PRELIMINARY DESIGN DATA

RWCD FLOODWAY BRIDGES

AT BASELINE AND ELLIOT ROADS

Sverdrup & Parcel

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PRELIMINARY DESIGN DATA
RWCD FLOODWAY BRIDGES
AT BASELINE AND ELLIOT ROADS

Prepared for the
FLOOD CONTROL DISTRICT OF
MARICOPA COUNTY

SVERDRUP & PARCEL AND ASSOCIATES, INC.
Engineers-Architects
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602/968-9048

February 25, 1980

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HYDRAULIC ANALYSIS

SVERDRUP & PARCEL

JOB #6784 MCFCD

SHEET NO. 1 OF 9

DATE 1/17/80

COMPUTATIONS FOR BRIDGE PIER LOSSES

BY HLS CHKD DLC

GENERAL MOMENTUM EQUATION:

SEE ENCLOSED SHEETS ENTITLED "MOMENTUM METHOD OF DETERMINING BRIDGE PIER LOSS"

$$\underbrace{M_1 - M_0 + \frac{Q^2}{gA_1^2}(A_1 - A_0)}_{I} = \underbrace{M_1 - M_0 + \frac{Q^2}{g(A_1 - A_0)}}_{II} = \underbrace{M_3 - M_0 + \frac{Q^2}{gA_3}}_{III}$$

I, II, III = MOMENTUM CURVES UPSTREAM, INSIDE AND DOWNSTREAM OF BRIDGE

Q = DISCHARGE IN C.F.S.

g = GRAVITY = 32.2 FT/SEC²

A_1 = AREA UPSTREAM OF BRIDGE IN SQ. FT.

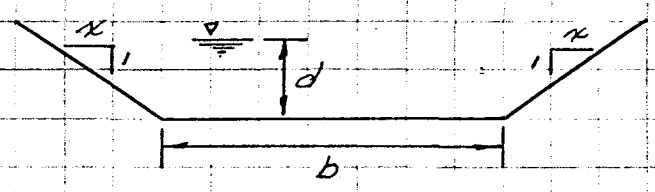
A_3 = AREA DOWNSTREAM OF BRIDGE IN SQ. FT.

A_0 = AREA OF BRIDGE PIER IN SQ. FT.

M_1 = STATIC MOMENT IN UNOBSTRUCTED CHANNEL UPSTREAM OF BRIDGE

M_3 = STATIC MOMENT IN UNOBSTRUCTED CHANNEL DOWNSTREAM OF BRIDGE

M_0 = STATIC MOMENT OF BRIDGE PIER



b = 140' AT BASELINE ROAD

b = 150' AT ELLIOT ROAD

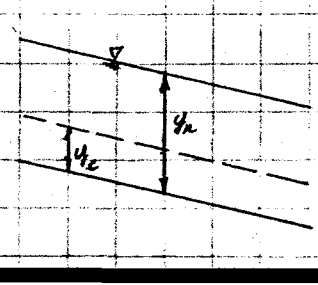
x = 3

$$A_1 = A_3 = bd + (\tfrac{1}{2} d(xd))2 = bd + xd^2 = d(b + xd)$$

$$M_1 = M_3 = \bar{y} A_1 = \frac{d(T+2b)}{3(T+b)} A_1$$

T = TOP WIDTH OF CHANNEL

$$M_0 = \tfrac{d}{2} A_0$$

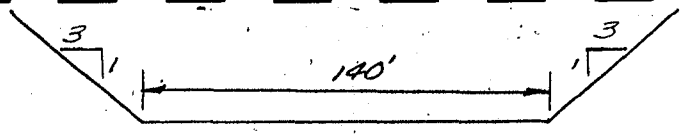


BASELINE RD.	ELLIOT RD.
Q = 4800 CFS V = 3.6 FPS	Q = 5100 CFS V = 3.5 CFS
S = 0.0003%	S = 0.0003%
y_n = 8.1'	y_n = 8.4'
y_c = 3.24'	y_c = 3.23'
F = 0.50	F = 0.51
SUBCRITICAL FLOW	SUBCRITICAL FLOW

MOMENTUM LOSSES AT BRIDGES

Project MCFCD #6784		Locality BASELINE ROAD	
Q = 4800 CFS	Sheet 2 of 9	By MCS	Date 2/18/80
		Ckd. DLC	Date 2/20/80

Section



d	$A_1 = A_3$	$M_1 = M_3$	A_0	M_0	$A_1 - A_0$	$M_1 - M_0$ (1)	$\frac{Q^2}{g(A_1 - A_0)}$ (2)	$\frac{Q^2}{g A_1^2}$	$\frac{Q^2 (A_1 - A_0)}{g A_1^2}$ (3)	$\frac{Q^2}{g A_3}$ (4)	I (1) + (3)	II (1) + (2)	III (1) + (4)
4	608	1184	56	112	552	1072	1296	1.9	1068	1177	2140	2368	2249
5	775	1875	75	188	700	1687	1022	1.2	834	923	2521	2709	2610
6	948	2736	96	288	852	2448	840	0.8	678	755	3126	3288	3203
7	1127	3773	119	417	1008	3356	710	0.6	568	635	3924	4066	3991
8	1312	4992	144	576	1168	4416	613	0.4	486	545	4902	5029	4961
9	1503	6399	171	770	1332	5629	537	0.3	422	476	6051	6166	6105
10	1700	8000	200	1000	1500	7000	477	0.3	371	421	7371	7477	7421
ASSUMING ACCUMULATION OF DEBRIS ON PIERS = AREA OF PIERS													
4	↑	↑	96	192	512	992	1398	↑	991	↑	1983	2390	2169
5			125	313	650	1562	1101		774		2336	2663	2485
6	SAME	SAME	156	468	792	2268	903	SAME	631	SAME	2899	3171	3023
7	AS	AS	189	662	938	3111	763	AS	528	AS	3639	3874	3746
8	ABOVE	ABOVE	224	896	1088	4096	658	ABOVE	452	ABOVE	4548	4754	4641
9	↓	↓	261	1175	1242	5224	576	↓	393	↓	5617	5800	5700
10			300	1500	1400	6500	511		347		6847	7011	6921

M_1 = Static moment in unobstructed channel $= \bar{y} A_1 = \frac{d(T+2b)}{3(T+b)} A_1$

M_0 = Static moment of obstruction $= \frac{d}{2} A_0$

$M_1 - M_0$ = Static moment in obstructed channel

T = Top Width of Channel
b = Base Width of Channel

$$M_1 - M_0 + \frac{Q^2}{g A_3} = M_1 - M_0 + \frac{Q^2}{g (A_1 - A_0)} = M_1 - M_0 + \frac{Q^2 (A_1 - A_0)}{g A_1^2}$$

III II I

$\frac{Q^2}{g (A_1 \quad A_2}$ = Kinetic momentum in obstructed channel

$\frac{Q^2}{g A_1}$ = Kinetic momentum in unobstructed channel

$\frac{A_0 \quad Q^2}{g \quad A_1^2}$ = Kinetic momentum lost

Figure 3

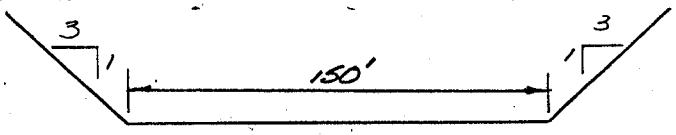
M-2181-38

Bridge Piers: 24" wide piers
5 in number

A_0 = area of piers + difference in area from 3:1 sideslopes to 2:1 sideslopes - see sheet 8

MOMENTUM LOSSES AT BRIDGES

Section



Project MCFCD		Locality ELLIOT ROAD	
Q = 5100 CFS	Sheet 3 of 9	By MRS	Date 2/18/80
		Ckd. DLC	Date 2/20/80

d	$A_1 = A_3$	$M_1 = M_3$	A_0	M_0	$A_1 - A_0$	$M_1 - M_0$ (1)	$\frac{Q^2}{g(A_1 - A_0)}$ (2)	$\frac{Q^2}{g A_1^2}$	$\frac{Q^2 (A_1 - A_0)}{g A_1^2}$ (3)	$\frac{Q^2}{g A_3}$ (4)	I (1) + (3)	II (1) + (2)	III (1) + (4)
4	648	1264	56	112	592	1152	1364	1.9	1139	1247	2291	2516	2399
5	825	2000	75	188	750	1812	1077	1.2	890	979	2702	2889	2791
6	1008	2916	96	288	912	2628	886	0.8	725	801	3353	3514	3429
7	1197	4018	119	417	1078	3601	749	0.6	608	675	4209	4350	4276
8	1392	5312	144	576	1248	4736	647	0.4	520	580	5256	5383	5316
9	1593	6804	171	770	1422	6034	568	0.3	453	507	6487	6602	6541
10	1800	8500	200	1000	1600	7500	505	0.3	399	449	7899	8005	7949
ASSUMING ACCUMULATION OF DEBRIS ON PIERS = AREA OF PIERS													
4	↑	↑	96	192	552	1072	1463	↑	1062	↑	2134	2535	2319
5			125	313	700	1687	1154		831		2518	2841	2666
6	SAME	SAME	156	468	852	2448	948	SAME	677	SAME	3125	3396	3249
7	AS	AS	189	662	1008	3356	801	AS	568	AS	3924	4157	4031
8	ABOVE	ABOVE	224	896	1168	4416	692	ABOVE	487	ABOVE	4903	5108	4996
9	↓	↓	261	1175	1332	5629	606	↓	424	↓	6053	6235	6136
10	↓	↓	300	1500	1500	7000	539	↓	374	↓	7374	7539	7449

M_1 = Static moment in unobstructed channel $= \bar{y} A_1 = \frac{d(T+2b)}{3(T+b)} A_1$

M_0 = Static moment of obstruction $= d/2\, A_0$

$M_1 - M_0$ = Static moment in obstructed channel

T = Top Width of Channel
b = Base Width of Channel

$$M_1 - M_0 + \frac{Q^2}{g A_3} = M_1 - M_0 + \frac{Q^2}{g(A_1 - A_0)} = M_1 - M_0 + \frac{Q^2 (A_1 - A_0)}{g A_1^2}$$

III II I

$\frac{Q^2}{g (A_1 \quad A_2}$ = Kinetic momentum in obstructed channel

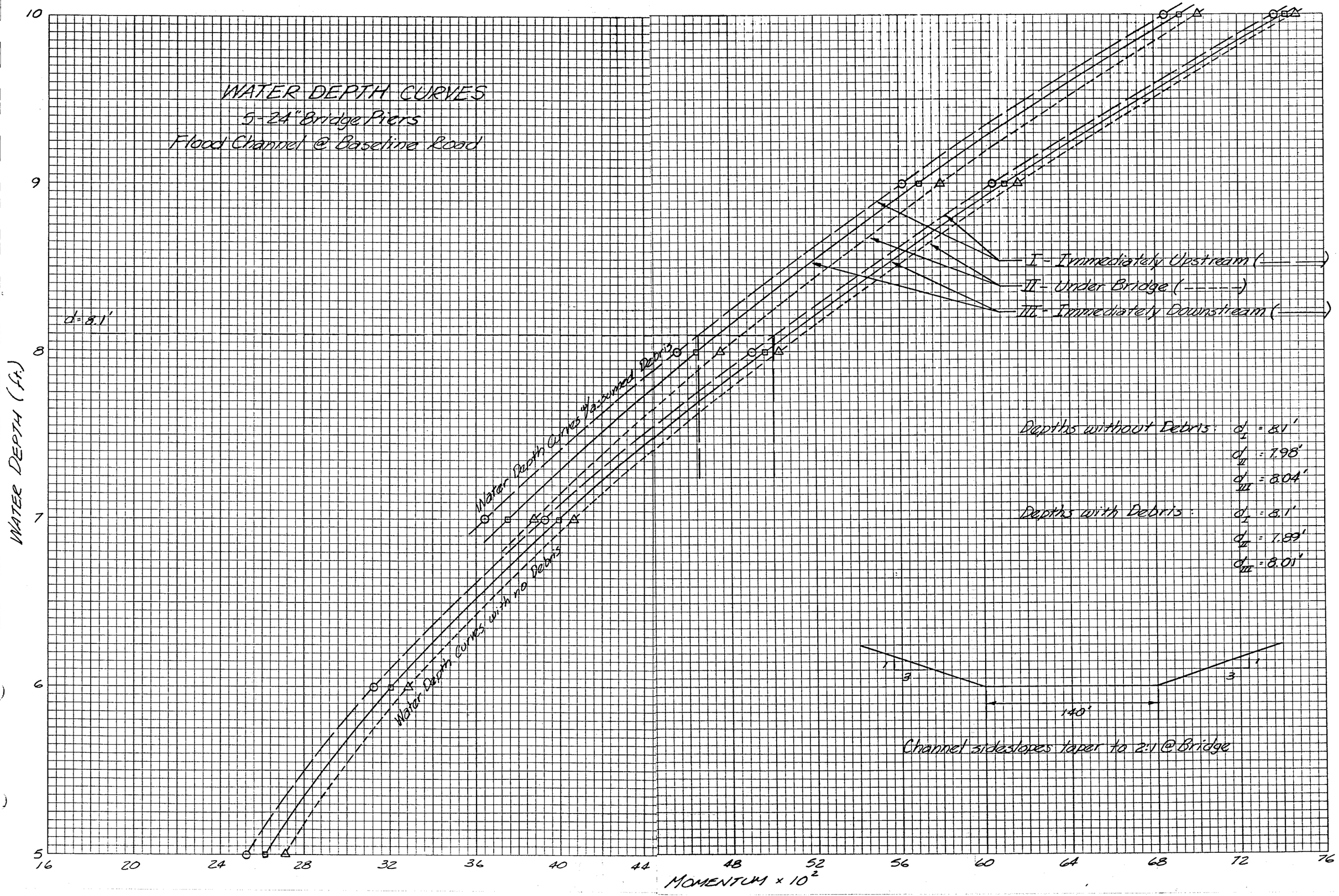
$\frac{Q^2}{g A_1}$ = Kinetic momentum in unobstructed channel

$\frac{A_0 \quad Q^2}{g \quad A_1^2}$ = Kinetic momentum lost

Figure 3

Bridge Piers: 24" Wide piers
5 in number

A_0 = area of piers + difference in area from 3:1 sideslope to 2:1 sideslopes — see sheet 8



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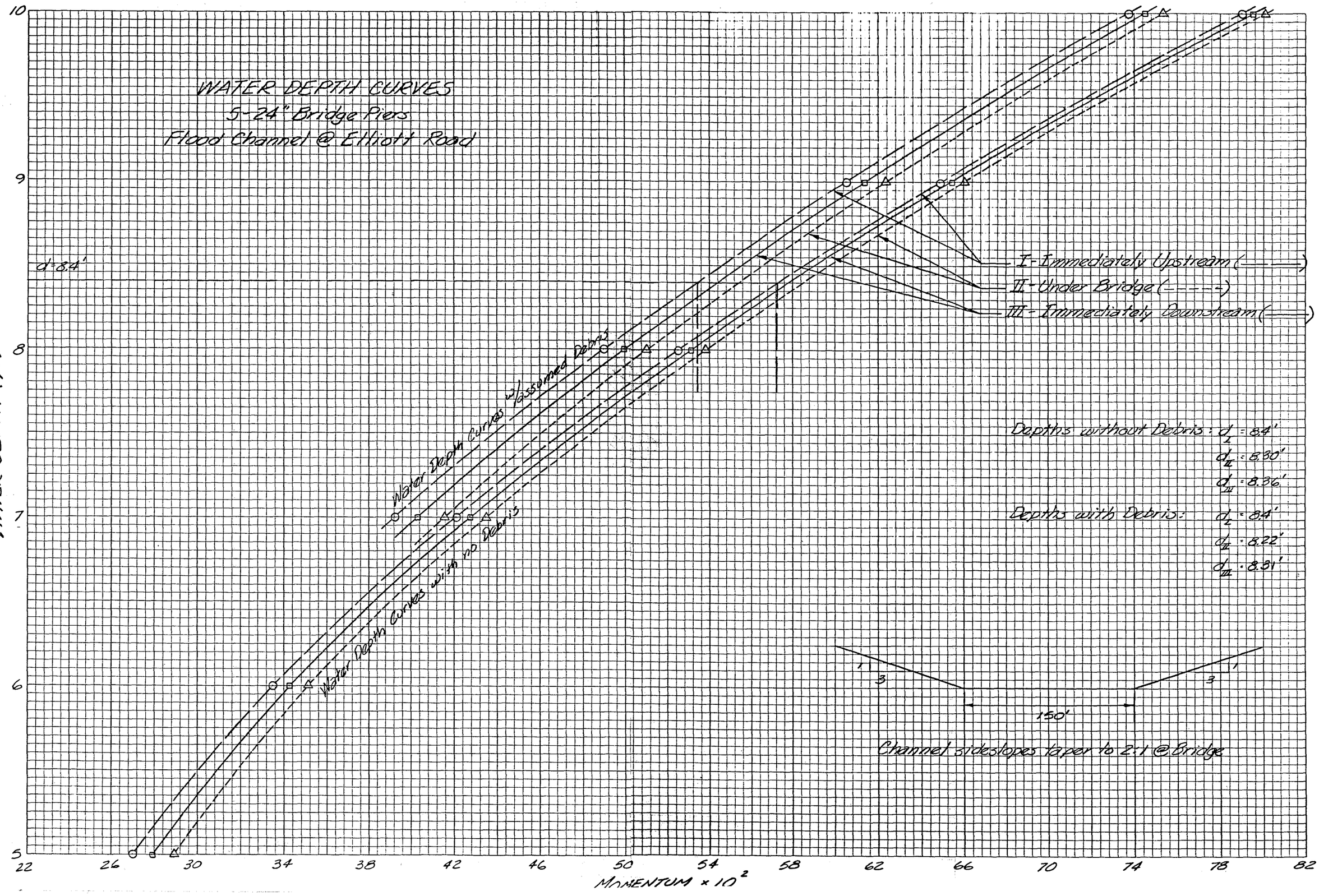

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DRAFT

Request for Proposal

Scope of Work: Design and construction management of two bridges over the RWCD Floodway.

Location: The Flood Control District of Maricopa County will design and construct bridges over the RWCD Floodway at Baseline and Elliot Roads.

Project Description: Project consists of providing all professional engineering services necessary for the design and construction management of bridges over the RWCD Floodway at Baseline and Elliot Roads. The proposal for these engineering services will be organized as Phase I Design, and Phase II Construction Management. One contract will be negotiated with the consulting engineering firm for both Phases of this Project.

Baseline Road

A. Bridge - On approximate 30° skew, 68 feet wide curb to curb roadway with one 8 foot wide hiking and riding path separated from the roadway by a physical barrier.

B. Length - 230 feet ±.

C. Channel - Trapezoidal section with a 150 foot base and 2 to 1 side slopes. - Reclamelization as required

D. Approach roadway on the east end of the bridge 200 feet ±; west end of the bridge to connect with the structure over the RWCD Canal.

Elliot Road

A. Bridge - At right angle 50 feet wide curb to curb roadway with one 8 foot wide hiking and riding path separated from the roadway by a physical barrier.

B. Length - 200 feet ±

C. Channel - Trapezoidal section with a 150 foot base and 2 to 1 side slopes. reclamelization as necessary.

D. Approach roadway on the east end of the bridge 200 feet ±; west end

of the bridge to connect with structure over the RWCD Canal.

General.

a. Bridges shall be designed to accommodate HS20-44 loading. Design will be in accordance with current ASHTO Specifications as interpreted by ADOT and as modified by SCS for concrete cover and requirements for temperature and shrinkage reinforcement. Calculations will be based upon service loads and the working stress method. Construction shall be in accordance with MAG Specifications as supplemented by Maricopa County.

b. Final drawings will be on sheet size 24 by 36 inch. Detailing will be in accordance with ADOT Highway Division, Bridge Section, Procedures. Standard details may be incorporated by reference number and shall be the most currently available. All design drawings and calculations will be independently checked in the consulting engineer's office, and each drawing or calculation sheet initialed and dated by the checker. All engineering assumptions made during the design other than standard engineering judgments will be documented with appropriate references on the calculation sheets.

c. The design shall include provisions for the temporary panel detour of traffic during construction.

d. The Floodway Channel is to be earth. Channel properties at the bridges are shown on Sheets 8 and 11 of 26; SCS Plan and Profile Sheets for the RWCD Floodway. Minimum of 1.5 feet clearance shall be provided between the top water surface elevation and the bottom of the bridge. Bridge piers shall be parallel with the flow and shall be deep enough to permit overexcavation of up to five feet to permit lowering of the invert and installation of rock riprap if necessary. The bridge shall be centered on the centerline of the Floodway.

6. Engineer's cost estimate.

7. Preparation and assembly of bid package.

B. Phase II. Construction Management. (90 days after notice to proceed to contractor).

1. Construction Staking. The consulting engineer shall provide field surveying horizontal and vertical control necessary for construction.

2. Construction inspection and materials testing. The consulting engineer shall provide full-time inspection of the construction site. Construction inspectors shall maintain daily inspection journals which will be available to the Flood Control District for examination at any time. A monthly summary of the inspection journals shall be provided to the Flood Control District. All testing shall be as provided in MAG Specifications. The consulting engineer shall be responsible for all soils testing and retesting, as appropriate, necessary for quality control during construction. The consulting engineer shall have concrete cylinder specimens taken from each concrete placement to be tested as per MAG Specifications. The consulting engineer shall inspect the placement of all reinforcing steel for appropriate size, spacing, and clearance and for compliance with manufacturer's certification. Copies of test results to be furnished to the Flood Control District.

3. Review of Shop Drawings.

4. Preparation of monthly pay estimates and recommendations and change orders as appropriate.

5. Furnish as built drawings.

Project Engineer:

The consulting engineer shall designate and assign a responsible engineer as Project Engineer who shall maintain a project file containing all correspondence and information pertinent to the Project.

e. The approach roadway shall be designed to match Maricopa County Highway Department plans for Baseline Road. The approach roadway for Elliot Road shall be designed based upon D-109-1 for County highways. We will furnish

f. Utilities requiring relocation may be incorporated or attached to the structure as appropriate.

g. The consulting engineer shall prepare final plans and specifications for the construction of both bridges. Reproducibles of all drawings and specifications shall be provided to the Flood Control District within five days of notification of approval. Eight copies will be provided of all drawings and design calculations presented for checking.

h. The consulting engineer shall provide the Flood Control District with bi-weekly progress reports during the design phase of the Project. coordinating Eng.

Scope of Professional Services:

A. Phase I. Design. (60 days from notice to proceed) exclusive of review time

1. Field Survey. A field survey in the immediate area of the proposed structure will include location of all existing utilities and irrigation facilities and other structures or improvements that may be affected by construction.

2. Soils Investigation. The consultant shall be responsible for foundation exploration, interpretation, and design in accordance with ADOT standards.

3. Structural Design and Report.

4. Bridge Hydraulics.

5. Plans, Special Provisions to the Specifications, ~~Special Construction~~ Constr. Special Provisions, and Quantity Estimates.

SVERDRUP & PARCEL

JOB # 6784 A MCFCD

SHEET NO. 6 OF 9

DATE 1/10/80

COMPUTATIONS FOR CRITICAL DEPTHS & VELOCITIES UPSTREAM & DOWNSTREAM OF BRIDGE

BY MRS CHKD DLC

CRITICAL DEPTH: $Q^2/g = A^3/B$

REF.: FLUID MECHANICS WITH ENGINEERING APPLICATIONS BY DAUGHERTY & FRANZINI, 6TH EDITION, PGS. 293-294

B = WIDTH OF WATER SURFACE

BASELINE ROAD:

$Q = 4800$ CFS

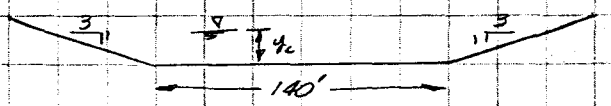
$V = 3.6$ FPS

$A = 1332$ S.F.

$n = 0.027$

$S = 0.00030$

SIDESLOPES: 3:1



FOR y_c: $Q^2/g = A^3/B = (4800)^2/32.2 = [(140+3y_c)y_c]^3/(6y_c+140)$

$715{,}528 = [(140+3y_c)y_c]^3/(6y_c+140)$

$\therefore y_c = 3.24$ FT.

ELLIOT ROAD:

$Q = 5100$ CFS

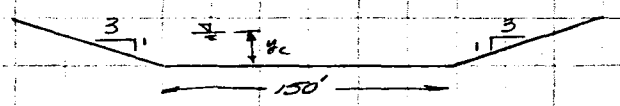
$V = 3.5$ FPS

$A = 1473$ S.F.

$n = 0.027$

$S = 0.00030$

SIDESLOPES: 3:1



FOR y_c: $Q^2/g = A^3/B = (5100)^2/32.2 = [(150+3y_c)y_c]^3/(6y_c+150)$

$807{,}764 = [(150+3y_c)y_c]^3/(6y_c+150)$

$\therefore y_c = 3.23$ FT.

SVERDRUP & PARCEL

JOB #6784 MCFCD

SHEET NO. 7 OF 9

DATE 1/10/80

COMPUTATIONS FOR CRITICAL DEPTHS & VELOCITIES UPSTREAM & DOWNSTREAM OF BRIDGE

BY MRS CHKD DLC

CRITICAL VELOCITIES: $V_c = \sqrt{g A_c / B_c}$

BASELINE ROAD: $V_c = \sqrt{g A_c / B_c}$

$A_c = 3.24(140 + 3(3.24)) = 485$ S.F.

$B_c = 3.24(6) + 140 = 159.5$ FT.

$= \sqrt{32.2(485)/159.5} = 9.9$ FPS

$F = V_c / \sqrt{g y_c} = 9.9 / \sqrt{32.2(3.24)} = 0.97 \sim 1$ ∴ CRITICAL DEPTH & VELOCITY IS CORRECT

ELLIOT ROAD: $V_c = \sqrt{g A_c / B_c}$

$A_c = 3.23(150 + 3(3.23)) = 516$ S.F.

$B_c = 3.23(6) + 150 = 169.4$ FT.

$= \sqrt{32.2(516)/169.4} = 9.9$ FPS

$F = V_c / \sqrt{g y_c} = 9.9 / \sqrt{32.2(3.23)} = 0.97 \sim 1$ ∴ CRITICAL DEPTH & VELOCITY IS CORRECT

FROM INFORMATION SUPPLIED BY R.W.C.D. & THESE CALCULATIONS, THE FLOW IN THE CHANNEL IS SUBCRITICAL

$d_1 > y_c$

$d_2 > y_c$

WATER SURFACE ELEVS. W/DEBRIS @ PIERS

ROAD	INVERT EL.	UPSTREAM EL	@ BRIDGE EL.	DOWNSTREAM EL
BASELINE	1327.3			
ELLIOT	1320.8			

SVERDRUP & PARCEL

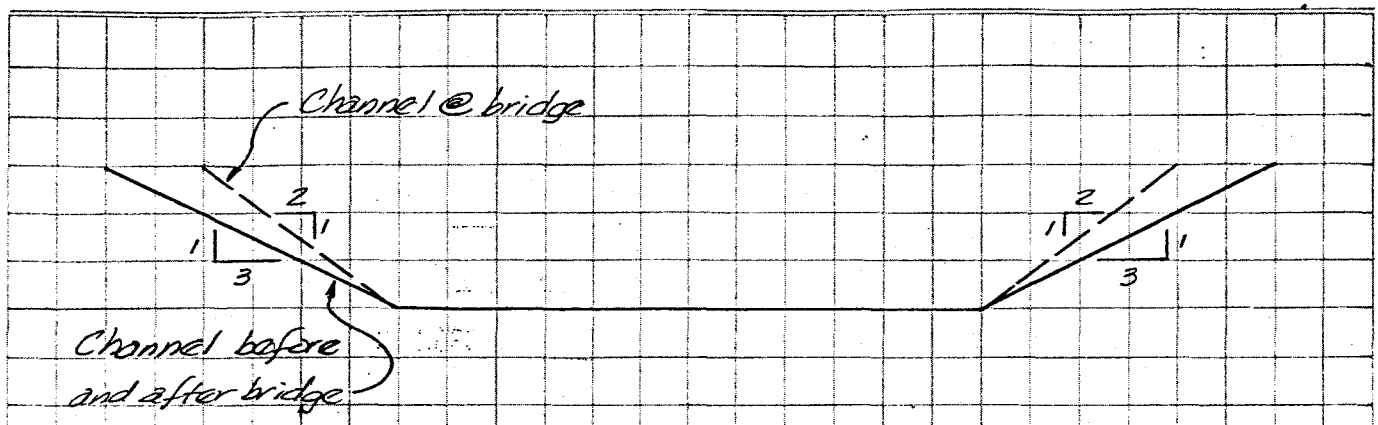
JOB #6784A MCFCD

SHEET NO. 8 OF 9

DATE 1/11/80

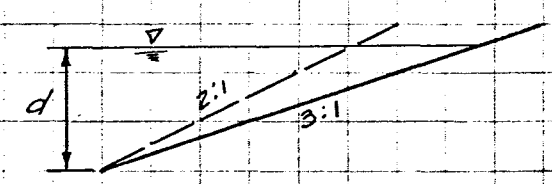
COMPUTATIONS FOR Additional Bridge Pier Area

BY MRS CHKD DLC



Will have a transition from 3:1 to 2:1 sideslopes @ bridge.
Suggest that the 2:1 sideslope begin and end at the bridge with a 100 ft. transition to the 3:1 sideslopes.
The momentum method of bridge pier loss computations does not take into affect the change in geometry of the channel section. I believe that if we treat the difference in area between the 2:1 and 3:1 sideslopes as additional pier area, the momentum method can be used.

d	Area 3:1	Area 2:1	ΔA : add to A_o in computation sheets
4	48	32	16
5	75	50	25
6	108	72	36
7	147	98	49
8	192	128	64
9	243	162	81
10	300	200	100



$$\text{Area}_{3:1} = 2(\tfrac{1}{2}(3d)d) = 3d^2$$

$$-\ \text{Area}_{2:1} = 2(\tfrac{1}{2}(2d)d) = 2d^2$$

$$\Delta A = d^2$$

SVERDRUP & PARCEL

JOB #6784 MCFCD

SHEET NO. 9 OF 9

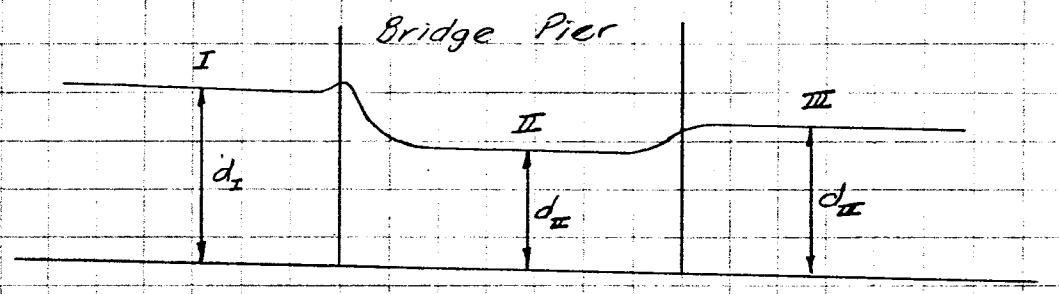
DATE 2/19/80

COMPUTATIONS FOR BRIDGE ELEVATIONS

BY MRS CHKD DLC 3/4/80

WATER SURFACE ELEVATIONS WITH DEBRIS AT PIERS

ROAD	INVERT EL.	(I) UPSTREAM EL.	(II) UNDER BOX. EL.	(III) DOWNSTREAM EL.
BASELINE	1327.3	1335.40	1335.19	1335.31
ELLIOT	1320.8	1329.20	1329.02	1329.11



THE FLOW IN THE CHANNEL AT BOTH BRIDGES IS SUBCRITICAL, AND THE UPSTREAM DEPTH WILL DICTATE THE MINIMUM SOFFIT ELEV. AS STATED IN THE DESIGN CRITERIA, THERE SHALL BE 1.5 FT. CLEARANCE FROM TOP OF WATER SURFACE TO BOTTOM STEEL.

THEREFORE, THE MINIMUM SOFFIT ELEV.

BASELINE ROAD: 1335.40 + 1.50 = 1336.90

ELLIOT ROAD: 1329.20 + 1.50 = 1330.70

HYDRAULIC ANALYSIS

METHOD

MOMENTUM METHOD OF DETERMINING BRIDGE PIER LOSS

(Data derived from "Report of Engineering Aspects, Flood of March 1938, Los Angeles, California," - Appendix I, Theoretical and Observed Bridge Pier Losses - U. S. Engineer's Office, Los Angeles, California, - May 1949 and from "Approximate Method Determines Bridge Pier Loss", by G. M. Allen, Jr., in March 1953, Civil Engineering.)

Flow past an obstruction has been divided into three types which follow roughly "Class A and B" flow as defined by Yarnell, and "Class C" flow as indicated by Yarnell and defined herein. The definitions as given by Koch and Carstanjen for the three flow conditions follow:

"Class A" flow is defined as a flow condition whereby critical flow within the constricted bridge section is insufficient to produce the momentum required downstream. It is apparent that for this type of flow, the bridge section is not a "control point" and, therefore, the upstream water depth is controlled by the downstream water depth plus the total losses incurred in passing the bridge section.

"Class B" flow is defined as a flow condition whereby critical flow within the constricted bridge section produces or exceeds the momentum required downstream. When this condition exists, the upstream water depth is independent of the downstream water depth, being controlled directly by the critical momentum required within the constricted bridge section and the entrance losses.

"Class C" - A special form of "Class B" flow occurs when the upstream water is flowing at a subcritical depth and containing sufficient momentum to overcome the entrance losses and produce a supercritical velocity within the constricted bridge section.

The drawing on the following page, entitled "Bridge Pier Losses by the Momentum Method" shows the water surface profiles and momentum curves for the three classes of flow.

MOMENTUM

Momentum, as referred to above, is defined as total momentum or the total of static and kinetic momentum, and may be written as $m + \frac{Q^2}{gA}$ where m = total static pressure of the water at a given section in pounds

Q = discharge in cubic feet per second

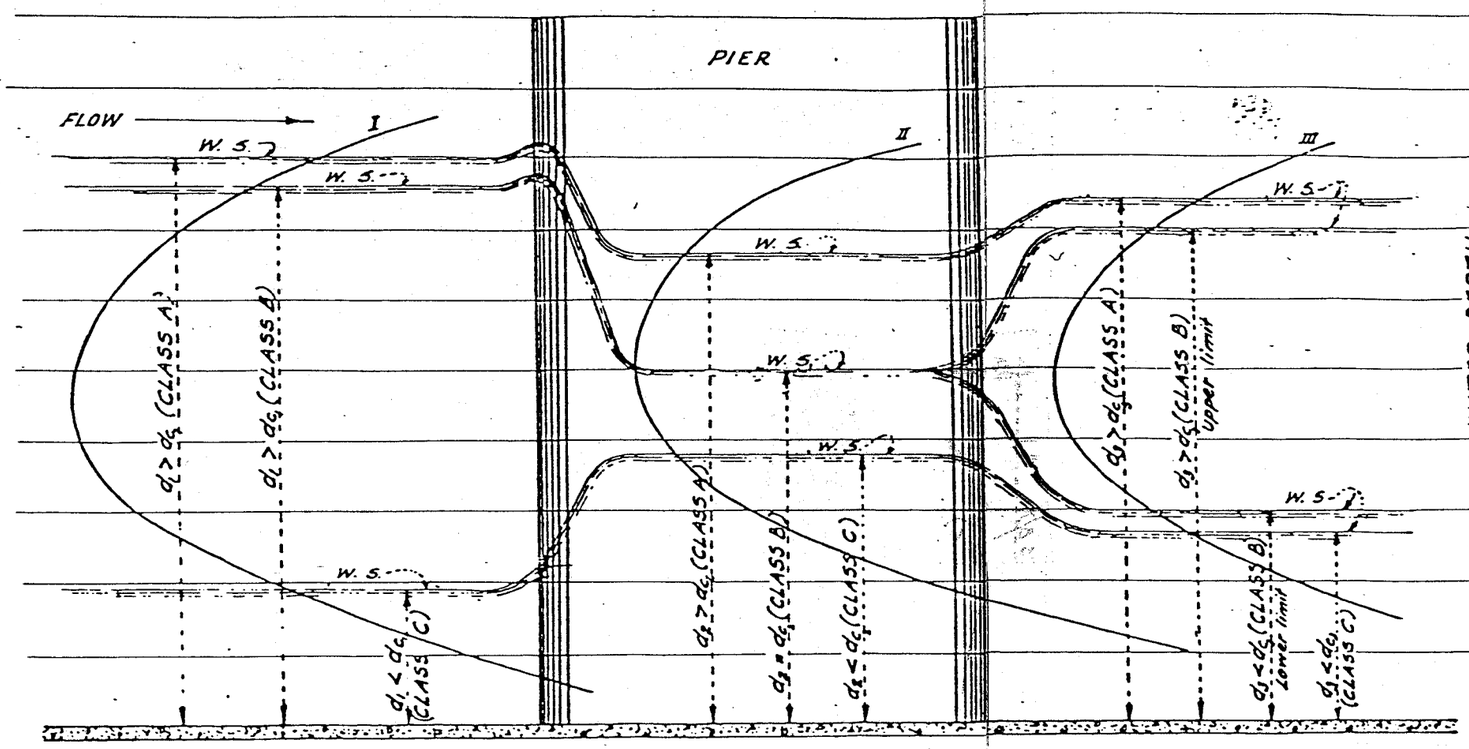
g = acceleration of gravity in feet per second per second

A = channel cross-sectional area in square feet.

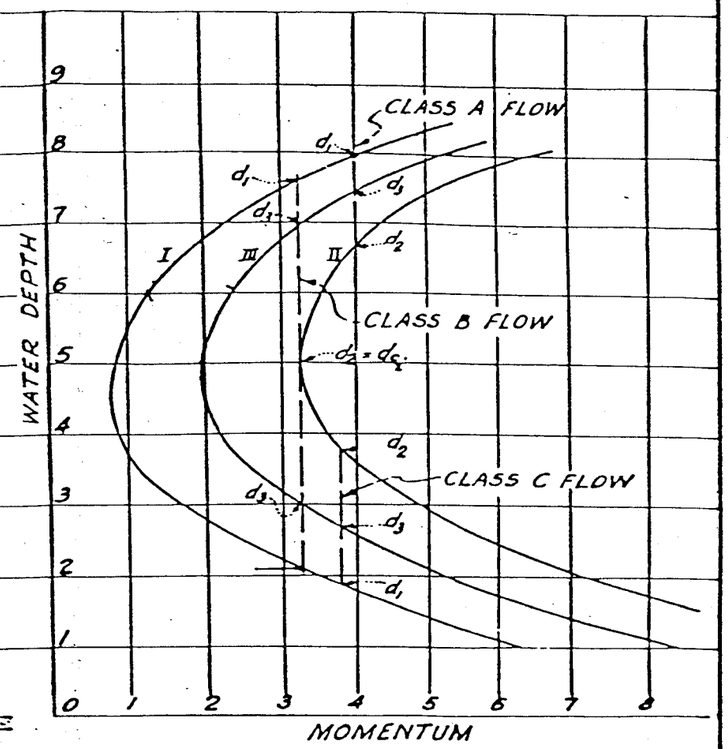
The unit weight of water (w) should appear in each term, but since it would cancel in the final equations, it has been assumed equal to unity, dimensions being pounds per cubic foot.

Based on experiments under all conditions of open channel flow where the channel was constricted by short flat surfaces perpendicular to flow, such as bridge pier, Koch and Carstanjen found that the total kinetic loss was equal to $\frac{A_0Q^2}{A_1gA_1}$ where A_0 is the area of the obstruction on the upstream surface and A_1 is the water area in the upstream unobstructed channel. For circular nose piers, Koch and Carstanjen show that 2/3 of $\frac{(A_0Q^2)}{(A_1gA_1)}$ should be used. It is apparent that the static pressure m_0 against the upstream obstructed area is not effective downstream, whereas the static pressure against the downstream obstructed area is effective downstream. Therefore, if we let the subscripts 1, 2, and 3 represent conditions upstream, within and downstream of the constricted section, respectively, we may write the general momentum relationship as follows:

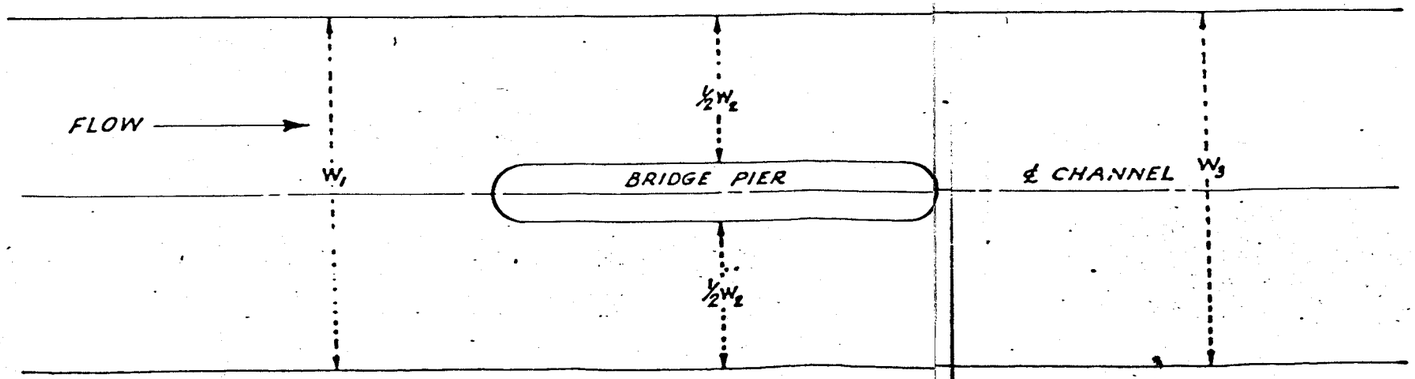
Total upstream momentum minus the momentum loss at entrance must equal the total momentum within the constricted section, or



LONGITUDINAL PROFILE



MOMENTUM CURVES



PLAN

GENERAL MOMENTUM EQUATION:

$$\underbrace{m_1 - m_p + \frac{Q^2}{gA_1^2}(A_1 - A_p)}_{\text{I}} = \underbrace{m_1 - m_p + \frac{Q^2}{g(A_1 - A_p)}}_{\text{II}} = \underbrace{m_3 - m_p + \frac{Q^2}{gA_3}}_{\text{III}}$$

NOTATIONS:

I, II, III = Momentum curves upstream, inside and downstream of bridge, respectively

d_1, d_2, d_3 = Water depths upstream, inside, and downstream of bridge, respectively.

d_{c_2} = Critical depth within bridge

W = Channel width

$m_1 = m_3$ = Static moment in unobstructed channel.

m_p = Static moment of bridge pier.

$A_1 = A_3$ = Area of unobstructed channel in sq. ft.

A_p = Area of bridge pier in sq. ft.

Q = Discharge in c.f.s.

g = Gravitational constant.

$d_{c_1} = d_{c_3}$ = Critical in unobstructed channel.

BRIDGE PIER LOSSES BY THE MOMENTUM METHOD

USDA SCS PORTLAND OREG 1958 M 2181-37

$$m_1 - m_0 + \frac{Q^2}{gA_1} - \frac{A_0}{A_1}\frac{Q^2}{gA_1} = m_2 + \frac{Q^2}{gA_2}, \text{ or}$$

$$m_1 - m_0 + \frac{Q^2}{gA_1^2}(A_1 - A_0) = m_2 + \frac{Q^2}{gA_2}$$

Total momentum within the constricted section plus static pressure on downstream obstructed area must equal the total momentum in the downstream channel, or

$$m_2 + \frac{Q^2}{gA_2} + m_0 = m_3 + \frac{Q^2}{gA_3}, \text{ or}$$

$$m_2 + \frac{Q^2}{gA_2} = m_3 - m_0 + \frac{Q^2}{gA_3}$$

The general momentum equation follows:

$$m_1 - m_0 + \frac{Q^2}{gA_1^2}(A_1 - A_0) = m_2 + \frac{Q^2}{gA_2} = m_3 - m_0 + \frac{Q^2}{gA_3}$$

The above equations cannot be solved as presented, and it is necessary that a simpler method be used. The total sum of momentum and hydrostatic pressure for each section (Fig. 2) for equal depths of flow past each section should first be determined. Using equal depths, $A_1 - A_0 = A_2 = A_3 - A_0$ (or $A_1 = A_3$) and $M_1 - M_0 = M_2 = M_3 - M_0$ (or $M_1 = M_3$).

Also, for equal depths, the sum of momentum and hydrostatic pressure for each section I, II, and III is:

$$I = M_1 - M_0 + \frac{Q^2 (A_1 - A_0)}{gA^2_1}$$

$$II = M_1 - M_0 + \frac{Q^2}{g(A_1 - A_0)}$$

$$III = M_1 - M_0 + \frac{Q^2}{gA_3} = M_1 - M_0 + \frac{Q^2}{gA_1}$$

where, for equal depths, $A_1 = A_3$

The values for equations I, II, and III are determined for various depths, both subcritical and supercritical. A curve for each section is plotted using the depth as the ordinate and the values from columns I, II, and III as the abscissa, (See Fig. 4). A vertical line passed through the three curves gives a graphic solution of the equations, as it gives, for

qual momentum, the corresponding depths of flow.

This vertical line must intersect a minimum of five depth values, nd preferably six. Drwg. No. 7-N-Eng. 248, page 6-15c shows the depth f flow and its indicated class. If only one value is intersected on curve II, the flow is critical at Section II.

Values of "d" on the lower portions of Curves I and III are used for supercritical flow, and on the upper portions for subcritical flow.

Backwater computations will determine either a flow depth at Section or III, depending upon type of flow conditions, and the curves give a direct solution, as the vertical line must pass through the known depth n Curve I or III, and must also pass through Curve II. If this vertical line does not pass through Curve II, it is possible that the momentum of the given depth is not great enough for the flow to pass the obstruction, nd a change in the computed depth must be made. The flow would then be critical at Section II, as the critical depth is the depth at which the omentum and pressure is the minimum.

Example

Given a trapezoidal channel, base-width 16 feet, side-slopes -3/4:1 and capacity Q = 5000 c.f.s.

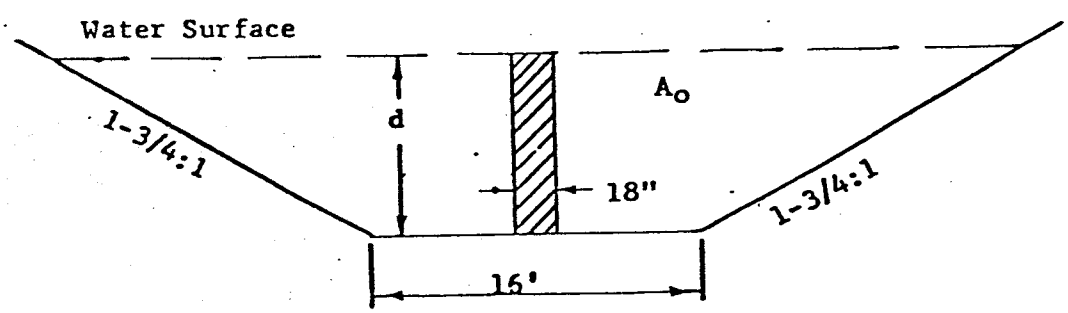


Fig. 1. Cross-section of channel showing center bridge pier.

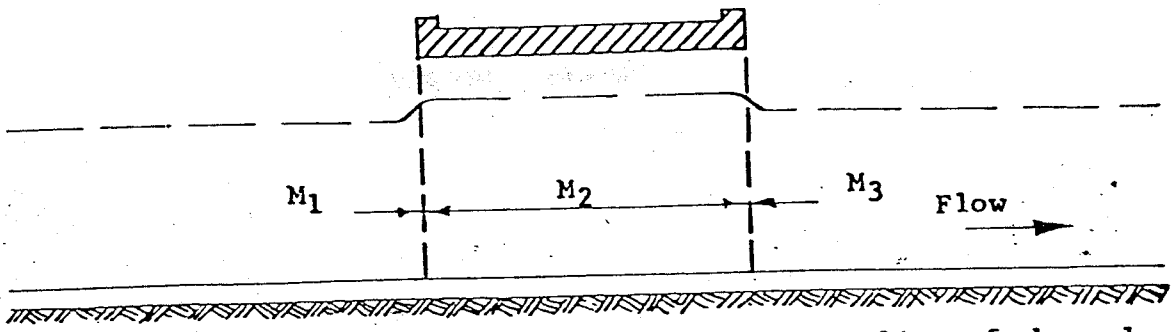


Fig. 2. Longitudinal section along centerline of channel indicates three locations: I - Immediately upstream, II - Under bridge, III - Immediately downstream.

Compute M_1 - M_3 by solving for the distance $\bar{y}$ from the water surface to the center of gravity of the trapezoidal section where

$$\bar{y} = \frac{d(T + 2b)}{3(T + b)}.$$

(T = top width and b = base width) and multiplying $\bar{y}$ by the area A, or ($M_1 = \bar{y} A_1$). The $\bar{y}$ distance for the obstruction, which is of rectangular area A_0 is $\frac{d}{2}$; this multiplied by A_0, will give M_0. Quantities for the remaining columns can be easily computed by use of the formulas given on pages 6-15b and 6-15d and in the column headings in Fig. 3, page 6-15j.

Momentum values given in columns I, II, and III, Fig. 3 are shown plotted on the graph, Fig. 4, giving curves I, II, and III. From a point on Curve I, which represents the upstream depth d_1, draw a vertical line through Curves II and III which will give the depth values for the sections under the bridge and immediately downstream. For the example given, refer to the curves on Fig. 4. For an upstream depth of 8.0 feet, the depth under the bridge is 9.3 feet and the depth immediately downstream is 8.7 feet. As the flow upstream is at subcritical depth, d_1 is less than d_c and "Class C" flow applies (See Drawing No. 7-N-Eng. 248, page 6-15c).

It is shown on Fig. 3 that the bridge section includes an 18-inch wide pier. As debris piles up on the center pier its net effect is to widen the center pier increasing A_0 and M_0. The effect of such debris accumulations can be estimated by computing flow conditions for the wider pier that would result when debris had accumulated. In critical cases the effect of debris lodging against piers can be minimized by constructing a 2:1 incline on the upstream edge of the piers. This causes debris to rise toward the surface and widen only a portion of the pier height. It should be noted, however, that the top eight (8) feet are normally considered to be affected by such debris so an inclined leading edge on piers in shallow streams would not be too effective.

The momentum method of computing the approximate change of water surface is not dependent upon coefficients "K" as are necessary in the formulas derived by Nagler, Weisbach, Rehbock and others (see USDA Technical Bulletin No. 429, "Pile Trestles as Channel Obstructions" and USDA Technical Bulletin No. 442, "Bridge Piers as Channel Obstructions.")

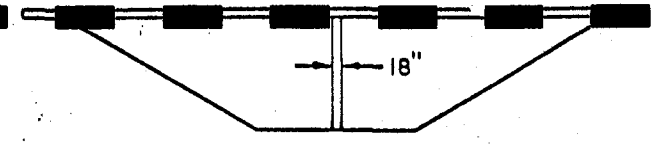
A check computation for the raise in water surface due to the bridge obstruction was made using the Nagler formula. The coefficient K varies from .87 to .94 with the channel contraction approximately five percent. The difference in water surface elevation between the depth in the unobstructed channel and the depth caused by the obstruction was from 0.7 to 0.8 foot. Difference in depths indicated by the Momentum Method was greater, shown by the curves to be 1.3 feet, and is on the conservative side.

The water surface profile, above and below bridges, can be computed by the standard step method, as described in a report "Technical Memorandum - Water Surface Computation in Open Channels" by R. F. Wong, Los Angeles District Corps of Engineers, and also given in King's Handbook of Hydraulics.

MOMENTUM LOSSES AT BRIDGES

Project: Bull Creek Channel | Locality: Bridges over channel

Q = 5,000 c.f.s. | Sheet 1 of 1 | By R.M.J. | Date February 1953



d	$A_1 = A_3$	$M_1 = M_3$	A_0	M_0	$A_1 - A_0$	$M_1 - M_0$ (1)	$\frac{Q^2}{g(A_1 - A_0)}$ (2)	$\frac{Q^2}{g A_1^2}$	$\frac{Q^2 (A_1 - A_0)}{g A_1^2}$ (3)	$\frac{Q^2}{g A_3}$ (4)	I (1) + (3)	II (1) + (2)	III (1) + (4)
4	92	165	6.0	12.0	86	154	9028	92	7889	8440	8043	9182	8594
5	124	274	7.5	18.8	116	255	6664	50	5908	6261	6163	6919	6516
6	159	413	9.0	27.0	150	386	5176	31	4607	4883	4993	5562	5269
7	198	592	10.5	36.8	187	555	4141	20	3723	3921	4278	4696	4476
8	240	811	12.0	48.0	228	763	3405	13.5	3073	3235	3836	4168	3998
9	286	1075	13.5	60.8	272	1014	2849	9.5	2591	2715	3605	3863	3729
10	335	1384	15.0	75.0	320	1309	2426	6.9	2214	2318	3523	3735	3627
11	388	1746	16.5	90.8	371	1655	2090	5.2	1924	2001	3556	3745	3656
12	444	2158	18.0	108	426	2050	1825	3.9	1680	1749	3730	3875	3799
13	504	2636	19.5	126.8	484	2509	1602	3.1	1482	1540	3991	4111	4049

M_1 = Static moment in unobstructed channel

M_0 = Static moment of obstruction

$M_1 - M_0$ = Static moment in obstructed channel

$$\underbrace{M_1 - M_0 + \frac{Q^2}{g A_3}}_{III} = \underbrace{M_1 - M_0 + \frac{Q^2}{g (A_1 - A_0)}}_{II} = \underbrace{M_1 - M_0 + \frac{Q^2 (A_1 - A_0)}{g A_1^2}}_{I}$$

$\frac{Q^2}{g (A_1 \quad A_2}$ = Kinetic momentum in obstructed channel

$\frac{Q^2}{g A_1}$ = Kinetic momentum in unobstructed channel

$\frac{A_0 \quad Q^2}{g \quad A_1^2}$ = Kinetic momentum lost

Figure 3

M-2181-38

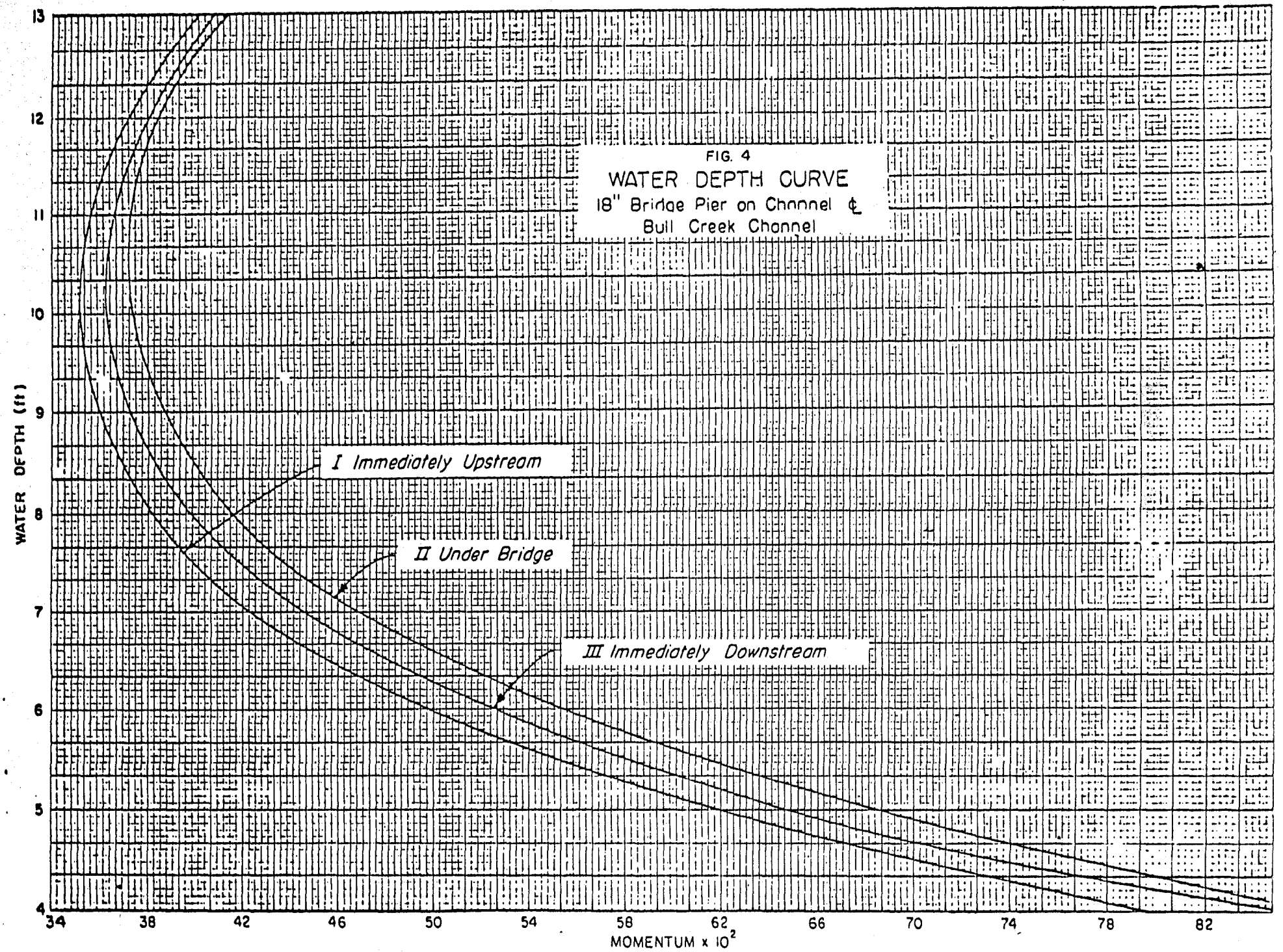


FIG. 4
WATER DEPTH CURVE
18" Bridge Pier on Channel ℄
Bull Creek Channel
I Immediately Upstream
II Under Bridge
III Immediately Downstream
WATER DEPTH (ft)
MOMENTUM x 10²
13
12
11
10
9
8
7
6
5
4
34
38
42
46
50
54
58
62
66
70
74
78
82

DESIGN CRITERIA

FLOOD CONTROL DISTRICT OF MARICOPA COUNTY
RWCD FLOODWAY BRIDGES
BASELINE AND ELLIOT ROADS

DESIGN CRITERIA

I. GENERAL

The design criteria is divided into two sections corresponding to civil and structural design disciplines. Upon acceptance by the County, the criteria contained herein will be used as the basis for final design for this project.

II. CIVIL

A. Design Specifications

To conform with the design criteria stated in this section, certain design elements (such as sight distance, cross slope, and vertical alignment) must be incorporated into the design. The guidelines for applying the design elements to the criteria are taken from the following sources:

1. Horizontal and vertical alignments - the 1973 AASHTO publication "A Policy on Design of Urban Highways and Arterial Streets" and supplemented by ADOT 1979 Roadway Standards.

2. Drainage - ADOT Hydrologic Design for Highway Drainage in Arizona.

3. Traffic control - ADOT Traffic Control Manual for Highway Construction and Maintenance, and the Federal Highway Administration Manual on Uniform Traffic Control Devices.

B. Construction Specifications

Specifications shall be in accordance with MAG Specifications, 1979 Edition, as supplemented by Maricopa County. ADOT, Maricopa County Highway Department and City of Phoenix Standard Drawings will be used where appropriate.

C. Design Criteria

1. Design speed.

   a. Ultimate Roadway Development - 65 mph.

   b. Intermediate Roadway Development

      (1) RWCD Canal Bridge replaced - 55 mph.

      (2) RWCD Canal Bridge not replaced -
      Baseline Rd. - 30 mph.
      Elliot Rd. - 25 mph.

   c. Detour - 30 mph (desirable), 25 mph (minimum).

2. Access Control - Existing access to abutting properties will be maintained as is. If required, temporary access during construction will be provided via the detour roadway.

3. Design Vehicle - The design vehicle used for the purpose of establishing geometric highway design controls will be the large semitrailer combination (WB-50).

4. Vertical Alignment.

   a. Maximum grade, Main Roadway - 3%.

   b. Maximum grade, Detour Roadway - 6%.

5. Drainage - Drainage design will conform to the criteria and methods outlined in the ADOT Hydrologic Design for Highway Drainage in Arizona.

   a. Design Storm Frequency for approaches - 50 year return frequency.

   b. Design Storm Frequency for detour - 10 year return frequency.

6. Roadway Section.

   a. Roadway widths - 68 feet wide clear roadway on bridge and approach slabs on Baseline Road. 50 feet wide clear roadway on bridge and approach slab on Elliot Road.

   b. Hiking and riding path - To be 8 feet wide and separated from vehicular traffic by concrete barrier, on bridge structure only. Elsewhere the earth shoulder outside pavement section on the south side will be utilized.

   c. Curb type - New Jersey barrier curb on bridge structure adjacent to outside traffic lanes. Outer edge of structure adjacent to hiking and riding path will be constructed with a chain link fence barrier.

   d. Roadway Transitions -

      (1) West side - from end of concrete bridge approach slab to connect with existing RWCD Canal bridge.

      (2) East side - from end of concrete bridge approach slab to a point where vertical alignment matches existing pavement sections.

   e. Cross slope - 2% typical in accordance with request of Maricopa County Highway Department.

   f. Sideslopes - In accordance with Maricopa County Highway Department Standards and recommendations.

   g. Pavement section - In accordance with Maricopa County Highway Department Standards and recommendations.

h. Detour Roadway - To match existing pavement edges at ends, and be constructed with a pavement width of 28 feet; pavement section = 2"A.C. over 6" A.B.C.; superelevation = 8% maximum.

7. Floodway Section.

a. Ultimate floodway development

(1) Normal channel bottom width 140 ft. at Baseline Road and 150 ft. at Elliot Road.

(2) Design high water - Elevation 1335.4 at Baseline Road and Elevation 1329.2 at Elliot Road.

(3) Freeboard - 1.5 ft. minimum clearance between bridge soffit and design high water.

(4) Channel side slopes - 2:1 at bridge with 100 ft. transition up and downstream from bridge to 3:1 sideslopes of normal floodway section.

b. Intermediate floodway development

Rechannel existing drainage way thru new bridge and maintain approximate existing drainage topography. Assumes that ultimate floodway section will be developed thru new bridge during future construction of floodway.

III. STRUCTURAL

A. Structure

The bridges will be reinforced concrete structures with continuous span slabs of the type covered by Arizona Department of Transportation (ADOT) Standard Number CS-20. The ADOT standard provides details for intermediate spans ranging from 25'-0" to 40'-0" in 5'-0" increments, and slab thicknesses ranging from 13½ inches to 19½ inches in 2-inch increments for each of the respective span lengths. End span lengths are in each case approximately 81% of the intermediate span length, end span lengths ranging from 20'-6" to 32'-6" in 4'-0" increments. If the bridge lengths and number of spans dictate the use of spans of some other length falling between the standard lengths, the slab thickness and steel reinforcement will be adjusted proportionally.

B. Design Specifications

The design shall be in accordance with Division I of the American Association of State Highway and Transportation Officials (AASHTO) "Standard Specifications for Highway Bridges", 1977 Edition, and the 1978 and 1979 Interim Specifications, except as modified herein.

1. The Working Stress Design method shall be used.

2. For the bridge deck slab the minimum clear concrete cover over bottom reinforcement is one inch. Otherwise the minimum clear concrete cover over reinforcement is two inches, except when concrete is deposited on or against earth, the minimum clear concrete cover is three inches.

3. Reinforcing steel is required in both faces and in both (orthogonal) directions in all concrete slabs and walls, except that only one grid of reinforcing is required in concrete linings of trapezoidal channels. This steel serves either as principal reinforcement or as temperature and shrinkage reinforcement. The minimum steel area for slabs and walls having the thickness equal to or less than 16 inches in each face and in each direction, expressed as the ratio (p_t) of reinforcement area (A_s) to gross concrete area (bt), are as follows:

   a. The steel in the direction in which the distance between expansion or contraction joints does not exceed thirty feet,

      p_t = 0.002 in the exposed face

      p_t = 0.001 in the unexposed face

   b. The steel in the direction in which the distance between expansion or contraction joints exceeds thirty feet,

      p_t = 0.003 in the exposed face

      p_t = 0.002 in the unexposed face

   The minimum steel area for slabs and walls having thicknesses greater than 16 inches shall be computed as though the thickness were 16 inches.

C. Construction Specifications

Construction shall be in accordance with the Maricopa Association of Governments "Uniform Standard Specifications for Public Works Construction", 1979 Edition, as supplemented by Maricopa County, with Special Provisions as required.

D. Design Loads

1. General - The design loads and loading combinations shall be in accordance with Division I of the American Association of State Highway and Transportation Officials (AASHTO) "Standard Specifications for Highway Bridges", 1977 Edition, and the 1978 and 1979 Interim Specifications, Sections 2 and 3.

2. Dead Load - In addition to the weight of the structure, provision shall be made for a future wearing surface of 25 pounds per square foot of roadway.

   Utility loads will be included as applicable.

   The weight of future wearing surface and other superimposed dead loads shall be distributed uniformly over the entire width of the superstructure slab.

3. Live Load - The basic vehicle live load shall be the AASHTO HS20-44 loading.

   The live load distribution shall be in accordance with AASHTO Article 1.3.2(C), Case B: $E=4+0.06S$. In this formula E is the effective slab width, in feet, over which a wheel load is distributed, and S is the effective end span length, in feet.

4. Earth Pressure - Structures which retain earth fills shall be proportioned to withstand an equivalent fluid pressure of 35 psf/ft. minimum.

5. Lateral Load - Lateral loads shall be applied in accordance with the AASHTO Specifications. Earthquake forces shall be applied in accordance with AASHTO Article 1.2.20(A) by the Equivalent Static Force Method, Zone 2, assuming the depth of alluvium to rock-like material to be between 11 and 80 feet.

E. Materials and Allowable Stresses

1. Concrete - All concrete shall be MAG Class A with minimum strength $f'_c=3,000$ psi, $f_c=1,200$ psi, and $n=9$.

2. Reinforcing Steel - All reinforcing steel shall conform to ASTM A615 Grade 40, $f_s=20,000$ psi.

F. Substructure

The final choice of foundation will be made between a drilled shaft concrete caisson system and driven steel H-piles, based on economic and practical considerations, with design capacities and foundation depths according to the soils and foundation investigation report prepared by Halpert Associates, Consulting Site and Geotechnical Engineers.

G. Miscellaneous Installations

1. Deck Drainage - Roadway drains shall accommodate a 10-year frequency rainfall with 100-percent runoff in five minutes. ADOT standard roadway drains shall be spaced to restrict the flow of water to an area within 8 feet of the curbs. Roadway drains will drop water directly to the floodway below.

2. Utilities - Provision shall be made for transporting utilities on the structure as required.

3. Chain-Link Fence - Material for chain-link fence shall conform to the requirements of ADOT "Standard Specifications for Road and Bridge Construction", 1969 Edition, plus Supplemental Specifications revised to date, Section 723.

BRIDGE FOUNDATION

TYPE STUDY

SVERDRUP & PARCEL

JOB 6784 FCDMC

COMPUTATIONS FOR Baseline

SHEET NO. 1 OF

DATE Feb 80

BY JFF CHKD WEG 2/15/80

Baseline Rd. Bridge Selection

Minimum Bridge Length = 186'-6" c. to c. Abut. Brgs.

Based on: minimum channel width = 140' (normal)

side slopes @ 2:1

depth to soffit = 17'2" + 1.5' freeboard

skew 22°30'00"

Superstructure –

Use superstr. similar to ADOT Standard No. CS-20

$$\text{ADOT span ratio} = \frac{\text{Intermediate Span}}{\text{End Span}} = \frac{35}{28.5} = 1.228$$

Say 6 spans

$$\text{"Exact" End Span} = \frac{186.5'}{2+4(1.228)} = 26.98'$$

$$\text{"Exact" Intermediate Span} = 1.228 \times 26.98' = 33.13'$$

Round span lengths to nominal distance, say 2 @ 26'-9"
4 @ 33'-3"

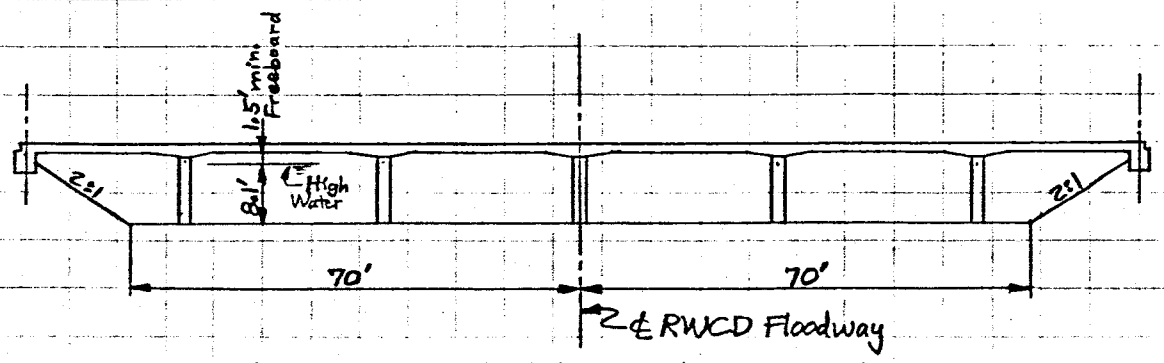
Overall Length = 186'-6"

$$\text{Span Ratio} = \frac{33.25}{26.75} = 1.243$$

$$\frac{1.243}{1.228} = 1.012, \text{ or } 1.2\%$$

over "best" ratio

Use: 26'-9" / 33'-3" / 33'-3" / 33'-3" / 33'-3" / 26'-9"



LONGIT. SECT. NORMAL TO ℄ FLOODWAY

SVERDRUP & PARCEL

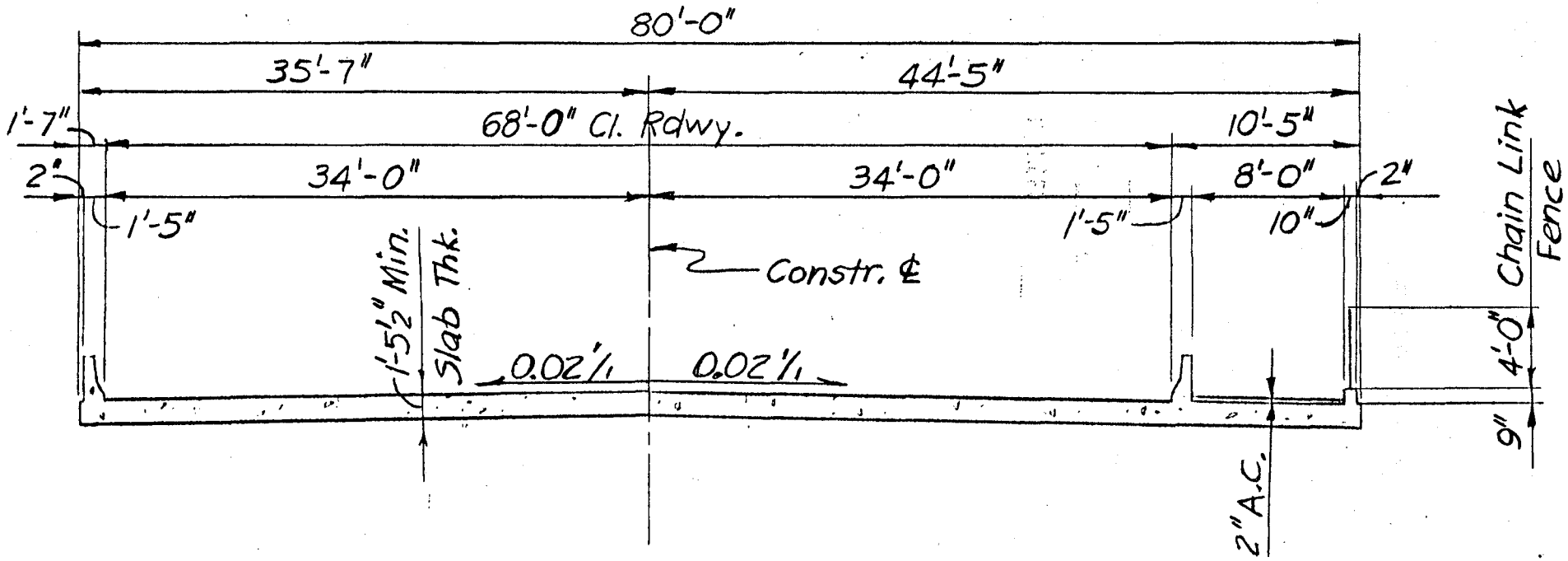
JOB 6784 FCDMC

COMPUTATIONS FOR Baseline Rd. Br.

SHEET NO. 2 OF

DATE Feb 80

BY JFF CHKD WEG 2/25/80



TYPICAL CROSS SECTION

Scale: 1" = 10'-0"

SVERDRUP & PARCEL

JOB 6784 FCDMC

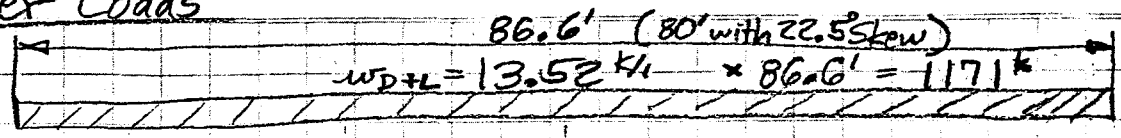
SHEET NO. 3 OF

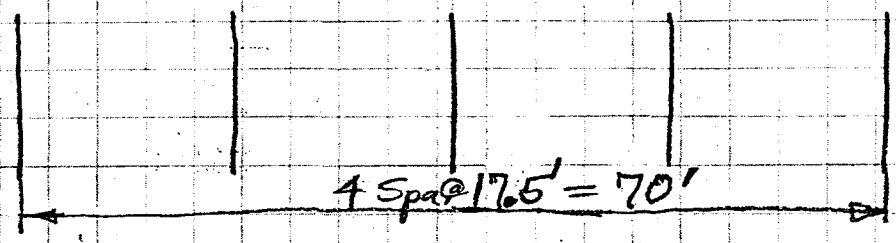
DATE Feb 80

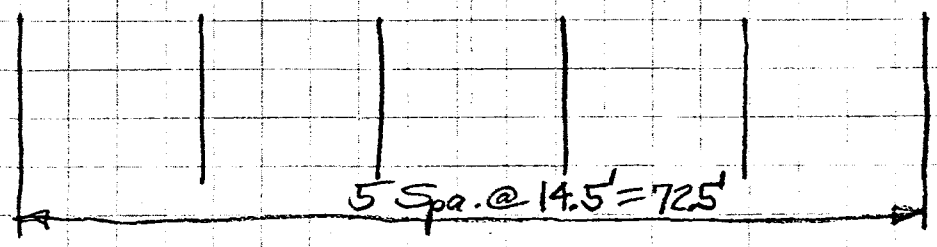
COMPUTATIONS FOR Baseline

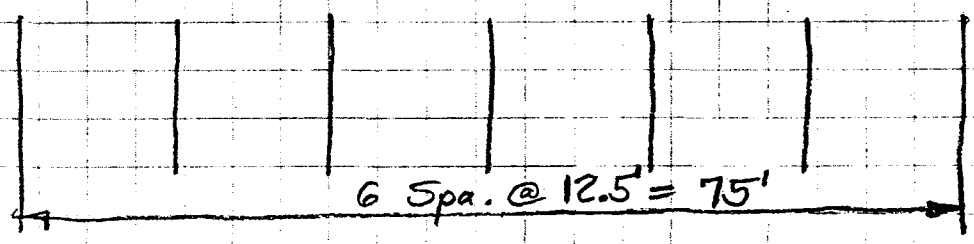
BY JFF CHKD WEG 2/25/80

Pier Loads









No. Cols.	Approx. Col. Ld.	Approx. Max. Cap Beam Moments Positive ($.08wL^2$)	Negative ($-.12wL^2$)	Approx. Max. Cap Beam Shear
5	234 k	331 'k	-497	117 k
6	195	227	-341	98
7	167	169	-254	84

SVERDRUP & PARCEL

JOB 6784 FCDMC

COMPUTATIONS FOR Baseline

SHEET NO. 4 OF

DATE Feb 80

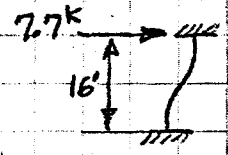
BY JFF CHKD WEG 2/25/80

24"φ Col. Capacity For Piers

Assume 7 Cols. 24"φ $A_g = 452^{in^2}$

$EQ \approx .07 \times \frac{8.88^{k/1}}{13.52^{k/1}} \times 167^k = 7.7^k/Col.$

Col. Length ≈ 1335.4 + 2.5 − 1327.3 + 5 = 15.6', use 16'



$M = \frac{VL}{2} = \frac{7.7 \times 16}{2} = 62'^k$ $P = \frac{7.7}{.07} = 110^k$

$\frac{P}{f'_c A_g} = \frac{110}{3 \times 452} = 0.081$ $\frac{M}{f'_c t A_g} = \frac{62}{3 \times 2 \times 452} = 0.0229$

From ACI SP-3, Diagram 37a, $f'_c = 3{,}000$ psi, $f_y = 40{,}000$ psi

$g = 0.7$, page 185:

Req'd. $\rho_g = 0.012 << .08$

Use 24"φ Cols. For Piers

Consider 2 Types of Foundation: Drilled Shafts & Steel H-Piles

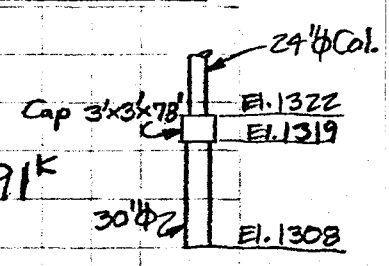
Drilled Shafts For Piers

Top Elev. 1319.0

Use 30"φ, Tip Elev. 1308.0

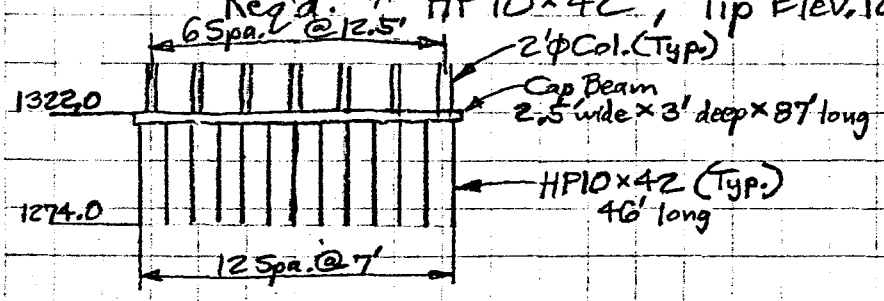
Load = 167k from superstr. + 24k col. & pile cap = 191k

Capacity = 245k > 191k, Ok



Steel H-Piles For Piers

Req'd. # HP10×42; Tip Elev. 1274 = 1171k / 120k/pile = say 13 piles @ 7' Spcg.



SVERDRUP & PARCEL

JOB 6784 FCDMC

COMPUTATIONS FOR Baseline

SHEET NO. 5 OF

DATE Feb 80

BY JFF CHKD WEG 2/25/80

Drilled Shafts For Abuts.

Use 24"Φ, Top Elev. 1334.0, Tip Elev. 1308.0 } 26'

Capacity = 170^k

Uniform w_{DL} (17½" slab + FWS + SDL) = 2.91$^{k/1}$ × cos 22.5° = 2.69$^{k/1}$

Uniform w_{LL} ≈ 46^k × cos 22.5°/12' = 3.54

6.23$^{k/1}$

Cap Bm w_{DL} = 2.9' × 3' × .15^{kcf} = 1.31$^{k/1}$

w_{D+L} = 7.54$^{k/1}$

Total Reaction D+L = 7.54$^{k/1}$ × 86.6' = 653^k

Req'd. # 24"Φ = 653/170 = 3.84

Use 7 - 24"Φ
(all vertical)

Steel H-Piles For Abuts.

Req'd. # of HP 10×42 with Tip Elev. 1290 = 653^k/86$^{k/pile}$
= 7.59

Use 9 piles @ 10' Spcg.
(all piles vertical)

Length = 1336 − 1290 = 46' each

SVERDRUP & PARCEL

JOB 6784 FCDMC

COMPUTATIONS FOR Baseline

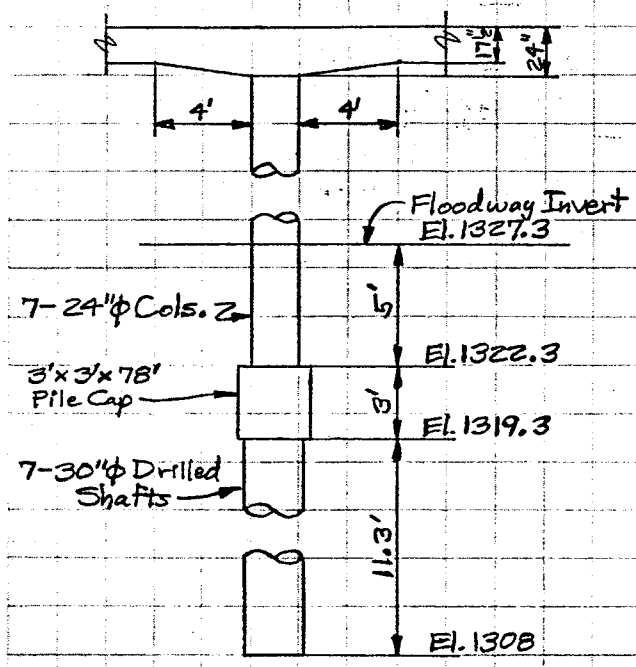
SHEET NO. 6 OF

DATE Feb 80

BY JFF CHKD WEG 2/25/80

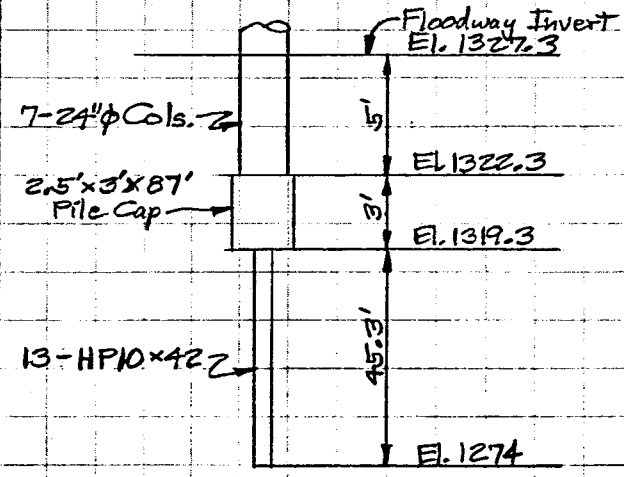
Substructure Types For Cost Comparison (Assumed dimensions for estimate of quantities)

Piers on Drilled Shafts

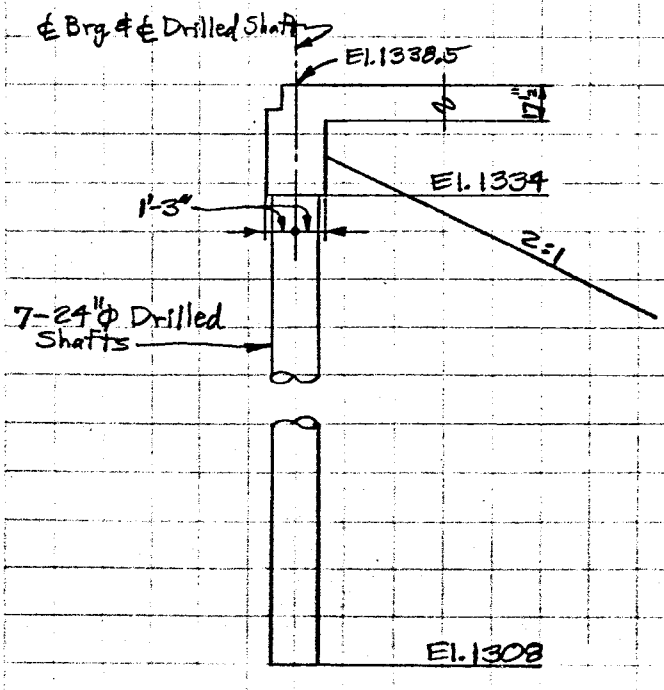


Piers on Steel H-Piles

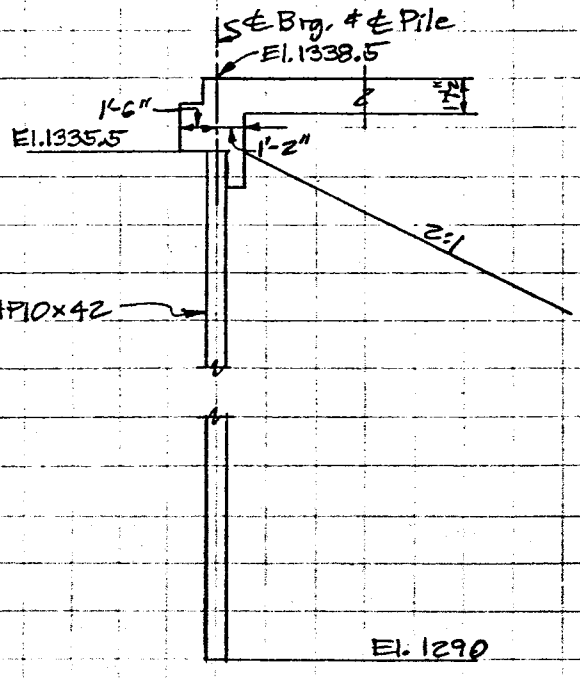
Top of Col. Same as For Piers on Drilled Shafts



Abuts. on Drilled Shafts



Abuts. on Steel H-Piles



SVERDRUP & PARCEL

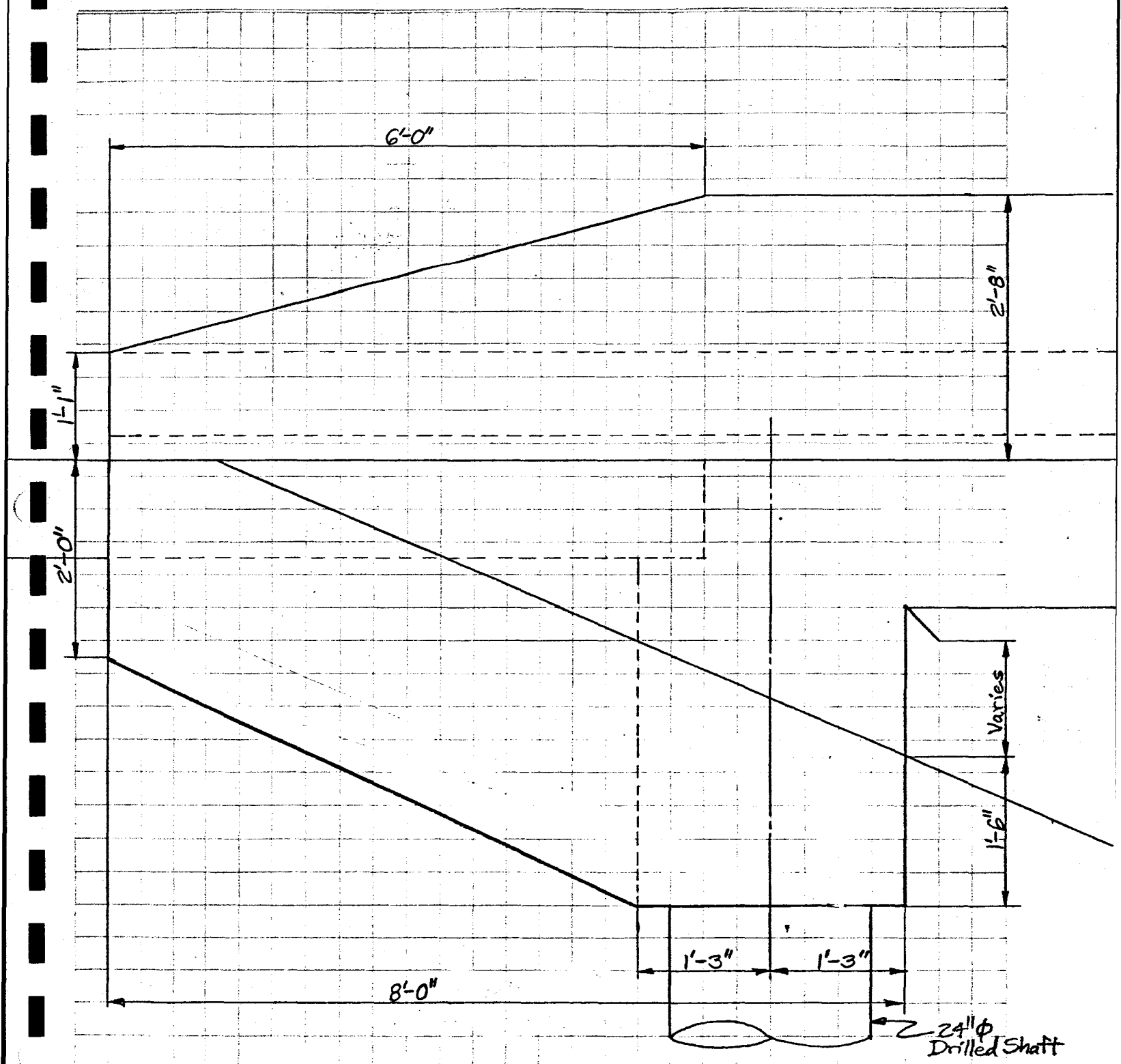
JOB 6784 FCDMC

COMPUTATIONS FOR Baseline & Elliot

SHEET NO. 7 OF

DATE Feb 80

BY VFF CHKD WEG 4/25/80



ELEVATION

Note: Horiz. dims. measured parallel to ℄ bridge.
Abut. on H-Piles similar.

SVERDRUP & PARCEL

JOB 6784 FCDMC

COMPUTATIONS FOR Baseline

SHEET NO. 8 OF

DATE Feb 80

BY JFF CHKD WEG 2/25/80

Prelim. Cost Estimate

For Sept. '80 (Midway thru 6 mo. constr. period from July thru Dec. '80)

For Piers on Steel H-Piles — Abuts. — Concrete 29.1 cu.yd. × $205 = $5,970
Re-Stl. 3,640 lb. × 0.40 = 1,460
H-Piles 414 lin.ft. × 42 = 17,390
Excavation 30.9 cu.yd. × 12 = 370
Backfill 18.5 cu.yd. × 6 = 110
$25,300

Piers — Concrete 36.1 cu.yd. × 205 = $7,400
Re-Stl. 12,515 lb. × 0.40 = 5,010
H-Piles 598 lin.ft. × 42 = 25,120
Excavation 306.2 cu.yd. × 12 = 3,670
Backfill 270.8 cu.yd. × 6 = 1,620
$42,820

Superstr. — Concrete 938.4 cu.yd. × 265 = $248,680
Re-Stl. 172,100 lb. × 0.40 = 68,840
Asph. Conc. 20.4 tons × 21 = 430
Chain-Link F. 202 lin.ft. × 16 = 3,230
$321,180

Approach Slabs —
2(6.5' × 8' + 15' × 68') × $13.40/□' = $28,700

Summary For Foundation on Driven Steel H-Piles:

2 Abuts.	@ $25,300 =	$ 50,600
5 Piers	@ $42,820 =	214,100
Superstr.		321,180
2 Appr. Slabs		28,700
		$614,580
	say	$615,000

÷ (80' × 186.5') = $41.22/□'

SVERDRUP & PARCEL

JOB 6784 FCDMC

COMPUTATIONS FOR Baseline

SHEET NO. 9 OF

DATE Feb. 80

BY JFF CHKD WEG 2/25/80

Prelim. Cost Est. (cont'd.)

For Piers on CIP Conc. Drilled Shafts —

Abuts. – Concrete	38.0 cu. yd.	× $205	=	$7,790
Re.-Stl.	4,750 lb.	× 0.40	=	1,900
24"φ Drilled Shafts	182 lin. ft.	× 40	=	7,280
Excavation	39.8 cu. yd.	× 12	=	480
Backfill	23.9 cu. yd.	× 6	=	140
				$17,590

Piers – Concrete	37.9 cu. yd.	× 205	=	$7,770
Re.-Stl.	12,740 lb.	× 0.40	=	5,100
30"φ Drilled Shafts	79.1 lin. ft.	× 45	=	3,560
Excavation	300.6 cu. yd.	× 12	=	3,610
Backfill	262.7 cu. yd.	× 6	=	1,580
				$21,620

Superstr. – same as for steel H-Piles = $321,180

Approach Slabs – same as for steel H-Piles = $28,700

Summary For Foundation on Cast-in-Place Concrete Drilled Shafts:

2 Abuts.	@ $17,590	=	$35,180
5 Piers	@ $21,620	=	108,100
Superstr.			321,180
2 Approach Slabs			28,700
			$493,160

say $493,000

÷ (80' × 186.5') = $33.04/□'

SVERDRUP & PARCEL

JOB 6784 FCDMC

COMPUTATIONS FOR Elliot

SHEET NO. 10 OF

DATE Feb 80

BY JFF CHKD WEG 2/25/80

Elliot Rd. Bridge Selection

Minimum Bridge Length = 199'-0" c. to c. Abut. Brgs.

Based on: minimum channel width = 150'

side slopes @ 2:1

depth to soffit = 17'2" + 1.5' freeboard

no skew

Superstructure –

Use superstr. similar to ADOT Standard No. CS-20

$$\text{ADOT span ratio} = \frac{\text{Intermediate Span}}{\text{End Span}} = \frac{35}{28.5} = 1.228$$

Say 6 spans

$$\text{"Exact" End Span} = \frac{199'}{2+4(1.228)} = 28.79'$$

$$\text{"Exact" Intermediate Span} = 1.228 \times 28.79' = 35.36'$$

Round span lengths to nominal distance, say 2 @ 28'-6"

4 @ 35'-6"

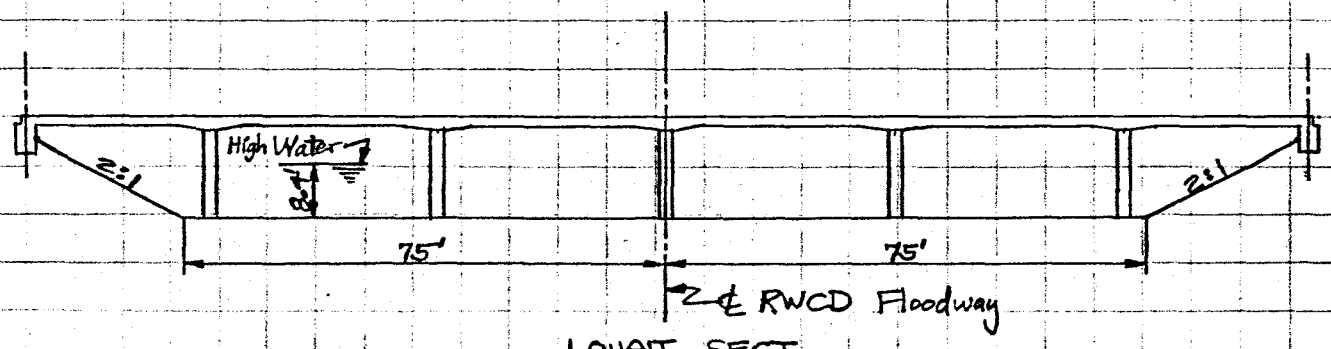
Overall Length = 199'-0"

$$\text{Span Ratio} = \frac{35.5}{28.5} = 1.246$$

$$\frac{1.246}{1.228} = 1.015, \text{ or } 1.5\%$$

over "best" ratio

Use: 28'-6" / 35'-6" / 35'-6" / 35'-6" / 35'-6" / 28'-6"



LONGIT. SECT.

SVERDRUP & PARCEL

JOB 6784 FCDMC

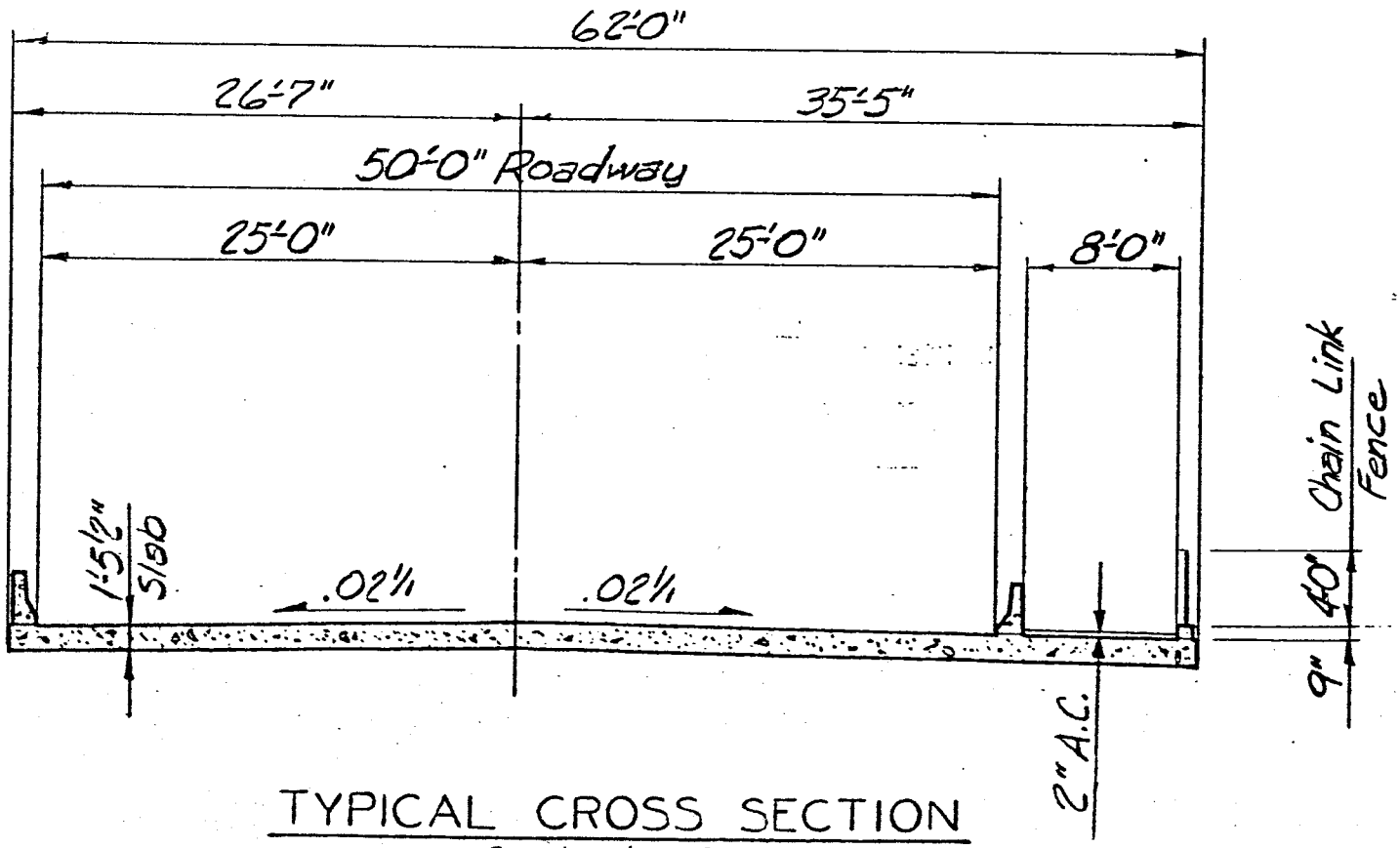
COMPUTATIONS FOR Elliot

SHEET NO. 11 OF

DATE Feb 80

BY JFF CHKD WEG 2/25/80

Elliot Rd.



TYPICAL CROSS SECTION

Scale: 1" = 10'

SVERDRUP & PARCEL

JOB 6784 FCDMC

COMPUTATIONS FOR Elliot

SHEET NO. 12 OF

DATE Feb 80

BY JFF CHKD WEG 2/25/80

Elliot Rd.

Bridge length = 199.00' c. to c. Brg. @ Abuts.

Use span lengths:

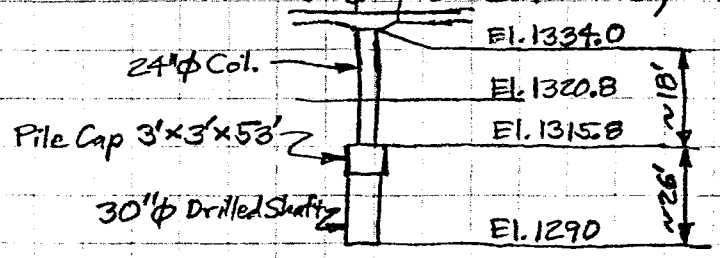
28.5' + 4 @ 35.5' + 28.5' = 199.00'

Use same design as for Baseline Rd., adjust quantities & cost estimate.

Drilled Shafts – For Piers:

For 24"φ pier columns, Use 30"φ Drilled Shafts

5 Cols. & Shafts @ 12.5' Spcg.



For Abuts.: Total reaction D+L = 7.26 k/l × 62' = 450k

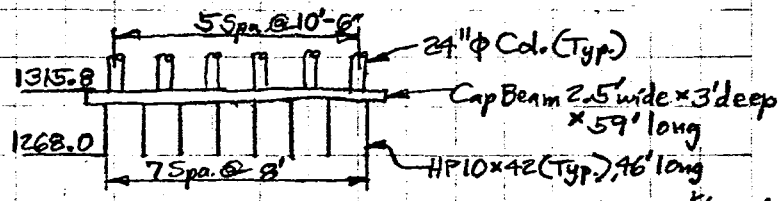
Use 24"φ, Top El. 1331, Tip El. 1290

Capacity = 160k ±

Req'd. # = 450/160 = 2.81

Use 5 – 24"φ (vertical)

Steel H-Piles – For Piers:



Req'd. # of HP10×42, Tip El. 1268 = $\frac{13.52^{k/l} \times 62'}{110^{k/pile}}$

= say 8 piles @ 8' Spcg., 46' long

For Abuts.: Top El. 1332 – 46' = Tip El. 1286

Capacity of HP10×42 with Tip El. 1286 = 70k/pile

Req'd. # of HP10×42 = 450k / 70k/pile = 6.43

Use 7 piles @ 10' Spcg., 46' long

(all piles vertical)

SVERDRUP & PARCEL

JOB 6784 FCDMC

COMPUTATIONS FOR Elliot

SHEET NO. 13 OF

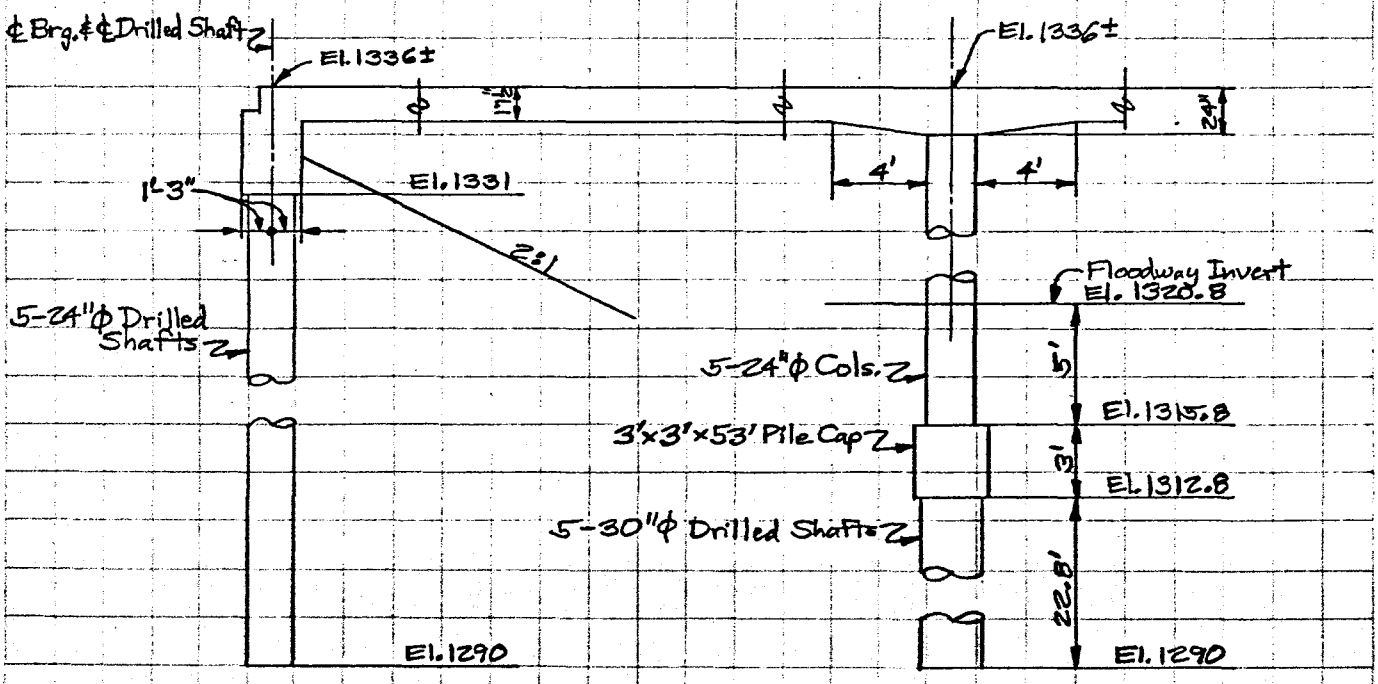
DATE Feb 80

BY JFF CHKD WEG 2/25/80

Substructure –

Based on prelim. design on preceding sheet, loads & substructure quantities are proportional to those for bridge @ Baseline Rd. Therefore, cast-in-place concrete drilled shafts will be more economical than steel H-piles @ Elliot Rd. also. Only will calculate quantities & cost estimate for drilled shafts @ Elliot Rd.

Assumed dimensions for estimate of quantities:



BUDGET CONSTRUCTION

COST ESTIMATE

SVERDRUP & PARCEL
CONSTRUCTION COST ESTIMATE

PAGE ____ SHEETS THIS SET 5

SHEET 1

JOB NO. 6784 CLIENT FCDMC

PROJECT Baseline Rd. Bridge Over RWCD Floodway

PHASE OR DIVISION

BASIS FOR ESTIMATE
- ☐ NO DESIGN COMPLETED
- ☑ PRELIMINARY DESIGN
- ☐ FINAL DESIGN
- ☐

OFFICE Phx. SECTION BY JFF CHKD WEG DATE 2-25-80

	DESCRIPTION	QUANTITY NO. UNITS	QUANTITY UNIT MEAS.	~~MATERIAL OR EQUIPMENT~~ PER UNIT	~~MATERIAL OR EQUIPMENT~~ COST	MAT'L.+LABOR ~~OR LUMP SUM OR SUBCONTRACT~~ PER UNIT	MAT'L.+LABOR ~~OR LUMP SUM OR SUBCONTRACT~~ COST	TOTAL COST
1	Structural-Baseline Rd.							
2	Reinf. Steel, Grade 40	245,300	LB.			$ 0.40		$98,100
3	Drilled Shafts, 24"ϕ	364	L.F.			40.00		14,600
4	Drilled Shafts, 30"ϕ	396	L.F.			45.00		17,800
5	Structural Excavation	1,580	C.Y.			12.00		19,000
6	Structural Backfill	1,360	C.Y.			6.00		8,200
7	Chain-Link Fence, 4 ft.	202	L.F.			16.00		3,200
8	Asphaltic Concrete	20.4	TONS			21.00		400
9	Approach Slabs	1	L.S.					28,700
10	Substr. Concrete, f'_c=3,000 psi	265	C.Y.			205.00		54,300
11	Superstr. Concrete, f'_c=3,000 psi	940	C.Y.			265.00		249,100
12								
13	Baseline Rd. Structural Sub-Total							$493,400
14								
15								
16								
17								
18								
19								
20								

MAT'L. $ ____ LABOR $ ____ TOTALS THIS SHEET

EQUIP. $ ____ L. SUM $ ____

SUB C. $ ____ $ ____

SVERDRUP & PARCEL
CONSTRUCTION COST ESTIMATE

PAGE ____ SHEETS THIS SET 5

SHEET 2

JOB NO. 6784 CLIENT Flood Control District Maricopa County

PROJECT RWCD Floodway @ Baseline Road

PHASE OR DIVISION ____

BASIS FOR ESTIMATE
- ☐ NO DESIGN COMPLETED
- ☒ PRELIMINARY DESIGN
- ☐ FINAL DESIGN
- ☐

OFFICE PHX SECTION Civil BY STR CHKD WEG DATE 2/25/80

	DESCRIPTION	QUANTITY NO. UNITS	QUANTITY UNIT MEAS.	MATERIAL OR EQUIPMENT PER UNIT	MATERIAL OR EQUIPMENT COST	LABOR OR LUMP SUM OR SUBCONTRACT PER UNIT	LABOR OR LUMP SUM OR SUBCONTRACT COST	TOTAL COST
1	Remove Conc. Headwalls	12	CY				60.00	720 —
2	Relocate Ditches	1545	CY				3.00	4635 —
3	Detour & Approach Embankments	3600	CY				5.25	18900 —
4	Road Base - ABC	3900	SY				6.00	23400 —
5	Road Surface - AC	3900	SY				5.25	20475 —
6	48" ϕ Pipe Culverts	130	LF				50.00	6500 —
7	Remove AC Pvmt	1800	SY				2.25	4050
8								
9								78680 —
10	General Conditions & Mobilization							28620
11								107,300
12								
13								
14								
15								
16								
17								
18								
19								
20								

MAT'L. $ ____ LABOR $ ____ TOTALS THIS SHEET

EQUIP. $ ____ L. SUM $ ____

SUB C. $ ____ $ ____

SVERDRUP & PARCEL
CONSTRUCTION COST ESTIMATE

PAGE ____ SHEETS THIS SET 5

SHEET 3

JOB NO. 6784 CLIENT FCDMC

PROJECT Elliot Rd. Bridge Over RWCD Floodway

PHASE OR DIVISION ____

BASIS FOR ESTIMATE
- ☐ NO DESIGN COMPLETED
- ☑ PRELIMINARY DESIGN
- ☐ FINAL DESIGN
- ☐

OFFICE Phx. SECTION Structural BY JFF CHKD WEG DATE 2-25-80

	DESCRIPTION	QUANTITY NO. UNITS	QUANTITY UNIT MEAS.	~~MATERIAL OR EQUIPMENT~~ PER UNIT	~~MATERIAL OR EQUIPMENT~~ COST	MAT'L+LABOR ~~OR LUMP SUM OR SUBCONTRACT~~ PER UNIT	MAT'L+LABOR ~~OR LUMP SUM OR SUBCONTRACT~~ COST	TOTAL COST
1	Structural-Elliot Rd.							
2	Reinf. Steel, Grade 40	195,400	LB.			$ 0.40		$ 78,200
3	Drilled Shafts, 24"ϕ	410	LF.			40.00		16,400
4	Drilled Shafts, 30"ϕ	575	LF.			45.00		25,900
5	Structural Excavation	1,270	C.Y.			12.00		15,200
6	Structural Backfill	1,100	C.Y.			6.00		6,600
7	Chain-Link Fence, 4 ft.	213	L.F.			16.00		3,400
8	Asphaltic Concrete	21.5	TONS			21.00		500
9	Approach Slabs	1	L.S.					21,500
10	Substr. Concrete, f'_c=3,000 psi	205	C.Y.			205.00		42,000
11	Superstr. Concrete, f'_c=3,000 psi	760	C.Y.			265.00		201,400
12								
13		Elliot	Rd.	Structural		Sub-	Total	$ 411,100
14								
15								
16								
17								
18								
19								
20								

MAT'L. $ ____ LABOR $ ____ TOTALS THIS SHEET

EQUIP. $ ____ L. SUM $ ____

SUB C. $ ____ $ ____

SVERDRUP & PARCEL
CONSTRUCTION COST ESTIMATE

PAGE _____
SHEETS THIS SET 5
SHEET 4

JOB NO. 6784 CLIENT Flood Control District Maricopa County

PROJECT RWCD Floodway @ Elliot Road

PHASE OR DIVISION _____

BASIS FOR ESTIMATE
- ☐ NO DESIGN COMPLETED
- ☒ PRELIMINARY DESIGN
- ☐ FINAL DESIGN
- ☐

OFFICE PHX SECTION Civil BY JTR CHKD WEG DATE 2/25/80

	DESCRIPTION	QUANTITY NO. UNITS	QUANTITY UNIT MEAS.	MATERIAL OR EQUIPMENT PER UNIT	MATERIAL OR EQUIPMENT COST	LABOR OR LUMP SUM OR SUBCONTRACT PER UNIT	LABOR OR LUMP SUM OR SUBCONTRACT COST	TOTAL COST
1	Remove Conc Headwalls	22	CY				60.00	1320 —
2	Remove Pipes - 36"ϕ & Smaller	50	LF				30.00	1500 —
3	Relocate Ditches	1105	LF				3.00	3315 —
4	Detour & Approach Embankments	1900	CY				5.25	9975 —
5	Road Base - ABC	3200	SY				6.00	19200 —
6	Road Surface - AC	3200	SY				5.25	16800 —
7	48"ϕ Pipe Culverts	160	LF				50.00	8000 —
8	Remove AC Pvm't	1700	SY				2.25	3825 —
9								
10								63935
11	General Conditions & Mobilization							23765
12								87,700
13								
14								
15								
16								
17								
18								
19								
20								

MAT'L. $ _____ LABOR $ _____ TOTALS THIS SHEET

EQUIP. $ _____ L. SUM $ _____

SUB C. $ _____ $ _____

SVERDRUP & PARCEL
CONSTRUCTION COST ESTIMATE

PAGE _____ SHEETS THIS SET 5

SHEET 5

JOB NO. 6784 CLIENT FCDMC

PROJECT Baseline Rd. & Elliot Rd. Bridges Over RWCD Floodway

PHASE OR DIVISION _____

BASIS FOR ESTIMATE
- ☐ NO DESIGN COMPLETED
- ☑ PRELIMINARY DESIGN
- ☐ FINAL DESIGN
- ☐

OFFICE Phx SECTION _____ BY JFF CHKD WEG DATE 2-25-80

	DESCRIPTION	QUANTITY NO. UNITS	QUANTITY UNIT MEAS.	MATERIAL OR EQUIPMENT PER UNIT	MATERIAL OR EQUIPMENT COST	LABOR OR LUMP SUM OR SUBCONTRACT PER UNIT	LABOR OR LUMP SUM OR SUBCONTRACT COST	TOTAL COST
1	Summary							
2								
3	Baseline Rd.							
4	Bridge Structure							$493,400
5	Approach Rdwy. & Detour							107,300
6								$600,700
7	Contingencies 10%±							60,300
8	Sub-Total Baseline Rd.							$661,000
9								
10								
11	Elliot Rd.							
12	Bridge Structure							$411,100
13	Approach Rdwy. & Detour							87,700
14								$498,800
15	Contingencies 10%±							50,200
16	Sub-Total Elliot Rd.							$549,000
17								
18								
19	Grand Total Both Sites							$1,210,000
20								

MAT'L. $ _____ LABOR $ _____ TOTALS THIS SHEET

EQUIP. $ _____ L. SUM $ _____

SUB C. $ _____ $ _____