutions were sent to the President, Secretary of the Interior, Secretary of Agriculture, War Food

Administrator, War Production Board, Federal Power Commission, California Members in the Congress and congressional committees considering appropriations for the project.

AUTHORITY DELEGATES AT WASHINGTON

State Treasurer Charles A. Johnson, senior member of the Authority, State Engineer Edward Hyatt and Supervising Hydraulic Engineer Raymond Matthew, representing the Water Project Authority, went to Washington to present the case of the Central Valley Project to the Department of the Interior, Department of Agriculture, the War Food Administrator, Federal Power Commission and the House Subcommittee on Appropriations. They were materially assisted by Northcutt Ely, special representative of the Authority in Washington.

In these presentations it was shown what completion of various units of the project would make possible in the way of increased production. For example, installation of control gates on Friant Dam alone would provide some 600,000 acre-feet of additional water on the average annually for use in the San Joaquin Valley where at present there is a grave deficiency.

With improved regulation of the San Joaquin River by Friant Dam alone it has been estimated by the State Division of Water Resources that the better irrigation supply to approximately 200,000 acres downstream would make possible increased production on lands now farmed equal to bringing in 27,000 acres of new lands. The principal advantage of this production lies in the fact that the lands are now cultivated, the farm equipment is highly mechanized and most of the manpower needed for the additional production is already employed on the lands to be served.

The Madera Canal, extending from Friant Dam northward through Madera County, has been completed for a distance of eight miles, bringing it through the foothills to the valley floor. It stops just short of the lands that could be supplied with water. Completion of this canal will make possible an increase in farm production equivalent to bringing 30,000 acres of new class A lands into production. Under the WPB orders this work has been authorized.

Work on the Friant-Kern Canal which will extend from Friant Dam southward to Bakersfield, a distance of 160 miles, has not been authorized by the War Production Board. The area to be served by this canal is in great need of additional water supplies. The United States Bureau of Reclamation has submitted to the WPB a revised plan of construction for this canal which materially reduces the amount of critical materials required.

As in the case of the Madera Canal, the Friant-Kern Canal would serve lands now largely under irrigation but which have an inadequate water supply. It has been estimated that the increased production of critical war crops possible under this canal would be the equivalent of bringing 200,000 acres of new class A lands into production.

Through the Contra Costa Canal which runs along the south shore of Suisun Bay from Knightsen westward it has been estimated that an area of 16,000 acres can be brought under irrigation by 1945.

Thus completion of these units of the project would make possible an increased production of critical war crops in the Central Valley alone equal to bringing more than a quarter of a million acres of new lands into production. It has been estimated that these lands would produce more than a million tons of critical crops which now must be imported from outside sources.

Roughly this increased production in California would save the use of a 100-car freight train a day for every day in the year—a tremendous saving in transportation alone, which today presents one of the greatest bottlenecks in supplying the war of the Pacific. Much needed steel, tanks, guns, ammunition and other war materiel could be moved into the California supply bases if trains now required to transport food for the State's bulging civilian and military population were released through the increased production which is possible under the Central Valley Project.

Waterway Ratings Adopted

(Continued from page 10)

velocity of only 10 feet per second. Velocity of 21 feet per second would have been figured from an assumption that energy gradient equaled the culvert slope of 0.02.

Like computations for box culverts are much simpler and no table is needed. For the first step, the critical depth in terms of discharge, Q and span, b, is

$$d_c = \sqrt[3]{\frac{Q^2}{b^2 g}} = 0.314 \left(\frac{Q}{b} \right)^{2/3}$$

For arch culverts, the computations would be just like those for pipes if a table (like **Table 8**) of elements was available. It is recommended that such a table be prepared for each standard arch and placed on the detail drawing.

Conclusions of Committee

Summarizing its findings, the committee recommends generally that:

(1) Culverts larger than 15 sq. ft. in section be classed as "large culverts."

(2) The equivalent usable wetted section of a large culvert with free outlet be called its "rated waterway."

(3) For preliminary estimates, the rated waterway may be determined from formula or **Tables 4-7** herein, for use if culvert section is selected on an area basis.

(4) For final design, a hydraulic analysis may be advisable, particularly for the larger sections on steeper gradients discharging in erodible channels. Method of analysis is outlined and illustrated in the report.

(5) Design of arch culverts should be more considerate of hydraulic elements. The multiple arch has hydraulic advantages, suggesting economy of more frequent use in design.

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September, 1942 — Comparative Hydrology Pertinent to California Culvert Practice.
October, 1942—Debris Control at Culvert Entrances on California State Highway System.
November, 1942—Highway Culvert Location and Slope from a Review of California Practice.
December, 1942 — Culvert Entrances and Headwalls on California Highway System.
January, 1943—Culvert Outlets and Endwalls on California Highway System.
February, 1943—Utilization of Siphon Principles in California Culvert Practice.
March-April, 1943—Earth Loading Factors Affecting Field Installations of Culverts.

Western Highway Officials Discuss War Transportation Problems

HIGHWAY transportation matters of importance to the war effort and the postwar era were acted upon at the recent two-day annual meeting in San Francisco of the Western Association of State Highway Officials, which includes 12 States.

Officials of the California Highway Department and the eleven other western and southwestern States make up the organization. Robert Lee Bobbitt of San Antonio, former member of the Texas Highway Commission, presided at the conference as president before retiring and handing affairs of his office over to Fred J. Grumm, Assistant State Highway Engineer of California, who was elected to succeed him.

Director C. H. Purcell of the California Department of Public Works, State Highway Engineer G. T. McCoy, Mr. Grumm, and other California road officials took part in the meeting.

DEVOTED TO WARTIME PROBLEMS

The conference—the twenty-second annual meeting of the association—was strictly a wartime business session, President Bobbitt pointed out.

President Brady Gentry of the American Association of State Highway Officials and Chairman of the Texas Highway Commission; Thomas H. MacDonald, Commissioner of the Public Roads Administration, Washington; G. Donald Kennedy, Vice President of the Automotive Safety Foundation and president last year of the American Association of State Highway Officials, also Washington, and other wartime highway road and transportation officials, addressed the meeting.

President Bobbitt announced that wartime highway transportation problems would be the chief topic, since the first objective of everyone, of course, is to win the war. At the same time, however, he added, State road officials are working on practical plans for highway rehabilitation and development in the postwar period because highways will play a major part in that era and will go far to help bring a sound, prosperous, peace-time period.

Highway development on a vast new scale will be a chief asset for economic prosperity in the postwar period when development of all types of transportation will be tremendous. Highways, airways, railways, and waterways all will have their place and will be dependent upon each other.

POSTWAR BUILDING PROGRAM

More than 80 per cent of every dollar spent for highway construction goes for employment. Thus, highway projects by State Highway Departments can do much to ease the transition from war to peace tasks, will employ hundreds of thousands of persons, and will help take care of the necessary shift of employment when peace comes.

A chief subject considered by the Western Association of State Highway Officials' meeting was the postwar highway and road building program by the States. As recommended by the American Association of State Highway Officials to Congress, this would provide for a $1,000,000,000 per year distribution among the States of road users' tax revenues as Federal highway aid during the first three years of the postwar period.

COVERING RESOLUTIONS PASSED

Action was taken at the meeting designed to assist in early passage of Congressional legislation to authorize this program in order that work may start as soon as the war ends and the transition to peacetime begins.

A number of resolutions covering this and other recommendations made by the speakers were later adopted.

A recommendation that the transportation problem in California, Oregon, and Washington be considered a war-emergency will be made to the War Production Board by Thomas H. MacDonald, Chief of the Public Roads Administration in Washington, D. C., in the hope that present restrictions imposed by military necessity on highway construction will be lightened.

MACDONALD CITES TRUCK EFFICIENCY

Commissioner MacDonald told the delegates that speed and flexibility are characteristics which give to truck transportation an indispensable wartime function in the long haul field, supplemental to that of rail transportation.

"The movement of war goods is characterized by urgency and sudden changes in plans, requiring, in many cases, a form of transportation more flexible than that offered by railroads with their long trains and rigid schedules," MacDonald said. He added that he has completed a survey in California, Oregon, and Washington, to determine the importance of

Fred J. Grumm Elected President of W. A. S. H. O.

Fred J. Grumm, Assistant State Highway Engineer of California, was elected president of the Western Association of State Highway Officials at the concluding session of the twenty-second annual meeting at San Francisco, succeeding the retiring president, Robert Lee Bobbitt of San Antonio, Texas. The association represents 12 western and southwestern states.

Bernard Touhey, State Highway Engineer of Arizona, was named vice president; W. L. Anderson, Utah, secretary-treasurer, and W. T. Holcomb, Nevada, assistant secretary-treasurer.

DeWitt Greer, State Highway Engineer of Texas, was elected chairman of the war and postwar roads committee, which will consist of one member from each state highway department in the association.

Resolution on Manpower and Equipment Shortages on Highway Work

Resolution No. 3 passed by the Western Association of Highway Officials at its recent meeting reads as follows:

"Whereas, Adequate maintenance of highway facilities is a critical problem, not only from the standpoint of providing service to assential war-time traffic, but likewise in connection with the conservation of vehicles, parts, and tires to maintain the requisite transportion service to our civilian economy; and

"Whereas, The western States are handicapped by shortage of manpower, by shortage of maintenance equipment, and by difficulty in obtaining necessary materials and equipment parts; and

"Whereas, Necessities of war economy have curtailed new highway construction, which makes replacement of wornout highway facilities almost impossible during this emergency; now, therefore, be it

Resolved, That the Western Association of State Highway Officials, meeting in San Francisco, California, on June 3 and 4, respectfully request that consideration by the War Manpower Commission, the Selective Service Authorities, and the War Production Board be given to the problem of the need for manpower to maintain and operate the highway transportation system and to the simplification of the procedures for obtaining materials and equipment needed to keep highway facilities in good condition; and be it further

"Resolved, That a copy of this resolution be presented to the national and regional heads of the War Manpower Commission, War Production Board, the Selective Service Authorities, and the Transportation Corps of the United States Army."

highway transportation in wartime economy.

TRUCK TRANSPORT FASTER

"The average speed of trucks over long runs," MacDonald said, "such as, for example, from Seattle to San Francisco, is only slightly, if any, lower than that of the fastest passenger trains, and the elapsed time between pickup and delivery is much less than for any express service.

"C. H. Purcell, Director of the California Department of Public Works, submitted a number of examples, including one concerning boiler tubes shipped by truck from Oakland to Seattle in 30 hours to effect emergency repairs to a transport.

"In another case, cited by Mr. Purcell, a carload of special powder consigned to the Benicia Arsenal was delayed in transit and located in the Roseville freight yards of the Southern Pacific Company. Arrangement was made to haul this material from Roseville to the Benicia Arsenal, a distance of 75 miles, by truck overnight. The powder was then placed in ammunition and the ammunition shipped by truck to San Francisco in time to meet a transport sailing for a Pacific combat zone. It is estimated that this movement would have required about seven days by rail, owing to freight congestion.

"Chief Engineer R. H. Baldock of the Oregon State Highway Department reported that 11,487 pounds of cast iron pipe which left the Puget Sound Navy Yard at Bremerton, Washington, by truck on the morning of April 10 had to arrive at the Navy Overseas Terminal at Alameda before noon the next day and made the entire distance in less than 36 hours elapsed time.

"Following the recent Mississippi floods, the War Production Board saw fit to declare the problem of highway, bridge, and levee repair in the flooded area an emergency, which permitted the restrictions on road building and critical materials to be lifted for the purpose of restoration work.

"I am hopeful that we can convince the War Production Board that the transportation problem on the West Coast is also an emergency, requiring more flexible regulations governing highway construction and maintenance."

Formula Approved for Post-War Fund Apportionments

The following resolution was passed by the Western Association of State Highway Officials at the recent twenty-second annual meeting:

"Whereas, The American Association of State Highway Officials has recommended that Congress authorize one billion dollars per year for each of the first three post-war years, said money to be apportioned to the various States on the basis of a formula giving one-half weight to p o p u l a t i o n, one-quarter weight to area, and one-quarter weight to mileage of post roads; and

"Whereas, It appears quite necessary for all States to present a united front to the Congress; now, therefore, be it

"Resolved, That the Western Association of State Highway Officials endorses and approves the amount recommended and the proposed method of apportionment; and be it further

"Resolved, That the Western Association of State Highway Officials has every confidence in the Executive Committee of the American Association of State Highway Officials and compliments and thanks the Executive Committee for the able manner in which it is handling this problem; and be it further

"Resolved, That the Secretary of the Western Association of State Highway Officials be instructed to transmit a copy of this resolution to Senator McKellar of Tennessee and to the Honorable Mr. Robinson of Utah, the authors of S-971 and HR-2426, with a request that S-971 and HR-2426 be passed as submitted, and that a copy of this resolution likewise be forwarded to Mr. Brady Gentry, President of the American Association of State Highway Officials and Miss Helen Whitaker, Acting Executive Secretary of the American Association of State Highway Officials."

Report on Highway Maintenance Equipment and Rental Procedure

By T. H. DENNIS, Maintenance Engineer

The following article is the second installment of a condensed report of the Sub-Committee on Highway Maintenance Equipment appointed by the Highway Research Board in 1940 to make a specific study of various types of equipment available or in use in performing highway maintenance work with a view to recommending the most suitable and practicable equipment for specific maintenance operations and the establishment of uniform equipment rental procedure throughout the United States. The report represents two years' work by the sub-committee members, T. H. Dennis, Chairman; A. A. Anderson, Portland Cement Association; H. K. Bishop, Chief of Construction, Public Roads Administration; B. E. Gray, Chief Engineer, Asphalt Institute; J. E. Lawrence, State Highway Maintenance Engineer, Massachusetts; Rex M. Whitton, State Highway Maintenance Engineer, Missouri, and was presented at the recent convention of the Board at Detroit. The pictures shown illustrate type of equipment only and the type is not restricted to any particular product. The first article appeared in the issue of December, 1942.

RECOMMENDATIONS received for the different size motor graders covered, in general, two classes, namely the 35 to 55 H.P. with 10-foot to 12-foot blade and the 60 plus H.P. with 12-foot to 14-foot blade. There is apparently no definite explanation of this classification other than the distinction indicated by the length of blade. The 14-foot blade, incidentally, is not standard and is probably accomplished by special extensions.

FIGURE 19

The motor grader is recommended above all other blading units for normal requirements. It is also adaptable to snow and ice removal

FIGURE 20

operations within its capacity. For this particular work the 45 to 65 plus H.P. unit is the most popular and is operated either with the blade or a "V" type snow plow attached to the front end. For ice removal a saw tooth blade is recommended.

Equipment Rental

(Continued from December Issue)

STATES AGREE

It may be assumed that in States where the cost of fuel and lubricants and other operating items are not included as part of the rental rates, such charges are distributed directly to the cost of the work. On that assumption there is very substantial agreement among the 33 States as to the items which should be included.

The inclusion of charges for fuel and lubricants as part of the rental rates presents little difficulty. There is no question but that the inclusion of these items in the rental rate would permit a more accurate distribution of the cost of work than is the case when fuel, oil and other lubricants are delivered in bulk and distribution of the cost thereof is made to road sections on a mileage or some other fixed basis. This is not the case with the labor engaged in servicing and operating the equipment.

Maintenance crews are generally organized and trained to perform the routine as well as special work within their sections. Obviously each section is not fully equipped for all such operations since much of it is either intermittent or seasonal.

(Continued on next page)

FIGURE 21

Length of Blade	Max. B.H.P. Not less than	Single Drive Shipping Weight*	Single Drive Tires	Tandem Drive Shipping Weight	Tandem Drive Tires
10′	31**	9,500	12.00x24	13,250	10.00x24
12′	34**	15,000	13.00x20	16,000	11.00x24
12′	62**	18,500	13.00x24	19,300	13.00x24
10′	32***	11,000	13.00x20	13,200	10.00x24
12′	50***	15,800	14.00x20	17,500	12.00x24
12′	65***	18,000	13.22x24	20,000	13.00x24

*Includes Scarifier. **Gasoline. ***Diesel.

The motor grader should be power controlled and should have not less than four speeds forward with a high gear speed at governed speed of engine not less than 10 miles per hour. It should be equipped with service brakes on at least two of the driving wheels with a hand operated brake for parking or emergency. The scarifier attachment should be mounted independently of the blade and with separate controls so that either the blade or scarifier may be operated separately or simultaneously. The scarifier teeth should be spaced not more than 4½ inches on centers and should be held in the block by means of wedges or keys. The wearing joints should be fitted with take-up bear-

FIGURE 22

ings to compensate for wear, particularly by the blade-lift control.

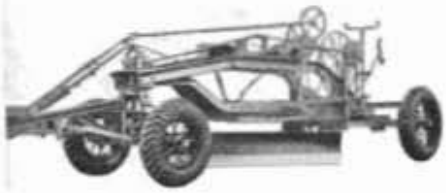

FIGURE 23

Length of Blade	Min. Weight Less Scarifier	Power Unit Required: Tractor Size H.P.	Power Unit Required: Truck Size
8'	1,400	25	1½ to 2 ton
8'	3,300	25	2 to 5 ton 4-wheel drive
8'	5,800	40	2 to 5 ton 4-wheel drive
10'	7,300	45	2 to 5 ton 4-wheel drive
12'	9,500	60 plus	2 to 5 ton 4-wheel drive

The tow type blade grader should be pneumatic-tired, hand operated, leaning-wheel* high lift type, equipped with a steerable* hitch. The wearing joints should be fitted with take-up bearings to compensate for wear, particularly the blade-lift control. All gears requiring constant lubrication should be enclosed in oil-tight cases and all bearings protected from dust.

FIGURE 24

The scarifier attachments* should have not less than five teeth, and should be mounted separately from the blade with separate controls so that either the blade or scarifier can be operated independently or simultaneously as desired. The scarifier teeth should be secured in the block by means of wedges or keys. The open space between teeth should not exceed 5 inches.

Mudjack

The mudjack is used in all but the Mountain States where there is a comparatively small amount of concrete pavement. On badly warped slabs the mudjack has proven effective for corrective work. Practice varies—in some instances, premixed asphaltic material is used for leveling rather than attempting to restore the slabs to their original positions; and in others, the premix is laid as a temporary measure pending final restoration to grade with the mudjack at which time the patch is removed.

* Not applicable for 1,400 minimum weight graders.

Equipment Rental

(Continued from preceding page)

As a result equipment is transferred from place to place as the need arises. Equipment rented on an operated basis under such conditions would necessitate a uniform rate which might conflict with the classification and pay scale of the particular crew. Likewise the permanent assignment of the operator to the equipment might not always be either economical to the maintenance organization or fair to the equipment operator.

RENTAL SYSTEM FAVORED

The majority opinion favors a rental system which includes depreciation, repairs and upkeep, plant and storage, and all operating costs except wages of operator. From a cost accounting viewpoint, such a system permits a day by day cost distribution on the basis of actual use of equipment. It simplifies the daily accumulation of expenditures so that the men in charge can readily ascertain the status of their job funds at any time.

A study of data furnished by the States shows the variety of methods followed in calculating rates and a wide range in the rates for similar units of equipment.

There is also a wide variance in the basis on which rates were established. For instance, rates were reported as being on an hourly, daily, weekly, monthly, mileage and seasonal basis. One State reported a seasonal rate for its snow plows and a second State reported a weekly rate for two water pumps. A number of States use either a per mile or monthly basis for automobiles and a monthly rate for graders and similar equipment.

BASIS FOR RATES

By grouping like equipment and neglecting incidental differences it was ascertained that the following basis for rates prevailed among the 33 States reporting:

(Continued on next page)

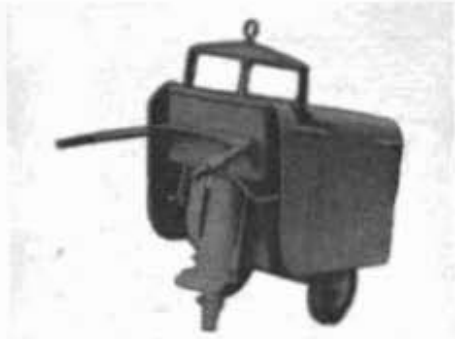

FIGURE 25

The two wheel pneumatic-tired cart type mudjack (Figure 25) should have a hopper capacity of approximately 4 cubic feet with full skirted guard. The height should not exceed 36 inches. The mud pump should be the single piston type with rubber ring built-in inlet valve and capable of producing 100 pounds pressure per square inch. The mud valve should be the floating ball, self-cleaning type.

The unit should be powered with an air-cooled gasoline engine and should weigh approximately 500 pounds.

FIGURE 26

The large type mudjack (Figure 26) should have a capacity of approximately 12 cubic feet and should be mounted on a four-wheel pneumatic-tired trailer. The mixing unit should consist of a chamber containing a paddle type mixing shaft with sealed antifriction bearings and independent mud glands. The mud pumps should have rubber ring pistons and built-in inlet valves all capable of safely withstanding 250 pounds pressure per square inch. The mud valves should be the floating ball self-cleaning type. A two-way valve should be provided to permit use of two hose lines. The water supply should consist of at least a 1-inch rotary type pump having a capacity of 20 gallons per minute. The unit should be powered with at least a 25 H.P. gasoline engine, radiator cooled. The complete unit will weigh approximately 5,000 pounds completely equipped with the necessary hose and nozzles.

The type of equipment required for snow removal varies with local conditions. The field includes straight blade and "V" type push plows and rotary plows.

The push plow will handle 12 inches to 24 inches of new snow at truck speeds of 12 miles per hour. The reversible type push plow lacks the capacity of the one-way push plow and is efficient in fresh snow depths of less than 15 inches.

The "V" type plows can be operated in approximately four feet of fresh snow at truck speeds of three miles to six miles per hour. Equipped with wing blades, they are capable of maintaining sections where the maximum seasonal snowfall does not exceed nine feet. The rotary type plows are essential for opening, widening and clean-up operations where heavy and continuing snowfall makes disposal necessary.

FIGURE 27

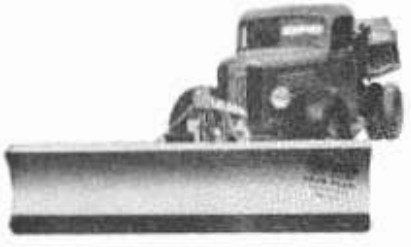

FIGURE 28

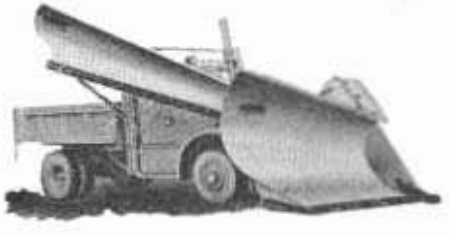

FIGURE 29

The one-way snow plows (Figure 27) should be from 10 to 12 feet in length and weigh from 1,500 to 2,400 pounds, including the push frames. The reversible type plows (Figure 28) should be at least 10 feet in length and weigh approximately 1,400 pounds including the push frame. The "V" type plows (Figures 29, 30 and 31) should have cutting edges at least 8 feet in length, and will weigh from 1,500 to 2,200 pounds including the push frame but without the wing attachment. The wing attachment which is most generally used on the heavier type of plow should be about 10 feet in length and will weigh approximately 1,100 pounds including attachment frame.

Equipment Rental

(Continued from preceding page)

Basis of Applying Rates	Percentage of Units Reported
Hourly	59.1
Daily	15.9
Weekly	0.1
Monthly	20.3
Mileage	4.4
Seasonal	0.2
	100.0

The 59.1 per cent that favored rental on an hourly basis was broken down to indicate the preference as to method of computing rates:

79.9% favored an hourly rental to cover all operating costs except operator.

12.6% favored an hourly rental to cover depreciation, repairs and upkeep.

4.8% favored an hourly rental to cover all operating costs exclusive of depreciation and operator.

2.7% favored an hourly rental to cover all operating costs including operator.

These percentages are representative only of the total units reported in the hourly rate group.

SUMMARY

A summary of the information and recommendations secured from the different States and views of the subcommittee members lead to the following conclusions in regard to the subjects covered.

In view of the many methods of handling equipment as reported by the different States, it is evident that considerable difficulty would be encountered in attempting to establish a uniform policy. The reporting agencies appear satisfied with their present setup and no changes from the adopted policies are contemplated.

(Continued on next page)

FIGURE 30

FIGURE 31

The push frame or under frame hitches for the light duty plows (1,500 pounds or less) should be adjustable and interchangeable on the 1½ to 2 ton two-wheel drive trucks. The heavy duty snow plows should be hinged ahead of the front axle or pushed from a bracket in the middle of the frame by push members hinged to the front axle. The plows should be supported on adjustable type runners with replaceable shoes, and controlled from the cab by a hand operated hydraulic lifting device. The plows should also be equipped with a hinged spring mounted deflector.

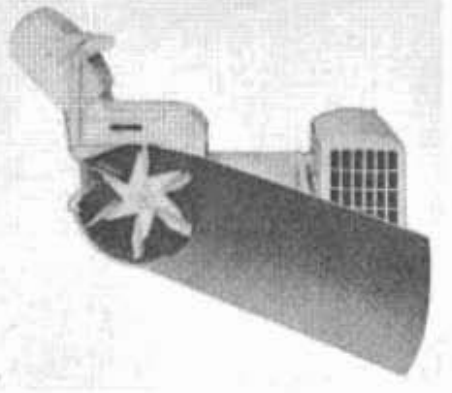

FIGURE 32

The rotary type snow plow should be designed so that the snow will be forced into the rotor or rotors. The plow should be mounted on a heavy duty truck, preferably driven from both the front and rear axles. In general a separate engine should be provided for operating the snow removal mechanism in addition to the engine that propels the truck. Under certain conditions where snowfall is comparatively light, the plow mechanism may be operated from the truck motor by means of a power take-off and reduction gears.

FIGURE 33

The plow should be capable of cutting an 8-foot cleared width and should be designed so that all loosened snow or slough from either opening, widening or windrow clean-up operations, should be forced into the rotor and thereby removed from the cleared strip. Raising and lowering the plow should be accomplished by means of a hydraulic lifting device with hand controls located in the truck cab. The cutting edge clearance should be regulated with an adjustable runner equipped with a removable shoe. The plow should be capable of clearing the snow down to the road surface and have possible vertical clearance range of at least 12 inches.

FIGURE 34

The plow should be equipped with adjustable deflector chutes that will permit directing the discharge either to the right or to the left. The plow should be designed so that a power operated attachment may be installed which may be used to break down drifts to within range of the plow.

Rollers

The pneumatic-tired roller is recommended for compaction of oiled gravel, road mix, plant mix and retread surfaces. It is also used to a lesser extent on other types of surfacing. The five to 10-ton three-wheel rollers are generally accepted as the "all-around" unit, apparently meeting any and all rolling requirements. The third selection is the two to five-ton power-driven portable roller closely followed by the two to five-ton portable tow type. Due to their portability these latter two units are particularly suited to scattered patch work. The five to 10-ton tandem ranks fifth in preference, the five-ton unit being generally used more on routine maintenance work.

The pneumatic-tired roller should consist of pneumatic-tired wheels of equal size and diameter with an effective rolling area of not less than 60 inches. The frame should be rigid construction and provided with a loading platform or body suitable for carrying ballast. The front axle should rotate around a king pin so located that the roller may turn within a minimum circle. The roller should be designed to carry sufficient load to provide not less than 325 pounds per inch of tire tread.

Equipment Rental

(Continued from preceding page)

Maintenance of State highways should be performed with State personnel and equipment. Work of considerable consequence where the quantities involved are readily determinable and other conditions are favorable may frequently be let to contract.

The State should own all equipment that is extensively used or special units that are particularly designed for highway maintenance. Seasonal equipment should be rented from privately owned sources during the required period.

Administration of State-owned equipment should be handled by a separate department under an equipment engineer who is directly subordinate to the chief engineer or commissioner.

All mobile equipment and certain other units of a pre-determined minimum value should be placed on a rental basis. Rental rates should be established from actual records of the costs and experience as to usable life for the particular type of equipment involved.

Depreciation is generally calculated by the "Straight Line" method based on the estimated trade-in value of the equipment, and applied throughout the entire service life of the unit.

Rental rates established for each class of equipment should be sufficient to cover all costs except operator. The most generally favored method of assessment is on an hourly basis.

FIGURE 35

FIGURE 36

FIGURE 37

The three-wheel roller should be powered with a gasoline engine of at least four cylinders and have a transmission with two or more speeds in each direction. A water tank should be provided and all wheels fitted with an attachment for wetting. Suitable brakes should be provided capable of holding the roller on grades without the gears being engaged. The three-wheel roller most generally used for highway maintenance operations will weigh from 5 to 10 tons, approximately one-third of which should be carried by the front roll.

The motorized roller of the trailer type should have a drive roller drum not less than 24 inches wide and provide a pressure of at least 150 pounds per lineal inch when empty. It should be equipped preferably with an air-cooled gasoline engine and have at least two speeds forward and one in reverse. A water tank should be provided and both rollers fitted with an attachment for wetting.

The roller should be equipped with pneumatic-tired wheels for trailing and provided with suitable raising and lower-

ing mechanism. Also a trailer tongue for trailing should be included.

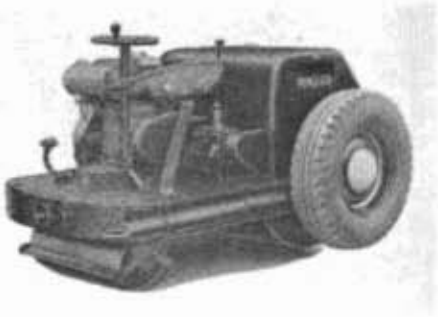

FIGURE 38

The roller should weigh at least 5,000 pounds without operator or added water in the rollers.

FIGURE 39

The tow type roller should have a single drum 48 inches or 60 inches in width. The drum should be of hollow semi-steel casting with a full length hub so constructed that it will hold water, sand, dirt or any other ballast material. Ballast filler openings and plugs should be provided in the ends of the roller drum. The roller should be equipped with a water tank and fitted with a device for wetting the roller. Check valves to prevent emptying tank when in trailer position should be provided.

The roller construction should include permanently attached pneumatic-tired wheels for trailing which become operative when the unit is in trailer position. The roller should weigh not less than 100 pounds per lineal inch of drum width without ballast.

The tandem roller should be powered with a gasoline engine of at least four cylinders and should have a transmission with two or more speeds in each direction. A water tank should be provided and both roller drums fitted with an attachment for wetting. Suitable brakes should be provided capable of holding the roller on grades without the gears being engaged. The tandem roller most generally used for highway maintenance operations will weigh from 5 to 10 tons.

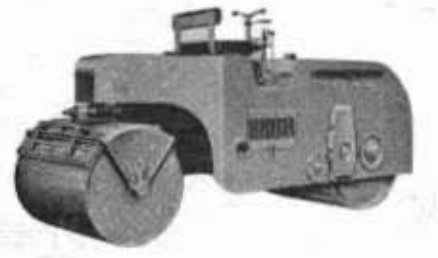

FIGURE 40

Shovels

The one-half cubic yard shovel is definitely the preference of all reporting agencies. The crawler type with trailer is more popular than the truck mounted type. The crawler type possesses a tractive advantage which evidently outweighs the lack of portability. Some agencies are still operating units of three-eighths cubic yard capacity, but there is little economic justification for such practice.

FIGURE 41

FIGURE 42

The truck mounted shovel should be the full revolving type. The revolving frame rollers should be readily replaceable without the necessity of raising the revolving frame from the rotating base. The capacity of the dipper should be struck measurement. The sizes most generally used on highway maintenance work are the $\frac{3}{8}$ or $\frac{1}{2}$ cubic yard capacity. The dipper should be constructed with tooth bases that will permit the use of detachable points. The boom should be self-locking type, power operated. Provision should be made for taking up wear at the points where the dipper stick or sticks pass through the saddle blocks.

The shovel unit should be mounted on a pneumatic-tired truck chassis powered with at least a six-cylinder gasoline engine. A separate power unit is not necessarily required for the $\frac{3}{8}$ cubic yard shovel. The $\frac{1}{2}$ cubic yard outfit should weigh not less than 18,500 pounds complete, as against 27,000 pounds for the $\frac{1}{2}$ cubic yard unit.

A dragline boom with a clamshell and dragline bucket should be provided.

FIGURE 43

The crawler shovel should be the full revolving type powered with an industrial type gasoline or diesel engine. The revolving frame rollers should be readily replaceable without the necessity of raising the revolving frame from the rotating base. The $\frac{1}{2}$ cubic yard capacity truck measurement is the most popular sized used on highway maintenance work. The dipper should be constructed with tooth bases that will permit the use of detachable points. The boom should be self-locking type power operated. Provision should be made to take up wear at the points where the dipper sticks pass through the saddle blocks.

The steering controls should be located at the operator's position in the cab and the machine should be steerable with the boom in any position with relation to the tracks. Brakes should be provided to hold the shovel both during travel or operation on any grade usually encountered on highway work. They should be designed so that full braking effect can be secured from the operator's position in the cab.

The shovel should not weigh less than 25,000 pounds nor more than 30,000 pounds. A dragline boom with a clamshell and dragline bucket should be provided. A skeleton or platform type trailer equipped with pneumatic tires should be provided for transporting the shovel. The crawler shoes should be flat without grousers.

Spreaders—Sand, Chip or Stone

The two-wheel roll feed hopper type spreader, 10 feet or 12 feet in length, is highly favored, particularly for the maintenance and construction of thin oil top, retread and nonskid type surfaces.

FIGURE 44

Second in choice is the tail gate gravity spreader generally used where it is desirable to operate the vehicle in reverse to apply material in advance of the wheels.

The revolving disc type spreader, while not rated as highly as the other two for spreading aggregate, is definitely the more popular unit for sanding operations on snow and ice removal. It is also suitable for spreading chlorides.

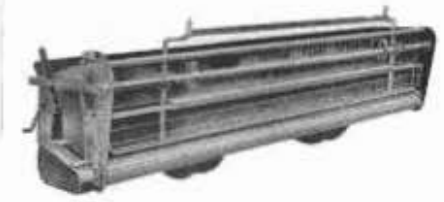

FIGURE 45

FIGURE 46

FIGURE 47

The gravity type spreader box (Figure 44) should be designed to permit quick attachment and to operate entirely suspended from the transporting vehicle. The box should be so constructed as to permit blanking off at least 50% of the effective opening and the rate of spread should be controlled by decreasing the width of the discharge opening. The spreader should not weigh less than 300 pounds.

The force feed spreader box (Figure 45) should be the hopper type mounted on pneumatic tires with a driving mechanism from the wheels to control the feed roll and agitator. It should be of sufficient size to permit spreading of aggregate up to 2½ inches in size and should weigh not less than 1,500 pounds.

The rotating disc spreader (Figure 46) is operated entirely suspended from the rear of the transporting vehicle. The material distributing disc is rotated by means of a small air-cooled gasoline engine. The spreader should weigh not less than 300 pounds.

The rotating disc type spreader (Figure 47) is also powered with a small air-cooled gasoline engine. It differs, however, from the spreader illustrated in Figure 72 in that it is mounted on pneumatic-tired wheels and is towed behind the transporting vehicle. This type spreader should weigh not less than 900 pounds.

Sweepers

The front-end tractor mounted rotary broom is the most extensively employed type of sweeper reported. The reason for this evidently is the compactness of the unit which permits turning within a short radius, thus minimizing interference with traffic. The attachment is easily removed, freeing the tractor for other operations. The greatest use of this unit is in connection with seal coat application.

The four-wheel trailer mounted power-driven broom is a close second choice for all sweeping requirements.

The four-wheel trailer mounted traction-driven broom is apparently less popular than the power-driven types.

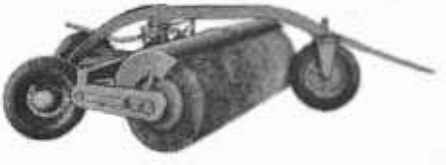

FIGURE 48

The broom used in rotary sweepers should be the refillable type and shielded with a full length metal hood. The broom should be driven by means of roller chains and sprockets. Construction should be such that the broom can be raised from the roadbed and disengaged while not in use for sweeping and also adjustable for variable sweeping pressures. It should be reversible type capable of sweeping either to the right or left.

The three different types of mountings are as follows:

The traction driven broom, tow type (Figure 48), should be mounted on not less than three pneumatic-tired wheels with transmission drive of not less than two speeds, preferably three.

FIGURE 49

FIGURE 50

The power driven broom, tow type (Figure 49) should be mounted on four pneumatic-tired wheels and driven with an industrial type gasoline engine.

The wheel tractor attachment type sweeper (Figure 50), is driven by means of a power take-off and universal joint.

Tanks—Oil Storage

Oil supply tanks covered a wide range of capacities. General practice indicates little preference as to type of mount for the group between 800-gallon and 1200-gallon capacity. There is a definite trend toward truck mounting of tanks ranging from 1200-gallon to 2000-gallon capacity.

The 10,000-gallon to 14,000-gallon capacity oil storage tanks are not generally used, due perhaps to the ease of securing material deliveries as needed. Present transportation difficulties will no doubt encourage a return to the early practice of road oil and asphalt storage.

Tanks—Water

The 700 to 1000-gallon capacity truck mounted tanks with sprinklers are not extensively used, but are preferred to the trailer mounted tank of the same capacity. The truck mounted unit of approxi-

mately 1000-gallon capacity is the most popular size for tree watering.

Tractors, Tow Graders

The reporting agencies generally favor the 25 H.P. to 50 H.P. tracklaying type tractor towing an eight to 12-foot blade grader for the maintenance of earth, gravel and crushed rock surfaces. The unit is also adaptable to maintenance of oiled surfaces as well as shoulder and roadside blading. The size and capacity of the unit are governed by local conditions.

A tractor of approximately 40 H.P. with 10-foot blade grader meets the demands of routine maintenance. Tractors up to 70 H.P. with 12 to 14-foot blades were accorded second choice for maintenance of earth roads, possibly due to their adaptability to construction work when not required as maintenance units.

Wheel type tractors of 25 to 50 H.P. towing an eight to 12-foot blade grader have also proven satisfactory for traveled way maintenance on both treated and untreated surfaces. This particular combination is more adaptable to light work where tractive conditions are favorable. The wheel type tractor is particularly suited to the operation of various attachments such as the front-end loader, hoists, tractor driven rotary sweeper and mowers.

The track-laying type tractors of 40 to 95 H.P. are very popular. The larger sizes equipped with angle or bulldozers are most efficient in slide removal and grading work, especially where traction is poor. They also perform exceptionally well in combination with loading attachments. The 40 H.P. unit is the most widely used on highway maintenance work.

Drawbar H.P.: Maximum not less than—	25	35	44	54	69	95
Weight: Not less than, lbs.—						
Diesel	6,000	9,000	12,500	16,000	20,000	27,800
Gasoline	6,000	9,000		11,000		

The tracklaying type tractor should be powered with either a gasoline or diesel engine and equipped with a suitable starter.

The tractor should be provided with a take-off suitable for operating mechanical or hydraulic units. A canopy top and side curtains should be provided.

Drawbar H.P.: Maximum not less than	15	30	40	45
Weight: Not less than, lbs...	2,500*	3,800*	4,700*	6,200*
Recommended working weight, lbs.	2,500	5,800	8,000	10,500

* Not applicable for 1400 minimum weight graders.

The wheel type tractor should be powered with either a gasoline or diesel engine and equipped with a suitable starter and provision for power take-off, either front, side or rear as desired.

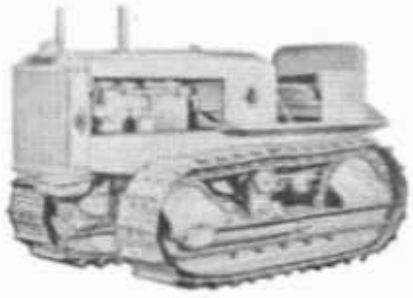

FIGURE 51

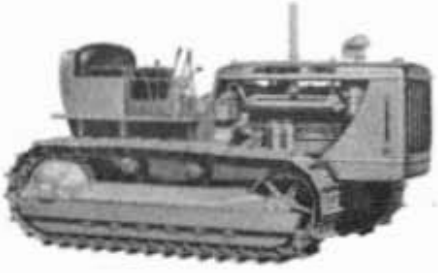

FIGURE 52

FIGURE 53

The transmission should have at least four speeds forward with a high gear speed of not less than 10 miles per hour, and a low gear speed of not less than 2.25 miles per hour, both at recommended governed speed of motor. Suitable service and parking brakes should be provided.

Trucks

The one-half to three-fourths ton express body, while very popular for shoulder, roadside and traveled way maintenance in the Pacific States, is not so extensively used in the remaining areas where the one and one-half to two-ton capacity dump truck apparently meets general demands.

The one and one-half to two-ton capacity dump truck is the most widely used truck on highway maintenance. The unit is consistently favored on all types of maintenance, other than bridges, even for hauling material. It is likewise used in towing light blade graders, drags, road maintainers, mowing machines, propelling the light duty straight blade snow plow, sanding icy pavements and all related work.

The one and one-half to two-ton capacity flat bed is widely used in the maintenance of safety devices, since special racks or compartments can be constructed readily.

In certain localities a limited number of three to six-ton dump trucks have been found desirable either because such units are required for snow removal operations, or they can not be rented readily from outside sources as needed for slide removal, grading and large scale hauling. Apparently their necessity and advantages for specific operations outweigh their lack of adaptability to routine maintenance.

On snow removal work the four-wheel drive truck, two to five-ton capacity, with dump body is greatly favored over the two-wheel drive of similar capacities. They are also suitable for towing grading units and the transportation of maintenance materials. Where snow removal is of no consequence the two-wheel drive trucks will meet all requirements.

FIGURE 54

FIGURE 55

The ½ and ¾ ton capacity express body truck should have a chassis weight of not less than 2,000 pounds and 2,400 pounds

respectively and should have at least a 75 H.P. six-cylinder gasoline engine. The cab should be steel enclosed with safety glass.

FIGURE 56

FIGURE 57

FIGURE 58

Size: Tons	1½–2	2–2½	2½–3	5–6
Capacity: Manufacturers gross load rating not less than, pounds	13,000	14,000	18,000	23,000
Weight, Chassis: Not less than, pounds	4,100	4,250	6,000	7,100
Wheelbase: Approximate inches	160	160	170	160
Engine: Gasoline at least six-cylinder and not less than, H.P.	70	70	88	90

Geographical Effect

Contrary to general expectations, geographical locations exhibit little influence on the general trends of equipment usage. The few instances where this occurred and the particular units affected are enumerated herewith:

The light one-half to three-fourths ton capacity express body truck is used as a patrol unit in the Pacific and Mountain group of States. This particular unit was not recommended elsewhere. The one and one-half to two-ton capacity dump truck is favored by the remaining reporting agencies.

The portable two-blade maintainer is most commonly used on maintenance of untreated crushed rock or gravel surfacing. Its use is confined mainly to the Central States having a considerabe mileage of untreated rock or gravel surfacing.

Small portable bituminous mixers are favored in all but the Pacific and Mountain States. This might indicate that in the latter two areas patch material is either blade mixed or purchased from commercial sources.

Discs and harrows were recommended by the Pacific Group of States for use in oil treatment work. This equipment is apparently not used in other areas.

Large dump trucks are recommended only by the Pacific and and Mountain States. The one and one-half to two-ton capacity dump truck is more popular in all other areas. This use of heavy trucks may be due, in part, to the necessity of utilizing the heavy trucks when not required for snow removal work.

For loading operations the Pacific and Mountain States prefer the power shovel rather than the mechanical loaders used in the other localities.

FIGURE 59

FIGURE 60

Size: Tons	2½–3	3–4	6
Capacity: Manufacturers gross load rate not less than	14,000	18,000	23,000
Weight, Chassis: Not less than pounds	4,200	7,300	8,000
Engine: Gasoline, under hood, should have at least six cylinders developing not less than, H.P.	85	85	110

Control of Roadside Vegetation to Reduce Fire Hazards

(Continued from page 5)

This kind of burning, without the drying effect of diesel oil, progresses slowly. It can be devastatingly swift in action, however, in dry vegetation and must be done with care. Then—there is always the possibility of using soil sterilizing and growth killing chemicals to produce a firebreak. So far, materials available for such work are either based on arsenical compounds, which cannot be used by highway forces on the State right of way because of danger to livestock, or are chlorate compounds that cause too great a fire hazard either when sprayed on growth or inadvertently on operator's clothing. Other types are too costly to use in a large operation involving over 1,000 miles of roadside.

Under general conditions in California diesel oil is the most satisfactory material that has been found for use in control of roadside vegetation. It is economical in first cost and application. In areas where livestock raising is a predominant industry, there is no possibility of poisoning stock which travels along the highway or is pastured on adjoining lands. During its application, no undue hazard to operators or equipment develops because of a high degree of inflammability.

It is felt that a greater degree of cooperation between the property owners or operators and the Division of Highways is much to be desired.

TRUCKS GENERAL:

All trucks up to 3 ton capacity should have at least four speeds forward, the trucks above 3 ton capacity should have not less than five. Helper springs should be provided on the rear and vacuum booster or compressed air type brakes should be provided on all four wheels. The wheels should be steel, dual on rear with balloon tires. The cab should be steel enclosed with safety glass.

The dump body on trucks should not exceed 120 inches in length by 72 inches in width. The body should be square cornered with straight sides which are reinforced with gusset type braces attached to the running board which should extend the full length of the body. The top of the sides should be reinforced and provisions made for extending the height with wooden sideboards. The dumping mechanism should be hydraulically operated with controls located in the cab.

Bids and Awards of Highway Contracts for April and May

ALAMEDA COUNTY—On Atlantic Avenue in the city of Alameda, between Main Street and Webster Street, about 0.8 mile to be graded and paved with asphalt concrete on crusher run base. District IV. Louis Biasotti & Son, Stockton, $96,678; Stolte, Inc., Alameda, $101,622; Lee J. Immel, Berkeley, $104,229; Chas. L. Harney, San Francisco, $113,893; Guerin Bros., South San Francisco, $135,397. Contract awarded to Healey-Moore Co., Oakland, $96,414.

IMPERIAL COUNTY—Between El Centro and Brawley, about 11.8 miles to be surfaced with plant-mixed surfacing. District XI, Route 26, Section F, Imp., G. R. E. Hazard & Sons Contracting Co., San Diego, $80,800; Southwest Paving Co., Roscoe, $82,940; Daley Corp., San Diego, $86,585; Griffith Co., Los Angeles, $86,740; Oswald Bros., Los Angeles, $88,420; Pacific Rock & Gravel Co., Los Angeles, $107,000. Contract awarded to Basich Bros., Torrance, $73,520.

INYO AND MONO COUNTIES—Between Laws Bridge and one mile south of Benton Station, portions about 11.1 miles to be repaired by constructing road-mixed surfacing over the existing bituminous surfacing. District IX, Route 76, Sections A, AB. M. E. Whitney, Bakersfield, $44,618; Basich Bros., Torrance, $45,441; A. S. Vinnell Co., Alhambra, $47,136; Owl Truck & Construction Co., Compton, $50,236; Oswald Bros., Los Angeles, $50,945; Sierra Trucking Co., Inc., Reno, Nev., $51,281; Bonadiman McCain, Inc., Los Angeles, $58,161; Claude C. Wood, Lodi, $63,091. Contract awarded to Phoenix Construction Co., Bakersfield, $43,172.

KINGS COUNTY — Between Lemoore Flying School and the junction with Houston Avenue, 1.5 miles west of Lemoore, about 10.8 miles to be graded and surfaced with plant-mixed surfacing. District VI, Route 10, Section B. Calowell Construction Co., Long Beach, $278,654; N. M. Ball Sons, Berkeley, $282,121; A. J. Raisch, San Jose, $282,483; Phoenix Construction Co., Bakersfield, $300,326; Pacific Rock & Gravel Co. & M. W. Stanfield Co., Los Angeles, $306,164; J. E. Haddock, Ltd., Pasadena, $316,157; Guerin Bros., South San Francisco, $331,025. Contract awarded to Piazza & Huntley, San Jose, $270,974.

MARIN AND SONOMA COUNTIES—About 4 miles east of Ignacio Junction, the northerly timber trestle approach spans of the bridge across Petaluma Creek to be reconstructed with concrete floor on steel stringers. District IV, Route 8, Sections A, A. James B. Allen, San Carlos $77,377; Fred J. Maurer & Son, San Francisco, $86,752; Dan Caputo, San Jose, $91,902; Engineers, Ltd., San Francisco, $93,475; Underground Construction Co., Oakland, $94,237; Kiss Crane Co., El Cerrito, $94,970; Bent Construction Co., Los Angeles, $99,365; Lee J. Immel, Berkeley, $100,330; Fredrickson & Watson Construction Co., Fredrickson Bros., Oakland, $105,197; Trewhitt-Shields & Fisher, Fresno, $107,464; Fred D. Kyle, Los Angeles, $109,742; Ralph A. Bell, San Marina, $110,791; M. R. McGowan, Inc., San Francisco, $113,429; Harry J. Oser & Peter Sorenson, Redwood City, $138,406. Contract awarded to A. Soda & Son, Oakland, $95,909.

MENDOCINO COUNTY—Between Hopland and Crawford Ranch, about 6.7 miles, armor coat to be constructed. District I, Route 1, Section B, Clements & Co., Hayward, $43,130; Granite Construction Co., Watsonville, $47,892; Harold Smith, St. Helena, $49,480; Close Building Supply, Hayward, $49,855; N. M. Ball Sons, Berkeley, $52,700. Contract awarded to E. A. Forde, San Anselmo, $41,465.

MENDOCINO AND HUMBOLDT COUNTIES—Between McCoy Creek and Benbow at various locations, furnishing and stockpiling screenings. District I, Route 1, Sections K, A. Harold Smith, St. Helena, $13,982; Mercer, Fraser Co., Eureka, $14,500. Contract awarded to Tom Hull, Eureka, $12,250.

MENDOCINO COUNTY—Between Old Sherwood Road and Rattlesnake Creek crossing No. 3, portions only, a net length of about 4.4 miles, armor coat to be constructed. District I, Route 1, Sections G, H. I. Pacific Truck Service, Inc., San Jose, $20,854; E. A. Forde, San Anselmo, $25,882; California Paving Co., San Mateo, $29,996. Contract awarded to Close Building Supply, Hayward, $18,894.

NEVADA AND SIERRA COUNTIES—Portions between Truckee and Nevada State line, about 5.6 miles, plant-mixed surfacing to be placed. District III, Route 38, Sections A, B, A. Claude C. Wood, Lodi, $52,665; A. Teichert & Co., Sacramento, $53,389. Contract awarded to Hemstreet & Bell, Marysville, $40,000.

PLACER COUNTY — Between Baxters and Airport, about 3.0 miles, plant-mixed surfacing to be placed. District III, Route 37, Sections D, E. Claude C. Wood, Lodi, $26,480; A. Teichert & Co., Sacramento, $26,564; McGillivray Construction Co., Sacramento, $27,028; Clements & Co., Hayward, $28,200. Contract awarded to Hemstreet & Bell, Marysville, $25,780.

PLUMAS, LASSEN, SIERRA COUNTIES—Between Ede's Ranch and State line, portions about 15.8 miles in length to be repaired by construction of plant-mixed surfacing over the existing bituminous surface. District II, Routes 21, 29, Sections G, A, E, A. A. Teichert & Company, Sacramento, $88,960; Parish Bros., Sacramento, $91,878; A. J. Raisch, San Jose, $99,950; Hemstreet & Bell, Marysville, $106,640; Southwest Paving Co., Roscoe, $120,100; Claude C. Wood and Frank B. Marks & Sons, Lodi, $120,920; M. J. Ruddy & Son, Modesto, $137,486. Contract awarded to Isbell Construction Co., Reno, $84,065.

SAN DIEGO COUNTY—Between Route 2 and Route 77, about 7.5 miles to be graded and surfaced with road-mixed surfacing. District XI, Miramar Road. Bressi & Bevanda Constructors, Inc., Los Angeles, $118,524; Basich Bros., Torrance, $123,351; V. R. Dennis Construction Co., San Diego, $153,418; Oswald Bros., Los Angeles, $160,187; George Herz & Co., San Bernardino, $167,830; Daley Corp., San Diego, $193,333; B. G. Carroll, San Diego, $193,816; R. E. Hazard & Sons Contracting Co., San Diego, $199,089; Griffith Co., Los Angeles, $221,063. Contract awarded to Calowell Construction Co., Long Beach $111,711.

SAN MATEO COUNTY—At Finney Creek, a portland cement concrete arch culvert to be constructed and about 0.4 mile to be graded and bituminous surface treatment applied. District IV, Route 56, Section A. M. E. Whitney, Bakersfield, $20,370; Peter Sorenson, Redwood City, $20,819; Frank George, Sacramento, $21,540; Louis Biasotti & Son, $24,692; Harms Bros., Sacramento, $26,018; Dan Caputo, San Jose, $27,153; F. Fredenburg, South San Francisco, $29,997. Contract awarded to California Paving Co., San Mateo, $20,105.

SAN MATEO COUNTY—San Bruno Avenue at Bayshore Highway intersection, a reinforced concrete bridge to be constructed and road connection and widenings to be graded and surfaced with plant-mixed surfacing on crusher run base. District IV, San Bruno. Guerin Bros., South San Francisco, $15,752; James B. Allen, San Carlos, $15,228; S. J. Amoroso Construction Co., San Francisco, $16,160; Dan Caputo, San Jose, $17,618; N. M. Ball Sons, Berkeley, $22,126. Contract awarded to Wm. E. Thomas Concrete Construction, Sacramento, $14,069.

SANTA BARBARA COUNTY—Between Cebada Canyon and Reservation Boundary, about 3.3 miles to be graded and surfaced with plant-mixed surfacing. District V, Lompoc Cutoff. M. W. Stanfield Company, Los Angeles, $172,482; Fredrickson & Watson Construction Co., Fredrickson Bros., Oakland, $173,023; Basich Bros., Torrance, $173,625; Brown, Doko & Baun, Pismo Beach, $185,939; J. E. Haddock, Ltd., Pasadena, $217,767. Contract awarded to Calowell Construction Co., Long Beach, $153,360.

SHASTA COUNTY — Portions between Redding and Bass Hill, about 8.5 miles to be surfaced with plant-mixed surfacing. District II, Route 3, Section B. A. Teichert & Co., Sacramento, $43,430. Contract awarded to M. J. Ruddy & Son, Modesto, $39,562.

SHASTA COUNTY—Between ½ mile south of Clear Creek and Redding Subway, about four miles to be graded and surfaced with plant-mixed surfacing over cement treated base. District II, Route 3, Section A. Elmer J. Warner, Stockton $210,851; M. W. Stanfield Co., Los Angeles, $214,739; M. J. Ruddy & Son, Modesto, $219,787; Hemstreet & Bell, Marysville, $223,893; Marshall S. Hanrahan, Redwood City, $228,027; A. J. Raisch, San Jose, $239,953; Contract awarded to A. Teichert & Co., Sacramento, $208,971.

SOLANO COUNTY—Between Route 74 near Flosden and Route 7 near junction with Blue Rock Springs Road, about 3.1 miles to be graded and surfaced with plant-mixed surfacing on crusher run base. District X, Route 208, 7, Sections B, G. Fredrickson & Watson Construction Co., Fredrickson Bros., Oakland, $172,128; Louis Biasotti & Son, Stockton, $178,848; Bressi & Bevanda Constructors, Inc., Los Angeles, $179,227; Guerin Bros., South San Francisco, $184,650; Lee J. Immel, Berkeley, $198,570; Chas. L. Harney, San Francisco, $284,887. Contract awarded to Healey-Moore Co., Oakland, $163,219.

TRINITY COUNTY — Between Helena and Weaverville, about 14.5 miles to be resurfaced with plant-mixed surfacing. District II, Route 20, Section F. Contract awarded to Clements & Co., Hayward, $35,960.

VENTURA COUNTY—On various roads and streets in the vicinity of Huneneme, about 9.1 miles to be graded, untreated rock base to be constructed, and plant-mixed surfacing to be placed over existing pavement and newly constructed untreated rock base. District VII, Griffith Co., Los Angeles, $197,796; M. W. Stanfield, Los Angeles, $197,812; Bressi & Bevanda Constructors, Inc., Los Angeles, $198,717; Vido Kovacevich, South Gate, $202,671; Guerin Bros., South San Francisco, $227,484; Oswald Bros., Los Angeles, $233,596; J. E. Haddock, Ltd., Pasadena, $235,815. Contract awarded to Basich Bros., Torrance, $175,260.

YOLO COUNTY — Between Irrigation Canal and Reclamation Ditch, portions about 2.4 miles, plant-mixed surfacing to be constructed. District III, Route 99, Section B. A. Teichert & Co., Sacramento, $16,445. Contract awarded to McGillivray Construction Co., Sacramento, $16,128.

A man could save twenty years of his life by studying the experience of others.

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