Greiner Engineering

Greiner
Engineering
Sciences
Inc.
3240 East Camelback Road
Phoenix, Arizona 85018

COMPARATIVE DESIGN STUDY FOR SCS RWCD FLOODWAY REACH 6

CONTRACT NO. 53-9457-00469
JOB NO. E 101012

FEBRUARY, 1986

VOLUME II

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Tucson 602 327-3413
Phoenix 602 275-5400

Job RWCD Reach 4 E101012
Description Proposed structure at Brown Road
Calculated by M. Shapiro Date 2/8/86 Sheet No. 1
Checked by B. G. S. Date 2/11/86 of 2

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A proposed structure at Brown Road was investigated. The requirements for this structure are as follows: The design flow is 900 cfs and it must have a freeboard of a minimum of 1.0 feet inside the structure. Standard Arizona Department of Transportation, Highway Division, Standard Drawings for concrete box culverts and wingwalls were used for the selection process.

Preliminary sizing of this structure was acheived by using figures and charts developed by the Bureau of Public Roads, Jan. 1963. (figure 7 and charts 1 and 8) Other procedures for the preliminary sizing are based on Hydraulic Charts for the Selection of Highway Culverts, Hydraulic Engineering Circular No. 5, December 1965. An invert slope of .0001 ft/ft and a length of 124 ft. was used for the selection process.

Four concrete box culverts were analyzed for hydraulics and its associated costs using the above criteria and procedures. In addition A.D.O.T. quantities from their standard drawing and a unit cost for structural steel and structural concrete were developed using former reach 2 & 3 bid tabs and A.D.O.T. 1985 bid tabs. Selected boxes were a 2-barrel 8'x7' box culvert with wingwalls, a 2-barrel 8'x8' box culvert with wingwalls, a 2-barrel 10'x8' box culvert with wingwalls and a 2-barrel 12'x8' box culvert with wingwalls. Hydraulicly all the structures except the 2-barrel 8'x7' functioned adaquately. The range in costs between the 2-barrel 8'x8' box culvert with wingwalls and the 2-barrel 12'-8' box culvert with wingwalls is $61,400 to $99,100 respectively.

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Based on preliminary calculations the 2-barrel 8'x8' concrete box culvert was selected for further evaluation. This structure was then modelled using "WSPG" for water surface profile analysis. See sections 4 and 23 and the computer printouts for additional information and more details. According to the water surface profile calculations this structure meet all criteria, there a 2-barrel 8'x8' concrete box culvert with wingwalls approximately 124 feet in length is recommended for this structure. A.D.O.T. Std. Drawing No.s' CB-2, CWG-6 and CWQ-1 are recommended for the final design of this structure. The structure will have 30° skew.

Tractive power analysis (See Section 8) shows that inlet and outlet aprons are not required.

See the following pages for more details.

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Job E101012 RWCD Reach 6
Description Prelim - Design for Box Culvert @ Brown Rd.
Calculated by M. Shapiro Date 10/3/85 Sheet No. 1
Checked by B. G. B. Date 10/3/85 of 2

Q_D = 900 cfs

VOID
10/24/85

Max height to roadway 12.3 ft.

12' x 8' box culvert - Conc. 1.620 C.Y./L.F. x 124 L.F. = 200.88 C.Y.
Steel 282.1 lb/L.F. x 124 L.F. = 34,980.40 lbs

Wingwalls
Inlet - Conc. 22.23 C.Y.
Steel 1350 lbs
Outlet - Conc. 22.25 C.Y.
Steel 1350 lbs

Apron Conc. 7.49 C.Y.
Steel 628 lbs

Total - Conc 252.85 C.Y. @ $ 165 /C.Y. = $41,720.35
Steel 38,308.4 lbs @ $ .38 /lb. 14,557.19
$56,277.44

10' x 8' box culvert - Conc. 1.282 C.Y./L.F. x 124 L.F. = 158.97 C.Y.
Steel 208.7 lb/L.F. x 124 L.F. = 25,878.8 lbs

Wingwalls
Inlet - Conc. 21.84 C.Y.
Steel 1287 lbs
Outlet - Conc 21.85 C.Y.
Steel 1287 lbs

Apron Conc 6.67 C.Y.
Steel 565 lbs

Total - Conc. 209.33 C.Y. @ $ 165 /C.Y. = $34,539.12
Steel 29,017.8 lbs @ .38 /lb. = 11,026.76
$45,565.88

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VOID 10/24/85

Job E10102 RWCD Reach 6
Description Prelim - Design for Box Culvert @ Brown Rd.
Calculated by M. Shapiro Date 10/3/85 Sheet No. 2
Checked by B. G. S. Date 10/3/85 of 2

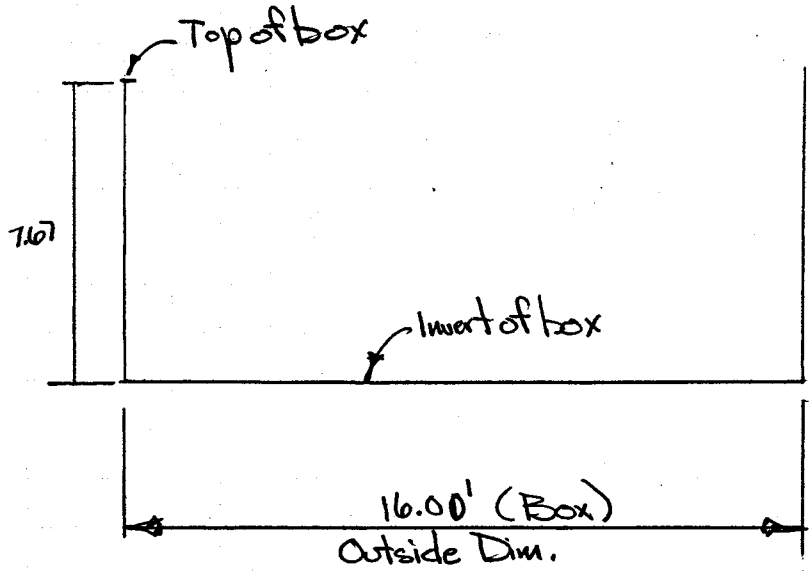
2 barrel 6'x7' box culvert - Conc. 1.290 C.Y./L.F. x 124 LF = 159.95 C.Y.
Steel 196.8 lb/L.F. x 124 LF = 24,403.2 lbs

Wingwalls
Inlet - Conc. 15.78 C.Y.
Steel 1129 lbs
Outlet - Conc. 15.78 C.Y.
Steel 1129 lb

Aprons Conc. 6.6 C.Y.
Steel 557 lbs

Total Conc. 198.12 C.Y. @ $165/C.Y. = $32,689.8
Steel 27,218.2 lbs @ .38/lb. = $10,429.16
$43,118.96

2-6'x7' box



PROJECT: RWCD Reach 6

DESIGNER: M. Shapiro

DATE: 10/3/85

HYDROLOGIC AND CHANNEL INFORMATION

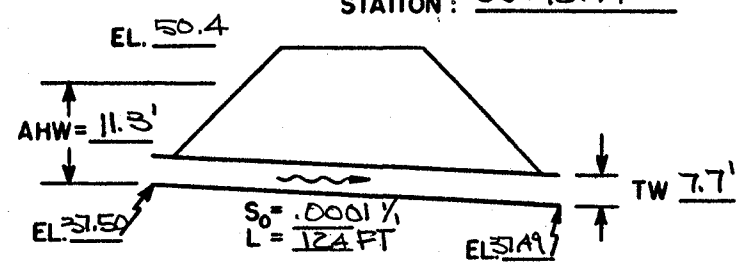
Q_1 = 900 cfs TW_1 = 7.7'

Q_2 = _____ TW_2 = _____

(Q_1 = DESIGN DISCHARGE, SAY Q_{25}
Q_2 = CHECK DISCHARGE, SAY Q_{50} OR Q_{100})

SKETCH

STATION: 33+12.99



MEAN STREAM VELOCITY = _____

MAX. STREAM VELOCITY = _____

CULVERT DESCRIPTION (ENTRANCE TYPE)	Q	SIZE	HEADWATER COMPUTATION: INLET CONT. HW/D	INLET CONT. HW	OUTLET CONTROL HW=H+h_o−LS_o: K_e	H	d_c	$\frac{d_c+D}{2}$	TW	h_o	LS_o	HW	CONTROLLING HW	OUTLET VELOCITY	COST	COMMENTS
8'x8' Single Cell Box Culvert w/wingwalls	900	8'x8'	1.68	13.44			5.60	6.80								N.G.
" "	"	12'x8'	1.11	8.8	.4	2.4	1.9	~~4.92~~ 7.17	7.7	7.7	.01	10.09	10.09	9.40	56,300	O.K
" "	"	10'x8'	1.30	10.4	.4	3.4	1.9 6.33	~~4.92~~ 7.17	7.7	7.7	.01	11.09	11.09	13.19	45,600	O.K
2-barrel Box Culvert w/wingwalls	"	6'x7'	1.33	9.31	.4	3.2	1.9 5.60	~~4.45~~ 6.30	7.7	7.7	.01	10.89	10.89	10.78	43,100	O.K

SUMMARY & RECOMMENDATIONS:

Use 2barrel 6'x7' box culvert w/ wingwalls 30° skew

Void 10/24/85

Figure 7

Q = 900 cfs

Void 10/2/85

Trial 1

8'x8'

$\frac{Q}{B} = \frac{900}{8} = 112.5$ N.G.

Trial 2

12'x8'

$\frac{Q}{B} = \frac{900}{12} = 75$ O.K

Trial 3

10'x8'

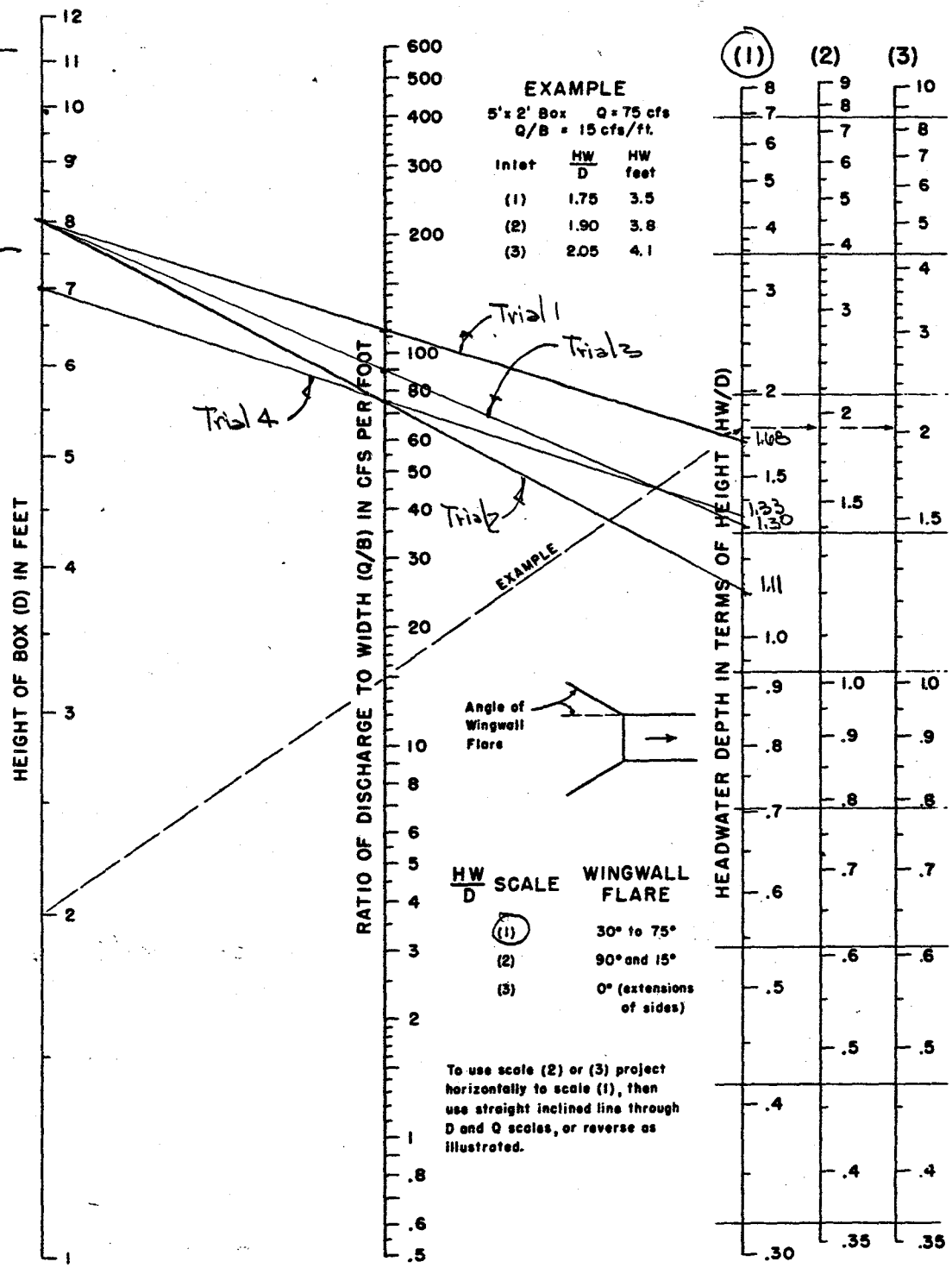
$\frac{Q}{B} = 90$ O.K.

Trial 4

2-6'x7'

$\frac{Q}{B} = 75 \times 1.75$

CHART I



HEADWATER DEPTH FOR BOX CULVERTS WITH INLET CONTROL

BUREAU OF PUBLIC ROADS JAN. 1963

Q = 900 cfs

Trial 1
8'x8' box
= 64 ft N.G.

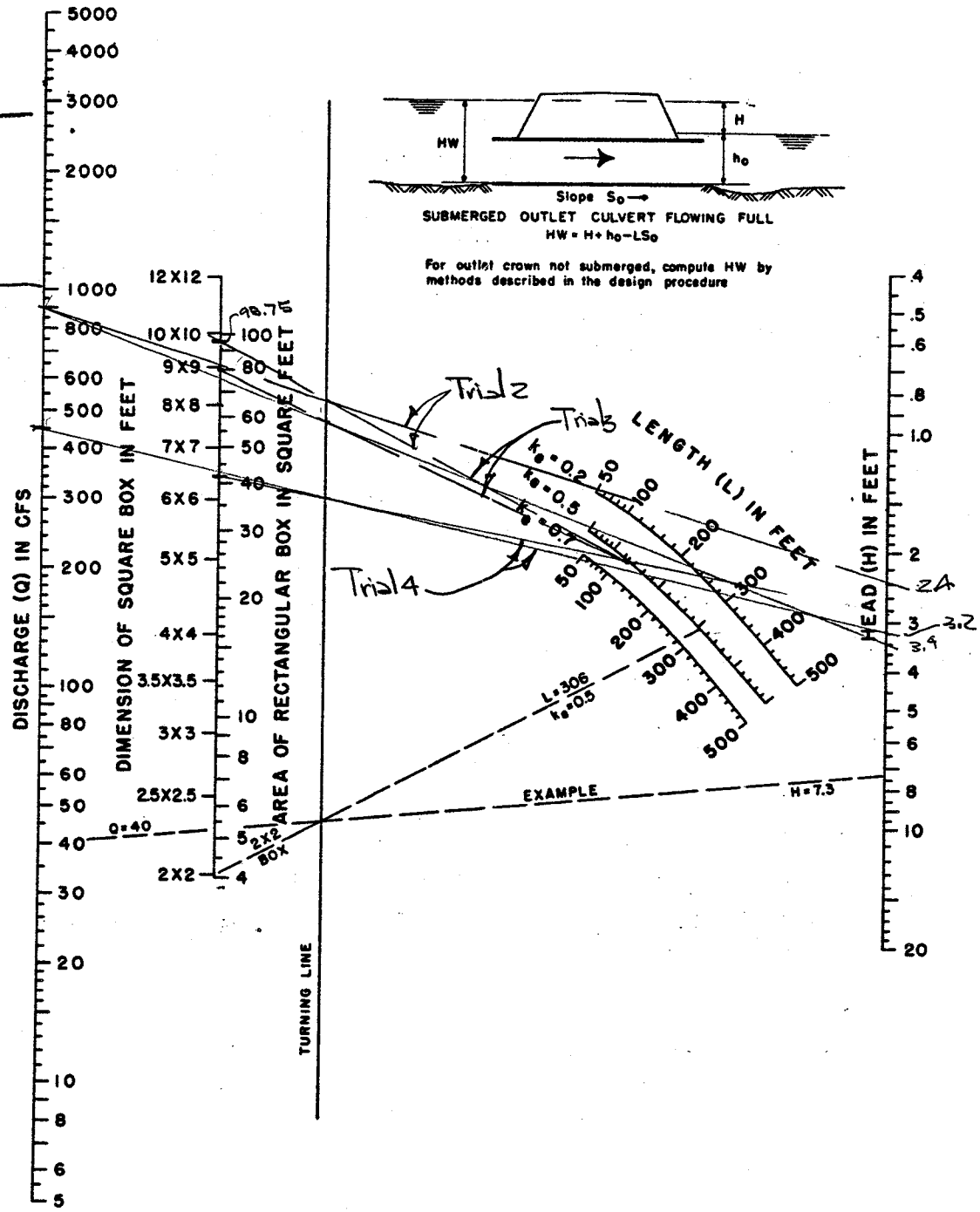
Trial 2 H=2.4
12'x8' box
A=95.75. OK

Trial 3
10'x8' box
A=79.75 H=3.4

Trial 4
2-6'x7'
A=41.75 H=3.2

Void 10/24/85

CHART 8



HEAD FOR
CONCRETE BOX CULVERTS
FLOWING FULL
n = 0.012

BUREAU OF PUBLIC ROADS JAN. 1963

Void 10/24/85

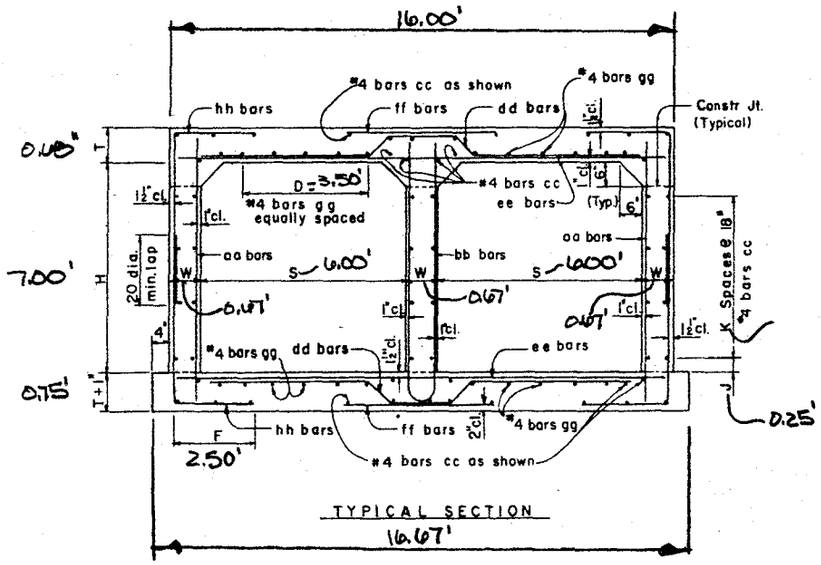
QUANTITIES PER LIN. FOOT OF BARRELS

Span "S"	Height "H"	Table I Concrete C.Y.	Table I Reinf. Steel Lbs.	Table II Concrete C.Y.	Table II Reinf. Steel Lbs.	Table III Concrete C.Y.	Table III Reinf. Steel Lbs.	Table IV Concrete C.Y.	Table IV Reinf. Steel Lbs.	Table V Concrete C.Y.	Table V Reinf. Steel Lbs.
6'	3'	.994	159.4	.994	132.5	1.082	139.6	1.215	143.2	1.303	149.7
	4'	1.068	167.0	1.068	142.9	1.156	149.5	1.289	153.0	1.378	159.1
	5'	1.142	174.0	1.142	148.2	1.230	155.3	1.363	158.9	1.452	164.4
	6'	1.216	186.7	1.216	167.1	1.305	165.1	1.437	169.0	1.526	174.1
	7'	1.290	196.8	1.290	166.8	1.379	176.6	1.511	186.9	1.600	188.8
8'	3'	1.302	213.2	1.474	206.9	1.646	191.4	1.876	195.1	2.105	200.2
	4'	1.385	246.9	1.557	201.4	1.729	200.7	1.959	204.9	2.188	210.1
	5'	1.526	239.0	1.641	206.7	1.813	220.5	2.042	210.7	2.272	213.7
	6'	1.609	251.3	1.724	216.1	1.896	230.8	2.126	222.0	2.355	223.5
	7'	1.693	263.6	1.807	225.4	1.979	241.2	2.209	231.9	2.438	234.8
	8'	1.776	274.4	1.891	254.6	2.063	249.4	2.292	244.4	2.522	266.9
10'	3'	1.777	310.8	2.059	261.3	2.412	259.9	2.693	278.2	3.046	281.9
	4'	1.940	325.4	2.152	272.8	2.504	270.2	2.856	273.3	3.138	291.7
	5'	2.033	328.7	2.315	281.9	2.667	278.6	2.949	278.6	3.231	297.6
	6'	2.126	322.6	2.407	271.3	2.760	288.9	3.042	288.0	3.324	307.4
	7'	2.218	335.5	2.500	281.1	2.852	299.3	3.134	298.6	3.416	317.2
	8'	2.311	336.1	2.593	315.0	2.945	305.6	3.227	329.3	3.509	329.9
	9'	2.403	349.8	2.685	325.3	3.038	316.5	3.319	340.2	3.601	348.4
	10'	2.496	362.0	2.778	337.6	3.130	348.1	3.412	358.0	3.694	387.8
12'	8'	3.102	460.5	3.524	389.6	4.030	394.6	4.452	385.5	4.837	392.9
	9'	3.213	476.7	3.635	402.7	4.141	407.5	4.563	428.9	4.985	439.3
	10'	3.324	484.2	3.746	414.9	4.252	418.4	4.674	449.5	5.096	451.0
	11'	3.435	493.9	3.857	422.3	4.363	425.2	4.785	455.3	5.207	474.0
	12'	3.546	505.6	3.968	436.1	4.474	491.5	4.896	483.0	5.318	501.6

TABLE NO. I
0'-10' FILL

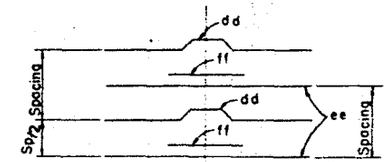
Span "S"	Height "H"	Top Slab "T"	Walls "W"	aa Size	aa Spacing	aa Length	bb Size	bb Spacing	bb Length	cc Number ◆	dd Size	dd Spacing	dd Length	dd A	dd B	dd C	ee Size	ee Spacing	ee Length	ff Size	ff Spacing	ff Length	gg Number ◆	gg D	hh Size	hh Spacing	hh Length	hh F
6'	3'	8"	8"	#4	11"	3'-9	#5	11"	8'-3	48	#4	11"	13'-6	5'-0	2'-3	5½"	#5	11"	13'-6	#5	11"	9'-3	20	3'-6	#4	5½"	4'-9	2'-3
	4'	8"	8"	#4	11"	4'-9	#4	11"	10'-3	54	#4	11"	13'-6	5'-0	2'-3	5½"	#5	11"	13'-6	#5	11"	9'-9	20	3'-6	#4	5½"	5'-3	2'-3
	5'	8"	8"	#4	11"	5'-9	#4	11"	12'-3	54	#4	11"	13'-6	5'-0	2'-3	5½"	#5	11"	13'-6	#5	11"	10'-3	20	3'-6	#4	5½"	5'-9	2'-3
	6'	8"	8"	#4	11"	6'-9	#4	11"	14'-3	60	#4	11"	13'-6	5'-0	2'-3	5½"	#5	11"	13'-6	#5	11"	11'-6	20	3'-6	#4	5½"	6'-3	2'-3
	7'	8"	8"	#4	11"	7'-9	#4	11"	16'-3	66	#4	11"	13'-6	5'-0	2'-3	5½"	#5	11"	13'-6	#5	11"	11'-0	20	3'-6	#4	5½"	7'-0	2'-6
8'	3'	8½"	9"	#4	12"	4'-0	#4	6"	8'-6	48	#5	12"	16'-0	5'-7½	3'-4	6"	#5	12"	17'-9	#6	12"	10'-0	24	4'-5	#5	6"	5'-9	3'-1
	4'	8½"	9"	#4	12"	5'-0	#4	6"	10'-6	54	#5	12"	16'-6	5'-10	3'-4	6"	#6	12"	17'-9	#6	12"	10'-6	28	4'-5	#5	6"	6'-3	3'-1
	5'	9"	9"	#4	14"	6'-0	#4	7"	12'-6	54	#6	14"	16'-6	6'-0	3'-0	6½"	#6	14"	17'-9	#6	14"	11'-0	28	4'-8	#5	7"	6'-6	2'-9
	6'	9"	9"	#4	14"	7'-0	#4	7"	14'-6	60	#6	14"	16'-6	6'-0	3'-0	6½"	#6	14"	17'-9	#6	14"	11'-6	28	4'-8	#5	7"	7'-0	2'-9
	7'	9"	9"	#4	14"	8'-0	#4	7"	16'-6	66	#6	14"	16'-6	5'-9½	3'-4	6½"	#6	14"	17'-9	#6	14"	12'-0	28	4'-4	#5	7"	7'-6	2'-9
	8'	9"	9"	#4	14"	9'-0	#4	7"	18'-6	66	#6	14"	17'-0	6'-1	3'-4	6½"	#6	14"	17'-9	#6	14"	13'-0	28	4'-4	#5	7"	8'-0	2'-9
10'	3'	10"	10"	#4	11"	4'-3	#5	5½"	9'-0	48	#6	11"	19'-9	6'-11	4'-2	7½"	#5	11"	21'-9	#6	11"	17'-6	32	5'-5	#5	5½"	6'-6	3'-9
	4'	10½"	10"	#4	11"	5'-3	#5	5½"	11'-0	54	#6	11"	19'-9	6'-10	4'-2	8"	#5	11"	21'-9	#6	11"	17'-6	32	5'-4	#5	5½"	7'-0	3'-9
	5'	10½"	10"	#4	11"	6'-3	#6	11"	13'-0	54	#6	11"	20'-3	7'-1	4'-2	8"	#5	11"	21'-9	#6	11"	18'-0	32	5'-4	#5	5½"	7'-3	3'-6
	6'	10½"	10"	#4	13"	7'-3	#5	6½"	15'-0	60	#6	13"	20'-3	7'-2	4'-0	8"	#6	13"	21'-9	#7	13"	12'-6	32	5'-6	#5	6½"	7'-9	3'-6
	7'	10½"	10"	#4	13"	8'-3	#5	6½"	17'-0	66	#6	13"	20'-3	7'-2	4'-0	8"	#6	13"	21'-9	#7	13"	13'-0	32	5'-6	#5	6½"	8'-0	3'-3
	8'	10½"	10"	#4	13"	9'-3	#6	13"	19'-0	66	#6	13"	20'-3	7'-2	4'-0	8"	#6	13"	21'-9	#7	13"	13'-6	32	5'-6	#5	6½"	8'-6	3'-3
	9'	10½"	10"	#4	13"	10'-3	#6	13"	21'-0	72	#6	13"	20'-3	7'-2	4'-0	8"	#6	13"	21'-9	#7	13	14'-0	32	5'-6	#5	6½"	9'-0	3'-3
	10'	10½"	10"	#4	13"	11'-3	#4	6½"	23'-0	78	#6	13"	20'-3	7'-2	4'-0	8"	#6	13"	21'-9	#7	13"	15'-0	32	5'-6	#5	6½"	9'-6	3'-3
12'	8'	12½"	12"	#4	11"	9'-6	#5	5½"	20'-0	66	#6	11"	23'-9	8'-2	5'-0	10"	#6	11"	26'-6	#7	11"	17'-3	40	6'-4	#5	5½"	9'-9	4'-3
	9'	12½"	12"	#4	11"	10'-6	#5	5½"	22'-0	72	#6	11"	24'-3	8'-5	5'-0	10"	#6	11"	26'-6	#7	11"	17'-3	40	6'-4	#5	5½"	10'-3	4'-3
	10'	12½"	12"	#4	12"	11'-6	#5	6"	24'-0	78	#7	12"	24'-6	8'-6½	5'-0	10"	#6	12"	26'-6	#7	12"	17'-3	40	6'-4	#5	6"	10'-9	4'-3
	11'	12½"	12"	#4	12"	12'-6	#5	6"	26'-0	78	#7	12"	24'-6	8'-6½	5'-0	10"	#6	12"	26'-6	#7	12	17'-3	40	6'-4	#5	6"	11'-3	4'-3
	12'	12½	12"	#4	12"	13'-6	#5	6"	28'-0	84	#7	12"	24'-0	8'-3½	5'-0	10"	#6	12"	26'-6	#7	12"	17'-3	40	6'-4	#5	6"	11'-9	4'-3

◆ Total number of bars in the cross-section.

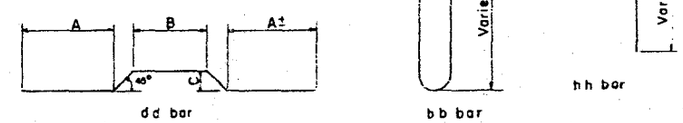


TYPICAL SECTION

Height "H"	"J" Dim.	"K" Spaces
3'	9"	—
4'	3"	2
5'	12"	2
6'	9"	3
7'	3"	4
8'	12"	4
9'	9"	5
10'	3"	6
11'	12"	6
12'	9"	7



REINFORCING BAR PLACING DIAGRAM



dd bar bb bar hh bar

BENDS

NOTE:

See B-02.25 for Tables No. II through V.
See B-01.10 for general notes and miscellaneous details.
All bend dimensions are out to out of bar.

NO	DESCRIPTION OF REVISIONS	MADE BY	DATE
1	Conc. Quantities Table II 6' Span	JTW	7-76
2			
3			

DESIGN	DRAWN	CHECKED
DRT	APV	MAB
12-71	7-72	3-73

DESIGN APPROVED

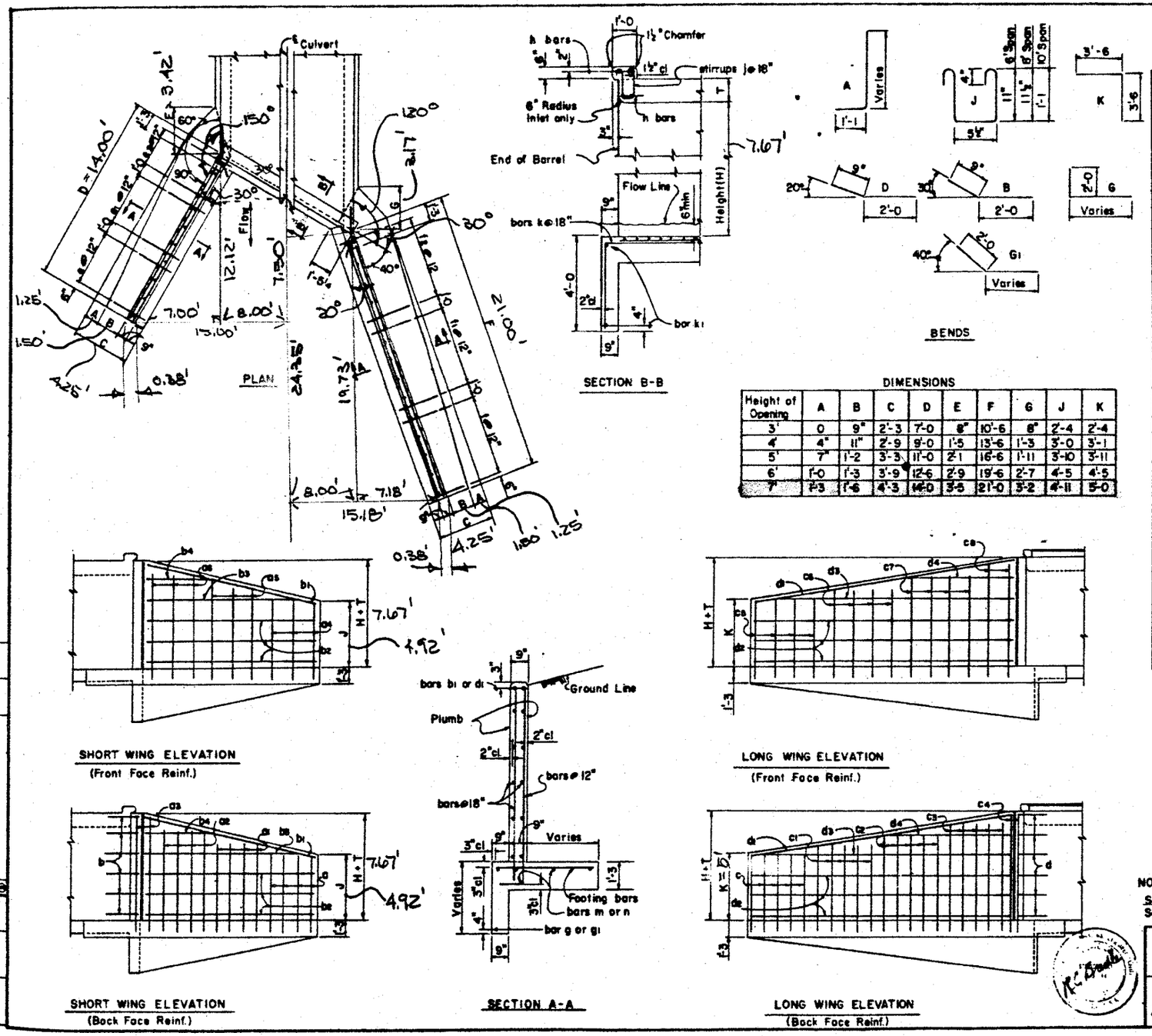
APPROVED FOR DISTRIBUTION

ARIZONA
DEPARTMENT OF TRANSPORTATION
HIGHWAYS DIVISION
STANDARD DRAWINGS

DOUBLE BARREL
BOX CULVERT

REVISION

STANDARD NO. CB-2
PLAN NO. B-02.20



DIMENSIONS

Height of Opening	A	B	C	D	E	F	G	J	K
3'	0	9"	2'-3	7'-0	8"	10'-6	8"	2'-4	2'-4
4'	4"	11"	2'-9	9'-0	1'-5	13'-6	1'-3	3'-0	3'-1
5'	7"	1'-2	3'-3	11'-0	2'-1	16'-6	1'-11	3'-10	3'-11
6'	1'-0	1'-3	3'-9	12'-6	2'-9	19'-6	2'-7	4'-5	4'-5
7'	1'-3	1'-6	4'-3	14'-0	3'-5	21'-0	3'-2	4'-11	5'-0

INLET OR OUTLET WINGS STEEL LIST

Mark	Bend	3' Height			4' Height			5' Height			6' Height			7' Height		
		No	Size	Lgth	No	Size	Lgth	No	Size	Lgth	No	Size	Lgth	No	Size	Lgth
SHORT WING																
a	A	3	#5	4'-3	4	#5	5'-0	4	#5	5'-9	4	#5	6'-3	4	#5	6'-9
a1	✓	3	✓	5'-0	4	✓	5'-9	4	✓	6'-6	4	✓	7'-3	4	✓	7'-9
a2	✓	2	✓	5'-9	2	✓	6'-6	2	✓	7'-3	3	✓	8'-0	4	✓	8'-6
a3	✓							2	✓	7'-6	2	✓	8'-6	3	✓	9'-6
a4	str.	2	#4	3'-3	3	#4	3'-9	3	#4	4'-9	3	#4	5'-3	3	#4	5'-9
a5	✓	2	✓	4'-0	3	✓	4'-9	3	✓	5'-6	3	✓	6'-3	3	✓	6'-9
a6	✓	1	✓	4'-9				2	✓	6'-6	2	✓	7'-0	4	✓	7'-9
b	B	3	✓	2'-9	4	#4	2'-9	5	✓	2'-9	5	✓	2'-9	6	✓	2'-9
b1	str.	2	#6	6'-3	2	#6	8'-3	2	#6	10'-0	2	#6	11'-6	2	#6	13'-3
b2	✓	4	#4	6'-0	4	#4	8'-0	6	#4	10'-0	6	#4	11'-3	6	#4	13'-0
b3	✓				2	✓	6'-9	2	✓	4'-6	2	✓	8'-9	2	✓	12'-0
b4	✓													2	✓	6'-9
c	✓	7	#4	1'-9	5	#4	1'-9	4	#4	2'-0	5	#4	2'-3	5	✓	2'-6
c1	✓				4	✓	2'-0	4	✓	2'-3	4	✓	2'-9	5	✓	3'-0
c2	✓							3	✓	2'-6	4	✓	3'-0	4	✓	3'-6
g	G	1	#4	8'-9	1	#4	10'-9	1	✓	12'-9	1	✓	14'-0	1	✓	15'-6
m	str.	4	✓	6'-6	4	✓	8'-6	5	✓	10'-6	5	✓	12'-0	5	✓	15'-6
LONG WING																
c	A	3	#5	4'-3	4	#5	5'-0	4	#5	5'-9	5	#5	6'-3	5	#5	7'-0
c1	✓	3	✓	4'-9	4	✓	5'-6	4	✓	6'-3	5	✓	7'-0	5	✓	7'-6
c2	✓	3	✓	5'-3	4	✓	6'-0	4	✓	6'-9	5	✓	7'-6	5	✓	8'-3
c3	✓	2	✓	5'-9	2	✓	6'-6	3	✓	7'-3	3	✓	8'-3	5	✓	9'-0
c4	✓							2	✓	7'-9	2	✓	8'-6	2	✓	9'-6
c5	str.	2	#4	3'-3	3	#4	4'-0	3	#4	4'-9	4	#4	5'-3	4	#4	5'-9
c6	✓	2	✓	3'-9	3	✓	4'-6	3	✓	5'-3	4	✓	6'-0	4	✓	6'-9
c7	✓	2	✓	4'-3	3	✓	5'-3	3	✓	5'-9	4	✓	6'-9	4	✓	7'-6
c8	✓	1	✓	4'-6				2	✓	6'-6	1	✓	7'-6	2	✓	8'-3
d	D	3	✓	2'-9	4	#4	2'-9	5	✓	2'-9	5	✓	2'-9	6	✓	2'-9
d1	str.	2	#6	9'-6	2	#6	12'-6	2	#6	15'-6	2	#6	18'-6	2	#6	20'-3
d2	✓	4	#4	9'-3	4	#4	12'-3	6	#4	15'-3	6	#4	18'-3	6	#4	20'-0
d3	✓				2	✓	11'-0	2	✓	7'-3	2	✓	14'-3	2	✓	19'-0
d4	✓													2	✓	10'-0
f	✓	11	#4	1'-9	7	#4	1'-9	6	#4	2'-0	7	#4	2'-3	7	✓	2'-6
f1	✓				7	✓	2'-0	6	✓	2'-3	7	✓	2'-6	7	✓	3'-0
f2	✓							5	✓	2'-6	6	✓	3'-0	7	✓	3'-3
g1	G1	1	#4	12'-9	1	#4	15'-9	1	✓	18'-6	1	✓	21'-6	1	✓	23'-0
n	str.	4	✓	10'-0	4	✓	13'-0	5	✓	16'-0	5	✓	19'-0	5	✓	20'-6

CURB & CUT-OFF WALL STEEL LIST

Mark	Bend	6' Spans					8' Spans					10' Spans				
		1 Barrel			○	◇	1 Barrel			○	◇	1 Barrel			○	◇
		No	Size	Lgth	No	Lgth	No	Size	Lgth	No	Lgth	No	Size	Lgth	No	Lgth
h	str.	4	#6	8'-0		7'-9	4	#6	10'-6		10'-1	4	#6	13'-0		12'-6
j	J	6	#4	3'-6	5		7	#4	3'-6	7		9	#4	3'-9	8	
k	K	4	✓	7'-0	5		6	✓	7'-0	6		7	✓	7'-0	8	
k1	str.	2	✓	5'-9		7'-9	2	✓	8'-0		10'-1	2	✓	10'-6		12'-6

○ Additional number of bars per each extra barrel.
◇ Additional length of bars per each extra barrel.

NOTE:
See B-01.10 for general notes and miscellaneous details.
See B-07.10 for concrete and steel headwall quantities.

DESIGN APPROVED R.C. Bruchler
APPROVED FOR DISTRIBUTION F.D. Lewis

ARIZONA
DEPARTMENT OF TRANSPORTATION
HIGHWAYS DIVISION
STANDARD DRAWINGS

INLET OR OUTLET WINGS
30° SKEW CULVERT
3:1 SLOPE, HEIGHT 3' TO 7'

REVISION

STANDARD NO. B-06-5
PLAN NO. B-06.50

R.C. Bruchler

Greiner Engineering

Greiner Engineering Sciences, Inc.
Tucson 602 327-3413
Phoenix 602 275-5400

Job SCB RWCD Floodway Reach 6 - E101012
Description Preliminary Design for Box Culvert @ Brown Rd.
Calculated by B. Gary Sun Date 10/24/85 Sheet No. 1
Checked by M.S.S Date _____ of 2

Redesign Box Culvert @ Brown Road to have at least 1 foot freeboard inside the Box with Q = 900 cfs.

Use Double Barrel 12'x8' Box Culvert

Concrete : 3.102 C.Y./L.F. X 124 L.F. = 384.65 C.Y.

Steel : 460.5 lbs/L.F. X 124 L.F. = 57,102 lbs

} For Box

Wingwalls : 30° skew culvert 6:1 slope

Inlet — Concrete : (22.23 + 1.95) = 24.18 C.Y.

Steel : 1350 + 213.1 = 1563.10 lbs.

Outlet — Concrete : 22.25 + 1.95 = 24.20 C.Y.

Steel : 1350 + 213.1 = 1563.10 lbs.

Aprons — 30° skew culvert

Concrete = 12.03 X 2 = 24.06 C.Y.

Steel : 979 X 2 = 1958 lbs

Total

Concrete : 457.09 C.Y. @ $165/C.Y = $ 75,419.85

Steel : 62186.2 lbs. @ $.38/lbs = $ 23,630.76

$ 99,050.61

Greiner Engineering

Greiner Engineering Sciences, Inc.

Tucson 602 327-3413
Phoenix 602 275-5400

Job SCS RMCD Floodway Reach 6 - E101012

Description Preliminary Design of Box Culvert @ Brown Road

Calculated by B. Gary Run Date 10/29/85 Sheet No. 2

Checked by M.S.S. Date _____ of 2

Use 2 barrel 8'x8' box culvert 30° skew, 6:1 slope

Box:

Concrete: 1.776 C.Y./L.F. x 124 L.F. = 220.22 C.Y.

Steel: 274.4 lbs/L.F. x 124 = 34,025.6 lbs

Wingwalls:

Inlet:

Concrete: 21.48 + 1.31 = 22.79 C.Y.

Steel: 1253 + 118.4 = 1371.4 lbs.

Outlet:

Concrete: 21.49 + 1.31 = 22.80 C.Y.

Steel: 1253 + 118.4 = 1371.4 lbs

Aprons:

Concrete: 8.96 x 2 = 17.92 C.Y.

Steel: 740 x 2 = 1,480 lbs

Total

Concrete: 283.73 C.Y. @ $165/C.Y = $ 46,815.45

Steel: 38,248.4 lbs @ $.38/lbs = $ 14,534.39

$ 61,349.84

PROJECT: RWCD Reach 6

DESIGNER: B. Gary Sun

DATE: 10/24/85

HYDROLOGIC AND CHANNEL INFORMATION

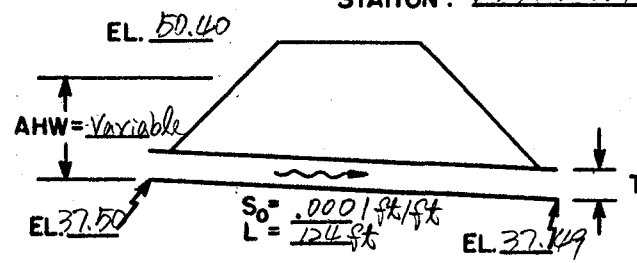
Q_1 = 900 cfs TW_1 = 5.75'

Q_2 = _____ TW_2 = _____

(Q_1 = DESIGN DISCHARGE, SAY Q_{25}
Q_2 = CHECK DISCHARGE, SAY Q_{50} OR Q_{100})

SKETCH

STATION: 33+12.99



→ (WSPG AI2 run)

MEAN STREAM VELOCITY = _____

MAX. STREAM VELOCITY = _____

CULVERT DESCRIPTION (ENTRANCE TYPE)	Q	SIZE	HEADWATER COMPUTATION: INLET CONT. HW/D	INLET CONT. HW	OUTLET CONTROL HW=H + h_o − LS_o: K_e	H	d_c	$\frac{d_c+D}{2}$	TW	h_o	LS_o	HW	CONTROLLING HW	OUTLET VELOCITY	COST	COMMENTS
2-barrel Box Culvert w/wingwalls	900	8'x7'	1.02	7.14	.4	1.68	4.62	5.81	5.75	5.81	.01	7.48	7.48	8.07		N.G. (AHW= 6.67')
" "	900	8'x8'	.89	7.12	.4	1.29	4.62	6.31	5.75	6.31	.01	7.59	7.59	7.06	61,400.-	O.K. (AHW= 7.75')
" "	900	10'x8'	.76	6.08	.4	.81	3.99	5.99	5.75	5.99	.01	6.79	6.79	5.64		O.K. (AHW= 7.88')
" "	900	12'x8'	.68	5.44	.4	.54	3.53	5.76	5.75	5.76	.01	6.29	6.29	4.70	99,100.-	O.K. (AHW= 8.04')

$d_c = .315\sqrt[3]{Q/B^2}$

SUMMARY & RECOMMENDATIONS:

Use Double Barrel 8'x8' Box Culvert w/wingwalls 30° skew

$h_o = \frac{d_c+D}{2}$ or TW, whichever is the greater

Figure 7

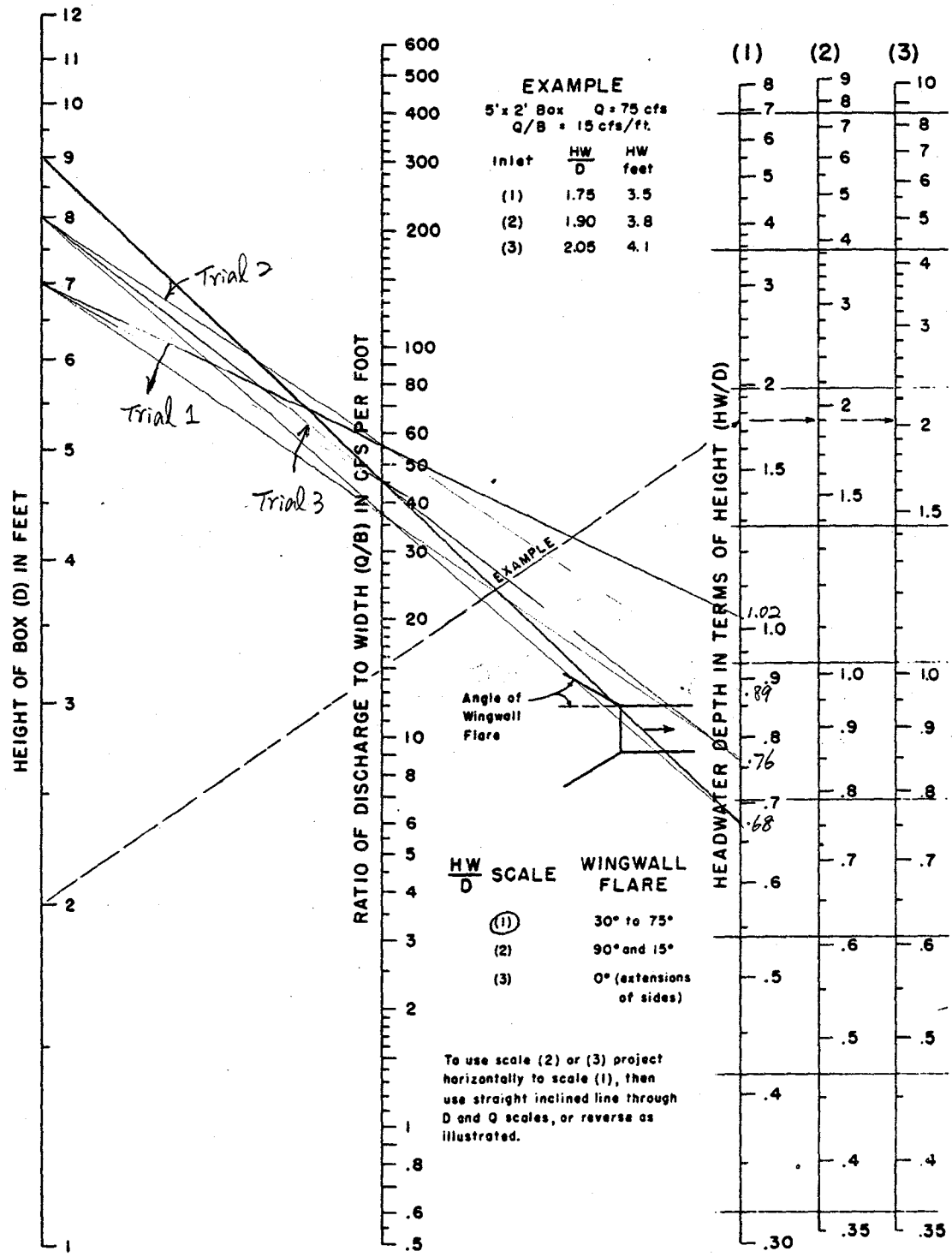
Trial 1
2-8'x7'
B D
$\frac{Q}{B} = \frac{900}{16} = 56.25$

Trial 2
2-8'x8'
$\frac{Q}{B} = 56.25$

Trial 3
2-10'x8'
$\frac{Q}{B} = 45$

Trial 4
2-12'x8'
$\frac{Q}{B} = 37.5$

CHART I



HEADWATER DEPTH FOR BOX CULVERTS WITH INLET CONTROL

BUREAU OF PUBLIC ROADS JAN. 1963

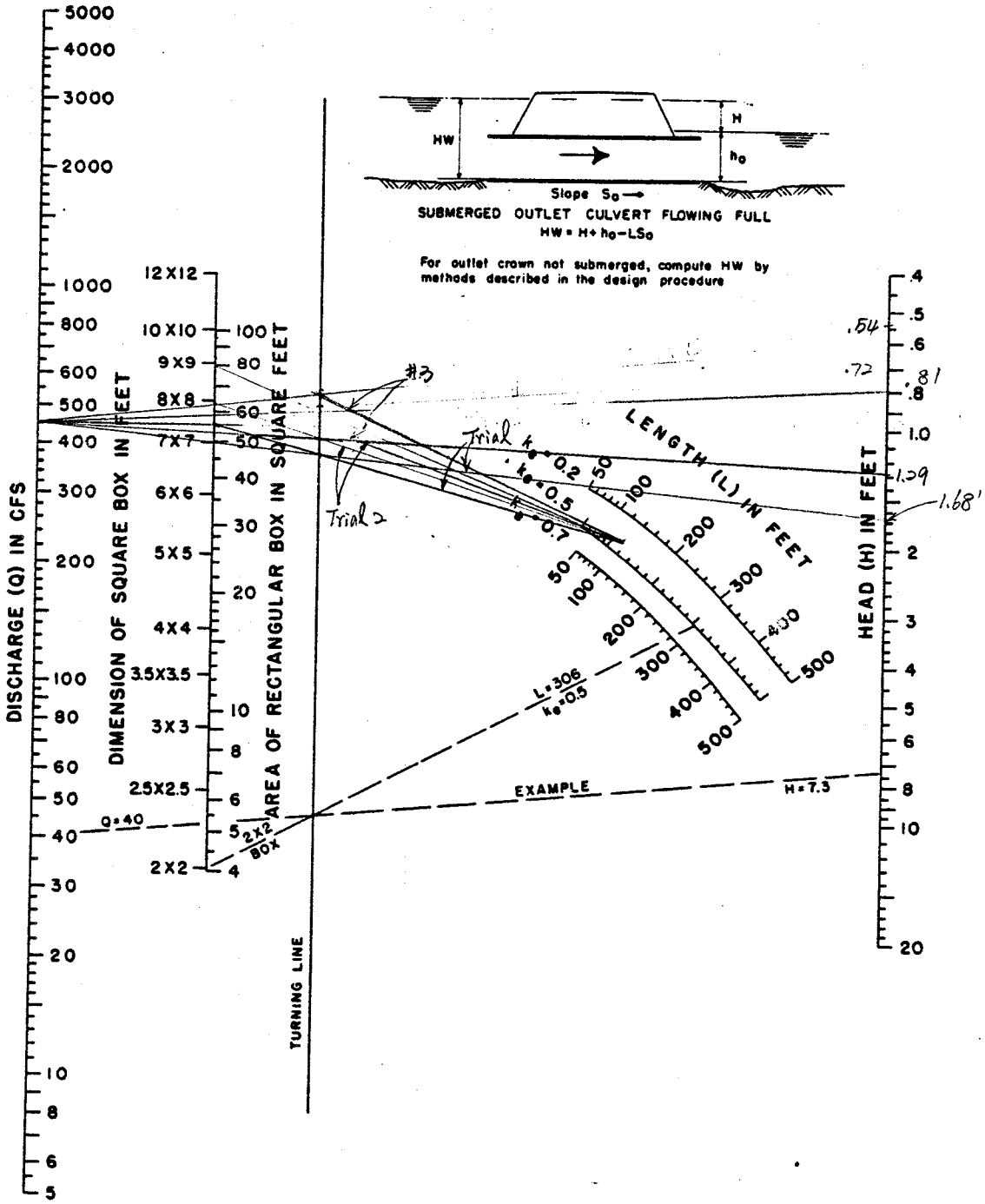
Trial 1
2-8'x7'
A=8x7-2(½·5x.5)
= 55.75 (for 1 Box)

Trial 2
2-8'x8'
A=8x8-2(½.5x.5)
= 62.75 (1 Box)

Trial 3
2-10'x8'
A=10x8-2(½.5x.5)
= 79.75

Trial 4
2-10'x8'
A=95.75

CHART 8



HEAD FOR
CONCRETE BOX CULVERTS
FLOWING FULL
n = 0.012

BUREAU OF PUBLIC ROADS JAN. 1963

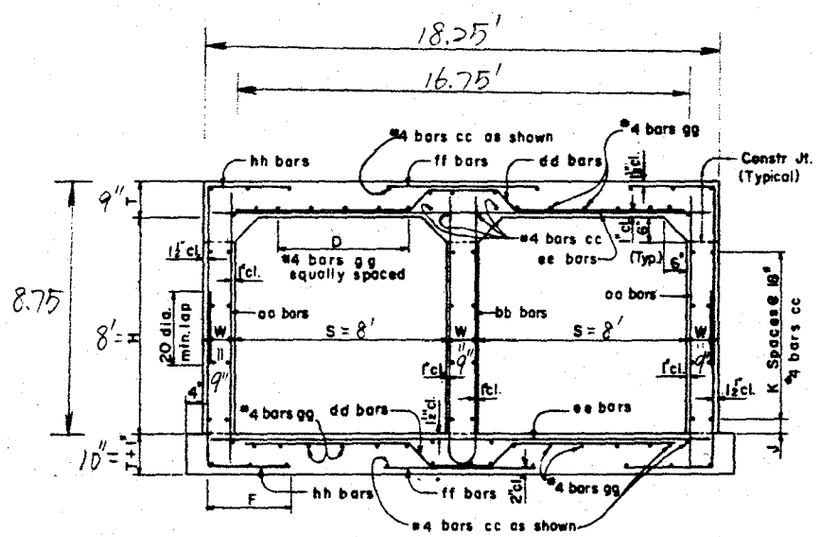
QUANTITIES PER LIN. FOOT OF BARRELS

Span "S"	Height "H"	Table I Concrete C.Y.	Table I Reinf. Steel Lbs.	Table II Concrete C.Y.	Table II Reinf. Steel Lbs.	Table III Concrete C.Y.	Table III Reinf. Steel Lbs.	Table IV Concrete C.Y.	Table IV Reinf. Steel Lbs.	Table V Concrete C.Y.	Table V Reinf. Steel Lbs.
6'	3'	.994	159.4	.994	132.5	1.082	139.6	1.215	143.2	1.303	149.7
	4'	1.068	167.0	1.068	142.9	1.156	149.5	1.289	153.0	1.378	159.1
	5'	1.142	174.0	1.142	148.2	1.230	155.3	1.363	158.9	1.452	164.4
	6'	1.216	186.7	1.216	167.1	1.305	165.1	1.437	169.0	1.526	174.1
	7'	1.290	196.8	1.290	176.9	1.379	175.0	1.511	178.9	1.600	188.0
8'	3'	1.302	213.2	1.474	206.9	1.646	191.4	1.876	195.1	2.105	200.2
	4'	1.385	246.9	1.557	201.4	1.729	200.7	1.959	204.9	2.188	210.1
	5'	1.526	239.0	1.641	206.7	1.813	220.5	2.042	210.7	2.272	213.7
	6'	1.609	251.3	1.724	216.1	1.896	230.8	2.126	222.0	2.355	223.5
	7'	1.693	263.6	1.807	225.4	1.979	241.2	2.209	231.9	2.438	234.8
	[illegible]	1.776	[illegible]	1.891	254.6	2.063	249.4	2.292	244.4	2.522	266.9
10'	3'	1.777	310.8	2.059	261.3	2.412	259.9	2.693	278.2	3.046	281.9
	4'	1.940	325.4	2.152	272.8	2.504	270.2	2.856	273.3	3.138	291.7
	5'	2.033	328.7	2.315	281.9	2.667	278.6	2.949	278.6	3.231	297.6
	6'	2.126	322.6	2.407	271.3	2.760	288.9	3.042	288.0	3.324	307.4
	7'	2.218	335.5	2.500	281.1	2.852	299.3	3.134	298.6	3.416	317.2
	8'	2.311	336.1	2.593	315.0	2.945	305.6	3.227	329.3	3.509	329.9
	9'	2.403	349.8	2.685	325.3	3.038	316.5	3.319	340.2	3.601	348.4
	10'	2.496	362.0	2.778	337.6	3.130	348.1	3.412	358.0	3.694	367.8
12'	8'	3.102	460.5	3.524	389.5	4.030	394.6	4.452	385.5	4.837	392.9
	9'	3.213	476.7	3.635	402.7	4.141	407.5	4.563	428.9	4.985	439.3
	10'	3.324	484.2	3.746	414.9	4.252	418.4	4.674	449.5	5.096	451.0
	11'	3.435	493.9	3.857	422.3	4.363	425.2	4.785	455.3	5.207	474.0
	12'	3.546	505.6	3.968	436.1	4.474	491.5	4.896	483.0	5.318	501.6

TABLE NO. I
0'-10' FILL

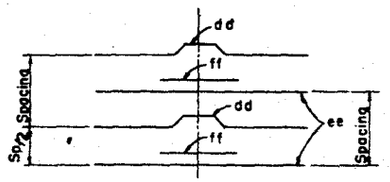
Span "S"	Height "H"	Top Slab "T"	Walls "W"	aa Size	aa Spacing	aa Length	bb Size	bb Spacing	bb Length	cc Number ✦	dd Size	dd Spacing	dd Length	dd A	dd B	dd C	ee Size	ee Spacing	ee Length	ff Size	ff Spacing	ff Length	gg Number ✦	gg D	hh Size	hh Spacing	hh Length	hh F
6'	3'	8"	8"	#4	11"	3'-9	#5	11"	8'-3	48	#4	11"	13'-6	5'-0	2'-3	5½"	#5	11"	13'-6	#5	11"	9'-3	20	3'-6	#4	5½"	4'-9	2'-3
	4'	8"	8"	#4	11"	4'-9	#4	11"	10'-3	54	#4	11"	13'-6	5'-0	2'-3	5½"	#5	11"	13'-6	#5	11"	9'-9	20	3'-6	#4	5½"	5'-3	2'-3
	5'	8"	8"	#4	11"	5'-9	#4	11"	12'-3	54	#4	11"	13'-6	5'-0	2'-3	5½"	#5	11"	13'-6	#5	11"	10'-3	20	3'-6	#4	5½"	5'-9	2'-3
	6'	8"	8"	#4	11"	6'-9	#4	11"	14'-3	60	#4	11"	13'-6	5'-0	2'-3	5½"	#5	11"	13'-6	#5	11"	11'-6	20	3'-6	#4	5½"	6'-3	2'-3
	7'	8"	8"	#4	11"	7'-9	#4	11"	16'-3	66	#4	11"	13'-6	5'-0	2'-3	5½"	#5	11"	13'-6	#5	11"	11'-0	20	3'-6	#4	5½"	7'-0	2'-6
8'	3'	8½"	9"	#4	12"	4'-0	#4	6"	8'-6	48	#5	12"	16'-0	5'-7½	3'-4	6"	#5	12"	17'-9	#6	12"	10'-0	24	4'-5	#5	6"	5'-9	3'-1
	4'	8½"	9"	#4	12"	5'-0	#4	6"	10'-6	54	#5	12"	16'-6	5'-10	3'-4	6"	#6	12"	17'-9	#6	12"	10'-6	28	4'-5	#5	6"	6'-3	3'-1
	5'	9"	9"	#4	14"	6'-0	#4	7"	12'-6	54	#6	14"	16'-6	6'-0	3'-0	6½"	#6	14"	17'-9	#6	14"	11'-0	28	4'-8	#5	7"	6'-6	2'-9
	6'	9"	9"	#4	14"	7'-0	#4	7"	14'-6	60	#6	14"	16'-6	6'-0	3'-0	6½"	#6	14"	17'-9	#6	14"	11'-6	28	4'-8	#5	7"	7'-0	2'-9
	7'	9"	9"	#4	14"	8'-0	#4	7"	16'-6	66	#6	14"	16'-6	5'-9½	3'-4	6½"	#6	14"	17'-9	#6	14"	12'-0	28	4'-4	#5	7"	7'-6	2'-9
	[illegible]	[illegible]	[illegible]	#4	14"	9'-0	#4	7"	18'-6	66	#6	14"	17'-0	6'-1	3'-4	6½"	#6	14"	17'-9	#6	14"	13'-0	28	4'-4	#5	7"	8'-0	2'-9
10'	3'	10"	10"	#4	11"	4'-3	#5	5½"	9'-0	48	#6	11"	19'-9	6'-11	4'-2	7½"	#5	11"	21'-9	#6	11"	17'-6	32	5'-5	#5	5½"	6'-6	3'-9
	4'	10½"	10"	#4	11"	5'-3	#5	5½"	11'-0	54	#6	11"	19'-9	6'-10	4'-2	8"	#5	11"	21'-9	#6	11"	17'-6	32	5'-4	#5	5½"	7'-0	3'-9
	5'	10½"	10"	#4	11"	6'-3	#6	11"	13'-0	54	#6	11"	20'-3	7'-1	4'-2	8"	#5	11"	21'-9	#6	11"	18'-0	32	5'-4	#5	5½"	7'-3	3'-6
	6'	10½"	10"	#4	13"	7'-3	#5	6½"	15'-0	60	#6	13"	20'-3	7'-2	4'-0	8"	#6	13"	21'-9	#7	13"	12'-6	32	5'-6	#5	6½"	7'-9	3'-6
	7'	10½"	10"	#4	13"	8'-3	#5	6½"	17'-0	66	#6	13"	20'-3	7'-2	4'-0	8"	#6	13"	21'-9	#7	13"	13'-0	32	5'-6	#5	6½"	8'-0	3'-3
	8'	10½"	10"	#4	13"	9'-3	#6	13"	19'-0	66	#6	13"	20'-3	7'-2	4'-0	8"	#6	13"	21'-9	#7	13"	13'-6	32	5'-6	#5	6½"	8'-6	3'-3
	9'	10½"	10"	#4	13"	10'-3	#6	13"	21'-0	72	#6	13"	20'-3	7'-2	4'-0	8"	#6	13"	21'-9	#7	13	14'-0	32	5'-6	#5	6½"	9'-0	3'-3
	10'	10½"	10"	#4	13"	11'-3	#4	6½"	23'-0	78	#6	13"	20'-3	7'-2	4'-0	8"	#6	13"	21'-9	#7	13"	15'-0	32	5'-6	#5	6½"	9'-6	3'-3
12'	8'	12½"	12"	#4	11"	9'-6	#5	5½"	20'-0	66	#6	11"	23'-9	8'-2	5'-0	10"	#6	11"	26'-6	#7	11"	17'-3	40	6'-4	#5	5½"	9'-9	4'-3
	9'	12½"	12"	#4	11"	10'-6	#5	5½"	22'-0	72	#6	11"	24'-3	8'-5	5'-0	10"	#6	11"	26'-6	#7	11"	17'-3	40	6'-4	#5	5½"	10'-3	4'-3
	10'	12½"	12"	#4	12"	11'-6	#5	6"	24'-0	78	#7	12"	24'-6	8'-6½	5'-0	10"	#6	12"	26'-6	#7	12"	17'-3	40	6'-4	#5	6"	10'-9	4'-3
	11'	12½"	12"	#4	12"	12'-6	#5	6"	26'-0	78	#7	12"	24'-6	8'-6½	5'-0	10"	#6	12"	26'-6	#7	12	17'-3	40	6'-4	#5	6"	11'-3	4'-3
	12'	12½"	12"	#4	12"	13'-6	#5	6"	28'-0	84	#7	12"	24'-0	8'-3½	5'-0	10"	#6	12"	26'-6	#7	12"	17'-3	40	6'-4	#5	6"	11'-9	4'-3

✦ Total number of bars in the cross-section.

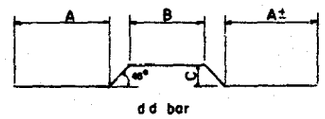


TYPICAL SECTION

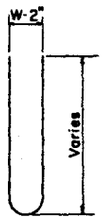
Height "H"	"J" Dim.	"K" Spaces
3'	9"	1
4'	3"	2
5'	12"	2
6'	9"	3
7'	3"	4
8'	12"	4
9'	9"	5
10'	3"	6
11'	12"	6
12'	9"	7



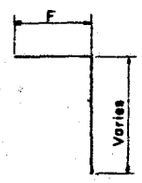
REINFORCING BAR PLACING DIAGRAM



dd bar



bb bar



hh bar

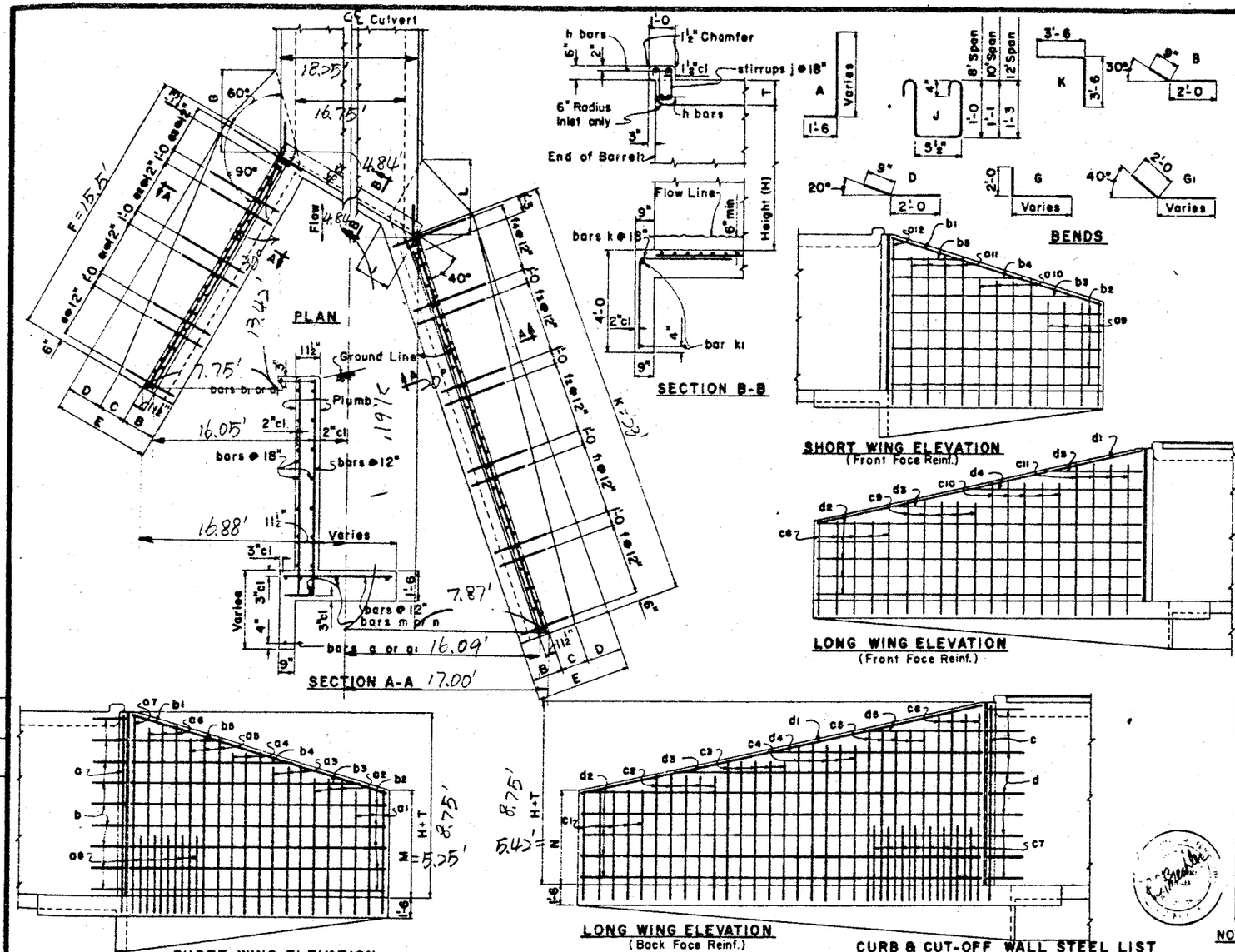
BENDS

NOTE:

See B-02.25 for Tables No. II through V.
See B-01.10 for general notes and miscellaneous details.
All bend dimensions are out to out of bar.

DESIGN APPROVED	ARIZONA DEPARTMENT OF TRANSPORTATION HIGHWAYS DIVISION STANDARD DRAWINGS	REVISION
APPROVED FOR DISTRIBUTION	DOUBLE BARREL BOX CULVERT	STANDARD NO. CB-2 / PLAN NO. B-02.20

A.D.O.T. Highway Division Structures Section Standard Drawings 1983



INLET OR OUTLET WINGS STEEL LIST

Mark	Bend	8' Height No	8' Height Size	8' Height Lgth	9' Height No	9' Height Size	9' Height Lgth	10' Height No	10' Height Size	10' Height Lgth	11' Height No	11' Height Size	11' Height Lgth	12' Height No	12' Height Size	12' Height Lgth
SHORT WING																
a	A	1	#6	11'-3	1	#6	12'-3	1	#7	13'-3	1	#7	14'-3	1	#7	15'-3
a1	✓	3	#5	8'-0	3	#5	8'-3	3	#5	8'-9	3	#5	9'-0	3	#5	9'-3
a2	✓	3	✓	8'-9	3	✓	9'-0	3	✓	9'-6	3	✓	10'-0	3	✓	10'-3
a3	✓	3	✓	9'-6	3	✓	10'-0	3	✓	10'-6	3	#6	11'-0	3	#6	11'-3
a4	✓	3	✓	10'-3	3	#6	10'-9	3	#6	11'-3	3	#7	12'-0	3	#7	12'-3
a5	✓	3	#6	11'-0	3	✓	11'-6	3	#7	12'-3	3	✓	12'-9	3	✓	13'-3
a6	✓				1	✓	12'-3	2	✓	13'-0	3	✓	13'-9	3	✓	14'-3
a7	✓													1	✓	15'-3
a8	✓										3	#5	6'-3	5	#5	6'-9
a9	str	4	#4	6'-3	4	#4	6'-9	4	#4	7'-3	4	#4	7'-6	4	#4	7'-9
a10	✓	4	✓	7'-9	4	✓	8'-6	4	✓	9'-0	4	✓	9'-6	4	✓	9'-9
a11	✓	2	✓	9'-3	3	✓	10'-0	3	✓	10'-9	4	✓	11'-3	4	✓	11'-9
a12	✓													1	✓	13'-9
b	B	6	#4	2'-9	7	#4	2'-9	7	#4	2'-9	8	#4	2'-9	9	✓	2'-9
b1	str	2	#6	14'-6	2	#6	15'-9	2	#6	16'-9	2	#6	18'-0	2	#6	19'-3
b2	✓	8	#4	14'-3	8	#4	15'-3	8	#4	16'-3	8	#4	17'-3	8	#4	18'-3
b3	✓	2	✓	7'-9	2	✓	10'-9	2	✓	13'-6	2	✓	15'-9	2	✓	17'-6
b4	✓				2	✓	5'-3	2	✓	8'-3	2	✓	11'-0	2	✓	13'-3
b5	✓										2	✓	6'-3	2	✓	8'-9
e	✓	4	#4	2'-9	5	#4	3'-0	5	#4	3'-3	5	✓	3'-3	5	✓	3'-3
e1	✓	4	✓	3'-0	4	✓	3'-6	5	✓	3'-9	5	#5	4'-0	5	#5	4'-0
e2	✓	4	✓	3'-9	4	✓	4'-0	4	#5	4'-6	5	#6	4'-9	5	#6	5'-0
e3	✓	4	✓	4'-0	4	#5	4'-6	4	#6	5'-0	4	✓	5'-6	5	#7	5'-9
g	G	1	✓	17'-0	1	#4	18'-0	1	#4	19'-0	1	#4	20'-0	1	#4	21'-0
m	str	5	✓	15'-0	5	✓	16'-0	5	✓	17'-0	6	✓	18'-0	6	✓	19'-0
LONG WING																
c	A	1	#6	11'-3	1	#6	12'-3	1	#7	13'-3	1	#7	14'-3	1	#7	15'-3
c1	✓	5	#5	8'-0	5	#5	8'-6	5	#5	8'-9	5	#5	9'-0	5	#5	9'-3
c2	✓	5	✓	8'-9	5	✓	9'-3	5	✓	9'-6	5	✓	10'-0	5	✓	10'-6
c3	✓	5	✓	9'-6	5	✓	10'-0	5	#6	10'-6	5	#6	11'-0	5	#6	11'-6
c4	✓	5	✓	10'-3	5	#6	11'-0	5	✓	11'-6	5	#7	12'-0	5	#7	12'-6
c5	✓	2	#6	11'-3	4	✓	11'-9	5	#7	12'-6	5	✓	13'-0	5	✓	13'-9
c6	✓							1	✓	13'-3	2	✓	14'-0	4	✓	14'-9
c7	✓										4	#5	6'-3	8	#5	6'-9
c8	str	5	#4	6'-6	5	#4	7'-0	5	#4	7'-3	5	#4	7'-6	5	#4	7'-9
c9	✓	5	✓	7'-9	5	✓	8'-3	5	✓	8'-9	5	✓	9'-0	5	✓	9'-6
c10	✓	5	✓	8'-9	4	✓	9'-6	5	✓	10'-0	5	✓	10'-6	5	✓	11'-0
c11	✓				2	✓	10'-9	2	✓	11'-6	3	✓	12'-0	4	✓	12'-9
d	D	6	#4	2'-9	7	✓	2'-9	7	✓	2'-9	8	✓	2'-9	9	✓	2'-9
d1	str	2	#6	22'-0	2	#6	24'-0	2	#6	25'-6	2	#6	27'-3	2	#6	28'-9
d2	✓	8	#4	21'-9	8	#4	23'-9	8	#4	25'-3	8	#4	26'-9	10	#4	28'-3
d3	✓	2	✓	12'-6	2	✓	17'-6	2	✓	21'-3	2	✓	24'-9	2	✓	20'-9
d4	✓				2	✓	8'-9	2	✓	13'-3	2	✓	17'-3	2	✓	13'-9
d5	✓										2	✓	9'-9	2	✓	6'-9
f	✓	5	#4	2'-9	5	#4	3'-0	6	#4	3'-3	6	✓	3'-3	6	✓	3'-3
f1	✓	5	✓	3'-0	5	✓	3'-3	6	✓	3'-9	6	✓	3'-9	6	✓	4'-0
f2	✓	5	✓	3'-6	5	✓	3'-9	5	✓	4'-3	6	#5	4'-3	6	#5	4'-6
f3	✓	4	✓	3'-9	5	#5	4'-0	5	#5	4'-6	5	#6	5'-0	6	#6	5'-3
f4	✓	4	✓	4'-0	5	✓	4'-6	5	#6	5'-0	5	✓	5'-6	6	#7	5'-9
g1	G1	1	✓	26'-0	1	#4	28'-0	1	#4	29'-9	1	#4	31'-3	1	#4	32'-9
n	str	5	✓	22'-6	5	✓	24'-6	5	✓	26'-0	6	✓	27'-6	6	✓	29'-0

DIMENSIONS

Height of Opening	B	C	D	E	F	G	J	K	L	M	N
8'	2'-0	1'-4	1'-8	5'-2	16'-0	4'-0	2'-4 3/8	25'-0	3'-8	5'-7	5'-9
9'	2'-1	1'-5	1'-9	5'-3	16'-6	4'-0	2'-4 3/8	25'-0	3'-9	5'-8	5'-10
10'	2'-2	1'-7	2'-0	5'-9	17'-6	4'-7	2'-5 3/4	26'-6	4'-3	6'-1	6'-2
11'	2'-3	1'-6	2'-6	6'-3	18'-6	5'-2	2'-7 1/4	28'-0	4'-10	6'-5	6'-6
12'	2'-4	1'-5	3'-0	6'-9	19'-6	5'-8	2'-8 7/8	29'-6	5'-4	6'-7	6'-9

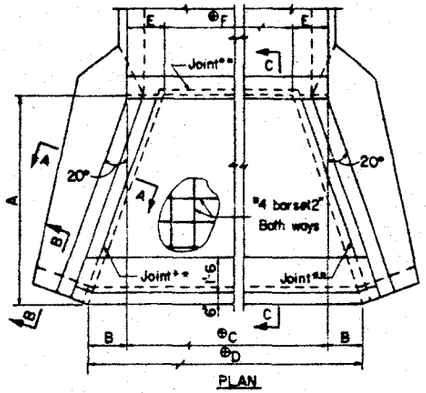
CURB & CUT-OFF WALL STEEL LIST

Mark	Bend	8' Spans 1 Barrel No	Size	Lgth	○ No	◇ Lgth	10' Spans 1 Barrel No	Size	Lgth	○ No	◇ Lgth	12' Spans 1 Barrel No	Size	Lgth	○ No	◇ Lgth
h	str	4	#6	10'-6		10'-1	4	#6	13'-0		12'-6	4	#7	15'-9		15'-0
j	J	7	#4	3'-6	7		9	#4	3'-9	8		10	#4	4'-3	10	
k	K	5	✓	7'-0	6		7	✓	7'-0	8		8	✓	7'-0	9	
k1	str	2	✓	6'-9		10'-1	2	✓	8'-9		12'-6	2	✓	11'-3		15'-0

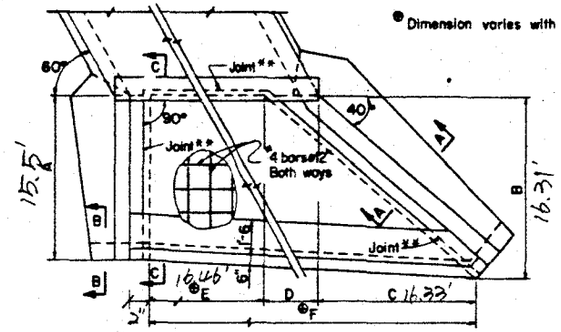
○ Additional number of bars per each extra barrel.
◇ Additional length of bars per each extra barrel.

NOTE:
See B-01.10 for general notes and miscellaneous details.
See B-07.10 for concrete and steel headwall quantities.

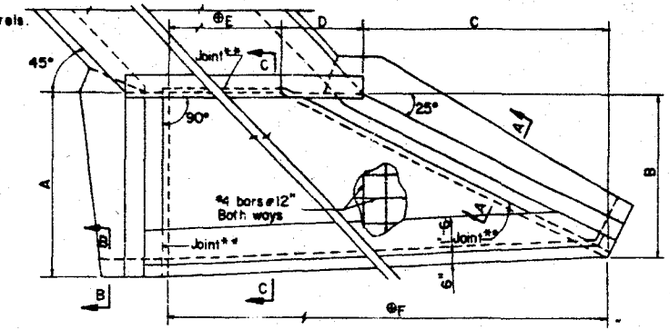
DESIGN APPROVED R.C. Breden	ARIZONA DEPARTMENT OF TRANSPORTATION HIGHWAYS DIVISION STANDARD DRAWINGS	REVISION
APPROVED FOR DISTRIBUTION	INLET OR OUTLET WINGS 30° SKEW CULVERT 6:1 SLOPE, HEIGHT 8' TO 12'	STANDARD NO CW6-6 PLAN NO B-05.60



PLAN
Apron for Rt ∢ box culv.

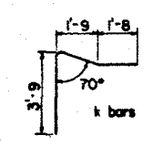


PLAN
Apron for 30° skew box culv.

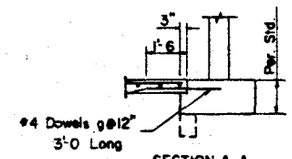


PLAN
Apron for 45° skew box culv.

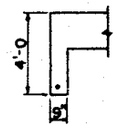
** Optional construction joint. Apron may be poured with wingwall footings and bottom slab of barrel.



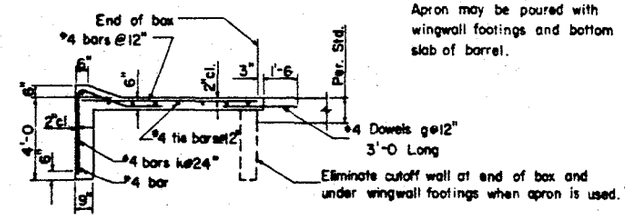
BEND DIAGRAM



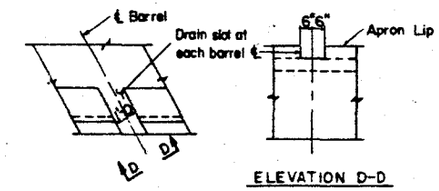
SECTION A-A



SECTION B-B



SECTION C-C



ELEVATION D-D

APRON DRAIN DETAILS

OUTLET APRON QUANTITIES FOR CW2 WINGS

Span	Hgt.	RT. ANGLE Conc. C.Y. 1 Bbl.	2 Bbl.	Δc	Steel lbs. 1 Bbl.	2 Bbl.	Δs	30° SKEW Conc. C.Y. 1 Bbl.	2 Bbl.	Δc	Steel lbs 1 Bbl.	2 Bbl.	Δs	45° SKEW Conc. C.Y. 1 Bbl.	2 Bbl.	Δc	Steel lbs. 1 Bbl.	2 Bbl.	Δs
6'	3'	.86	1.55	.69	91	151	60	1.27	2.07	.80	120	189	69	1.80	2.75	.95	145	222	77
	4'	1.04	1.84	.80	105	179	74	1.49	2.40	.91	136	215	79	2.23	3.34	1.11	178	267	89
	5'	1.23	2.14	.91	120	202	82	1.71	2.75	1.04	157	241	84	2.68	3.95	1.27	212	313	101
	6'	1.51	2.59	1.08	147	241	94	1.94	3.10	1.16	180	277	97	3.16	4.60	1.44	251	364	113
	7'	1.81	3.07	1.26	188	286	98	2.19	3.48	1.29	205	307	102	3.67	5.27	1.60	284	414	130
8'	3'	1.09	1.99	.90	111	187	76	1.54	2.61	1.07	137	232	95	2.12	3.37	1.25	171	270	99
	4'	1.31	2.37	1.06	132	220	88	1.79	3.01	1.22	160	263	103	2.59	4.06	1.47	209	323	114
	5'	1.53	2.74	1.21	155	253	98	2.06	3.44	1.38	184	300	116	3.10	4.78	1.68	246	377	131
	6'	1.87	3.30	1.43	184	306	122	2.33	3.86	1.53	210	338	128	3.63	5.52	1.89	284	435	151
	7'	2.22	3.89	1.67	222	355	133	2.61	4.32	1.71	233	379	146	4.30	6.30	2.10	327	493	166
	8'	2.52	4.43	1.91	235	383	148	3.22	5.18	1.96	271	435	164	4.76	7.13	2.37	360	544	184
10'	3'	1.32	2.44	1.12	131	230	99	1.80	3.13	1.33	159	271	112	2.44	4.00	1.56	193	318	125
	4'	1.58	2.89	1.31	154	267	113	2.10	3.61	1.51	186	313	127	2.97	4.79	1.82	234	378	144
	5'	1.84	3.34	1.50	180	302	122	2.40	4.11	1.71	213	351	138	3.52	5.61	2.09	276	440	164
	6'	2.23	4.01	1.78	219	365	146	2.71	4.61	1.90	237	400	163	4.11	6.46	2.35	322	506	184
	7'	2.64	4.70	2.06	255	420	165	3.05	5.17	2.12	273	442	169	4.72	7.33	2.61	369	572	203
	8'	3.00	5.38	2.38	275	451	176	3.71	6.15	2.44	315	503	188	5.35	8.28	2.93	402	631	229
	9'	3.41	6.08	2.67	314	528	214	4.16	6.84	2.68	344	556	212	6.04	9.25	3.21	449	693	244
	10'	3.86	7.82	3.96	347	573	226	4.64	7.55	2.91	388	609	221	6.75	10.23	3.48	502	766	264
12'	8'	3.51	6.37	2.86	315	535	220	4.24	7.17	2.93	362	594	232	5.99	9.51	3.52	457	721	264
	9'	3.99	7.20	3.21	359	610	251	4.75	7.96	3.21	392	649	257	6.73	10.59	3.86	503	798	295
	10'	4.50	8.06	3.56	403	670	267	5.27	8.76	3.49	440	713	273	7.50	11.68	4.18	560	872	312
	11'	5.01	8.91	3.90	449	751	302	5.93	9.75	3.82	485	780	295	8.30	12.80	4.50	615	953	338
	12'	5.36	9.50	4.14	481	795	314	6.40	10.59	4.19	532	852	320	9.12	13.95	4.83	668	1036	368

OUTLET APRON QUANTITIES FOR CW6 WINGS

Span	Hgt.	RT. ANGLE Conc. C.Y. 1 Bbl.	2 Bbl.	Δc	Steel lbs. 1 Bbl.	2 Bbl.	Δs	30° SKEW Conc. C.Y. 1 Bbl.	2 Bbl.	Δc	Steel lbs. 1 Bbl.	2 Bbl.	Δs	45° SKEW Conc. C.Y. 1 Bbl.	2 Bbl.	Δc	Steel lbs. 1 Bbl.	2 Bbl.	Δs
6'	3'	1.35	2.38	1.03	145	231	86	1.86	2.97	1.11	170	261	91	2.21	3.32	1.11	178	268	90
	4'	1.86	3.18	1.32	192	299	107	2.50	3.89	1.39	224	336	112	2.98	4.35	1.37	231	335	104
	5'	2.57	4.24	1.67	260	394	134	3.24	4.92	1.68	292	417	125	3.85	5.48	1.63	296	422	126
	6'	3.09	5.00	1.91	315	456	141	3.98	5.88	1.90	357	500	143	4.62	6.45	1.83	352	493	141
	7'	3.68	5.81	2.13	358	531	173	4.52	6.61	2.09	393	557	164	5.43	7.46	2.03	412	564	152
8'	3'	1.69	3.05	1.36	173	288	115	2.23	3.69	1.46	198	317	119	2.57	4.04	1.47	209	323	114
	4'	2.30	4.03	1.73	227	367	140	2.96	4.79	1.83	260	405	145	3.43	5.24	1.81	261	401	140
	5'	3.12	5.31	2.19	303	478	175	3.80	6.00	2.20	332	504	172	4.39	6.54	2.15	339	502	163
	6'	3.72	6.23	2.51	363	561	198	4.60	7.12	2.52	402	599	197	5.22	7.63	2.41	394	581	187
	7'	4.38	7.18	2.80	411	637	226	5.20	7.96	2.76	447	659	212	6.11	8.77	2.66	463	660	197
	8'	4.69	7.75	3.06	445	687	242	5.92	[illegible]	3.04	504	[illegible]	236	6.74	9.69	2.95	519	746	227
10'	3'	2.03	3.72	1.69	200	342	142	2.60	4.41	1.81	232	378	146	2.94	4.76	1.82	234	379	145
	4'	2.73	4.89	2.16	260	429	169	3.42	5.70	2.28	299	480	181	3.88	6.10	2.22	297	466	169
	5'	3.67	6.39	2.72	345	555	210	4.35	7.08	2.73	380	587	207	4.92	7.60	2.68	376	581	205
	6'	4.35	7.45	3.10	410	649	239	5.24	8.12	2.88	457	688	231	5.82	8.81	2.99	441	669	228
	7'	5.08	8.55	3.47	475	736	261	5.89	9.30	3.41	501	766	265	6.77	10.08	3.31	510	757	247
	8'	5.46	9.25	3.79	499	797	298	6.67	10.45	3.78	565	850	285	7.47	11.14	3.67	577	856	279
	9'	5.83	9.82	3.99	529	837	308	7.37	11.42	4.05	612	926	314	8.24	12.18	3.94	608	903	295
	10'	6.19	10.38	4.19	545	860	315	7.97	12.26	4.29	662	987	325	9.03	13.24	4.21	668	974	306
12'	8'	6.29	10.85	4.56	565	912	347	7.49	12.03	4.54	628	979	351	8.28	12.67	4.39	632	968	336
	9'	6.69	11.48	4.79	606	970	364	8.25	13.12	4.87	683	1060	377	9.10	13.82	4.72	676	1024	348
	10'	7.10	12.13	5.03	622	999	377	8.90	14.05	5.15	730	1123	393	9.95	15.00	5.05	731	1108	377
	11'	7.52	12.78	5.26	652	1046	394	9.55	14.97	5.42	786	1203	417	10.83	16.21	5.38	794	1197	403
	12'	7.94	13.44	5.50	686	1093	407	10.20	15.91	5.71	833	1266	433	11.74	17.44	5.70	866	1277	411

NOTES:

The apron quantities take into consideration the cutoff walls being omitted along outlet headwall, and shall be used on new box culverts only.

See B-01.10 for general notes and miscellaneous detail.

See B-06.20 for Apron Dimensions.

NOTATIONS:

Δc = Amount of concrete to be added for each additional barrel.

Δs = Amount of steel to be added for each additional barrel.

DESIGN APPROVED	ARIZONA DEPARTMENT OF TRANSPORTATION HIGHWAYS DIVISION STANDARD DRAWINGS	REVISION
R C Buehler		
APPROVED FOR DISTRIBUTION	OUTLET APRONS FOR CW2 AND CW6 WINGS	STANDARD NO. CWA-1
		PLAN NO. B-06.10

RT. ANGLE OUTLET APRON FOR CW2 WINGS

Span	Hgt.	Dimensions								
		A	B	C_1	C_2	D_1	D_2	E	F_1	F_2	Δ
6'	3'	5'-2 1/2	0'-3 5/8	7'-4	14'-0	7'-11 1/4	14'-7 1/4	1'-7 1/8	4'-1 3/4	10'-9 3/4	6'-8
	4'	6'-1 7/8	0'-7 3/4	7'-4	14'-0	8'-7 1/2	15'-3 1/2	1'-7 1/8	4'-1 3/4	10'-9 3/4	6'-8
	5'	7'-1 1/8	0'-11 7/8	7'-4	14'-0	9'-3 3/4	15'-11 3/4	1'-7 1/8	4'-1 3/4	10'-9 3/4	6'-8
	6'	8'-6	1'-6	7'-4	14'-0	10'-4	17'-0	1'-7 1/8	4'-1 3/4	10'-9 3/4	6'-8
	7'	9'-10 7/8	2'-0 1/8	7'-4	14'-0	11'-4 1/4	18'-0 1/4	1'-7 1/8	4'-1 3/4	10'-9 3/4	6'-8
8'	3'	5'-2 1/2	0'-3 5/8	9'-6	18'-3	10'-1 1/4	18'-10 1/4	1'-7 1/8	6'-3 3/4	15'-0 3/4	8'-9
	4'	6'-1 7/8	0'-7 3/4	9'-6	18'-3	10'-9 1/2	19'-6 1/2	1'-7 1/8	6'-3 3/4	15'-0 3/4	8'-9
	5'	7'-1 1/8	0'-11 7/8	9'-6	18'-3	11'-5 3/4	20'-2 3/4	1'-7 1/8	6'-3 3/4	15'-0 3/4	8'-9
	6'	8'-6	1'-6	9'-6	18'-3	12'-6	21'-3	1'-7 1/8	6'-3 3/4	15'-0 3/4	8'-9
	7'	9'-10 7/8	2'-0 1/8	9'-6	18'-3	13'-6 1/4	22'-3 1/4	1'-7 1/8	6'-3 3/4	15'-0 3/4	8'-9
	8'	11'-5 7/8	2'-0 5/8	9'-6	18'-3	13'-7 1/4	22'-4 1/4	2'-1 1/2	5'-3	14'-0	8'-9
10'	3'	5'-2 1/2	0'-3 5/8	11'-8	22'-6	12'-3 1/4	23'-1 1/4	1'-7 1/8	8'-5 3/4	19'-3 3/4	10'-10
	4'	6'-1 7/8	0'-7 3/4	11'-8	22'-6	12'-11 1/2	23'-9 1/2	1'-7 1/8	8'-5 3/4	19'-3 3/4	10'-10
	5'	7'-1 1/8	0'-11 7/8	11'-8	22'-6	13'-7 3/4	24'-5 3/4	1'-7 1/8	8'-5 3/4	19'-3 3/4	10'-10
	6'	8'-6	1'-6	11'-8	22'-6	14'-8	25'-6	1'-7 1/8	8'-5 3/4	19'-3 3/4	10'-10
	7'	9'-10 7/8	2'-0 1/8	11'-8	22'-6	15'-8 1/4	26'-6 1/4	1'-7 1/8	8'-5 3/4	19'-3 3/4	10'-10
	8'	11'-5 7/8	2'-0 5/8	11'-8	22'-6	15'-9 1/4	26'-7 1/4	2'-1 1/2	7'-5	18'-3	10'-10
	9'	12'-11 1/8	2'-5 7/8	11'-8	22'-6	16'-7 3/4	27'-5 3/4	2'-2 5/8	7'-2 3/4	18'-0 3/4	10'-10
	10'	14'-4 3/8	2'-11 1/8	11'-8	22'-6	17'-6 1/4	28'-4 1/4	2'-3 5/8	7'-0 3/4	17'-10 3/4	10'-10
12'	8'	11'-5 7/8	2'-0 5/8	14'-0	27'-0	18'-1 1/4	31'-1 1/4	2'-1 1/2	9'-9	22'-9	13'-0
	9'	12'-11 1/8	2'-5 7/8	14'-0	27'-0	18'-11 3/4	31'-11 3/4	2'-2 5/8	9'-6 3/4	22'-6 3/4	13'-0
	10'	14'-4 3/8	2'-11 1/8	14'-0	27'-0	19'-10 1/4	32'-10 1/4	2'-3 5/8	9'-4 1/2	22'-4 1/2	13'-0
	11'	15'-9 5/8	3'-4 1/4	14'-0	27'-0	20'-8 1/2	33'-8 1/2	2'-4 3/4	9'-2 1/2	22'-2 1/2	13'-0
	12'	16'-9 1/4	3'-7 1/2	14'-0	27'-0	21'-3	34'-3	2'-5 3/4	9'-0 1/2	22'-0 1/2	13'-0

30° SKEW OUTLET APRON FOR CW2 WINGS

Span	Hgt.	Dimensions								
		A	B	C	D	E_1	E_2	F_1	F_2	Δ
6'	3'	5'-0	5'-7 3/4	4'-4 3/4	2'-4	4'-7 5/8	12'-4	11'-4 5/8	19'-0 3/4	7'-8 3/8
	4'	6'-0	6'-3 1/2	5'-2	2'-4	4'-7 5/8	12'-4	12'-1 5/8	19'-10	7'-8 3/8
	5'	7'-0	6'-11 1/4	5'-11 1/8	2'-4	4'-7 5/8	12'-4	12'-10 3/4	20'-7 1/2	7'-8 3/8
	6'	8'-0	7'-6 7/8	6'-8 3/8	2'-4	4'-7 5/8	12'-4	13'-8	21'-4 3/8	7'-8 3/8
	7'	9'-0	8'-6 1/2	7'-5 1/2	2'-4	4'-7 3/8	12'-4	14'-5 1/8	22'-1 1/8	7'-8 3/8
8'	3'	5'-0	5'-7 3/4	4'-4 3/4	2'-4	7'-1 5/8	17'-2 7/8	13'-10 3/8	23'-11 5/8	10'-1 1/4
	4'	6'-0	6'-3 1/2	5'-2	2'-4	7'-1 5/8	17'-2 7/8	14'-7 5/8	24'-8 7/8	10'-1 1/4
	5'	7'-0	6'-11 1/4	5'-11 1/8	2'-4	7'-1 5/8	17'-2 7/8	15'-4 3/4	25'-6	10'-1 1/4
	6'	8'-0	7'-6 7/8	6'-8 3/8	2'-4	7'-1 5/8	17'-2 7/8	16'-2	26'-3 1/4	10'-1 1/4
	7'	9'-0	8'-6 1/2	7'-5 1/2	2'-4	7'-1 5/8	17'-2 7/8	16'-11 1/8	27'-0 3/8	10'-1 1/4
	8'	10'-0	10'-2 1/2	9'-0 5/8	3'-1 3/8	6'-4 1/4	16'-5 1/2	18'-6 1/4	28'-7 1/2	10'-1 1/4
10'	3'	5'-0	5'-7 3/4	4'-4 3/4	2'-4	9'-7 3/8	22'-1 3/8	16'-4 3/8	28'-10 1/2	12'-6 1/8
	4'	6'-0	6'-3 1/2	5'-2	2'-4	9'-7 5/8	22'-1 3/8	17'-1 5/8	29'-7 3/4	12'-6 1/8
	5'	7'-0	6'-11 1/4	5'-11 1/8	2'-4	9'-7 5/8	22'-1 3/8	17'-10 3/8	30'-4 7/8	12'-6 1/8
	6'	8'-0	7'-6 7/8	6'-8 3/8	2'-4	9'-7 5/8	22'-1 3/4	18'-8	31'-2 1/8	12'-6 1/8
	7'	9'-0	8'-6 1/2	7'-5 1/2	2'-4	9'-7 3/8	22'-1 3/8	19'-5 1/8	31'-11 1/4	12'-6 1/8
	8'	10'-0	10'-2 1/2	9'-0 5/8	3'-1 3/8	8'-10 1/4	21'-4 3/8	21'-0 1/4	33'-6 5/8	12'-6 1/8
	9'	11'-0	11'-2 7/8	10'-1 3/4	3'-2 7/8	8'-8 3/4	21'-2 7/8	22'-1 3/8	34'-7 1/2	12'-6 1/8
	10'	12'-0	12'-3 1/4	11'-3	3'-4 1/2	8'-7 1/8	21'-1 1/4	23'-2 5/8	35'-8 3/4	12'-6 1/8
12'	8'	10'-0	10'-2 1/2	9'-0 5/8	3'-1 3/8	11'-6 5/8	26'-6 3/4	23'-8 5/8	38'-8 3/4	15'-0 1/8
	9'	11'-0	11'-2 7/8	10'-1 3/4	3'-2 7/8	11'-5 1/8	26'-5 1/4	24'-9 3/4	39'-9 7/8	15'-0 1/8
	10'	12'-0	12'-3 1/4	11'-3	3'-4 1/2	11'-3 1/2	26'-3 3/4	25'-11	40'-11 1/8	15'-0 1/8
	11'	13'-0	13'-7 3/8	12'-8 3/8	3'-6	11'-2	26'-2 1/8	27'-4 3/8	42'-4 7/8	15'-0 1/8
	12'	14'-0	14'-7 3/8	13'-9 7/8	3'-7 1/2	11'-0 1/2	26'-0 5/8	28'-5 7/8	43'-6	15'-0 1/8

45° SKEW OUTLET APRON FOR CW2 WINGS

Span	Hgt.	Dimensions								
		A	B	C	D	E_1	E_2	F_1	F_2	Δ
6'	3'	5'-0	5'-2	7'-6 1/4	3'-6 5/8	5'-3 7/8	14'-9	16'-4 3/4	25'-9 7/8	9'-5 1/8
	4'	6'-0	6'-0 1/8	9'-4	3'-6 5/8	5'-3 7/8	14'-9	18'-2 1/2	27'-7 5/8	9'-5 1/8
	5'	7'-0	6'-10 1/4	11'-1 3/4	3'-6 5/8	5'-3 7/8	14'-9	20'-0 1/4	29'-5 3/8	9'-5 1/8
	6'	8'-0	7'-8 3/8	12'-11 1/2	3'-6 5/8	5'-3 7/8	14'-9	21'-10	31'-3 1/8	9'-5 1/8
	7'	9'-0	8'-6 1/2	14'-9 1/4	3'-6 5/8	5'-3 7/8	14'-9	23'-7 3/4	33'-0 3/8	9'-5 1/8
8'	3'	5'-0	5'-2	7'-6 1/4	3'-6 5/8	8'-4 3/8	20'-9 1/8	19'-5 1/2	31'-10	12'-4 1/2
	4'	6'-0	6'-0 1/8	9'-4	3'-6 5/8	8'-4 3/8	20'-9 1/8	21'-3 1/4	33'-7 3/4	12'-4 1/2
	5'	7'-0	6'-10 1/4	11'-1 3/4	3'-6 5/8	8'-4 3/8	20'-9 1/8	23'-1	35'-5 1/2	12'-4 1/2
	6'	8'-0	7'-8 3/8	12'-11 1/2	3'-6 5/8	8'-4 3/8	20'-9 1/8	24'-10 3/4	37'-3 1/4	12'-4 1/2
	7'	9'-0	8'-6 1/2	14'-9 1/4	3'-6 5/8	8'-4 3/8	20'-9 1/8	26'-8 1/2	39'-1	12'-4 1/2
	8'	10'-0	9'-10 1/8	16'-4 1/2	4'-8 3/4	6'-8 1/2	19'-1	27'-9 3/4	40'-2 1/4	12'-4 1/2
10'	3'	5'-0	5'-2	7'-6 1/4	3'-6 5/8	11'-5 3/8	26'-9 1/4	22'-6 1/4	37'-10 1/8	15'-3 7/8
	4'	6'-0	6'-0 1/8	9'-4	3'-6 5/8	11'-5 3/8	26'-9 1/4	24'-4	39'-7 7/8	15'-3 7/8
	5'	7'-0	6'-10 1/4	11'-1 3/4	3'-6 5/8	11'-5 3/8	26'-9 1/4	26'-1 3/4	41'-5 3/8	15'-3 7/8
	6'	8'-0	7'-8 3/8	12'-11 1/2	3'-6 5/8	11'-5 3/8	26'-9 1/4	27'-11 1/2	43'-3 1/8	15'-3 7/8
	7	9'-0	8'-6 1/2	14'-9 1/4	3'-6 5/8	11'-5 3/8	26'-9 1/4	29'-9 1/4	45'-1 1/8	15'-3 7/8
	8'	10'-0	9'-10 1/8	16'-4 1/2	4'-8 3/4	9'-9 1/4	25'-1 1/8	30'-10 1/2	46'-2 3/8	15'-3 7/8
	9'	11'-0	10'-9 1/8	18'-1 7/8	4'-11 1/8	9'-5 7/8	24'-9 3/4	32'-6 7/8	47'-10 3/4	15'-3 7/8
	10'	12'-0	11'-8 1/4	19'-11 1/8	5'-1 1/8	9'-2 1/2	24'-6 5/8	34'-3 1/8	49'-7	15'-3 7/8
12'	8'	10'-0	9'-10 1/8	16'-4 1/2	4'-8 3/4	13'-0 1/8	31'-5 1/2	34'-2 1/8	52'-6 3/4	18'-4 3/8
	9'	11'-0	10'-9 1/8	18'-1 7/8	4'-11 1/8	12'-9 1/2	31'-2 1/8	35'-10 1/2	54'-3 1/8	18'-4 3/8
	10'	12'-0	11'-8 1/4	19'-11 1/8	5'-1 1/2	12'-6 1/8	30'-10 3/4	37'-6 3/4	55'-11 5/8	18'-4 3/8
	11'	13'-0	12'-7 1/4	21'-8 1/2	5'-3 7/8	12'-2 3/4	30'-7 3/8	39'-3 1/8	57'-7 3/4	18'-4 3/8
	12'	14'-0	13'-6 1/4	23'-5 3/4	5'-6 1/4	11'-11 5/8	30-4	40'-11 5/8	59'-4	18-4 3/8

RT. ANGLE OUTLET APRON FOR CW6 WINGS

Span	Hgt.	Dimensions								
		A	B	C_1	C_2	D_1	D_2	E	F_1	F_2	Δ
6'	3'	8'-0 3/8	1'-3 7/8	7'-4	14'-0	9'-11 5/8	16'-7 5/8	1'-7 1/8	4'-1 3/4	10'-9 3/4	6'-8
	4'	10'-4 1/2	2'-2 1/8	7'-4	14'-0	11'-8 3/8	18'-4 3/8	1'-7 1/8	4'-1 3/4	10'-9 3/4	6'-8
	5'	13'-2 3/8	3'-2 1/2	7'-4	14'-0	13'-9	20'-5	1'-7 1/8	4'-1 3/4	10'-9 3/4	6'-8
	6'	15'-1	3'-10 3/4	7'-4	14'-0	15'-1 5/8	21'-9 3/8	1'-7 1/8	4'-1 3/4	10'-9 3/4	6'-8
	7'	16'-11 1/8	4'-6 7/8	7'-4	14'-0	16'-5 7/8	23'-1 7/8	1'-7 1/8	4'-1 3/4	10'-9 3/4	6'-8
8'	3'	8'-0 3/8	1'-3 7/8	9'-6	18'-3	12'-1 3/4	20'-10 3/4	1'-7 1/8	6'-3 3/4	15'-0 3/4	8'-9
	4'	10'-4 1/2	2'-2 1/8	9'-6	18'-3	13'-10 1/4	22'-7 1/4	1'-7 1/8	6'-3 3/4	15'-0 3/4	8'-9
	5'	13'-2 3/8	3'-2 1/2	9'-6	18'-3	15'-11	24'-8	1'-7 1/8	6'-3 3/4	15'-0 3/4	8'-9
	6'	15'-1	3'-10 3/4	9'-6	18'-3	17'-3 1/2	26'-0 1/2	1'-7 1/8	6'-3 3/4	15'-0 3/4	8'-9
	7'	16'-11 1/2	4'-6 7/8	9'-6	18'-3	18'-7 3/8	27'-4 3/4	1'-7 1/8	6'-3 3/4	15'-0 3/4	8'-9
	8'	18'-6 1/2	4'-7 3/4	9'-6	18'-3	18'-8 3/4	27'-5 3/4	2'-1 1/2	5'-3	14'-0	8'-9
10'	3'	8'-0 3/8	1'-3 7/8	11'-8	22'-6	14'-3 3/4	25'-1 3/4	1'-7 1/8	8'-5 3/4	19'-3 3/4	10'-10
	4'	10'-4 1/2	2'-2 1/8	11'-8	22'-6	16'-0 1/4	26'-10 1/4	1'-7 1/8	8'-5 3/4	19'-3 3/4	10'-10
	5'	13'-2 3/8	3'-2 1/2	11'-8	22'-6	18'-1	28'-11	1'-7 1/8	8'-5 3/4	19'-3 3/4	10'-10
	6'	15'-1	3'-10 3/4	11'-8	22'-6	19'-5 1/2	30'-3 1/2	1'-7 1/8	8'-5 3/4	19'-3 3/4	10'-10
	7'	16'-11 1/2	4'-6 7/8	11'-8	22'-6	20'-9 3/4	31'-7 3/4	1'-7 1/8	8'-5 3/4	19'-3 3/4	10'-10
	8'	18'-6 1/2	4'-7 3/4	11'-8	22'-6	20'-10 3/4	31'-8 3/4	2'-1 1/2	7'-5	18'-3	10'-10
	9'	19'-6 1/8	4'-10 5/8	11'-8	22'-6	21'-5 1/4	32'-3 1/4	2'-2 5/8	7'-2 3/8	18'-0 3/8	10'-10
	10'	20'-5 3/4	5'-1 3/8	11'-8	22'-6	21'-11 1/2	32'-9 1/2	2'-3 3/4	7'-0 1/2	17'-10 1/2	10'-10
12'	8'	18'-6 1/2	4'-7 3/4	14'-0	27'-0	23'-2 3/4	36'-2 3/4	2'-1 1/2	9'-9	22'-9	13'-0
	9'	19'-6 1/8	4'-10 5/8	14'-0	27'-0	23'-9 1/4	36'-9 1/4	2'-2 5/8	9'-6 3/8	22'-6 3/8	13'-0
	10'	20'-5 3/4	5'-1 3/8	14'-0	27'-0	24'-3 1/2	37'-3 1/2	2'-3 3/4	9'-4 1/2	22'-4 1/2	13'-0
	11'	21'-5 3/8	5'-4 7/8	14'-0	27'-0	24'-9 3/4	37'-9 3/4	2'-4 3/4	9'-2 1/2	22'-2 1/2	13'-0
	12'	22'-5	5'-8 1/8	14'-0	27'-0	25'-4 1/4	38'-4 1/2	2'-5 3/4	9'-0 1/2	22'-0 1/2	13'-0

30° SKEW OUTLET APRON FOR CW6 WINGS

Span	Hgt.	Dimensions								
		A	B	C	D	E_1	E_2	F_1	F_2	Δ
6'	3'	7'-0	7'-10 3/8	7'-1	2'-4	4'-7 5/8	12'-4	14'-0 1/2	21'-9	7'-8 3/8
	4'	9'-0	9'-9 7/8	9'-4 1/2	2'-4	4'-7 5/8	12'-4	16'-4 1/8	24'-0 1/2	7'-8 3/8
	5'	11'-0	11'-9	11'-8 1/8	2'-4	4'-7 5/8	12'-4	18'-7 3/4	26'-4 1/8	7'-8 3/8
	6'	12'-6	13'-8 1/4	13'-11 5/8	2'-4	4'-7 5/8	12'-4	20'-11 1/4	28'-7 5/8	7'-8 3/8
	7'	14'-0	14'-7 3/8	15'-1 1/2	2'-4	4'-7 3/8	12'-4	22'-1 1/8	29'-9 1/2	7'-8 3/8
8'	3'	7'-0	7'-10 3/4	7'-1	2'-4	7'-1 5/8	17'-2 7/8	16'-6 5/8	26'-7 7/8	10'-1 1/4
	4'	9'-0	9'-9 7/8	9'-4 1/2	2'-4	7'-1 5/8	17'-2 7/8	18'-10 1/8	28'-11 3/8	10'-1 1/4
	5'	11'-0	11'-9	11'-8 1/8	2'-4	7'-1 5/8	17'-2 7/8	21'-1 1/4	31'-3	10'-1 1/4
	6'	12'-6	13'-8 1/4	13'-11 5/8	2'-4	7'-1 5/8	17'-2 7/8	23'-5 1/4	33'-6 1/2	10'-1 1/4
	7'	14'-0	14'-7 3/8	15'-1 1/2	2'-4	7'-1 5/8	17'-2 7/8	24'-7 1/8	34'-8 3/8	10'-1 1/4
	8'	15'-6	16'-3 3/8	16'-4	3'-1 3/8	6'-4 1/2	16'-5 1/2	25'-8 5/8	35'-10 1/8	10'-1 1/4
10'	3'	7'-0	7'-10 3/4	7'-1	2'-4	9'-7 5/8	22'-1 3/8	19'-0 5/8	31'-6 3/8	12'-6 1/8
	4'	9'-0	9'-9 7/8	9'-4 1/2	2'-4	9'-7 5/8	22'-1 3/8	21'-4 1/8	33'-10 1/4	12'-6 1/8
	5'	11'-0	11'-9	11'-8 1/8	2'-4	9'-7 5/8	22'-1 3/8	23'-7 3/4	36'-1 7/8	12'-6 1/8
	6'	12'-6	13'-8 1/4	13'-11 5/8	2'-4	9'-7 5/8	22'-1 3/4	25'-11 1/4	37'-5 5/8	12'-6 1/8
	7'	14'-0	14'-7 3/8	15'-1 1/2	2'-4	9'-7 5/8	22'-1 3/8	27'-1 1/8	39'-7 1/4	12'-6 1/8
	8'	15'-6	16'-3 3/8	16'-4	3'-1 3/8	8'-10 1/4	21'-4 3/8	28'-3 5/8	40'-9 3/8	12'-6 1/8
	9'	16'-6	17'-8	17'-9 3/8	3'-2 7/8	8'-8 3/4	21'-2 7/8	29'-9 3/8	42'-3 1/2	12'-6 1/8
	10'	17'-6	18'-8 3/8	18'-10 7/8	3'-4 1/2	8'-7 1/8	21'-1 1/4	30'-10 1/2	43'-4 3/8	12'-6 1/8
12'	8'	15'-6	16'-3 3/8	16'-4	3'-1 3/8	11'-6 5/8	26'-6 3/4	31'-0	46'-0 1/8	15'-0 1/8
	9'	16'-6	17'-8	17'-9 3/8	3'-2 7/8	11'-5 1/8	26'-5 1/4	32'-5 3/4	47'-5 7/8	15'-0 1/8
	10'	17'-6	18'-8 3/8	18'-10 7/8	3'-4 1/2	11'-3 1/2	26'-3 3/4	33'-6 7/8	48'-7	15'-0 1/8
	11'	18'-6	19'-8 3/8	20'-0	3'-6	11'-2	26'-2 1/8	34'-8	49'-8 1/8	15'-0 1/8
	12'	19'-6	20'-9	21'-1 1/8	3'-7 1/2	11'-0 1/2	26'-0 5/8	35'-9 1/8	50'-9 1/4	15'-0 1/8

45° SKEW OUTLET APRON FOR CW6 WINGS

Span	Hgt.	Dimensions								
		A	B	C	D	E_1	E_2	F_1	F_2	Δ
6'	3'	6'-0	6'-0 1/8	9'-4	3'-6 5/8	5'-3 7/8	14'-9	18'-2 1/2	27'-7 5/8	9'-5 1/8
	4'	7'-6	7'-5 7/8	12'-6 1/8	3'-6 5/8	5'-3 7/8	14'-9	21'-4 3/8	30'-9 3/8	9'-5 1/8
	5'	9'-0	8'-11 5/8	15'-8 1/8	3'-6 5/8	5'-3 7/8	14'-9	24'-6 5/8	33'-11 3/8	9'-5 1/8
	6'	10'-0	10'-2 7/8	18'-4 3/8	3'-6 5/8	5'-3 7/8	14'-9	27'-3 1/8	36'-8 3/8	9'-5 1/8
	7'	11'-0	11'-6	21'-1 3/8	3'-6 5/8	5'-3 7/8	14'-9	29'-11 5/8	39'-5	9'-5 1/8
8'	3'	6'-0	6'-0 1/8	9'-4	3'-6 5/8	8'-4 3/8	20'-9 1/8	21'-3 1/4	33'-7 3/4	12'-4 1/2
	4'	7'-6	7'-5 7/8	12'-6 1/8	3'-6 5/8	8'-4 3/8	20'-9 1/8	24'-5 3/8	36'-9 7/8	12'-4 1/2
	5'	9'-0	8'-11 5/8	15'-8 1/8	3'-6 5/8	8'-4 3/8	20'-9 1/8	27'-7 3/8	39'-11 7/8	12'-4 1/2
	6'	10'-0	10'-2 7/8	18'-4 3/8	3'-6 5/8	8'-4 3/8	20'-9 1/8	30'-4	42'-8 1/2	12'-4 1/2
	7'	11'-0	11'-6	21'-1 3/8	3'-6 5/8	8'-4 3/8	20'-9 1/8	33'-0 5/8	45'-5 1/8	12'-4 1/2
	8'	12'-0	13'-0 1/8	23'-2 1/8	4'-8 3/8	6'-8 1/2	19'-1	34'-7 5/8	46'-11 7/8	12'-4 1/2
10'	3'	6'-0	6'-0 1/8	9'-4	3'-6 5/8	11'-5 3/8	26'-9 1/4	24'-4	39'-7 7/8	15'-3 7/8
	4'	7'-6	7'-5 7/8	12'-6 1/8	3'-6 5/8	11'-5 3/8	26'-9 1/4	27'-6 1/8	42'-10	15'-3 7/8
	5'	9'-0	8'-11 5/8	15'-8 1/8	3'-6 5/8	11'-5 3/8	26'-9 1/4	30'-8 1/8	46'-0	15'-3 7/8
	6'	10'-0	10'-2 7/8	18'-4 3/4	3'-6 5/8	11'-5 3/8	26'-9 1/4	33'-4 3/4	48'-8 5/8	15'-3 7/8
	7'	11'-0	11'-6	21'-1 3/8	3'-6 5/8	11'-5 3/8	26'-9 1/4	36'-1 3/8	51'-5 1/4	15'-3 7/8
	8'	12'-0	13'-0 1/8	23'-2 1/8	4'-8 3/4	9'-9 1/4	25'-1 1/8	37'-8 1/8	53'-0	15'-3 7/8
	9'	13'-0	13'-11 1/4	24'-11 3/8	4'-11 1/8	9'-5 7/8	24'-9 3/4	39'-4 3/8	54'-8 1/4	15'-3 7/8
	10'	14'-0	14'-10 1/4	26'-8 3/4	5'-1 1/2	9'-2 1/2	24'-6 3/8	41'-0 3/8	56'-4 3/8	15'-3 7/8
12'	8'	12'-0	13'-0 1/8	23'-2 1/8	4'-8 3/4	13'-0 1/8	31'-5 1/2	40'-11 3/8	59'-4 5/8	18'-4 3/8
	9'	13'-0	13'-11 1/4	24'-11 3/8	4'-11 1/8	12'-9 1/2	31'-2 1/8	42'-8	61'-0 5/8	18'-4 3/8
	10'	14'-0	14'-10 1/4	26'-8 3/4	5'-1 1/2	12'-6 1/8	30'-10 3/4	44'-4 3/8	62'-9	18'-4 3/8
	11'	15'-0	15'-9 1/4	28'-6	5'-3 7/8	12'-2 3/4	30'-7 3/8	46'-0 5/8	64'-5 1/4	18'-4 3/8
	12'	16'-0	16'-8 3/4	30'-3 3/8	5'-6 1/4	11'-11 5/8	30'-4	47'-9	66'-1 3/8	18'-4 3/8

NOTES:

See B-06.10 for Details, Quantities and other Notes.

Δ = Length to be added for each additional barrel.

Subscript 1 or 2 indicates number of barrels.

DESIGN APPROVED	ARIZONA DEPARTMENT OF TRANSPORTATION HIGHWAYS DIVISION STANDARD DRAWINGS	REVISION
APPROVED FOR DISTRIBUTION	OUTLET APRONS FOR CW2 AND CW6 WINGS	STANDARD NO. CWA-2
		PLAN NO. B-06.20

HEADWALL QUANTITIES FOR CW2 WINGS

Span	Height	RIGHT ANGLE BARREL						30° SKEW BARREL						45° SKEW BARREL					
		Concrete (C.Y.)			Steel (Lbs.)			Concrete (C.Y.)			Steel (Lbs.)			Concrete (C.Y.)			Steel (Lbs.)		
		1 Barrel			1 Barrel			1 Barrel			1 Barrel			1 Barrel			1 Barrel		
		Inlet	Outlet	Δ_c	Inlet	Outlet	Δ_s	Inlet	Outlet	Δ_c	Inlet	Outlet	Δ_s	Inlet	Outlet	Δ_c	Inlet	Outlet	Δ_s
6'	3'	3.11	2.95	.86	263	258	77.0	3.59	3.60	1.00	300	300	92.0	4.31	4.31	1.22	362	362	111.9
	4'	4.07	3.88	.86	322	318	77.0	4.61	4.62	1.00	366	366	92.0	5.56	5.56	1.22	451	451	111.9
	5'	5.24	5.01	.86	410	397	77.0	5.82	5.82	1.00	451	451	92.0	7.24	7.24	1.22	555	555	111.9
	6'	6.51	6.53	.86	487	479	77.0	7.16	7.17	1.00	529	529	92.0	9.20	9.20	1.22	686	686	111.9
	7'	8.01	8.29	.86	568	585	77.0	8.84	8.85	1.00	643	643	92.0	11.22	11.22	1.22	826	826	111.9
8'	3'	3.37	3.21	1.13	286	281	106.4	3.89	3.89	1.31	328	328	118.4	4.68	4.68	1.60	393	393	146.7
	4'	4.33	4.15	1.13	345	341	106.4	4.91	4.91	1.31	395	395	118.4	6.04	6.04	1.60	482	482	146.7
	5'	5.50	5.27	1.13	433	420	106.4	6.12	6.13	1.31	479	479	118.4	7.63	7.63	1.60	586	586	146.7
	6'	6.78	6.80	1.13	510	502	106.4	7.45	7.46	1.31	558	558	118.4	9.57	9.57	1.60	717	717	146.7
	7'	8.26	8.56	1.13	591	608	106.4	9.15	9.16	1.31	672	672	118.4	11.63	11.63	1.60	857	857	146.7
	8'	12.11	12.62	1.13	696	742	106.4	13.77	13.78	1.31	781	781	118.4	16.71	16.71	1.60	955	955	146.7
10'	3'	3.70	3.53	1.40	312	306	129.8	4.25	4.26	1.62	363	363	149.3	5.14	5.14	1.99	467	467	217.7
	4'	4.65	4.46	1.40	371	367	129.8	5.27	5.28	1.62	430	430	149.3	6.47	6.47	1.99	556	556	217.7
	5'	5.79	5.55	1.40	458	446	129.8	6.44	6.45	1.62	515	515	149.3	8.02	8.02	1.99	660	660	217.7
	6'	7.07	7.10	1.40	535	527	129.8	7.80	7.81	1.62	593	593	149.3	9.99	9.99	1.99	791	791	217.7
	7'	8.54	8.85	1.40	617	634	129.8	9.48	9.49	1.62	707	707	149.3	12.01	12.01	1.99	932	932	217.7
	8'	12.39	12.91	1.40	716	773	129.8	14.09	14.10	1.62	815	815	149.3	17.11	17.11	1.99	1023	1023	217.7
	9'	14.68	15.59	1.40	856	919	129.8	16.74	16.75	1.62	1020	1020	149.3	20.46	20.46	1.99	1289	1289	217.7
	10'	17.22	18.47	1.40	1062	1175	129.8	19.28	19.29	1.62	1221	1221	149.3	24.08	24.08	1.99	1625	1625	217.7
12'	8'	12.67	13.21	1.68	748	800	155.6	14.44	14.46	1.95	879	879	213.1	17.54	17.54	2.38	1175	1175	365.3
	9'	14.99	15.93	1.68	888	946	155.6	17.12	17.14	1.95	1083	1083	213.1	20.92	20.92	2.38	1441	1441	365.3
	10'	17.55	18.83	1.68	1094	1202	155.6	19.68	19.69	1.95	1284	1284	213.1	24.56	24.56	2.38	1777	1777	365.3
	11'	20.93	22.07	1.68	1464	1513	155.6	23.13	23.14	1.95	1603	1603	213.1	28.57	28.57	2.38	2054	2054	365.3
	12'	23.98	25.04	1.68	1767	1830	155.6	26.54	26.55	1.95	1915	1915	213.1	32.93	32.93	2.38	2630	2630	365.3

HEADWALL QUANTITIES FOR CW6 WINGS

Span	Height	RIGHT ANGLE BARREL						30° SKEW BARREL						45° SKEW BARREL					
		Concrete (C.Y.)			Steel (Lbs.)			Concrete (C.Y.)			Steel (Lbs.)			Concrete (C.Y.)			Steel (Lbs.)		
		1 Barrel			1 Barrel			1 Barrel			1 Barrel			1 Barrel			1 Barrel		
		Inlet	Outlet	Δ_c	Inlet	Outlet	Δ_s	Inlet	Outlet	Δ_c	Inlet	Outlet	Δ_s	Inlet	Outlet	Δ_c	Inlet	Outlet	Δ_s
6'	3'	4.31	4.37	.86	343	364	77.0	4.94	4.95	1.00	396	396	92.0	5.25	5.25	1.22	420	420	111.9
	4'	5.53	6.35	.86	433	487	77.0	7.02	7.03	1.00	534	534	92.0	7.54	7.54	1.22	562	562	111.9
	5'	7.05	9.08	.86	522	688	77.0	9.61	9.62	1.00	721	721	92.0	10.39	10.39	1.22	729	729	111.9
	6'	9.01	11.49	.86	656	821	77.0	12.24	12.25	1.00	868	868	92.0	13.41	13.41	1.22	907	907	111.9
	7'	11.31	14.11	.86	783	997	77.0	14.78	14.78	1.00	1037	1037	92.0	16.81	16.81	1.22	1097	1097	111.9
8'	3'	4.57	4.64	1.13	366	387	106.4	5.24	5.25	1.31	425	425	118.4	5.62	5.62	1.60	451	451	146.7
	4'	5.80	6.62	1.13	456	510	106.4	7.32	7.33	1.31	562	562	118.4	7.92	7.92	1.60	594	594	146.7
	5'	7.33	9.36	1.13	545	711	106.4	9.92	9.93	1.31	749	749	118.4	10.77	10.77	1.60	761	761	146.7
	6'	9.28	11.76	1.13	679	844	106.4	12.54	12.55	1.31	896	896	118.4	13.79	13.79	1.60	939	939	146.7
	7'	11.59	14.41	1.13	805	1019	106.4	15.11	15.12	1.31	1066	1066	118.4	17.22	17.22	1.60	1128	1128	146.7
	[illegible]	17.05	20.35	1.13	942	1144	106.4	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	22.62	22.62	1.60	1317	1317	146.7
10'	3'	4.87	4.94	1.40	392	413	129.8	5.57	5.58	1.62	455	455	149.3	6.02	6.02	1.99	490	490	217.7
	4'	6.10	6.91	1.40	482	536	129.8	7.65	7.66	1.62	593	593	149.3	8.32	8.32	1.99	633	633	217.7
	5'	7.61	9.67	1.40	571	737	129.8	10.26	10.27	1.62	780	780	149.3	11.19	11.19	1.99	800	800	217.7
	6'	9.58	12.10	1.40	705	870	129.8	12.92	12.93	1.62	927	927	149.3	14.23	14.23	1.99	977	977	217.7
	7'	11.89	14.72	1.40	831	1045	129.8	15.46	15.47	1.62	1096	1096	149.3	17.63	17.63	1.99	1167	1167	217.7
	8'	17.34	20.68	1.40	963	1174	129.8	21.84	21.85	1.62	1287	1287	149.3	23.04	23.04	1.99	1390	1390	217.7
	9'	21.24	23.66	1.40	1252	1411	129.8	25.49	25.50	1.62	1539	1539	149.3	26.91	26.91	1.99	1689	1689	217.7
	10'	24.90	26.75	1.40	1615	1696	129.8	29.09	29.10	1.62	1853	1853	149.3	30.96	30.96	1.99	2097	2097	217.7
12'	8'	17.65	21.02	1.68	994	1201	155.6	22.23	22.25	1.95	1350	1350	213.1	23.49	23.49	2.38	1537	1537	365.3
	9'	21.58	24.04	1.68	1283	1439	155.6	25.92	25.93	1.95	1602	1602	213.1	27.40	27.40	2.38	1836	1836	365.3
	10'	25.25	27.15	1.68	1647	1723	155.6	29.53	29.54	1.95	1916	1916	213.1	31.47	31.47	2.38	2244	2244	365.3
	11'	29.24	30.51	1.68	2070	1973	155.6	33.09	33.10	1.95	2307	2307	213.1	35.88	35.88	2.38	2634	2634	365.3
	12'	33.40	33.99	1.68	2389	2335	155.6	36.75	36.76	1.95	2647	2647	213.1	40.54	40.54	2.38	3222	3222	365.3

NOTE:

All quantities are for headwalls of barrels shown in Table No. I (0-10' Fill).

Quantities are shown for single barrel culvert only. Multi-barrel culvert headwall quantities are obtained by adding, for each additional barrel, Δs and Δc to the inlet and outlet quantities.

NOTATIONS:

Δc = Inlet or outlet concrete quantity per additional barrel.

Δs = Inlet or outlet steel quantity per additional barrel.

DESIGN APPROVED	ARIZONA DEPARTMENT OF TRANSPORTATION HIGHWAYS DIVISION STANDARD DRAWINGS	REVISION
APPROVED FOR DISTRIBUTION	HEADWALL QUANTITIES FOR CW2 AND CW6 WINGS	STANDARD NO. CWQ-1 PLAN NO. B-07.10

A preliminary earthwork run was accomplished during the Comparative Design Study using the "DIRT" program. The "DIRT" program is a computerized earthwork program that uses either a cross sectional average end area method or a prizmoidal technique. It can be used by comparing a final design file against an existing terrain file or a template file in conjunction with a vertical point of intersection (VPI) file against an existing terrain file. (a copy of the user's manual has already been provided and approved by SCS Phoenix)

For the Comparitive Design Study the template file in conjunction with a (VPI) file was used to model the floodway channel base and side slopes of the banks only. Structures were also modeled including wingwalls. The digitized terrain from the aerial mapping performed for this job was used for the existing terrain. Cross section computer plotting was performed at all grade breaks in terrain, every one hundred foot station and at all other stations where additional information was needed.

The rationale for generating computer plots at this time is as follows:

- See how templates fit into the existing terrain.
- used to design maintenance roadway and east & west collector system
- used to assure limited encroachments outside of right-of-way and the feasibility

- of grading west collector channel to the RWCD canal.

- encroachments for maintenance ramps on the west side of RWCD floodway right of way were checked to assure feasibility in the vertical alignment.

- providing a working base for making any adjustments in channel geometry, alignment horizontally and vertically.

On the following pages are the standard template, template codes, transition templates and the command file.

Computer input, output and cross section plots have not been submitted at this time.

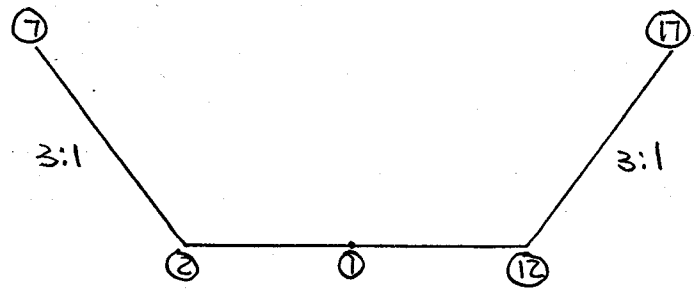
- utilitized within the floodway were plotted horizontally and vertically and checked against the design features

Greiner Engineering

Greiner Engineering Sciences, Inc.

Tucson 602 327-3413
Phoenix 602 275-5400

Job RWCD Reach 6 E10102
Description Prelim. Earthwork No. 1
Standard Template Codes
Calculated by M. Shapiro Date 10/5/85 Sheet No. 1
Checked by B. G. B. Date 10/5/85 of 1



Standard Templates for floodway looking up station

Greiner Engineering

Greiner Engineering Sciences, Inc.

Tucson 602 327-3413
Phoenix 602 275-5400

Job RWCD Reach 6 E101012
Description Prelim. Earthwork No. 1
Template codes
Calculated by M. Shapiro Date 10/5/85 Sheet No. 1
Checked by B.G.S. Date 10/5/85 of 1

TEMPLATE.FILE1

```
TEMP 11
   1 0 0
   2 13 0  7 28.5 9.5
   12 13 0 17 28.5 9.5
ENDD

TEMP 21
   1 00
   2 40 0  7 28.5 9.5
   12 40 0 17 28.5 9.5
ENDD

TEMP 31
   1 0 0
   2 55 0  7 28.5 9.5
   12 55 0 17 28.5 9.5
ENDD

TEMP 41
   1 0 0
   2 45 0  7 28.2 9.4
   12 45 0 17 28.2 9.4
ENDD

TEMP 51
   1 00
   2 8 0  7 0 7.67
   12 8 0 17 0 7.67
ENDD
TEMP 61
   1 00
   2 15 0  7 14.4 7.2
   12 15 0 17 14.4 7.2
ENDD
```

Add

Greiner Engineering

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```
TTR 11
0 58.15 2 14.85 0 12 15.56 0
58.15 75 2 15.38 0 12 13.35 0
75 77.88 2 13.63 0 12 8 0
77.88 87.12 2 8 0 12 8 0
87.12 201.88 2 8 0 12 8 0
201.88 211.12 2 8 0 12 13.63 0
211.12 214 2 13.35 0 12 15.38 0
214 230.85 2 15.56 0 12 14.85 0
230.85 514 2 40 0 12 40 0
0 58.15 13 0 4.92 17 27.47 4.58
0 75.00 3 0 4.92 7 27.47 4.58
58.15 77.88 13 0 7.67 17 10.98 1.83
75.00 87.12 3 0 7.67 7 10.98 1.83
87.12 201.88 13 0 7.67 17 10.98 1.83
77.88 211.12 3 0 7.67 7 10.98 1.83
201.88 214 13 0 4.92 17 27.47 4.58
211.12 230.85 3 0 4.92 7 27.47 4.58
214 514 13 0 0 17 40 9.5
230.85 514 3 0 0 7 40 9.5
ENDD
```

Greiner Engineering

Greiner Engineering Sciences, Inc.

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Phoenix 602 275-5400

Job RWCD Reach 6 E101012

Description Prelim. Earthwork No. 1 Transitions

Calculated by M. Shapiro Date 10/5/85 Sheet No. 4

Checked by B. G. R. Date 10/5/85 of 8

```
TTR 21
   0 150 12 110 0   17 16.82 8.41
   0 199.94 2 110 0   7 16.82 8.41
   150 238.78 12 110 0 17 16.82 8.41
   199.94 288.72 2 110 0 7 16.82 8.41
   238.78 438.72 12 110 0 17 19 9.5
   288.72 438.72 2 110 0 7 19 9.5
ENDD
```

Greiner Engineering

Greiner Engineering Sciences, Inc.

Tucson 602 327-3413
Phoenix 602 275-5400

Job RWCD Reach 6 E101012

Description Prelim. Earthwork No. 1
Transitions

Calculated by M. Shapiro Date 10/5/85 Sheet No. 6

Checked by B. G. S. Date 10/5/85 of 8

```
TTR 31
    0 264.25  2 38.5 0 12 38.5 0
    264.25 348.02  2 28 0 12 28 0
    348.02 743.06  2 28 0 12 28 0
    743.06 831.36  2 33 0 12 33 0
    831.36 1049.74  2 45 0 12 45 0
    0 264.25  7 0 8.6  17 0 8.6
    264.25 348.02  7 0 8.8  17 0 8.8
    348.02 743.06  7 0 8.8  17 0 8.0
    743.06 831.36  7 0 9  17 0 9
    831.36 1049.74  7 28.2 9.4  17 28.2 9.4
ENDD
```

```
TTR 41
  0 250   2 19.78 0 12 15 0
  250 297.36  2 15 0 12 15 0
  297.36 352.68  2 15 0 12 15 0
  352.68 400.04  2 15 0 12 17.50
  400.04 615.69  1 22 0  2 45 0 12 45 0
  615.69 855.02  1 39.71
  0 250  3 14.4 7.2  17 4 0
  0 297.36  13 14.4 7.2  17 4 0
  250 352.68  3 14.4 7.2  7 4 0
  297.36 400.04  13 14.4 7.2 17 4 0
  352.68 615.69  3 0 0  7 28.5 9.5
  400.04 615.69  13 0 0  17 28.5 9.5
ENDD
```

Greiner Engineering

Greiner Engineering Sciences, Inc.

Tucson 602 327-3413
Phoenix 602 275-5400

Job RWCD Reach 6 E10012
Description Prelim. Earthwork No 1
Command File
Calculated by M. Shapiro Date 10/5/85 Sheet No. 1
Checked by B. G. B. Date 10/5/85 of 2

CMRWCD.1

```
DIRT
JOB RWCD REACH 6 PRELIMINARY EARTHWORK NO. 1
OPEN 12 TNRWCD1 R
     14 ETRWCD1          17 TEMPLATE.FILE1.R
     16 FDRWCD1
EDID 100 100 12 102
FILE
ROAD,A,A  RWCD REACH 6 PRELIMINARY EARTHWORK NO.1
TEMP 11
CATCH3 3 3 3
VPI 0 0 0 13
      3000.00 46.40 0
      3148.00 37.51 0
      9052.99 36.90 0
      11854.07 36.48 0
      12116.72 36.39 0
      12664.45 35.45 0
      13000.00 35.20 0
      15500.00 34.45 0
      15700.00 33.40 0
      16100.00 32.10 0
      16130.00 31.24 0
ENDD
TTR 11 3168.49
APPLY 3000.00 3682.49
TEMP 21
TTR 21 8894.51
APPLY 3682.49 9333.23
TEMP 31
TTR 31 11854.07
APPLY 9333.23 12903.81
TEMP 41
TTR 41 15274.98
APPLY 12903.81 16130.00
ENDL
```

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Tucson 602 327-3413
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Job RWCD Reach 6 E.101012
Description Prelim. Earthwork No. 1
Command File
Calculated by M. Shapiro Date 10/5/85 Sheet No. 2
Checked by B. G. B. Date 10/5/85 of 2

```
INIT
FFILE RWCD.FFILE.1
OPEN 9 PLOTFILE,RWCD.1
PLOT,A,A 1 3 10 10 30 17 32
END
```

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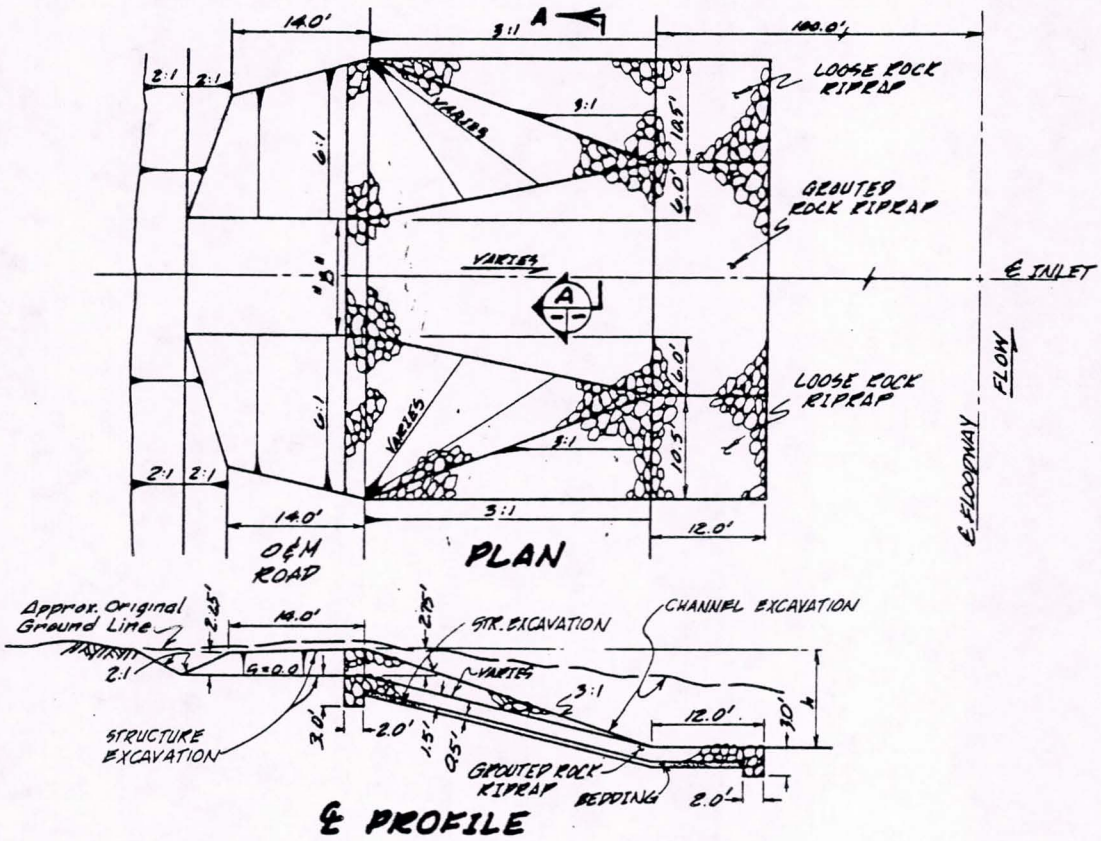
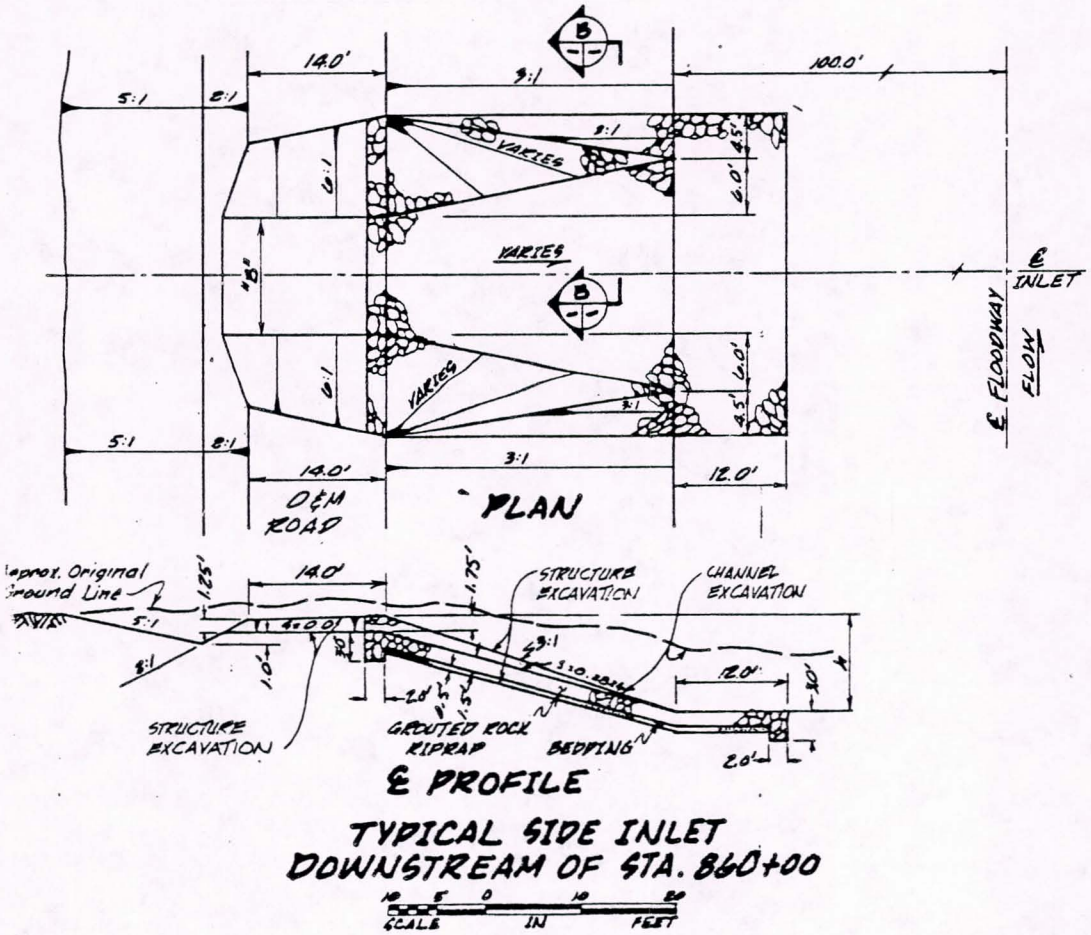
In looking and evaluating the major side inlets the following procedures were followed:

- a field trip to RWCD Reach 2 & 3 was made with Don Paulys, Harry Milsap, Michael Shapiro, Gary Son and Mustafa Chudnoff on August 6, 1985. Inlet structures along reaches 2 & 3 suffered many problems. The structures on reach 2 & 3 were designed and built per the following details.



TYPICAL SIDE INLET
UPSTREAM OF STA. 860+00



The problems as observed and discussed are as follows:

- instead of offsite flows coming down the main chute, flows moves laterally to the upstream or downstream side of the main chute moving around the 3 foot cut off wall at the top of the floodway bank.

- flows undermined the loose rip-rap area entering from the upstream side of the spillways.

- hydrostatic pressures and voids in the bedding and substructure material underneath the grouted riprap area of the main chutes caused collapses and blowouts to the grouted rip rap areas.

- a memorandum from SCS stating that these structures were under investigation and siting the same observations as above was read and noted.

- a memorandum from SCS stating problems with contractors due to limited information on design drawings and not enough prelimnary investigation was performed to assess the availability of the specified materials. (Eg. bedding material, drain material and gradation of agragate). This memo dated 9/9/83 was read and noted.

- a memorandum from SCS dated 6/27/83 was read and noted. This memorandum was concerning the Bass Mountain Diversion, Buckhorn Mesa Watershed and its grouted rock inlets and aprons. Recommendations from the memorandum were that thickness of grouted rock should be not less than 18 inches and greater than 24 inches, drain till be provided under the grouted rock to relieve uplift pressures, weep outlets just above the apron should be utilized and that and that the maximum rock size should approach the thickness of the grouted rock.

- a field trip was made to RWCD Reach 6 with Michael Shapiro, Gary Sun and Mustafa Chudnoff on September 3, 1985 to evaluate the potential placement on the major inlet structures along with direction of flows from major roadways. Three other field trips were made during the Comparative Design Phase to substantiate our design recommendations.

- a material investigation and evaluation was made. For details see Section 26.

- hydraulics for side inlets was performed for all inlet structures and collection systems. See Section 5 for more details.

- erosion protection design and analysis was performed. See Section 8 for more details.

- SCS recommended using in concept the side inlet structures designed for the Signal Butte Floodway Project. See Section 5 for a typical detail.

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Job SCS RWCD Reach 6
Description Maintenance road stabilization
Calculated by R. Beck Date 2-11-86 Sheet No. 1
Checked by MSS. Date of 1

Maintenance Road Stabilization.

Four alternatives have been developed for providing stabilization of the maintenance road.

Alternate 1 - Aggregate base course

Mix 4" of soil with aggregate in 50-50 ratio.

Volume of aggregate: 16,707 yd^3 cost = 183,777.

Alternate 2 - 6" ABC on roadway

Volume of aggregate 25061 c.y. cost = 275,671.

Alternate 3 - Provide 7" thick soil cement base with double chip seal coating. cost 141,109.

Alternate 4 - Provide one 9 inch lift of soil cement. Volume of S-C = 28,221 cu. yd.

Cost - 846663.

Recommend soil-cement in one 9" lift. This alternate would need replacement after 15 year life due to heavy vehicle loads.

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MEMO
A Greiner Engineering, Inc. Company

Date 2-6-86 **To** RWCD Floodway Reach 6 File

Subject Maintainance road stabilization

According to Craig Wiedeman of WTI No soil stabilization treatment is required for the maintainance roads, as long as there is adequate compaction during construction.

To improve road surface friction granular material may be added to the top 4"-6" of soil. The proportion of granular material to native soil should be 50-50. This treatment would be adequate for light vehicular traffic, ie pickup trucks. For heavier equipment (D-20 loading) standard base course construction should be followed using aggregate or other material.

According to Phil Turner, Greiner, the aggregate used should be well graded and angular to assure interlocking of material and to minimize loss. 6" base course thickness is standard as per MAG STD SPEC. 310.2.

The ASU Dept of Civil Eng and the UofA Dept of Soils and Water Eng. were contacted to determine if there are chemical treatments available to reduce slippage. Both Dr. Mamluke @ ASU and Dr. Dorge @ UofA were unaware of such chemicals. Ashland Chemical of Phoenix was also contacted and they too are unaware of such chemical treatments.

Signed Mustafa Chudnoff **Copies to**

Total road surface area = 37,629 S.Y.

Roads are 14' wide with cross slope of 1.75%

Aggregate base course

Option 1: Mixing with 4" of soil with aggregate in 50-50 ratio

Volume aggregate = 37,629 x 4" x 0.111 yd/in = 16,707 C.Y.

Cost for ADOT class 1 or 2 Aggregate base

@ $11.00 cu. yd. 16,707 x 11 = $183,777
does not include labour

Option 2: 6" ABC base on roadway

Volume ABC = 37,629 x 6" x 0.111 yd/in = 25,061 C.Y.

Cost = 25,061 x $11.0 = $275,671 does not include labour

Soil Cement

Paul Mueller of the Arizona Portland Cement Assoc. recommended the following for soil cement application.

Assuming in-situ use of materials no mixing or batch plant required.

Soil Cement base 7" thick with double chip seal coating.

Cost (raw dollars labour/material) $3.75/S.Y. x 37,629 = $141,109

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Job RWCD Reach 6 E101012
Description Project Feature Ranking

Calculated by M. Shapiro Date 2/9/86 Sheet No. 1
Checked by _____ Date _____ of 1

Ranking System 1-10 points (pts.)

Based On:

Items	Multiplier
Cost (C)	2
Maintenance (M)	1
Availability (A)	1
Ease of Construction (E)	0.5
Aesthetics (AE)	0.5
~~Hydraulic~~ Performance (H)	1
Total available points	60

Project Feature: Maintenance roadway

Item	Type of Material				
	Earth	Soil Cement w/2-Chipseal	Soil Cement	4" of Soil w/ ABC mix	6" ABC
C	10	6	8	4	4
M	4	9	6	6	6
A	10	8	9	8	8
E	10	7	8	8	8
AE	6	8	9	7	7
H	5	10	8	7	7
Total # of pts.	47	46.5	47.5	36.5	36.5

Recommended Material for Project Feature: Soil Cement

Maintenance Ramps.

Maintenance ramps are to be provided on the downstream side of each bridge on each side of the floodway. In further analysis of the ramps it was determined that the bridge clearance between the invert of the floodway and the bottom of the bridge deck was too low to provide access for maintenance vehicles to travel under the bridges. Therefore, it is recommended to place two additional maintenance ramps on the upstream side of each bridge. All maintenance ramps are to be built such that they ramp down in the direction of flow. This is considered essential to minimize the hydraulic resistance and prevent excessive erosion of the ramps which would require periodic maintenance. On the east side, maintenance ramps are located at high points in the collector channel where they do not intertere with the collector system. In addition, ramps were located

upstream or downstream of all major inlets.

Along the west side of the floodway due to the limitation of available area, some of the maintenance ramps encroach into the right of way of the RWCD canal. This encroachment does not extend into the canal maintenance road. This encroachment is not considered to be a problem due to the fact that a precedent has been set for Reach 2 and 3 where minor encroachments as described were allowed. The locations of the maintenance ramps which encroach on the west side are at the following locations: 63+06, 117+23, and 133+20.

On the east side the ramps are located such that they are upstream or downstream of all major inlet collection and spillway systems. Since ramps are aligned in the direction of flow, access to the floodway would require the following:

On the east or west side of the floodway, vehicles

traveling north would either have to back down the ramp or proceed to the next street crossing, cross to the other side of the floodway and go south to the nearest ramp and enter.

Vehicles on the east side traveling south can enter directly into the floodway.

Vehicles on the east side traveling north can turn around in the right of way at the ramp locations and enter the floodway in a forward direction

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Maintenance Ramps.

East Side - Maintenance ramps are provided on the east side of the floodway at the following locations

Entrance Station	Exit Station
40+04	40+54
55+41	56+01
68+48	68+92
85+00	85+46
97+08	97+60
116+05	116+50
130+20	130+70
153+58	154+18
160+17	160+62

Note: Need add'l ramp on E. side, @ Brown Rd.

The ramp locations are selected to provide access to the floodway from the east side upstream and downstream from all road crossings. Ramp locations are also selected to provide the least disruption to the collector channel system and major inlet structures on the east side. Typically, the ramps are located at the upstream ends of the collector channels where there is more room than in other areas. Ramps were also located away from major inlet structure locations.

West Side - Maintenance ramps are provided on the west side of the floodway at the following locations.

Entrance Station	Exit Station
34+43	34+93
55+41	56+01
70+70	71+20
88+75	89+25
92+88	93+32
117+23	117+77
133+20	133+75
151+19	151+72
157+53	158+08

Need add'l ramp @ Brown Rd.

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Job SCS RWCD Reach 6
Description Maint. Ramp Design.

Calculated by R. Beck Date 1-17-86 Sheet No. 2
Checked by M.S.S. Date _____ of 2

The ramp locations are selected to provide access to the floodway from the west side upstream and downstream from all road crossings. Ramp locations are also selected to provide the least disruption to the collector channel system. Note should be taken of the ramps located at Sta's.- 58+65, 66+52, 133+20. These ramps extend beyond the west R/W line. A determination must be made to allow the encroachment or to eliminate ramps at those locations. Note that the locations are just downstream of the collector channel inlets. This would eliminate the need for the collector channel to extend beyond the R/W line

Encroachment of ramps on Canal r/w

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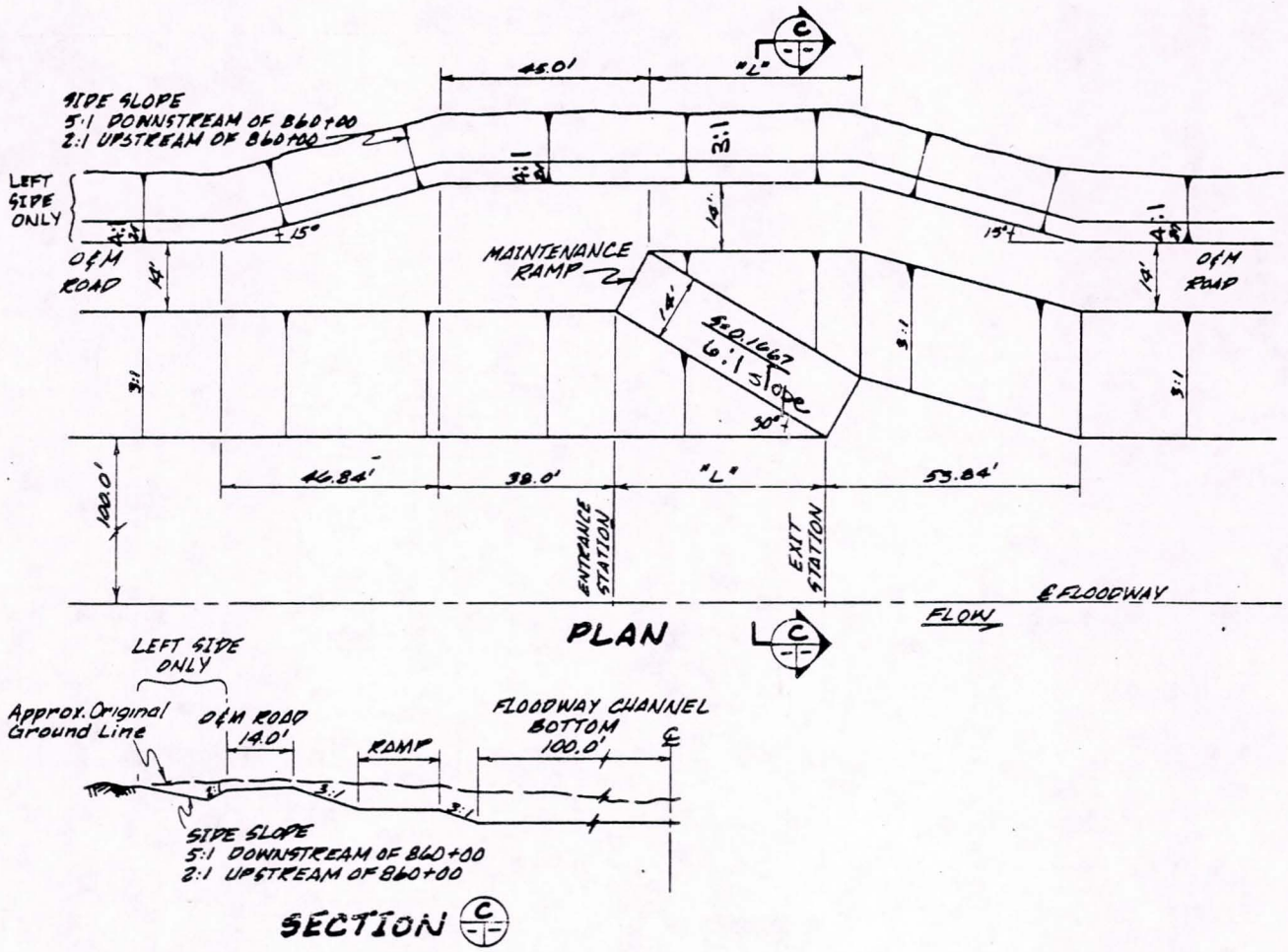
Job RWCD Reach 6 E101012

Description Typical Maintenance Ramp Detail

Calculated by R. Beck Date 1/16/86 Sheet No. 1

Checked by M.S.S. Date of 1



TYPICAL MAINTENANCE RAMP

10 5 0 10 20 30 40
SCALE IN FEET

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Phoenix 602 275-5400

Job RWCD

Description MAINTENANCE ROAD RAMP LOCATIONS

Calculated by DRL. Date 1-16-86 Sheet No. 1

Checked by M.S.S. Date 1-17 Nov. of 1

WEST SIDE EAST SIDE

BROWN - ROAD

1) STA. 34 + 43 TO STA. 34 + 93

2) STA. 40 + 04 TO STA. 40 + 54

3) 58 + 65 TO 59 + 25

4) 55 + 41 TO 56 + 01

ADOBE ROAD

5) 68 + 48 TO 68 + 92

6) 70 + 70 TO 71 + 20

7) 85 + 00 TO 85 + 46

8) 88 + 75 TO 89 + 25

UNIVERSITY DRIVE

9) 92 + 88 TO 93 + 32

10) 97 + 08 TO 97 + 60

11) 116 + 05 TO 116 + 50

12) 117 + 23 TO 117 + 77

APACHE - HIGLEY INT.

13) 133 + 20 TO 133 + 75

14) 130 + 20 TO 130 + 70

15) 151 + 19 TO 151 + 72

16) 153 + 58 TO 154 + 18

BROADWAY ROAD

17) 157 + 53 TO 158 + 08

18) 160 + 17 TO 160 + 62

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Job RWCD Reach 6 E101012

Description Project Feature Ranking

Calculated by M. Shapiro Date 2/9/86 Sheet No 1 of 1

Checked by _____ Date _____

Ranking System 1-10 points (pts.)

Based On:

Items	Multiplier
Cost (C)	2
Maintenance (M)	1
Availability (A)	1
Ease of Construction (E)	0.5
Aesthetics (AE)	0.5
~~Hydraulic~~ Performance (H)	1
Total available points	60

Project Feature: Maintenance Ramps

Item	Type of Material					
	Earth	Concrete	Soil Cement			
C	10	6	9			
M	4	10	6			
A	10	8	9			
E	10	8	9			
AE	6	8	9			
H	6	9	8			
Total # of pts.	48	47	50			

Recommended Material for Project Feature: Soil Cement

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Phoenix 602 275-5400

Job RWCD Reach 6 E101012

Description Existing operation and maintenance manuals for former reaches

Calculated by M. Shapiro Date 2/6/86 Sheet No. 1

Checked by B. G. S. Date 2/11/86 of

Previous operation and maintenance manuals for former reaches of the RWCD were reviewed and a meeting was held on October 10, 1985 with Don Paulus, Bill Osterquist from SCS, R.W. Shobe from FCD, and Michael Shapiro and Gary Sun from GES to get input for the Comparative Design Study on maintenance problems from existing reaches and how these ideas could be incorporated into the Reach 6 project to alleviate potential problems.

In the following pages a copy of the memorandum for the above mentioned meeting and copies of existing operation and maintenance manuals for reaches 2 and 3 are included.

Sections 3, 4, 5, 7, 8, 11, 13, 14, 17, 23, 24, 25 and 26 cover the specific procedures and recommendations based on the information in this section

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Greiner Engineering Sciences, Inc.
3240 E. Camelback Road
Phoenix, Arizona 85018
(602) 275-5400

A Greiner Engineering, Inc. Company

MEMORANDUM

TO: File

FROM: Michael Shapiro

SUBJECT: RWCD Floodway Reach 6
Contract No. 53-9457-00469
Comparative Design Study Meeting
Job No. E-101-012

DATE: October 21, 1985

A meeting was held October 10, 1985, at 10:00 a.m. at the Greiner Engineering Sciences, Inc. The following were present:

Mr. Don Paulus, Soil Conservation Service
Mr. Bill Osterquist, Soil Conservation Service
Mr. R.W. Shobe, Flood Control District
Mr. Michael Shapiro, Greiner Engineering Sciences
Mr. Gary Sun, Greiner Engineering Sciences

The meeting was held to get input for our comparative design studies on maintenance problems from existing reaches and how we could incorporate these ideas into our design to alleviate potential problems. We also went over the status of the job.

The first topic for discussion was the spacing of maintenance ramps for this project and to why in past projects, did maintenance ramps line up on either side of the floodway? Mr. Shobe stated that maintenance ramps should be at all major intersections and that there was no rationale as to why they had to line up on either side of the floodway. Further discussion took place for each of the major intersections as follows:

At Broadway Road it would be necessary to have maintenance ramps on both sides of the bridge (upstream and down-stream) because the channel under the bridge was only 30 feet wide and would most likely require either dumped rip-rap or grooted rip-rap because of high velocities. If other protection, such as, soils cement or a concrete lining were used, the number of ramps could be revaluated.

At Apache Boulevard it will be necessary to access from the north side of Apache Boulevard and the east side of Higley Road because there will be a box culvert in place and access through the box would be restrictive.

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At University Drive it will only be necessary to access through either the north or south side or to have one ramp on either side of the floodway, one to the north and one to the south, because access to either side could be handled through the bridge.

At Brown Road it would be necessary to have maintenance ramps on the north and south side because, most likely, this crossing will be a box culvert.

At this point, Mr. Shobe brought up that the City of Mesa was pushing for a bridge at Adobe Road and asked us if we could locate the inlets north and south to consider this future bridge. It was made clear that we would consider the bridge when designing our inlets but not during our backwater analysis. Therefore, it might be necessary to design a larger structure.

The second topic for discussion was the collector ditch on either side of the maintenance road on both sides of the floodway. Mr. Shapiro stated that the cross slope for the maintenance road would be designed to drain away from the main channel to eliminate ruts on the main channel banks from nuisance drainage. This minor drainage would be collected in minor collector ditches, on the east side of the floodway discharging into the major inlet structures, and on the west side of the floodway discharging through a pipe into the floodway. It was established that on the west side of the floodway a constant spacing for the inlet pipe would be set and used for the entire project. Questions were raised at this point as to maintenance problems in the minor collector ditches due to sedimentation and if there could possibly be more maintenance due to the collector ditch? Mr. Shapiro stated the velocities would be kept high enough to eliminate sedimentation in the collector ditch, therefore eliminating most maintenance. Mr. Shobe asked what would happen to the loss of material from the maintenance roads? Mr. Shapiro stated that cross slope for the maintenance roads would be established steep enough so loss of material would not be evident. Mr. Paulus stated that on the past projects, cross slopes were approximately at 1.75 percent. Mr. Shobe asked if there could be any way to prevent slippage off the maintenance roads, because if a maintenance vehicle were to slip off the roadway, the vehicle would either slide into the main channel or into the collector ditch? Mr. Shapiro stated that slippage would most likely occur away from the main channel and towards the collector ditch and the collector ditch could be designed with a four to one side slope so that in the event of slippage a vehicle could get out. Mr. Shapiro also stated that we would look into the use of chemically treating the maintenance road to make it more stable. Mr. Shapiro also stated that he would work to determine a friction coefficient for the maintenance roads to determine the maximum cross slope before slippage would occur.

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Mr. Shapiro asked if it was possible to grade outside of the floodways west right-of-way to connect to the existing RWCD Canal maintenance road. Mr. Paulus and Mr. Shobe saw no problem with this but said they would contact the RWCD to make sure. Mr. Shapiro asked if the side collector ditch could be placed outside of the west right-of-way. Mr. Shobe said they would like to see this ditch kept within the floodway right-of-way.

The third topic for discussion was the erosion problems along the maintenance roads at the major inlets. Mr. Shapiro asked if they should consider asphalt with concrete out off walls or possibly the use of concrete in this area. Mr. Shobe and Mr. Paulus thought that this would be too expensive and would not be necessary.

The fourth topic was access to the maintenance roads from major intersections. Mr. Shapiro asked if they could use the existing curb cuts from the RWCD Canal maintenance road. Mr. Shobe indicated that he would rather not use the existing curb cuts but would rather put in new ones. Mr. Shapiro indicated that his survey crews did not cross section any of the existing roadways at the major intersections per their scope of work and contract. Mr. Shapiro asked if they could state on their final plans to match into existing curb and gutter for these curb cuts. Mr. Shobe and Mr. Paulus stated that this would be adequate.

The fifth topic was the freeboard requirements for box culvert at Apache Boulevard and Higley Road and the box culvert at Brown Road. Mr. Shapiro asked if the one foot freeboard requirement was from the lowest bank of the channel or one foot within the box itself. Mr. Paulus stated that it was one foot within the box itself and would take a waiver if we recommended anything else.

The sixth topic was the design for connecting proposed approved storm drain facilities into the main channel. Mr. Shapiro asked if they needed to design our facility at this time to accept these proposed structures or do they design for the existing conditions? (East Brown Road and University Drive) Mr. Paulus stated that we do need to incorporate these proposed structures into our design at this time.

Mr. Shapiro asked if there were any freeboard requirements for the collector ditches? Mr. Paulus stated that there were no such requirements but freeboard should be considered and should be recommended by Greiner Engineering.

Mr. Shapiro stated that retention basins adjacent to the east right-of-way of the floodway have only been designed for the 50 year 24 hour storm and therefore, they need to design and provide inlets for the 100 year 24 hour discharge.

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The next topic for discussion was the maintenance road across the powerline easement channel. Mr. Shapiro stated that because the limitation of space within the right-of-way and the channel having a 6.5 foot depth with approximately 4 foot of water with a flow of 1150 cfs, it may be virtually impossible to provide a dip section for the maintenance road. Mr. Shapiro stated that it might be necessary to bridge this channel or use a box culvert. Mr. Shobe and Mr. Paulus agreed with Mr. Shapiro. Mr. Shapiro said that if we can grade outside of the floodway right-of-way into the powerline easement they might be able to transition the inlet channel and provide a dip section for the maintenance road. Mr. Paulus said that he would check into this. Mr. Shapiro brought up the point that they would also have to consider the effects of providing an interceptor for the proposed powerline easement channel on the existing retention basins located within this easement at this time.

At this time, Greiner Engineering presented there computerized cross section plots showing the preliminary floodway design against the existing ground at 100 foot intervals.

Mr. Shapiro and Mr. Sun went over the status of the RWCD Reach 6 project to date.

Mr. Paulus asked Mr. Shapiro to check the traverse for their panel points because he could not follow the computer printout and how it relates to the field book. Mr. Shapiro said that he would check into it.

The meeting was then adjourned.

cc: B. Berkowitz
D. Paulus
R.W. Shobe
M. Chudnoff
G. Sun

OPERATION AND MAINTENANCE AGREEMENT

THIS AGREEMENT made on August 5, 1982 is between the Soil Conservation Service, United States Department of Agriculture, hereinafter referred to as the Service, and the following organization, hereinafter referred to as the Sponsor:

Flood Control District of Maricopa County.

The Sponsor and the Service agree to carry out the terms of this agreement for the operation and maintenance of the project measures in the State of Arizona. The project measures covered by this agreement are identified as follows:

RWCD Floodway, Reach II, and Dip Crossings at Stations

I. OPERATIONS

A. The Sponsor will be responsible for operating the measure without cost to the Service as follows:

1. In compliance with applicable federal, state and local laws.

2. In compliance with the conditions set out in the instruments by which rights were acquired to install, operate and maintain the measure.

3. In a manner that will protect the environment and permit the measure to serve the purpose for which installed as set forth in the program agreement;

4. In keeping with the requirements to provide inspection, operation and maintenance reports within the time frame provided in the attached plan.

B. The Service will, upon request of the Sponsor and to the extent that its resources permit, provide consultative assistance in the operation of the structural measures.

C. Admission or users fees shall be charged only as necessary to produce revenues required by the Sponsor to amortize its share of installation costs for that portion of the measures pertaining to recreation or fish and wildlife and to provide adequate inspection, operation, maintenance, and replacement of the same.

D. In a recreation or fish and wildlife measure, the Sponsor(s) may dispense such services and commodities, or arrange with private concessionaires for the dispensing of such services and commodities, which will contribute to the full use and enjoyment of the measure by the public at prices which are reasonable and compatible with prices for similar services and commodities within the area served by the measure.

II. MAINTENANCE

A. The Sponsor will:

1. Be responsible for and promptly perform or have performed without cost to the Service all maintenance of the measures determined by either the Sponsor or the Service to be needed.

2. Obtain prior Service approval of all plans, designs and specifications for maintenance work.

B. The Service will, upon request of the Sponsor and to the extent that its resources will permit, provide consultative assistance in the maintenance of the measure.

III. REPLACEMENT

A. The Sponsor will be responsible for the replacement of parts or portions of the measure which has a physical life of less duration than the evaluated life of the measure.

B. The Service will, upon request of the Sponsor, provide consultative assistance in replacement of measure parts or portions.

IV. PLAN OF OPERATION AND MAINTENANCE

The Service and the Sponsor will prepare a detailed plan of operation and maintenance for each measure covered by this agreement. More than one measure may be included in a single plan provided that the measures are sufficiently similar to warrant such action. Each such plan shall be attached to and become a part of this agreement.

V. INSPECTIONS AND REPORTS

A. The Sponsor will inspect the measures at least annually and after each major storm or occurrence of any unusual condition that might adversely affect the measure.

B. The Service or Federal land administering agency may inspect the measures at any reasonable time during the period covered by this agreement. At the discretion of the State Conservationist, Service personnel may assist the Sponsor in their inspections.

C. A written report will be made of each inspection. A copy of each report will be provided by the inspecting party to the other party within ten days of the date on which the inspection was made. The report will describe the conditions found and list any corrective action needed with a time frame to complete each action.

VI. TIME OF RESPONSIBILITY

The Sponsor's responsibility for operation and maintenance begins when a part of or all of the work of installing a measure is completed and accepted or is determined complete by the Service. This responsibility shall continue

until the expiration of the evaluated life of all the installed project measures. This does not relieve the Sponsor's liability which continues throughout the life of the measure or until the measure is modified to remove potential loss of life or property.

VII. RECORDS

The Sponsor will maintain in a centralized location a record of all inspections and significant actions taken, cost of performance and completion date with respect to operation, maintenance and replacement. The Service may inspect these records at any reasonable time during the term of the agreement.

VIII. GENERAL

A. The Sponsor will:

1. Prohibit the installation of any structure of facilities that will interfere with the operation or maintenance of the project measures.

2. Obtain prior Service approval of the plans and specifications for any alteration or improvement to the structural measures.

3. Obtain prior Service approval of any agreement to be entered into with other parties for the operation or maintenance of all or any part of the project measures, and provide the Service with a copy of the agreement after it has been signed by the Sponsor and the other party.

B. Service personnel will be provided the right of free access to the project measures at any reasonable time for the purpose of carrying out the terms of this agreement.

C. The responsibilities of the Sponsor under this agreement are effective simultaneously with the acceptance of the project measures in whole or in part.

D. Comply with the attached PROPERTY MANAGEMENT STANDARDS.

FLOOD CONTROL DISTRICT OF MARICOPA COUNTY

By: [signature]

Title: Chairman, Board of Directors

Date: JUN 7 1982

This action was authorized at an official meeting of the Sponsor named on 7th day of June 1982 at Phoenix, Arizona.

Attest: [signature]

Title: Clerk of the Board

UNITED STATES DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

By: C. C. Cochran, Acty

Title: Acting Director Administrative Services

Date: 5 AUG 1982

PROPERTY MANAGEMENT STANDARDS
(Attachment to Operation and Maintenance Agreement)

The standards prescribed herein govern the utilization and disposition of property furnished by SCS or acquired in whole or in part with SCS-furnished funds by the sponsors. Sponsors are responsible for observing the standards set forth herein. Sponsors are authorized to use their own property management standards and procedures as long as the provisions set forth herein are included.

1. Definitions

(a) Real property. Real property means land, land improvements, structures and appurtenances thereto, excluding movable machinery and equipment.

(b) Personal property. Personal property means property of any kind except real property. It may be tangible -- having physical existence, or intangible -- having no physical existence, such as patents, inventions, and copyrights.

(c) Nonexpendable personal property. Nonexpendable personal property means tangible personal property having a useful life of more than one year and an acquisition cost of $300 or more per unit. A sponsor may use its own definition of nonexpendable personal property provided that such definition would at least include all tangible personal property as defined above.

(d) Expendable personal property. Expendable personal property refers to all tangible personal property other than nonexpendable property.

(e) Excess property. Excess property means property under the control of any federal agency which, as determined by the head thereof, is no longer required for its needs.

2. Use of Real Property

Sponsors shall use any real property acquired partly or wholly with SCS financial assistance, as long as needed for the purpose for which it was acquired and in accordance with the O&M agreement. When the real property is no longer needed for the purpose of the SCS financial assistance, the sponsor shall obtain SCS approval of its plans for future use or disposition.

3. Use of Nonexpendable Personal Property

(a) Nonexpendable personal property acquired with federal funds. When nonexpendable personal property is acquired by a sponsor wholly or in part with federal funds, title will not be taken by the federal government, but shall be vested in the sponsor subject to the following restrictions on use and disposition of the property:

(1) The sponsor shall retain the property acquired with federal funds in the federally financially assisted program as long as there is a need for the property to accomplish the purpose of the program whether or not the program continues to be supported by federal funds. When there is no longer a need for the property to accomplish the purpose of the federally financially assisted program, the sponsor shall use the property in connection with other federal grants it has received in the following order of priority:

(i) Other grants of the SCS needing the property.

(ii) Grants of other federal agencies needing the property.

(2) When the sponsor no longer has need for the property in any of its federal grant programs, the property may be used for its own official activities in accordance with the following standards:

(i) Nonexpendable property with an acquisition cost of less than $500 and used four years or more. The sponsor may use the property for its own official activities without reimbursement to SCS or sell the property and retain the proceeds.

(ii) All other nonexpendable property. The sponsor may retain the property for its own use provided that a fair compensation is made to the SCS for the SCS share of the cost of the property. The amount of compensation shall be computed by applying the percentage of SCS participation in the SCS financially assisted undertaking to the current fair market value of the property.

(3) If the sponsor has no need for the property, disposition of the property shall be made as follows:

(i) Nonexpendable property with an acquisition cost of $1,000 or less. Except for that property which meets the criteria of (2) (i) above, the sponsor shall sell the property and reimburse the SCS an amount which is computed in accordance with the last paragraph in (ii) below.

(ii) Nonexpendable property with an acquisition cost of over $1,000. The sponsor shall request disposition instructions from SCS. The SCS shall determine whether the property can be used to meet a SCS requirement. If no requirement exists within SCS, the availability of the property shall be reported to the General Services Administration (GSA) by the SCS to determine whether a requirement for the property exists in other federal agencies. The SCS shall issue instructions to the sponsor within 120 days and the following procedures shall govern:

If the sponsor is instructed to ship the property elsewhere, the sponsor shall be reimbursed by the benefiting federal agency with an amount which is computed by applying the percentage of the sponsor participation in the SCS financially assisted undertaking to the current fair market value of the property, plus any shipping or interim storage costs incurred.

If the sponsor is instructed to otherwise dispose of the property, he shall be reimbursed by the SCS for such costs incurred in its disposition.

If disposition instructions are not issued within 120 days after reporting, the sponsor shall sell the property and reimburse the SCS an amount which is computed by applying the percentage of SCS participation in the undertaking to the sales proceeds. Further, the sponsor shall be permitted to retain $100 or 10 percent of the proceeds, whichever is greater for the sponsor's selling and handling expenses.

4. Other Requirements for Nonexpendable Personal Property

The sponsor's property management standards for nonexpendable personal property shall also include the following procedural requirements:

(a) Property records shall be maintained accurately and provide for: a description of the property; manufacturer's serial number or other identification number; acquisition date and cost; source of the property; percentage of federal funds used in the purchase of property; location, use, and condition of the property; and ultimate disposition data including sales price or the method used to determine current fair market value if the sponsor reimburses SCS for its share.

(b) A physical inventory of property shall be taken and the results reconciled with the property records at least once every two years to verify the existence, current utilization, and continued need for the property.

(c) A control system shall be in effect to insure adequate safeguards to prevent loss, damage, or theft to the property. Any loss, damage, or theft of nonexpendable property shall be investigated and fully documented.

(d) Adequate maintenance procedures shall be implemented to keep the property in good condition.

(e) Proper sales procedures shall be established for unneeded property which would provide for competition to the extent practicable and result in the highest possible return.

5. Expendable Personal Property

When the total inventory value of any unused expendable personal property exceeds $500 at the expiration of need for any federal grant purposes, the sponsor may retain the property or sell the property as long as it compensates SCS for its share in the cost. The amount of compensation shall be computed in accordance with 3(a)(2)(ii) above.

6. Intangible Personal Property

(a) If any program produces patents, patent rights, processes, or inventions, in the course of work aided by a SCS financial assistance, such fact shall be promptly and fully reported to SCS. The SCS shall determine whether protection on such invention or discovery shall be sought and how the rights in the invention or discovery--including rights under any patent issued thereon-shall be disposed of and administered in order to protect the public interest consistent with "Government Patent Policy" (President's Memorandum for Heads of Executive Departments and Agencies, August 23, 1971, and Statement of Government Patent Policy as printed in 36 F.R. 16889).

(b) Where the SCS financial assistance results in a book or other copyrightable material, the sponsor is free to copyright the work, but SCS reserves a royalty-free, nonexclusive and irrevocable license to reproduce, publish, or otherwise use, and to authorize others to use the work for government purposes.

Weatbrt

OPERATIONS AND MAINTENANCE PLAN FOR RWCD FLOODWAY - REACH 2

This guide applies to the works of improvement to the RWCD Floodway between Station 981+05± and Station 1216+5±.

General

Within the floodway, weak soils have been removed and replaced with more erosion-resistant soils and unstable sections have been protected by installing either loose rock riprap or reinforced concrete. These measures do not, however, insure that the channel will be maintenance free.

A regular program of inspection and maintenance will point out areas that need to be monitored closely. This program will assure that excessive erosion, sedimentation or destruction of the floodway or appurtenances is not occurring.

The following items are to be used as a guide to properly operate and maintain the floodway.

Operation

There are no special requirements to properly operate the floodway.

Maintenance

Pipe Inlets:

Check pipe inlets annually to be sure they have not become plugged with debris or sediment. Any debris or sediment found should be removed and properly disposed of.

Loose Rock Riprap:

Check annually and after major flows to appraise riprap damage. Replace rock in those areas where damage has occurred.

Reinforced Concrete:

Inspect for cracks or other damage annually and after major flows. Remove debris and repair damage as needed. Inspect the drain outlets for free drainage and remove blockage where necessary.

Grouted Rock Riprap:

Inspect annually and after major flows have occurred to assess damage. Prompt damage repair and restriction removal is advised.

Earth Channel:

Inspect the floodway annually and after major flows for minor expected erosion. Repair damage by replacing and compacting material to designed grade.

Floodway Recompacted Earth Sections (Earth Lining):

Inspect the floodway during the summer months and after major flows to determine if the earth lining has been damaged. Evaluate damaged areas to determine if sufficient materials remain to withstand future flows. If the remaining material is not of sufficient depth, it must be removed and replaced to the original constructed depth.

Sedimentation:

Inspect the floodway annually and after significant flows to determine sediment accumulation from side drainages and remove sediment to designed grade.

Vegetation:

The floodway will be inspected annually and all vegetation which could create turbulent flow (shrubs, bunchgrasses, etc.) will be removed.

O&M Costs and Financial Resources

The average annual maintenance cost of this type of channel is unknown since there are no records relating to durability when used in this capacity. Financial resources for O&M costs will be the responsibility of the Flood Control District of Maricopa County.

O&M Responsibility and Procedures

NO

Maintenance is the responsibility of the Flood Control District of Maricopa County. Technical assistance and advice may be obtained from the Soil Conservation Service.

Critical Items

NO ?

All items listed under "Maintenance" are considered important and critical to the operation of the system. All of these items will be considered in all special and recurring on-site inspections.

address if needed

Environmental Concerns

At present, construction of the floodway is not considered a threat to the environment. However, should an adverse environmental effect occur, every reasonable effort should be made to correct the problem.

O&M Inspection and Followup

The sponsors will inspect the floodway at least annually and after each significant flow or after the occurrence of any unusual condition that might adversely affect the floodway. The annual inspection should be performed in October. Any supplemental inspections then determined necessary will be scheduled and agreed to at that time. A written report will be made of each inspection, describing the conditions found and the corrective action needed. A copy of each report will be provided to the Soil Conservation Service within ten (10) days of the inspection. All deficiencies found in the inspection will be corrected within an agreed-to time frame between the sponsors and the Soil Conservation Service.

State O&M Handbook

The book entitled "State of Arizona Watersheds Operation and Maintenance Handbook for Projects Installed with Assistance from the Soil Conservation Service," U.S. Department of Agriculture, Soil Conservation Service, dated May 1971 is herein made a part of this O&M Guide.

Time of Responsibility

The sponsor's responsibility for operation and maintenance begins when a part or all of the work of installing the floodway is completed and accepted or is determined complete by the Soil Conservation Service. This responsibility shall continue throughout the evaluated life of all the installed project measures. This does not relieve the sponsor's liability which continues throughout the life of the measure or until the measure is modified to remove potential loss of life or property.

Funds for O&M

Funds for O&M shall be provided by the Flood Control District of Maricopa County.

Provision for the Sponsor's Publication

Not applicable.

Records

The sponsors will maintain a record of all inspections and significant actions taken by the sponsors with respect to operation and maintenance. The Soil Conservation Service may inspect these records at any reasonable time.

General

The RWCD Floodway is being enlarged and extended under this project to reduce frequency and extent of inundation of developed lands within the watershed. This reach is the third of six planned and extends from Sta 977+25± to Sta 743+00±.

While no improvements in this reach require control or operation, maintenance is essential for the project to function as intended over its design life. Identified maintenance items are listed below.

→ Operation — address whether or not operations are needed

Maintenance

Channel

Remove accumulations of debris and sediment, note erosion in the channel bottom or on side slopes, and regrade or fill as necessary. Remove excessive woody vegetative growth. Replace and extend loose rock riprap as needed.

Inspect the floodway to determine if the earth lining has been damaged. Evaluate damaged areas to determine if sufficient materials remain to withstand future flows. If the remaining material is not of sufficient depth, it must be removed and replaced in accordance with the original construction drawing and specifications.

Drop Structure (Sta 857+00)

Note any chipping, cracking, erosion, or vandalism of the reinforced concrete. Report any sign of structural distress to the SCS State Conservation Engineer. Note, also, loss or damage of the drainage grates, loss of drainfill material, evidence of scour, erosion, settlement, or piping of the adjacent canal banks and make the appropriate repairs.

Side Inlets and Collector Ditch

Replace loose rock riprap and patch or repair grouted rock riprap. Remove debris and sediment from the collector ditch and the side inlets.

Sediment Basin (Sta 842+35) and Side Inlet Basin (Sta 858+70)

The sediment basin at STA 842+35 is designed to trap the major part of bedload sediment carried by Queen Creek at its junction with the RWCD Floodway during the design storm. The basin will retain 10AF of sediment. Remove sediment after 2AF has accumulated or after any events which deposit more than 2AF of sediment.

Fencing and Landscaping

Repair or replace any damaged or destroyed fencing. Repaint exposed metal surfaces as necessary. Replace any dead or missing plants installed under the landscaping contract as required in the landscaping plan.

O&M Inspection and Followup

The sponsors will inspect the floodway at least annually and after each significant flow or after the occurrence of any unusual condition that might adversely affect the floodway. The annual inspection should be performed in October. Any supplemental inspections then determined necessary will be scheduled and agreed to at that time. A written report will be made of each inspection, describing the conditions found and the corrective action needed. A copy of each report will be provided to the Soil Conservation Service within ten (10) days of the inspection. All deficiencies found in the inspection will be corrected within an agreed-to-time frame between the sponsors and the Soil Conservation Service.

State O&M Handbook

The book entitled "State of Arizona Watersheds Operation and Maintenance Handbook" for projects installed with assistance from the Soil Conservation Service, U.S. Department of Agriculture, Soil Conservation Service dated May, 1971, is herein made part of this O&M Guide.

Funds for O&M

Funds for O&M, shall be provided by the Flood Control District of Maricopa County (the sponsors).

Greiner Engineering

Greiner Engineering Sciences, Inc.
Tucson 602 327-3413
Phoenix 602 275-5400

Summary of Costs for Structures

Apache/Higley Intersection:

Description	Costs
five barrel 10'x7' box culvert (372 L.F.)	$619,000

Adobe Road:

Description	Costs
five barrel 10'x8' box culvert (100 L.F.)	$138,300
five barrel 8'x8' box culvert (100 L.F.)	$107,800
six barrel 8'x8' box culvert (100 L.F.)	$126,300
four barrel 10'x8' box culvert (100 L.F.)	$113,700

Recommended structure for Adobe Road: five barrel 8'x8' box culvert

Brown Road:

Description	Costs	
double barrel 6'x7' box culvert (124 L.F.)	$43,100	(Did not provide enough freeboard)
double barrel 8'x8' box culvert (124 L.F.)	$61,400	
double barrel 12'x8' box culvert (124 L.F.)	$99,100	

Recommended structure for Brown Road: double barrel 8'x8' box culvert

Greiner Engineering

Greiner Engineering Sciences, Inc.

Tucson 602 327-3413
Phoenix 602 275-5400

Job: SCS RWCD Reach 6

Description: Erosion Protection for Main Channel

Calculated by: R Beck Date: 2-12-86 Sheet No. 1

Checked by: M.S.S Date: of 4

Erosion Protection for

Main Floodway Channel.

Greiner Engineering

Greiner Engineering Sciences, Inc.

Tucson 602 327-3413
Phoenix 602 275-5400

Job: SCS RWCD Reach 6

Description: Erosion Protection for main floodway channel.

Calculated by: R. Beck Date: 2-10-86 Sheet No. 2

Checked by: M.S.S. Date: of 4

Material	Quantity	Unit Cost	Cost
Rip Rap (cu. yd.) (ass'd thickness = 18")	5408	20/yd³	108160
Gunite (ft²)	97377	2/ft²	194754
Concrete (ft²)	97377 (4" thick)	2/ft²	194754
Soil Cement (yd³)	7275 4907 (stairstep) 2368 (12" plate)	6.00/yd³ = 29442 22.00/yd³ = 52,096	81538
Revetment Mattress (ft²)	97377	3./ft²	292131
Gabions (yd²)	10815	65/yd²	702975
Grouted Rip rap (cu yd) (ass'd thickness = 18")	5408	40/yd²	216320

Ranking System 1-10 points (pts.)

Based On:

Items	Multiplier
Cost (C)	2
Maintenance (M)	1
Availability (A)	1
Ease of Construction (E)	0.5
Aesthetics (AE)	0.5
Hydraulic Performance (H)	1
Total available points	60

Project Feature: Erosion Protection For Main Channel

Item	Type of Material						
	RipRap	Gunite	Concrete	Soil Cement	Revetment Mat	Gabions	Grouted RipRap
C	8	7	7	9	5	3	6
M	6	9	10	9	9	8	7
A	8	10	10	10	7	8	8
E	9	10	9	10	10	7	7
AE	9	6	6	9	6	7	7
H	7	9	10	9	8	8	8
Total # of pts.	46	50	51.5	55.5	42	37	42 ~~46~~

Recommended Material for Project Feature: Soil Cement

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Phoenix 602 275-5400

Ranking System 1-10 points (pts.)

Based On:

Items	Multiplier
Cost (C)	2
Maintenance (M)	1
Availability (A)	1
Ease of Construction (E)	0.5
Aesthetics (AE)	0.5
Hydraulic Performance (H)	1
Total available points	60

Project Feature: Erosion Under Broadway Rd Bridge (Lining)

Item	Type of Material					
	Concrete	Granite				
C	8	8				
M	10	9				
A	9	9				
E	9	10				
AE	8	7				
H	9	9				
Total # of pts.	52.5	51.5				

Recommended Material for Project Feature: Concrete Lining

Greiner Engineering

Greiner Engineering Sciences, Inc.

Tucson 602 327-3413
Phoenix 602 275-5400

Job SCS RWCD Reach 6

Description Erosion Protection for Major Inlet Structures

Calculated by R. Beck Date 2-12-86 Sheet No. 1

Checked by MSS Date _____ of 3

Erosion Protection for Major Inlet Structures

Greiner Engineering

Greiner Engineering Sciences, Inc.
Tucson 602 327-3413
Phoenix 602 275-5400

Job SCS RWCD Reach 6
Description Erosion Protection for Major Inlet Structures
Calculated by R. Beck Date 2-10-86. Sheet No. 2
Checked by M.S.S. Date _____ of 3

Material	Quantity	Unit Cost	Cost.
RipRap (cu.yd.)	3060 yd^3	20.00	61200.
Gunite (ft^2)	55056 ft^2	2.00	110112.
Concrete (ft^2)	55056 ft^2	2.00	110112.
Soil Cement (yd^3)	3060 yd^3	14.00 includes excavation	42840
Revetment mattress (ft^2)	55056 ft^2	3.00	165168
gabions (yd^2)	6117 yd^2	65.00	397605
Grouted RipRap (cu yd)	3060 yd^3	40.00	122400

Greiner Engineering

Greiner Engineering Sciences, Inc.
Tucson 602 327-3413
Phoenix 602 275-5400

Job RWCD Reach C 101012
Description Project Feature Ranking
Calculated by M. Shapiro Date 2/9/86 Sheet No 3
Checked by B. G. B. Date of 3

Ranking System 1-10 points (pts.)

Based On:

Items	Multiplier
Cost (C)	2
Maintenance (M)	1
Availability (A)	1
Ease of Construction (E)	0.5
Aesthetics (AE)	0.5
Hydraulic Performance (H)	1
Total available points	60

Project Feature: Erosion Protection For Major Inlet Structures

Item	Type of Material						
	RipRap	Gunite	Concrete	Soil Cement	Revetment Mat	Gabions	Grouted RipRap
C	8	7	7	9	5	3	6
M	6	9	10	9	9	8	7
A	8	10	10	10	7	8	8
E	9	10	9	10	10	7	7
AE	9	6	6	9	6	7	7
H	1	3	10	9	5	7	8
Total # of pts.	40	44	51.5	55.5	39	36	~~46~~ 42

Recommended Material for Project Feature: Soil Cement

Greiner Engineering

Greiner Engineering Sciences, Inc.

Tucson 602 327-3413
Phoenix 602 275-5400

Erosion Protection for Collector Channel Outlets

Greiner Engineering

Greiner Engineering Sciences, Inc.
Tucson 602 327-3413
Phoenix 602 275-5400

Job SCS RWCD Reach 6
Description Erosion Protection for collector channel outlets.
Calculated by R. Beck Date 2-10-86 Sheet No. 2
Checked by M.S.S. Date _____ of 3

Material	Quantity	Unit Cost	Cost
Rip Rap (cu.yd)	816 yd^3	20/yd^3	16,320
Gunite (ft^2)	25200 ft^2	2/ft^2	50,400
Concrete (ft^2)	25200 ft^2	2/ft^2 (4" thick)	50,400
Soil Cement (yd^3)	933 yd^3	6/yd^3	5600
Revetment Mattress (ft^2)	25200 ft^2	3/ft^2	75600
Gabions (yd^2)	2800 yd^2	65/yd^2	182,000
Grouted RipRap (cu yd)	816 yd^3	40/yd^3	32,640

Greiner Engineering

Greiner Engineering Sciences, Inc.
Tucson 602 327-3413
Phoenix 602 275-5400

Job RWCD Reach 6 #101012
Description Project Feature Ranking
Calculated by M. Shapiro Date 2/9/86 Sheet No 3 of 3
Checked by B. G. S. Date

Ranking System 1-10 points (pts.)

Based On:

Items	Multiplier
Cost (C)	2
Maintenance (M)	1
Availability (A)	1
Ease of Construction (E)	0.5
Aesthetics (AE)	0.5
Hydraulic Performance (H)	1
Total available points	60

Project Feature: Erosion Protection For Collector Channel Outlets

Item	Type of Material						
	Rip Rap	Gunite	Concrete	Soil Cement	Revetment Mat	Gabions	Grouted Rip Rap
C	9	7	7	10	6	3	8
M	7	8	10	9	9	8	8
A	8	10	10	10	7	8	8
E	9	6	6	9	6	7	7
AE	9	6	6	9	6	7	7
H	8	9	9	9	8	8	9
Total # of pts.	50	47	49	57	42	37	48

Recommended Material for Project Feature: Soil Cement

Greiner Engineering

Greiner Engineering Sciences, Inc.

Tucson 602 327-3413
Phoenix 602 275-5400

Job SCS RWCD Reach 6

Description Erosion Protection for 42" pipe at Sta 143+66

Calculated by R. Bock Date 2-12-86 Sheet No. 1

Checked by M.S.S. Date _____ of 3

Erosion Protection for 42" pipe at Sta 143+66

Greiner Engineering

Greiner Engineering Sciences, Inc.

Tucson 602 327-3413
Phoenix 602 275-5400

Job SCS RWCD Reach 6
Description Erosion Protection for 42" pipe at Sta 143+66
Calculated by R. Beck Date _____ Sheet No. 2
Checked by M.S.S. Date _____ of 3

Material	Quantity	Unit Cost	Cost
Gunite (ft^2)	$2325 ft^2$	$2.00/ft^2$	4650.
Concrete (ft^2)	$2325 ft^2$	4" thick $2.00/ft^2$	4650.
Soil Cement (yd^3)	$86 yd^3$	$6 yd^3$	516.

Greiner Engineering

Greiner Engineering Sciences, Inc.
Tucson 602 327-3413
Phoenix 602 275-5400

Ranking System 1-10 points (pts.)

Based On:

Items	Multiplier
Cost (C)	2
Maintenance (M)	1
Availability (A)	1
Ease of Construction (E)	0.5
Aesthetics (AE)	0.5
Hydraulic Performance (H)	1
Total available points	60

Project Feature: Erosion Protection for 42" pipe at sta. 143+66

Item	Type of Material					
	Gunite	Concrete	Soil Cement			
C	5	5	10			
M	6	10	6			
A	9	9	10			
E	8	7	9			
AE	7	8	9			
H	9	9	9			
Total # of pts.	41.5	45.5	54			

Recommended Material for Project Feature: Soil Cement

Greiner Engineering

Greiner Engineering Sciences, Inc.

Tucson 602 327-3413
Phoenix 602 275-5400

Job SCS RWCD Reach 6

Description Erosion Protection for 36" pipe S. of Univ. Dr.

Calculated by R. Beck Date 2-12-86 Sheet No. 1

Checked by M.S.S. Date _____ of 3

Erosion Protection
for
36" pipe S. of University.

Greiner Engineering

Greiner Engineering Sciences, Inc.
Tucson 602 327-3413
Phoenix 602 275-5400

Job SCS RWCD Reach 6
Description Erosion Protection for 36" pipe S. of University Drive.
Calculated by R. Beck Date 2-10-86. Sheet No. 2
Checked by M.S.S. Date _____ of 3

Material	Quantity	Unit Cost	Cost
Rip Rap (cu yd)	57	20/yd^3	1140
Gunite (ft^2)	1550	2/ft^2	3100
Concrete (ft^2)	1550	2/ft^2 (4" thick)	3100
Soil Cement (yd^3)	57	6/yd^3	342
Revetment Mattress (ft^2)	1550	3/ft^2	4650
Gabions (yd^2)	172	65/yd^2	11180
Grouted riprap (yd^3)	57	40/yd^3	2280.

The headwall will require 2.01 yd^3 concrete and 150 lbs. steel.

Ranking System 1-10 points (pts.)

Based On:

Items	Multiplier
Cost (C)	2
Maintenance (M)	1
Availability (A)	1
Ease of Construction (E)	0.5
Aesthetics (AE)	0.5
Hydraulic Performance (H)	1
Total available points	60

Project Feature: Erosion Protection for the 36" Pipe South of Univ.

Item	Type of Material						
	Rip Rap	Gunite	Concrete	Soil Cement	Revetment Mat	Gabions	Grouted Rip Rap
C	9	7	7	10	6	3	8
M	7	8	10	9	9	8	8
A	8	10	10	10	7	8	8
E	9	6	6	9	6	7	7
AE	9	6	6	9	6	7	7
H	8	9	9	9	8	8	9
Total # of pts.	50	47	49	57	42	37	48

Recommended Material for Project Feature: Soil Cement

Greiner Engineering

Greiner Engineering Sciences, Inc.

Tucson 602 327-3413
Phoenix 602 275-5400

Job SCS RWCD Reach 6

Description Alternatives for west side collector channel

Calculated by R. Beck Date 2-12-86 Sheet No. 1

Checked by M.S.S. Date _____ of 3

Alternatives For West Side Collector Channel.

Summary of Cost for All Alternatives.

Material	Quantity	Unit Cost	Total Cost.
Earth Lining	1809 yd^3 Excavation	8.50/yd^3	15,380.
Concrete Lining	1120 yd^3 in place	165./yd^3	184,800.
Shotcrete or Gunite Lining	91605 ft^2 in place	2.00/ft^2	183,210.
Soil Cement Lining	2262 yd^3 in place (8.00/yd for excav. and 6.00/yd for s-c)	14.00/yd^3	28,043.
Corrugated Steel Lining	12214 ft.	14.00/ft.	170,996.
Half Concrete Pipe Lining	Not considered feasible due to cost and availability.		

Ranking System 1-10 points (pts.)

Based On:

Items	Multiplier
Cost (C)	2
Maintenance (M)	1
Availability (A)	1
Ease of Construction (E)	0.5
Aesthetics (AE)	0.5
Hydraulic Performance (H)	1
Total available points	60

Project Feature: West Side Collector Channel (Linings)

Item	Type of Material					
	Earth	Concrete	Gunite	Soil Cement	C.M.P.	Half Conc. Pipe
C	9	5	5	8	6	2
M	6	9	9	9	9	9
A	10	8	8	9	6	2
E	10	7	7	9	7	7
AE	10	8	7	9	5	6
H	6	9	8	8	7	9
Total # of pts.	50	43.5	42	46.5	40	30.5

Recommended Material for Project Feature: Earth Linings

Greiner Engineering

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Job SCS RWCD Reach 6

Description Alternatives for East Side Collector Channel

Calculated by R Beck Date 2-12-86 Sheet No. 1

Checked by M.S.S. Date _____ of 3

Alternatives For

East Side Collector

Channel.

Greiner Engineering

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Job SCS RWCD Reach 6
Description East Side Collector Channel
Write up and recommendation.
Calculated by R. Beck Date 2-10-86 Sheet No. 2
Checked by M.S.S. Date _____ of 3

Summary of Cost for all Alternatives.

Material	Quantity	Unit Cost	Cost.
Earth Lining	8864 yd^3 excav.	8.50/yd^3	75344.00
Concrete	1155 yd^3	165/yd^3	190575.00
Gunite	94500 ft^2	2.00/ft^2	189,000.00
Soil Cement	1750 yd^3	14.00/yd^3	24,500.00.

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Ranking System 1-10 points (pts.)

Based On:

Items	Multiplier
Cost (C)	2
Maintenance (M)	1
Availability (A)	1
Ease of Construction (E)	0.5
Aesthetics (AE)	0.5
Hydraulic Performance (H)	1
Total available points	60

Project Feature: East Side Collector Channel (Linings)

Item	Type of Material					
	Earth	Concrete	Gunite	Soil Cement		
C	10	6	6	8		
M	6	10	9	9		
A	10	8	8	9		
E	10	8	8	9		
AE	10	7	7	9		
H	8	10	10	9		
Total # of pts.	54	47.5	46.5	52		

Recommended Material for Project Feature: Earth Lining

Greiner Engineering

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Job SCS RWCD Reach 6

Description Inlet Structures for Collector Channels

Calculated by R Beck Date 2-12-86 Sheet No. 1

Checked by M.S.S. Date _____ of 3

Inlet Structures for Collector Channels.

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Job: SCS RWCD Reach 6
Description: Inlet Structures for Collector Channels
Calculated by: R. Beck Date: 2-12-86 Sheet No. 2
Checked by: M.S.S. Date: of 3

Material	Quantity	Unit Cost	Cost
Catch Basin	42	2000	84,000
Corrugated Drop Structure	42	600	25,200
Earth Spillway	42 (20 yd³ x $8/yd each)	160	6720.

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Ranking System 1-10 points (pts.)

Based On:

Items	Multiplier
Cost (C)	2
Maintenance (M)	1
Availability (A)	1
Ease of Construction (E)	0.5
Aesthetics (AE)	0.5
Hydraulic Performance (H)	1
Total available points	60

Project Feature: Inlet structures for the collector channel

Item	Type of Material					
	Spillway	A.D.O.T. C.B.	C.M.P. Drop Structure			
C	9	7	8			
M	4	7	8			
A	8	8	8			
E	8	6	7			
AE	5	8	7			
H	8	8	8			
Total # of pts.	44.5	44	47			

Recommended Material for Project Feature: C.M.P. Drop Structure

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Job SCS RWCD Reach 6

Description Maintenance Road Stabilization

Calculated by R Beck Date 2-12-86 Sheet No. 1

Checked by M.S.S. Date _____ of 3

Maintenance Road

Stabilization.

Greiner Engineering

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Phoenix 602 275-5400

Job: SCS RWCD Reach 6
Description: Maintenance road stabilization
Calculated by: R. Beck Date: 2-12-86 Sheet No. 2
Checked by: M.S.S. Date: of 3

Material	Quantity	Unit Cost	Cost.
50-50 mix of soil + aggregate 4" thick	16707 yd^3	11.00/yd^3 (material)	183,777.
6" ABC	25061 yd^3	11.00/yd^3 (material)	275671.
7" soil cement w/ double chip seal.	37629 yd^2	3.75/yd^2 (material)	141109.
9" soil cement	28221 yd^3	3.00/yd^3 (material)	84663.

Ranking System 1-10 points (pts.)

Based On:

Items	Multiplier
Cost (C)	2
Maintenance (M)	1
Availability (A)	1
Ease of Construction (E)	0.5
Aesthetics (AE)	0.5
~~Hydraulic~~ Performance (H)	1
Total available points	60

Project Feature: Maintenance roadway

Item	Type of Material				
	Earth	Soil Cement w/2-Chip Seal	Soil Cement	4" of Soil w/ ABC mix	6" ABC
C	10	6	8	4	4
M	4	9	6	6	6
A	10	8	9	8	8
E	10	7	8	8	8
AE	6	8	9	7	7
H	5	10	8	7	7
Total # of pts.	47	46.5	47.5	36.5	36.5

Recommended Material for Project Feature: Soil Cement

Greiner Engineering

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Job SCS RWCD Reach 6

Description Maintenance Ramp Stabilization.

Calculated by R Beck Date 2-12-86 Sheet No. 1

Checked by M.S.S. Date _____ of 3

Maintenance Ramp

Stabilization.

Greiner Engineering

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Job: SCS RWCD Reach 6

Description: Maintenance ramp alternatives

Calculated by: R. Beck Date: 2-12-86 Sheet No. 2

Checked by: M.S.S. Date: _____ of 3

Material	Quantity	Unit Cost	Cost.
Concrete	233 yd^3	165/yd^3	38,500.
Soil Cement	233 yd^3	6/yd^3	1398.
Earth.	233 yd^3	2/yd^3	466.

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Ranking System 1-10 points (pts.)

Based On:

Items	Multiplier
Cost (C)	2
Maintenance (M)	1
Availability (A)	1
Ease of Construction (E)	0.5
Aesthetics (AE)	0.5
~~Hydraulic~~ Performance (H)	1
Total available points	60

Project Feature: Maintenance Ramps

Item	Type of Material					
	Earth	Concrete	Soil Cement			
C	10	6	9			
M	4	10	6			
A	10	8	9			
E	10	8	9			
AE	6	8	9			
H	6	9	8			
Total # of pts.	48	47	50			

Recommended Material for Project Feature: Soil Cement

Greiner Engineering

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Phoenix 602 275-5400

Job: SCS RWCD Reach 6

Description: 54" pipe S. of Brown Rd.

Calculated by: R. Beck Date: 2-12-86 Sheet No. 1

Checked by: M.S.S. Date: _____ of 3

Outlet For 54" Pipe

South of Brown Rd.

Greiner Engineering

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Phoenix 602 275-5400

Job: SCS RWCD Reach 6
Description: Alternatives for 54" pipe S. of Brown Rd.
Calculated by: R Beck Date: 2-12-86 Sheet No. 2
Checked by: W.S.S. Date: of 3

Alt 1

Material	Quantity	Unit Cost	Cost
Riprap	140 yd³	20/yd³	2800.
Bedding	40 yd³	8/yd³	320.
54" Conc Pipe	108 l.f.	120/l.f.	12960.
Headwall	1	1000 ea.	1000.
			$17,080.

Alt 2

Material	Quantity	Unit Cost	Cost
Drywell	1	3000.	3000.
54" conc pipe	108 l.f.	120/l.f.	12960.
18" PVC pipe	60 l.f.	30/l.f.	1800.
Headwall & Apron	1	2,000.	2000.
Manhole	1	2,000.	2000.
			$21760

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Job RWCD Reach C 101012
Description Project Feature Ranking
Calculated by M. Shapiro Date 2/9/86 Sheet No 3
Checked by B. G. S. Date _____ of 3

Ranking System 1-10 points (pts.)

Based On:

Items	Multiplier
Cost (C)	2
Maintenance (M)	1
Availability (A)	1
Ease of Construction (E)	0.5
Aesthetics (AE)	0.5
Hydraulic Performance (H)	1
Total available points	60

Project Feature: Plunge Basin Vs. Drywell for 54" Pipe South Of Brown Road

Item	Type of Material					
	Plunge Basin	Drywell				
C	8	6				
M	9	7				
A	9	9				
E	8	6				
AE	8	8				
H	7	7				
Total # of pts.	49	42				

Recommended Material for Project Feature: Plunge Basin

Three different alternates (Alt. No 1, Alt. No. 2 and Alt. No. 3) were evaluated for the Comparative Design Study based on grade alignment and channel geometry for the main floodway channel. These alternates are under seperate cover on standard SCS plan and plan and profile sheets. In summary Alt. No 1 is based on the original work plan by SCS dated 10-7-4. Alt. No. 2 is a modified Alt No. 1 with the amendment due to Modification No. 3 (See Section 25). Alt. No. 3 is a modified concept based on a serpentine layout.

Common elements of all alternates:

The baseline of the floodway was established off the westerly right of way of the RWCD Reach 6 Floodway. The channel bottom width, depth of water plus 2 feet of freeboard, additional room for the maintenance road with an additional 10 foot added for safety measures. Therefore if you split the difference in the channel bottom width and add 50 feet to that this would establish the distance from the westerly right of way of the RWCD Reach 6 Floodway to the baseline. The rationale for this was to allow enough room on the east side of the floodway to collect offsite drainage and give enough room for the major inlet structures and collection systems while swinging the maintenance roadways around the major spillway inlets. Additional reason was to give the Flood Control District enough room on the east side of the floodway for future improvements (Eg. pump stations, etc.) Therefore it was not just a matter of splitting the entire floodway right of way in half to establish the floodway baseline. The horizontal alignment north of Brown Road was established by extending the baseline from the south.

As-Built plans for the structures at University Drive and Broadway Road were obtained. Proposed structure at Apache/Higley under design were received and reviewed. Horizontal alignments for the above structures were established based on the plans. Gentle curves were established using a 100 foot tangent to shift baseline off-set alignments. The radii of those curves range from 814.43 - 1,994.99 feet. To enter into the existing sedimentation basin designed for reach 4 at the south terminus of this project the centerline of the floodway shifted 39.71 feet to the right of the floodway baseline with a set of reverse curves as one exists the structure at Broadway Road.

All of the geometrics for the floodway baseline, centerline, right of ways and monument lines of cross streets were established using coordinate geometry on the state plane coordinate system and put on Greiner's computer. The stationing for all elements of the floodway was established by holding the intersection of the baseline of the flooding (P.I.'s) with the monument line of Broadway Road calling this station 156+00. Station equationing was used along all curved centerlines of the floodway to relate it back to the baseline stationing.

From station 30+70 to station 128+79.37 all invert grades for the floodway are identical for all alternates. Vertical alignments adhered to the original work plan by SCS dated 10-74 with the following exceptions. Grades established through the structure of the Apache/Higley culvert were based on the proposed plans by the Flood Control District. Modifications due to this structure were made between stations 91+13.87 to 118+54.07 changing the slope from -0.00015 ft/ft to

-0.000046 ft/ft until one gets to the end of the upstream transition area of the Apache/Higley structure. From station 118+54.07 to station 121+27 the slope changed from -0.000183 ft/ft to -0.00156 ft/ft through the upstream transition area of the Apache/Higley structure. From station 121+27 to station 126+46 the slope changed from -0.00216 ft/ft to -0.00180 ft/ft through the Apache/Higley structure itself. Then from station 126+46 to station 128+79.37 the slope changed from -0.0003 ft/ft to -0.00180 ft/ft through the outlet transition area of the Apache/Higley structure.

Greiner recommended adhering to the original vertical alignment as per the SCS work plan for the following reasons. Adjacent subdivisions along the east side of the floodway had & have designed many appurtenences draining into the floodway based on the original work plan. The City of Mesa had and have designed or proposed their east-west storm drains to drain into the floodway based on the original work plan. Raising the invert of the floodway would cause a hardship to the above projects. Lowering the floodway is a very difficult task. Many utility crossings dipping under the floodway at major roadways were based on the original work plan. There lowering the floodway at Brown Road, Adobe Road, the powerline easement and University Drive would be extremely costly due to all the utility relocation, not to mention the upset to utility users in having to shut off service for long periods of time during construction.

The bottom width of the channel, side slopes for banks, height of banks & transition lengths

for all alternates are identical between station 30+70 to station 118+54.07. All bottom transition are less they 12.5° conforming to SCS specifications. The only exception in the above area is around Adobe Road. Alternate No. 2 and three have a proposed culvert at this location with the appropriate transition structures.

Channel geometrics for the above stationing are as follows. From station 30+70 to station 31+48.00 the floodway has a 40 foot base width with a 9.5 ft depth and 3:1 side slopes. From station 31+48.00 the floodway bottom transitions into the wingwalls of the proposed 2-barrel 8'x8' box culvert starting at station 32+42.41. Then through the wingwalls, the structure itself and then leaving the wingwalls at the outlet at station 34+01.44. Then transitioning out to station 36+79.83 to a 80' foot base width with a 9.5ft. depth and 3:1 side slopes. From station 36+79.83 to station 59+37.98 and from station 65+06.02 to 88+47.84 the channel geometrics are identical to the latter. From station 88+47.84 to station 90+44.51 the channel transition to a 110 foot bottom with 2:1 side slopes. From station 90+44.51 to station 91+83.23 through the University Drive bridge the channel holds at a 110 foot bottom width with 2:1 side slopes and then transitions to station 93+97.84 holding the 110 foot bottom width and transitioning to 3:1 side slopes. From station 93+97.84 to station 118+75.72 the channel bottom width holds at 110ft. with 9.5 foot of depth and 3:1 side slopes to the transition area upstream of the Apache/Higley structure.

Other common floodway features for all alternates are as follows: the inlet channel to the north terminus of

the floodway, location and design of all the major inlets with their collection systems within the floodway, locations of all inlets for the east and west side collector channels, location of all maintenance ramps within the floodway except at Adobe Road, general configuration of maintenance roadways and east and west side collector channels and erosion protection for all outlet structures.

Alt. No. 1:

Diferences within this alternate are as follows:

From station 128+79.37 to station 161+30 the vertical alignment adheres in concept to the original workplan by SCS dated 10-74. In detail from station 128+79.37 to station 145+00 the invert slope changed from -0.0003 ft/ft to 0.00022 ft/ft. due to the adjustments made for the proposed Apache/Higley structure.

Channel geometrics from station 59+37.98 to station 65+06.02 and from station 118+75.72 to station 161+30 are as follows. From station 59+37.98 to station 65+06.02 the floodway has a base width of 80 feet with a 9.5 foot depth and 3:1 side slopes. From station 118+75.72 to station 121+13.05 the channel transitions from a 110 foot base width with a 9.5 foot depth with 3:1 side slopes to the wingwalls of from the 5 barrel 10'x8' box culvert at Apache/Higley with a base width at the wingwalls being 75.77 feet and side slopes at 1:1. The channel transitions through the level 9 foot high wingwalls from station 121+13.05 to station 122+24.72 to the entrance of the box culvert. The box culvert goes from station 122+24.72 to station 125+76.45 and then transition through the outlet wingwalls to station 126+71.23 where the

bottom width is 64.39 feet with 9 foot level wingwalls. From station 126+71.23 to station 128+79.37 the floodway transitions from a 64.39 foot bottom width with a depth of 9 feet with 1:1 side slopes to a bottom width of 90 feet with a depth of 9.5 feet with 3:1 side slopes. From station 128+79.37 to station 153+50.00 the floodway base width is 90 feet with a depth of 9.5 feet with 3:1 side slopes. From station 153+50.00 to station 155+61.84 the floodway base width transitions to a 30 foot bottom width with 2:1 side slope to the entrance of the Broadway Road bridge and hold to the exit of the bridge at station 156+39.50. From station 156+39.50 to station 158+90.67 the floodway channel transitions to a 90 foot base width with a 9.5 foot depth and 3:1 side slopes holding this geometry to the south terminus of reach 6 at station 161+30.00.

(See Alt. No. 1 bluelines under seperate cover for a graphical representation of this alternate including water surface elevation plots for the Q_{100} and the 50% Q_{100})

In general inadequacies of this alternate are that only 0.96 ft. of freeboard through the Apache/Higley structure is provided, very high velocities from Apache/Higley structure to the south terminus of the floodway requires erosion protection therefore this alternate is not recommended.

Alt. No. 2 (Modification No. 3):

The channel geometrics for this alternate are identical to Alt. No. 1 with the following exceptions. A structure

at Adobe Road has been included in this alternate therefore from station 59+37.98 to the inlet wingwalls of the recommended 5 barrel 8'x8' concrete box culvert at station 61+37.98 the floodway base width transition from a 80 foot base width with 9.5 foot of depth and 3:1 side slopes to 60.14 foot base width. Then transitioning through the wingwalls to the box culvert with the entrance at station 61+84.41 through the box with its exit at station 62+73.01 through the wingwalls which terminate at station 63+06.02 with a bottom width of 60.14 feet and finally transitioning to station 65+06.02 to a bottom width of 80 feet with a depth of 9.5 feet with 3:1 side slopes. The Apache/Higley structure has been modified to a 5 barrel 10'x7' concrete box culvert. From station 128+79.37 to station 161+30 the top of the bank will be set at a grade 2 foot above and parallel to the water surface elevation instead of a constant 9.5 feet in depth to minimize moving the floodway width outside of the right of way boundaries due to lowering the floodway invert in this area. From station 140+00 to station 153+50.00 the floodway would transition from a 90 foot bottom width with 3:1 side slopes to an 81 foot bottom width with 3:1 side slopes. From station 153+50.00 to station 155+61.84 the floodway base width transitions to a 30 foot bottom width with 1:1 side slopes to the entrance of the Broadway Road bridge and hold to the exist of the bridge at station 156+39.50. From station 156+39.50 to station 158+90.67 the floodway channel transitions to a 90 foot base width with 3:1 sides slopes.

Additional modifications between stations 128+79.37

and 161+30.00 at the south terminus were made holding the elevations at both these stations and a grade raked in between (-0.001163 FT/FT).

(See Alt. No. 2 bluelines under seperate cover for a graphical representation of this alternate including water surface elevation plots for the Q_{100} and the 50% Q_{100}. These bluelines show all the common features for all three alternates)

Greiner Engineering recommends that Alt. No. 2 be approved for the grade and alignment concept for the Reach 6 project with the associated other appurtenances.

(See Section 25 for more details)

Alt. No. 3 (Serpentine concept):

The channel geometrics and grade for Alt. No. 3 are identical to Alt. No. 2 including the hydraulics (water surface elevations). The major difference in concept is the horizontal shift in center line alignment from Brown Road to Apache/Higley. This shift was done to try to give more additional room to the west side collector ditch to improve its hydraulics and cut down on required maintenance. Shifting of the centerline alignment to the east was accomplished by using a set of reverse curves with 100 ft. tangent lengths. Shifts back to the original horizontal alignment was necessary before major inlet structure and transition areas before bridges and box culverts. A 26 foot shift was accomplished

between Brown Road and University Drive and a 10 foot shift was accomplished between University Drive and Apache/Higley. There was not enough right of way to accomplish a shift between Apache/Higley and the south terminus of the floodway.

(See Alt. No. 3 bluelines under seperate cover for a graphical representation of this alternate).

The benefits associated with less maintenance due to the horizontal shift in alignment compared with the additional $33,300 of cost due to the additional construction costs are not enough to outway these additional costs. Therefore Greiner does not recommend this alternate. (See cost backup on the following pages) Other benefits associated with the serpentine concept are a more pleasing looking and more natural looking project from an aesthetics standpoint.

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Job RWCD Reach 6 E101012

Description Project Feature Ranking

Calculated by M. Shapiro Date 2/9/86 Sheet No. 1

Checked by B. G. S. Date 2/11/86 of 1

Ranking System 1-10 points (pts.)

Based On:

Items	Multiplier
Cost (C)	2
Maintenance (M)	1
Availability (A)	1
Ease of Construction (E)	0.5
Aesthetics (AE)	0.5
Hydraulic Performance (H)	1
Total available points	60

Project Feature: Grade and Alignment of Main Floodway

Item	Type of Material					
	Alt. No 1	Alt. No. 2	Alt. No. 3			
C	9	10	8			
M	9	9	9			
A	10	10	10			
E	10	9	8			
AE	8	9	10			
H	6	10	10			
Total # of pts.	52	58	54			

Recommended Material for Project Feature: Alt. No. 2

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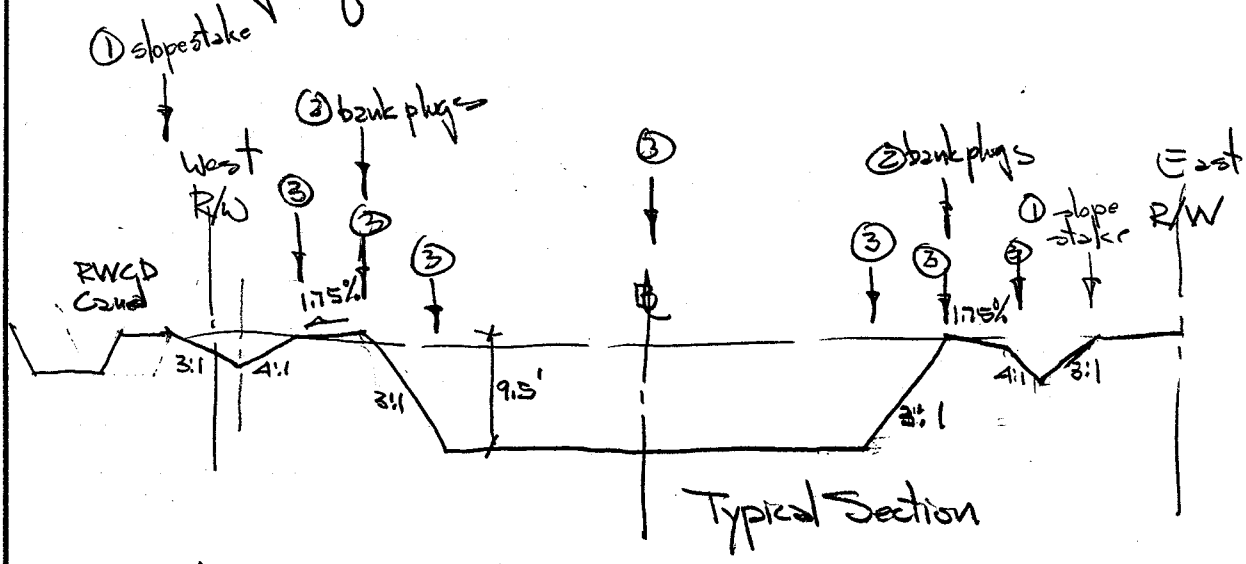
Job RWCD Reach 6 E101012
Description Staking concepts / Meeting w/ Jim Cristia @ 11:00 A.M.
Calculated by M. Shapiro Date 2/7/86 Sheet No. 1
Checked by B.G.S. Date 2/11/86 of 2

Staking requirements:



Typical Section

⓪ existing ground x sections
① rough grade
② finer grade
③ blue top for O&M road & channel
④ final as-built x-sections

- 3 man crew 15 sta./day $75/hr. for a 3 man crew
- in house eng. tech would take 1/3 more time for the serpentine area to be calc'd. A tech can calculate 400 L.F./hr. ∴ for the serpentine areas it would take 300 L.F./hr. @ $36/hr.

2500 L.F. of curves Alt. No. 3 (Serpentine concept)

Tangent	# of staking procedures	Curved
25 sta.		68 sta.
($1000) 5 = $5,000		($2,700) 5 = $13,500
+ 225		300
$5,225		$13,800

difference of $8,275 for staking

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Degree of difficulty in constructing 2500 L.F. of curves due to A.H.V. No. 3 (Serpentine concept)

Rationale: although a contractor would find it hard to assess the actual dollar amount it would take to construct a tangent section versus a curved section of floodway and put a unit cost to it, a contractor knows it is more difficult and additional care must be taken due to the increased amount of staking in these curved areas. Contractors rely on gut feelings when approaching these problems during the bidding process. Through the advise of our construction management department it was determined that a contractor would assess a degree of difficulty of an additional 5 percent to that portion of the project.

Total construction cost: $2,500,000

curved area - 2,500 L.F.
entire length of project - 13,176 L.F.

$\frac{2,500}{13,176}$ = 18.97% use 20%

∴ .2 × .05 = .01 or 1% ∴

$2,500,000 × .01 = $25,000 additional cost

survey cost + contractors cost = total cost

$8,275 + $25,000 = $33,275

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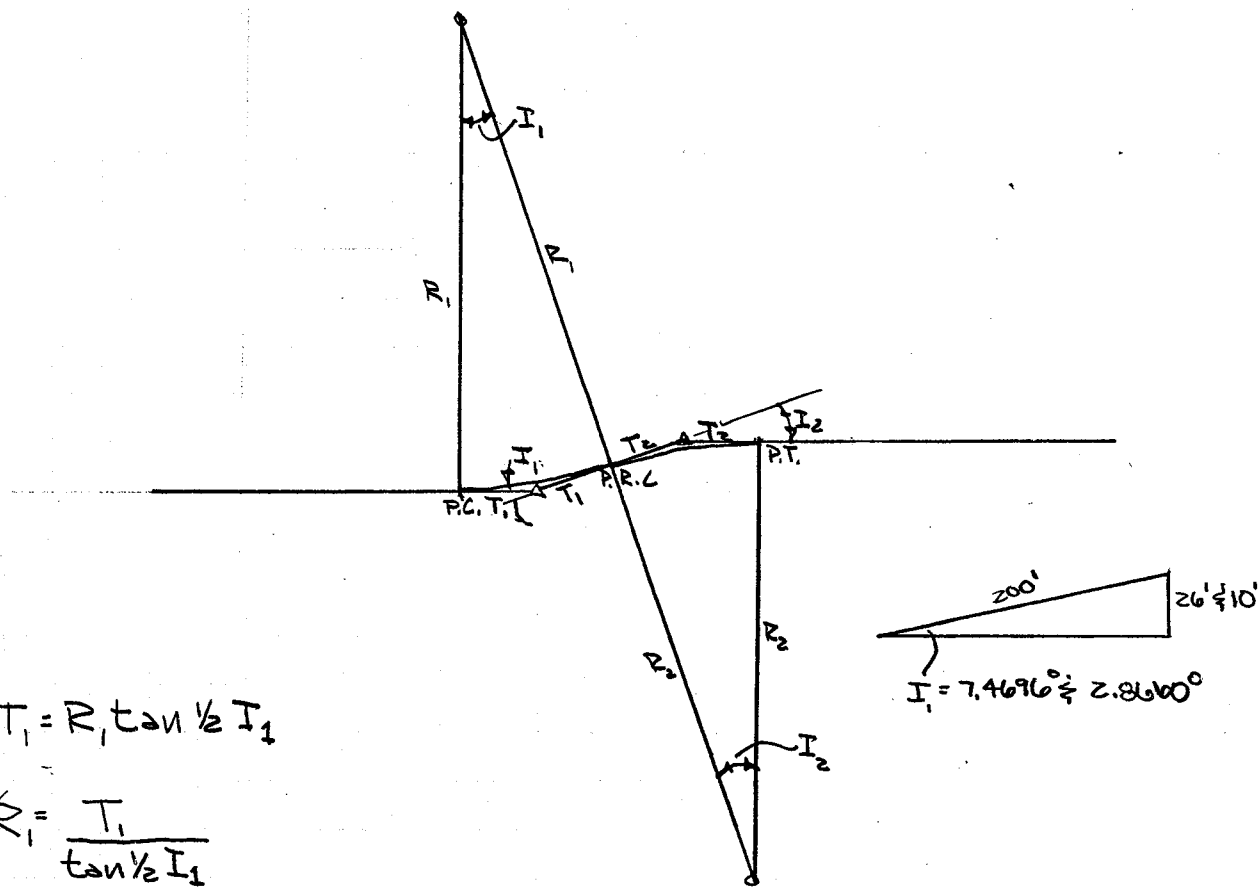
Job RWCD Reach 6 510101.2

Description Serpentine Concept

Calculated by M. Shapiro Date 2/4/86 Sheet No. 1

Checked by B. G. B. Date 2/11/86 of 1



$T_1 = R_1 \tan \frac{1}{2} I_1$

$R_1 = \dfrac{T_1}{\tan \frac{1}{2} I_1}$

$R_2 = T_2 \cot \frac{1}{2} I_2$

for a 26' offset I_1 & I_2 = 7.4696° ∴ R_1 & R_2 = 3063.87 ft

for a 10' offset I_1 & I_2 = 2.8660° R_1 & R_2 = 3,997.30 ft

Greiner Engineering

Greiner Engineering Sciences, Inc.

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Phoenix 602 275-5400

Job SCS RWCD Floodway Reach 6 – E101012
Description Comparative Design Studies
Peak Flows in Main Channel
Calculated by B. Gary Sun Date 2/3/86 Sheet No. ____
Checked by M.S.S. Date ____ of ____

Summary of Peak Flows in Main Channel
(Before Modification No. 3)

Station – Station	Q_{100}	50% of Q_{100}	Q_{10}
30+50.00 – 31+73.15 N. Brown	300 cfs	150 cfs	154 cfs
31+73.15 – 36+84.83 Brown Box	900 cfs	450 cfs	154 cfs
36+84.83 – 78+43.91 Adobe Rd.	1,200 cfs	600 cfs	193 cfs
78+43.91 – 88+89.51 Powerline	1,800 cfs	900 cfs	296 cfs
88+89.51 – University Dr.	1,840 cfs	920 cfs	460 cfs
– 121+15.05 1/4 mi. S. Univ.	1,840 cfs	920 cfs	453 cfs
121+15.05 – 128+84.37 Apache Trail	1,900 cfs	950 cfs	721 cfs
128+84.37 – S.E. of Higley	2,400 cfs	1,200 cfs	1,029 cfs
– 161+30.00 S. Broadway	2,400 cfs	1,200 cfs	1,014 cfs

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Job SCR RWCD Floodway Reach 6 - E101012
Description Summary of Peak Flows
Main Channel for Mod. No. 3
Calculated by B. Gary Sun Date 1/27/86 Sheet No. 1
Checked by M.S.B. Date _____ of _____

Summary of Peak Flows

1. Peak Flows Within Floodway Channel for Modification No. 3

Station — Station	Q_{100}	50% of Q_{100}	Q_{10}
30+70.00 – 32+19.53 N. Brown	300 cfs	150 cfs	154 cfs
32+19.53 – 36+84.83 Brown Box	900 cfs	450 cfs	154 cfs
36+84.83 – 78+43.91 Adobe Rd.	1,200 cfs	600 cfs	193 cfs
78+43.91 – 88+42.84 Powerline	1,800 cfs	900 cfs	296 cfs
88+42.84 – " University Dr.	1,840 cfs	920 cfs	460 cfs
– 118+70.72 1/4 mi S. of University	1,840 cfs	920 cfs	453 cfs
118+70.72 – 128+84.37 Apache Trail	1,900 cfs	950 cfs	721 cfs
128+84.37 – S.E. of Higley Road	2,400 cfs	1,200 cfs	1,029 cfs
– 161+30.00 S. of Broadway Rd.	2,400 cfs	1,200 cfs	1,014 cfs

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Job SCS RWCD Floodway Reach 6 - E101012
Description Summary of Peak Flows Side Inlets
Calculated by B. Gary Sun Date 1/27/86 Sheet No. 2
Checked by M.S.S. Date _____ of _____

Summary of Peak Flows (Cont'd)

2. Design Flows for Major Side Inlets

Description	Design Flows	Spillway Width	Invert Elev.
① North of Brown Road at Sta. 30+70	196 cfs	14 ft	37.52
*② South of Brown Road at Sta. 35+18	201 cfs	50 ft	37.48
③ North of Adobe Road at Sta. 60+60	194 cfs	45 ft	37.22
④ South of Adobe Road at Sta. 64+02	116 cfs	40 ft	37.19
⑤ Powerline Easement at Sta. 80+04	cfs	ft	37.03
**⑥ North of University Drive at Sta. 89+11	600 cfs	80 ft	36.91
⑦ South of University Drive at Sta. 93+98	133 cfs	66 ft	36.85
***⑧ North of Apache Blvd. at Sta. 120+21	727 cfs	90 ft	36.53
⑨ South East of Higley Road at Sta. 128+06	500 cfs	66 ft	35.16
****⑩ Mesa Shadows East 42" S.D. at Sta. 143+66	220 cfs	30 ft	34.78
⑪ Mesa Shadows East Spillway at Sta. 150+98	17 cfs	8 ft	34.57

Notes:

* Q = 159 cfs for 54" Pipe South of Brown Road at Sta. 35+84.5 Inv. = 37.47

** Q = 70 cfs for 36" S.D. South of University Drive at Sta. 92+25 Inv. = 41.00

*** Q = 273 cfs for 72" S.D. Higley Road

**** Existing 42" Pipe capacity of 118 cfs is included Inv. = 39.46

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Summary of Typical Cross Sections for Main Channel for Mod. No. 3

The following items are included:

1. Preliminary Channel Grade for Modification No. 3.
2. Design Peak Flows in Main Channel.
3. Channel Description
4. Sketches of the Channel Geometry.
5. Cross Section Sketches for Main Channel.

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Job SCR RWCD Floodway Reach 6 - E101012
Description Comparative Design Studies (Mod. #3)
Modification No. 3 Grade Line for Main Chan.
Calculated by B. Gary Sun Date 1/24/86 Sheet No. 2
Checked by M.S.S. Date _____ of 3

Preliminary Grade for Modification No. 3

Station	Invert Elevation	Invert Slope in ft/ft	Remarks
30+43.36	1346.40		
		S = 0.33333 ft/ft	
30+70.00	1337.52		Grade Break
		S = 0.00010	
31+48.00	1337.51		
		S = 0.00010	
45+00.00	1337.37		
		S = 0.00010	
65+00.00	1337.17		
		S = 0.00010	
85+00.00	1336.97		
		S = 0.00010	
88+47.84	1336.94		G.B.
		S = 0.00015	
93+97.84	1336.86		G.B.
		S = 0.00004	
105+00.00	1336.82		
		S = 0.00004	
118+75.72	1336.76		G.B.
		S = 0.00150	
120+71.45	1336.47		G.B.
		S = 0.00180	
125+00.00	1335.70		
		S = 0.00180	
128+79.37	1335.02		G.B.
		S = 0.00116	
145+00.00	1333.14		
		S = 0.00116	
161+30.00	1331.24		

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Summary of Peak Flows

1. Peak Flows Within Floodway Channel

Station — Station	Q_{100}	50% of Q_{100}	Q_{10}
30+70.00 – 32+19.53 N. Brown	300 cfs	150 cfs	154 cfs
32+19.53 – 36+84.83 Brown Box	900 cfs	450 cfs	154 cfs
36+84.83 – 78+43.91 Adobe Rd.	1,200 cfs	600 cfs	193 cfs
78+43.91 – 88+42.84 Powerline	1,800 cfs	900 cfs	296 cfs
88+42.84 – 118+70.72 University Dr.	1,840 cfs	920 cfs	460 cfs
118+70.72 – 1/4 mi S. of University	1,840 cfs	920 cfs	453 cfs
– 128+84.37 Apache Trail	1,900 cfs	950 cfs	721 cfs
128+84.37 – S.E. of Higley Road	2,400 cfs	1,200 cfs	1,029 cfs
– 161+30.00 S. of Broadway Rd.	2,400 cfs	1,200 cfs	1,014 cfs

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Job: SCS RWCD Floodway Reach 6 - E101012
Description: Comparative Design Studies (Mod. No. 3)
Channel Grade, Lining & Geometry of Floodway
Calculated by: B. Gary Sun Date: 2/5/86 Sheet No. 1
Checked by: M.S.S. Date: _____ of 3

DESCRIPTION OF MAIN CHANNEL FOR MOD. NO. 3

REACH		So	SIDE SLOPES		CHAN. WIDTH	PROTECTIONS		REMARKS
STA. (from)	STA. (to)	(ft/ft)	Lt.	Rt.	(ft)	Bottom	Banks	
30+43.36	30+70.00	0.333333	3:1	3:1	40	None	None	
30+70.00	31+48.00	0.000100	3:1	3:1	40	None	None	
31+48.00	32+24.54	0.000100	3:1	3:1	varies 40 ~ 33.1	None	None	Trans.
32+24.54	32+42.41	0.000100	3:1	0:0	varies 33.1 ~ 25.87	Partial Conc.	Rt. Conc.	Rt. wall
32+42.41	32+55.83	0.000100	0:0	0:0	varies 25.87 ~ 16.75	Conc.	Conc.	Wingwalls
32+55.83	33+70.15	0.000100	0:0	0:0	16.75	Conc.	Conc.	Brown Box
33+70.15	33+83.57	0.000100	0:0	0:0	varies 16.75 ~ 25.87	Conc.	Conc.	Wingwalls
33+83.57	34+01.44	0.000100	0:0	3:1	varies 25.87 ~ 33.1	Partial Conc.	Lt. Conc.	Lt. wall
34+01.44	36+79.83	0.000100	3:1	3:1	varies 33.1 ~ 80	None	None	Trans.
36+79.83	59+37.98	0.000100	3:1	3:1	80	None	None	
59+37.98	61+37.98	0.000100	3:1	3:1	varies 80 ~ 60.14	None	None	Trans.
61+37.98	61+70.99	0.000100	3:1	0:0	varies 60.14 ~ 50.79	Partial Conc.	Rt. Conc.	Rt. wall
61+70.99	61+84.41	0.000100	0:0	0:0	varies 50.79 ~ 43	Conc.	Conc.	Wingwalls
61+84.41	62+59.59	0.000100	0:0	0:0	43	Conc.	Conc.	Adobe Box
62+59.59	62+73.01	0.000100	0:0	0:0	varies 43 ~ 50.79	Conc.	Conc.	Wingwalls
62+73.01	63+06.02	0.000100	0:0	3:1	varies 50.79 ~ 60.14	Partial Conc.	Lt. Conc.	Lt. Wall

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DESCRIPTION OF MAIN CHANNEL FOR MOD. NO. 3 (Cont'd)

REACH		So	SIDE SLOPES		CHAN. WIDTH	PROTECTIONS		REMARKS
STA. (from)	STA. (to)	ft/ft	Lt.	Rt.	(ft)	Bottom	Banks	
63+06.02	65+06.02	0.000100	3:1	3:1	varies 60.14~80	None	None	Trans.
65+06.02	88+47.84	0.000100	3:1	3:1	80	None	None	
88+47.84	90+44.51	0.000150	varies 3:1~2.1:1	varies 3:1~2:1	varies 80~106	None	None	Trans.
90+44.51	90+94.45	0.000150	varies 2.1:1~2:1	2:1	varies 106~110	None	None	Trans.
90+94.45	91+33.29	0.000150	2:1	2:1	110	None	None	Univ. Bridge
91+33.29	91+83.23	0.000150	2:1	varies 2:1~2.12:1	110	None	None	Trans.
91+83.23	93+97.84	0.000150	varies 2:1~3:1	varies 2.12:1~3:1	110	None	None	Trans.
93+97.84	118+75.72	0.000150	3:1	3:1	110	None	None	
118+75.72	119+02.72	0.001500	varies 3:1~2.83:1	varies 3:1~2.83:1	varies 110~106	None	None	Trans.
119+02.72	120+71.45	0.001500	varies 2.83:1~1.39:1	varies 2.83:1~1.39:1	varies 106~84	None	Conc.	Trans.
120+71.45	121+13.05	0.001800	varies 1.39:1~1:1	varies 1.39~1:1	varies 84~75.77	None	Conc.	Trans.
121+13.05	122+24.72	0.001800	0:0	0:0	varies 75.77~53.33	Conc.	Conc.	Level Walls
122+24.72	125+76.45	0.001800	0:0	0:0	53.33	Conc.	Conc.	Apache/Higley Box
125+76.45	126+71.23	0.001800	0:0	0:0	varies 53.33~64.39	Conc.	Conc.	Level Walls
126+71.23	128+59.37	0.001800	varies 1:1~2.83:1	varies 1:1~2.83:1	varies 64.39~88	None	Conc.	Trans.
128+59.37	128+79.37	0.001800	varies 2.83:1~3:1	varies 2.83:1~3:1	varies 88~90	None	None	Trans.

DESCRIPTION OF MAIN CHANNEL FOR MOD. NO. 3 (Cont'd)

REACH		So	SIDE SLOPES		CHAN. WIDTH	PROTECTIONS		REMARKS
STA. (from)	STA. (to)	ft/ft	Lt.	Rt.	(ft)	Bottom	Banks	
128+79.37	140+00.00	0.001163	3:1	3:1	90	None	None	
140+00.00	153+50.00	0.001163	3:1	3:1	varies 90~81	None	None	Trans.
153+50.00	155+38.16	0.001163	varies 3:1~1.22:1	varies 3:1~1:1	varies 81~36.38	Conc.	Conc.	Trans.
155+38.16	155+61.84	0.001163	varies 1.22:1~1:1	1:1	varies 36.38~30	Conc.	Conc.	Trans.
155+61.84	156+39.50	0.001163	1:1	1:1	30	Conc.	Conc.	Broadway Bridge
156+39.50	156+63.18	0.001163	1:1	varies 1:1~1.2:1	varies 30~36.54	Conc.	Conc.	Trans.
156+63.18	158+90.67	0.001163	varies 1:1~3:1	varies 1.2:1~3:1	varies 36.54~90	Conc.	Conc.	Trans.
158+90.67	161+30.00	0.001163	3:1	3:1	90	None	None	

Note:

Channel protections may be slightly changed according to the tractive Power calculations. (See Section 8 for erosion protection).

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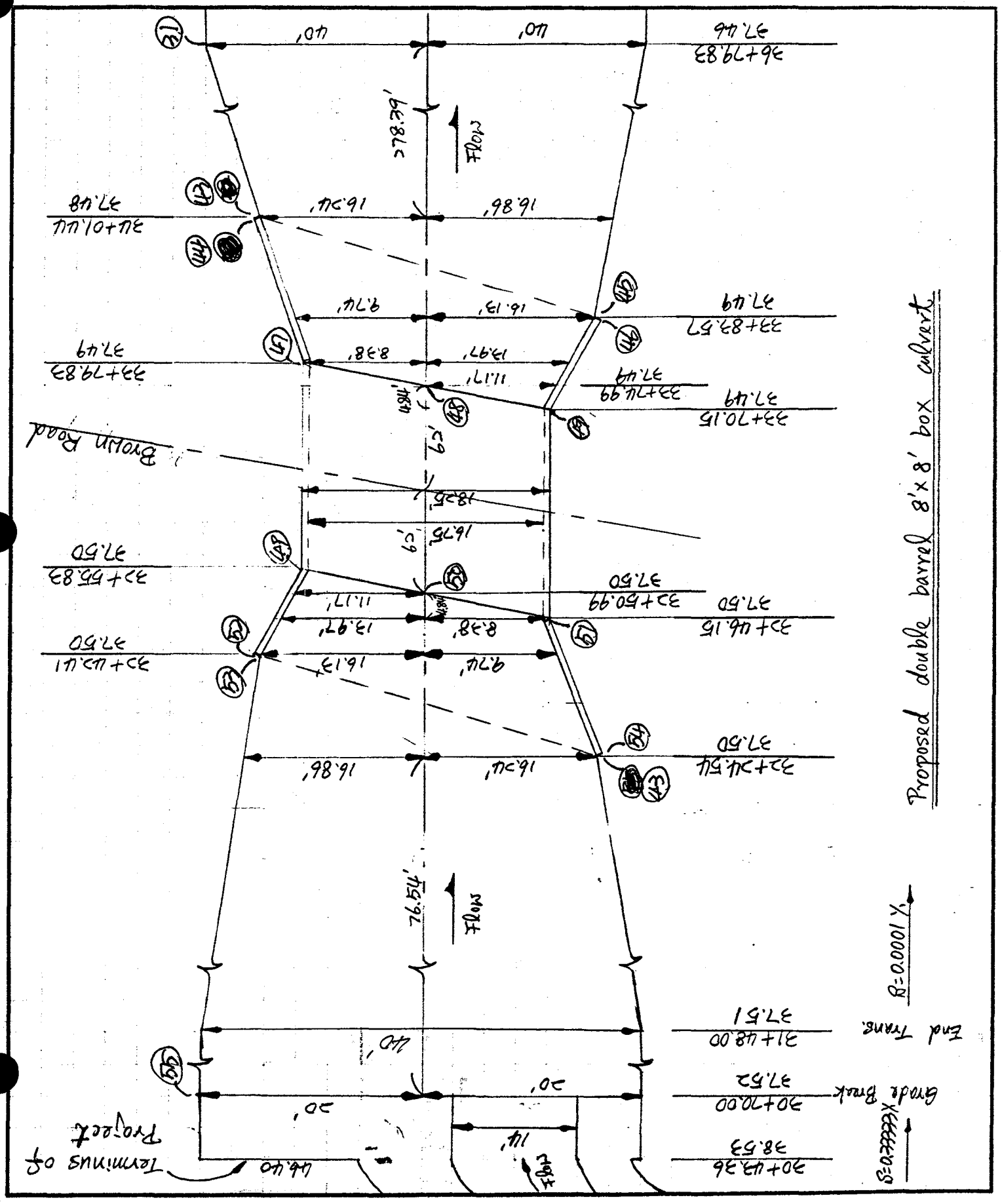
Job: SCS RWCD Floodway Reach 6 - E101012

Description: Comparative Design Studies (Mod. #3) Hydraulics for Main Channel

Calculated by: B. Gerst Sun Date: 1/23/86 Sheet No. 1

Checked by: M.S.S. Date _____ of _____



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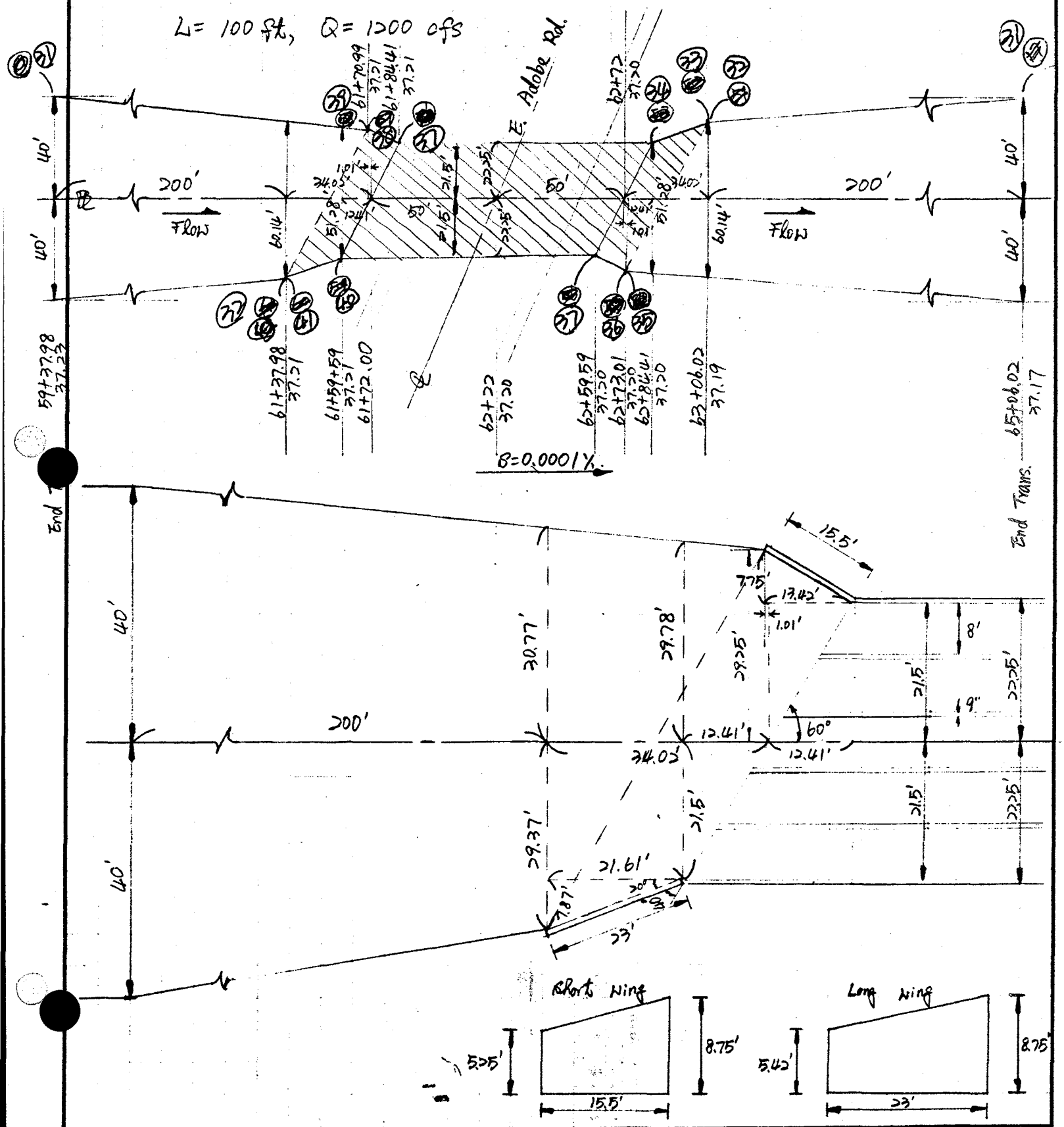
Job SCS RWCD Floodway Reach 6 - E101012
Description Comparative Design (Mod. No. 3)
Hydraulics for Main Channel
Calculated by B. Gary Sun Date 1/23/86 Sheet No. 2
Checked by M.S.S. Date _____ of _____

Proposed five barrel 8'x8' box culvert at E. Adobe Road

L = 100 ft, Q = 1200 cfs



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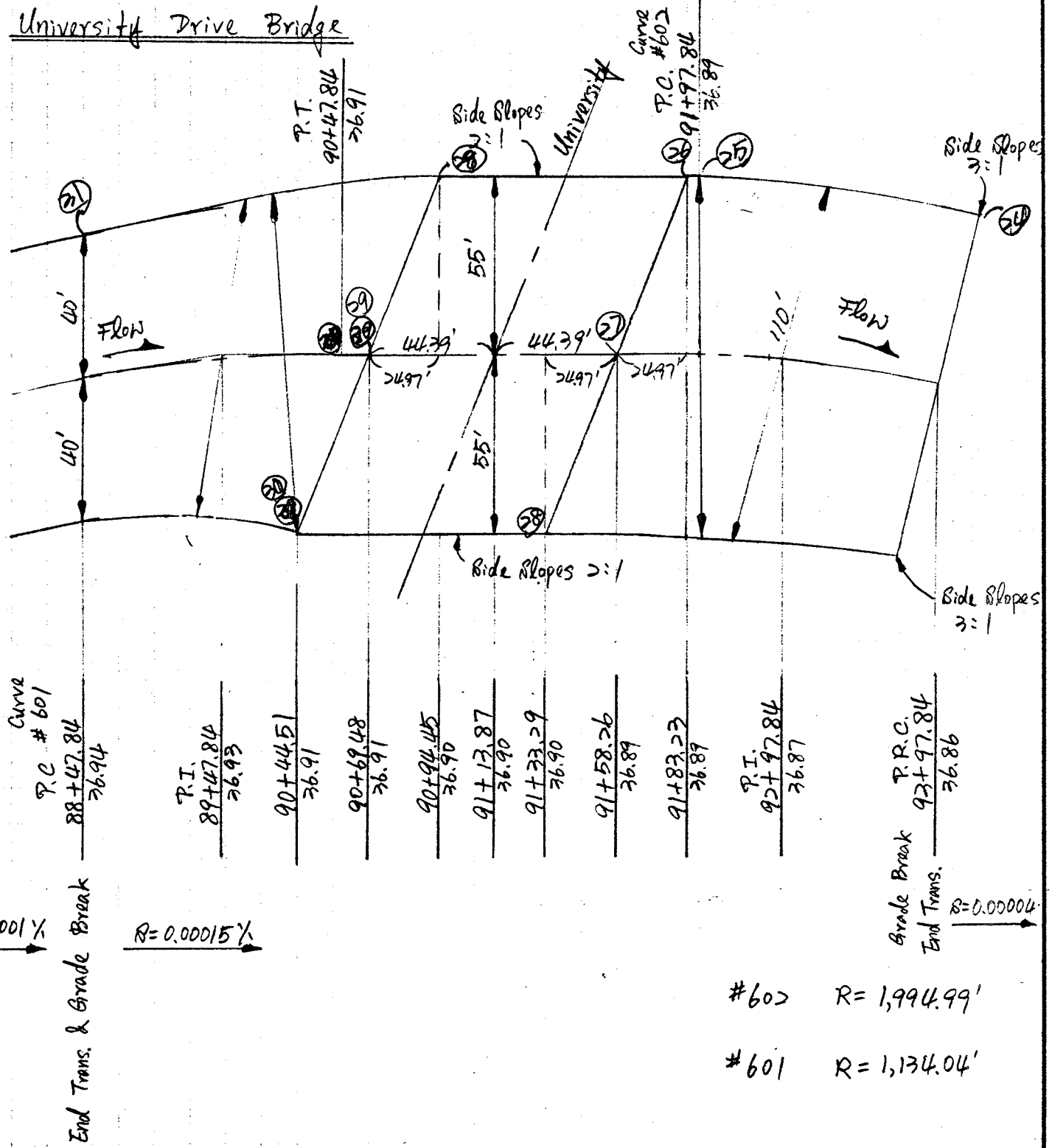
Job SCB RWCD Floodway Reach 6 - E101012
Description Comparative Design Studies (Mod. #3)
Hydraulics for Main Channel
Calculated by B. Gary Sun Date 1/23/86 Sheet No. 3
Checked by M.S.S. Date _____ of _____

University Drive Bridge



#602 R= 1,994.99'

#601 R= 1,134.04'

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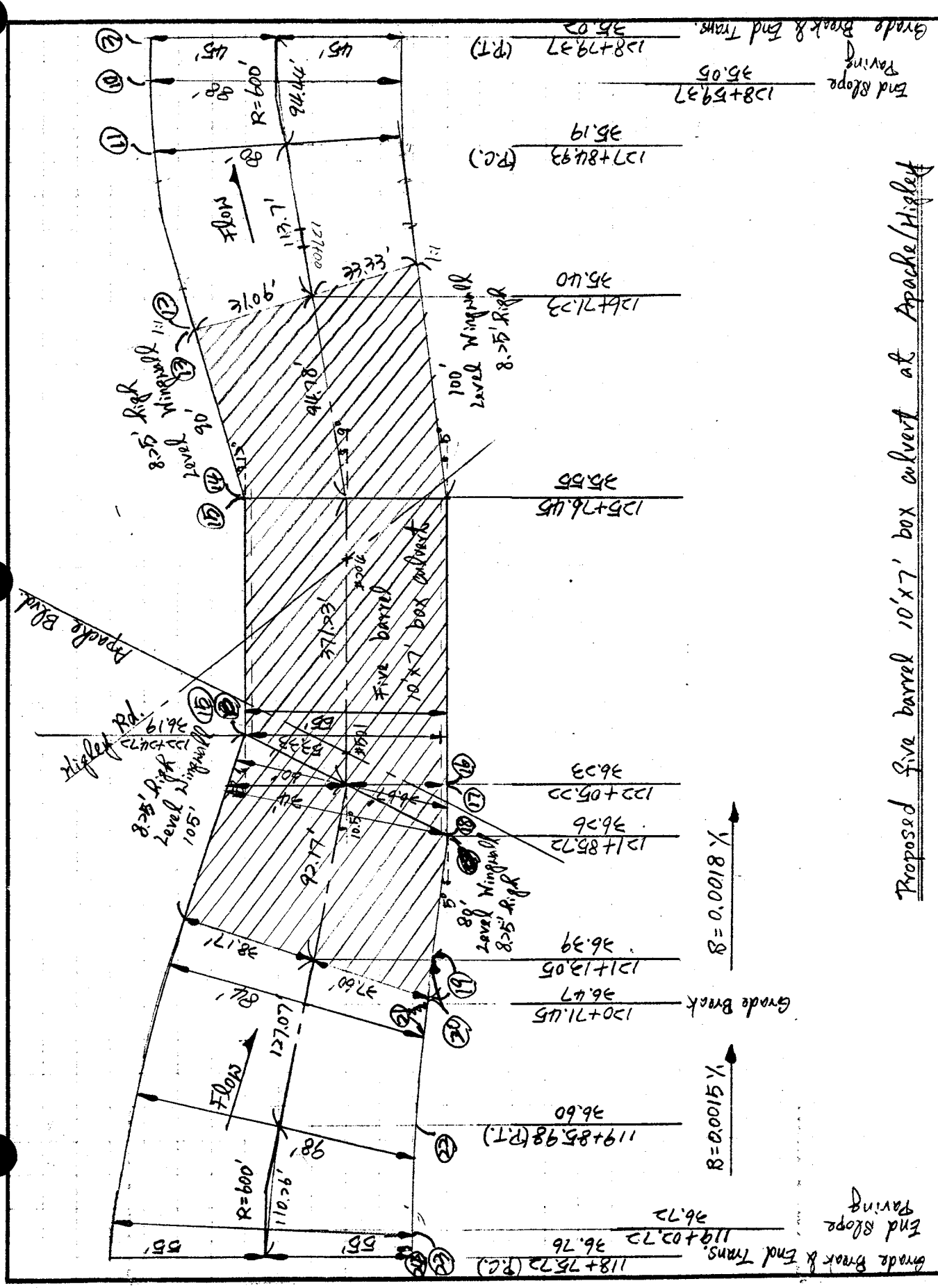
Job SCS RWCD Floodway Reach 6 - E101012

Description Comparative Design Studies (Mod. #3)
Hydraulics for Main Channel

Calculated by B. Gary Sun Date 1/24/86 Sheet No. 4

Checked by M.S.W. Date _____ of _____



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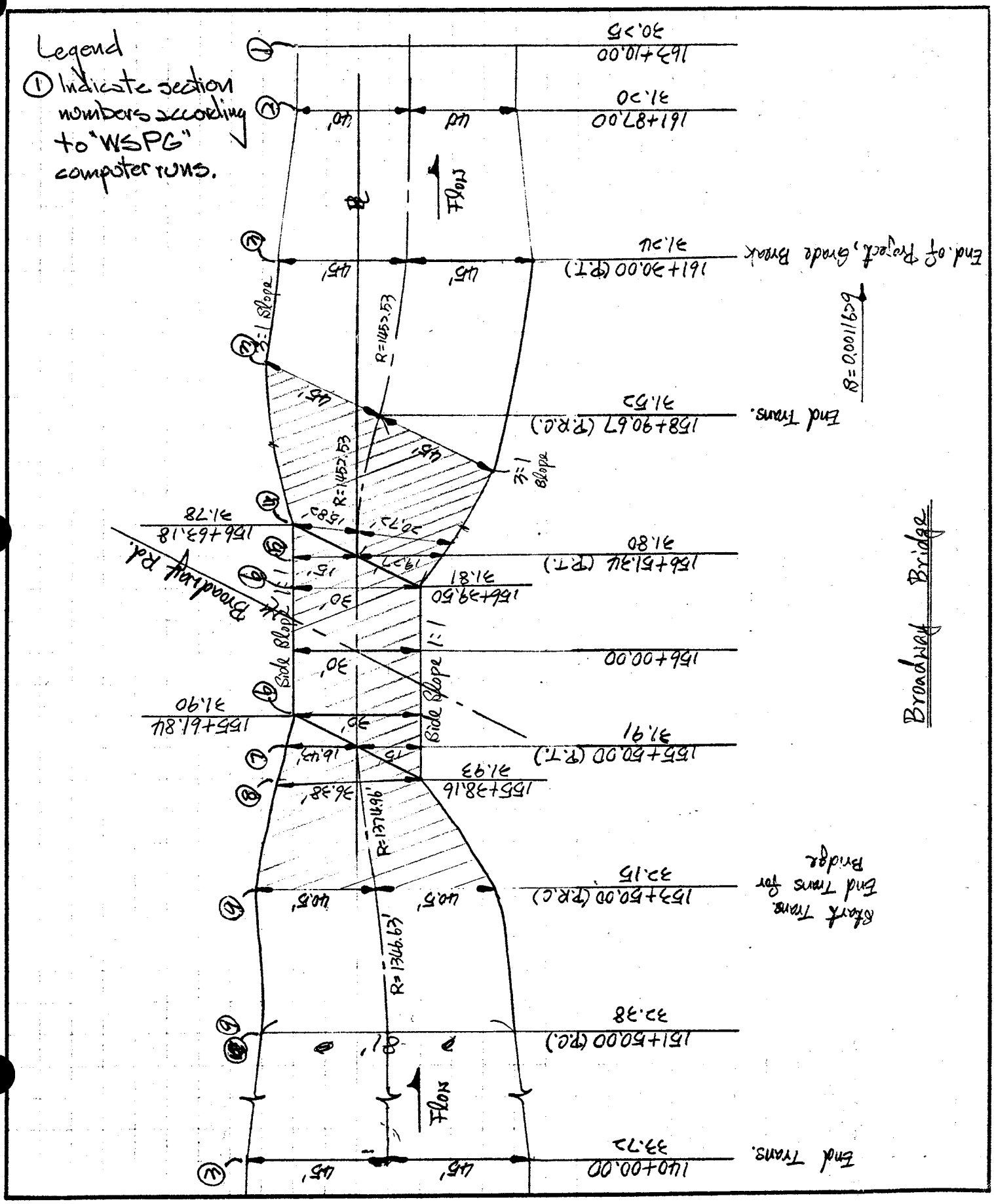
Job SCR RWCD Floodway Reach 6 - E101012

Description Comparative Design Studies (Mod. #3)
Hydraulics for Main Channel

Calculated by B. Gary Bun Date 1/24/86 Sheet No. 5

Checked by M. S. S. Date _____ of _____



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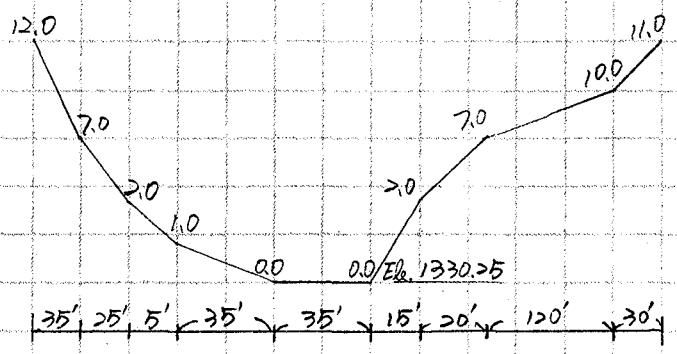
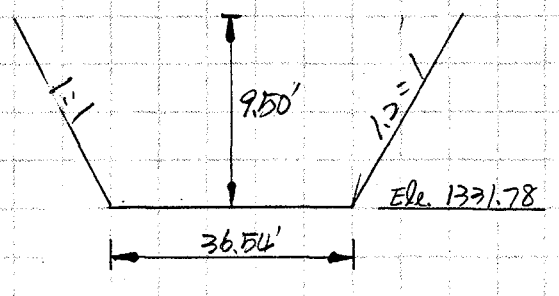
A>T18.DAT

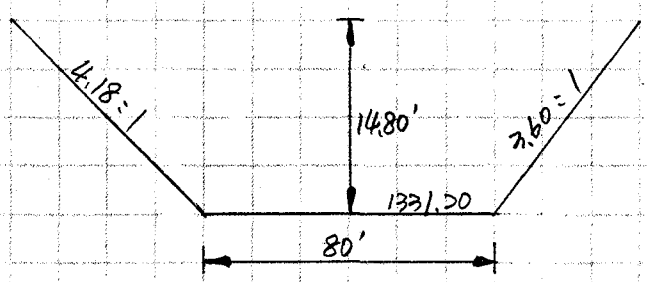
Job SCS RWCD Floodway Reach 6 - E101012
Description Comparative Design Studies (Mod. #3)
Cross Sections at Main Channel for Mod. No. 3
Calculated by B. Gary Sun Date 1/24/86 Sheet No. 1
Checked by M.S.S. Date _____ of _____



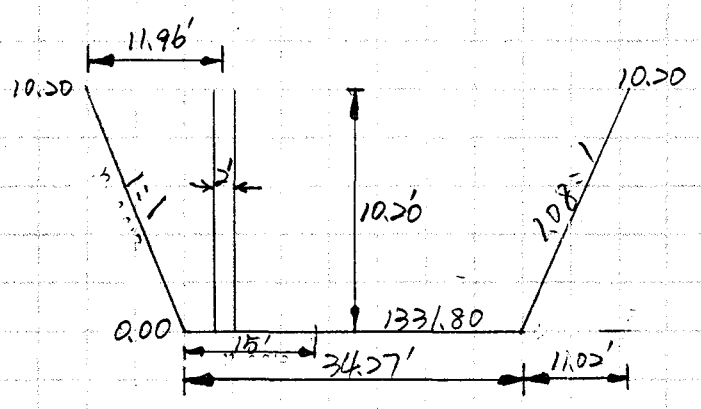
Sec. 1 Sta. 163+10.00 (9820.00)



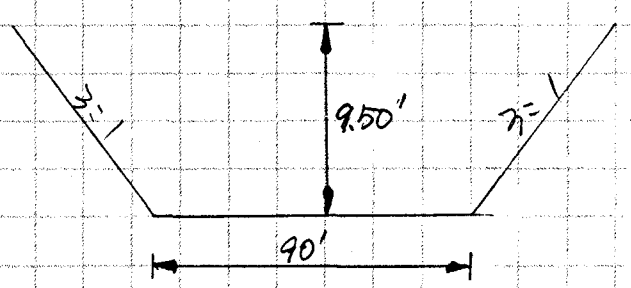
Sec. 4 Sta. 156+63.18 (10466.82)



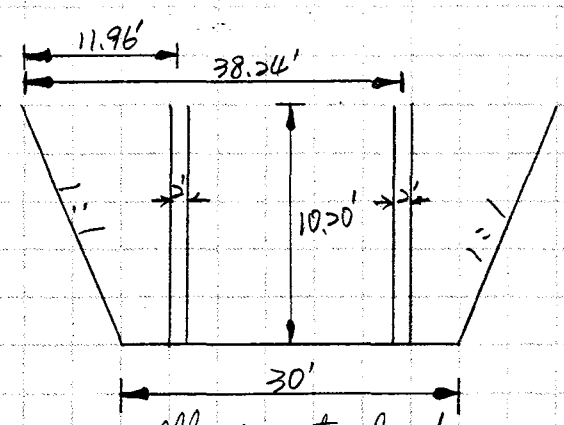
Sec. 2 Sta. 161+87 (9943.00)



Sec. 5 Sta. 156+51.34 (10478.66)
n use 0.020



Sec. 3 Sta. 161+30.00 (10000.00)
Sta. 140+00.00 (12130.00)
Sta. 128+79.37 (13250.63)



all concrete lined

Sec. 6 Sta. 156+39.50 (10490.50)
Sta. 155+61.84 (10568.16)

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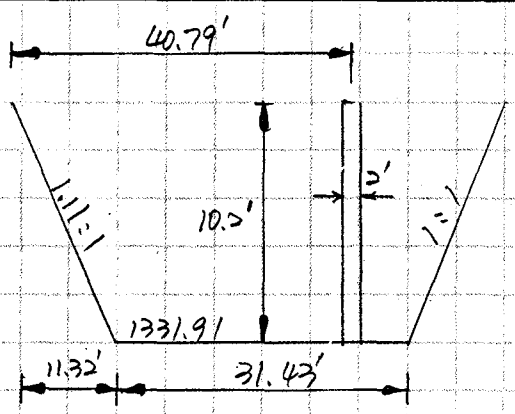
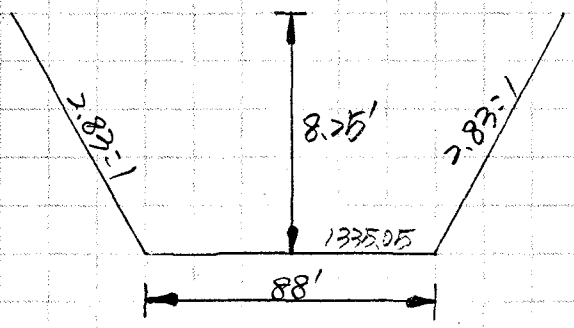
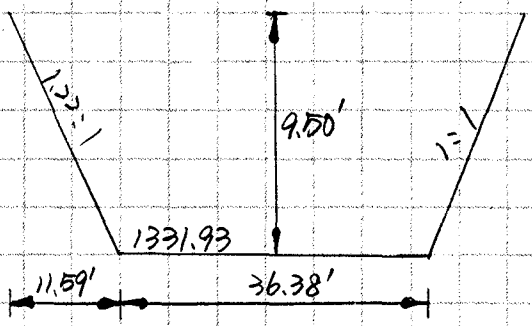
Job SCS RWCD Floodway Reach 6 - E101012
Description Comparative Design Studies
Cross Sections at Main Channel for Mod. No. 3
Calculated by Dr. Gary Sun Date 1/24/86 Sheet No. 2
Checked by MSS. Date _____ of _____



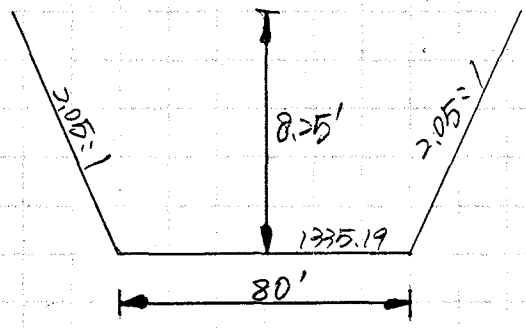
Sec. 7 Sta. 155+50.00 (10580.00)



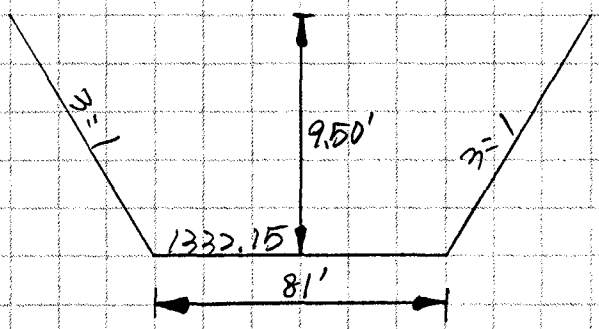
Sec. 10 Sta. 128+59.37 (13270.63)
n = 0.023



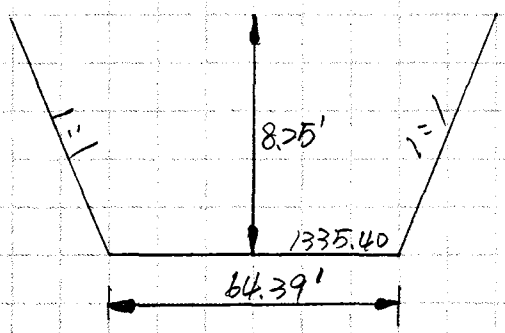
Sec. 8 Sta. 155+38.16 (10591.84)



Sec. 11 Sta. 127+84.93 (13345.07)



Sec. 9 Sta. 153+50.00 (10780.00)



Sec. 12 Sta. 126+71.25 (13458.75)

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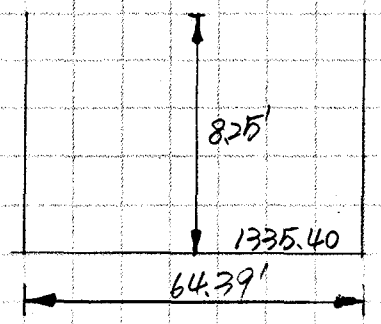
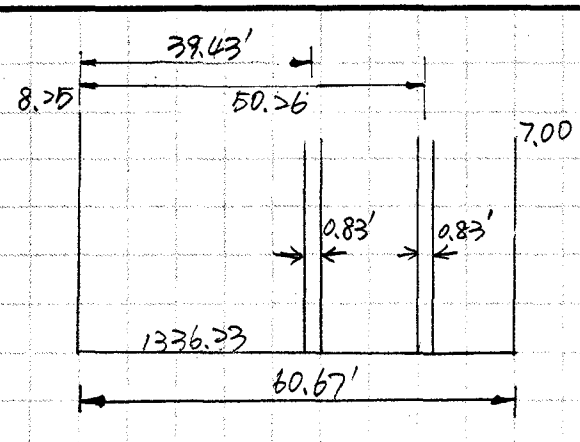
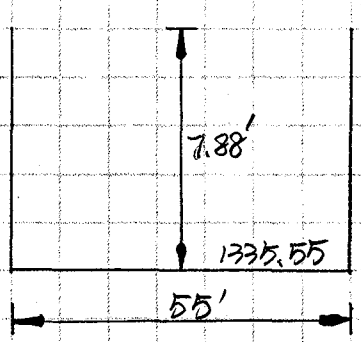
Job SCR RWCD Floodway Reach 6 – E101012
Description Comparative Design Studies
Cross Sections at Main Channel for Mod. #3
Calculated by B. Gary Sun Date 1/24/86 Sheet No. 3
Checked by M.S.S. Date _____ of _____



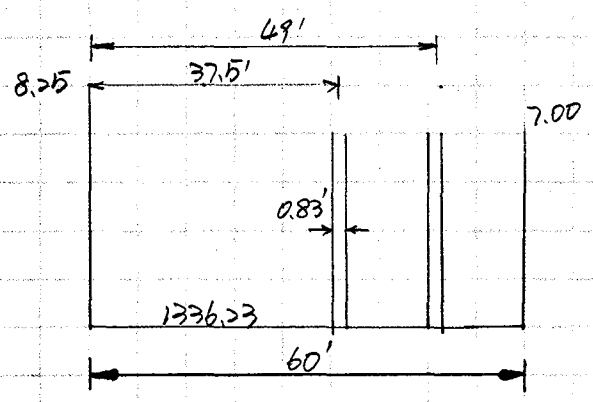
Sec. 13 Sta. 126+71.24 (13458.76)



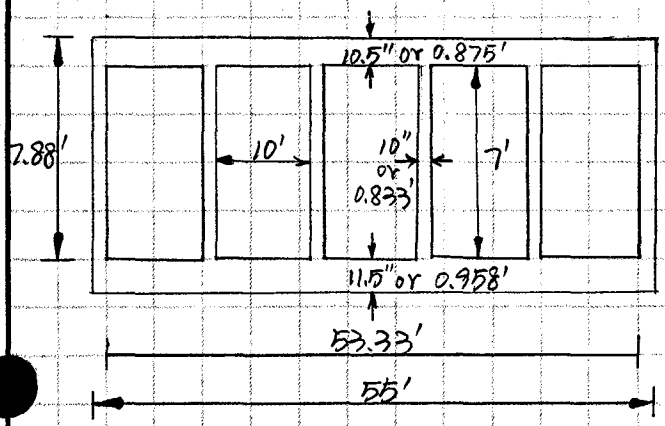
Sec. 16 Sta. 122+05.22 (13924.78)



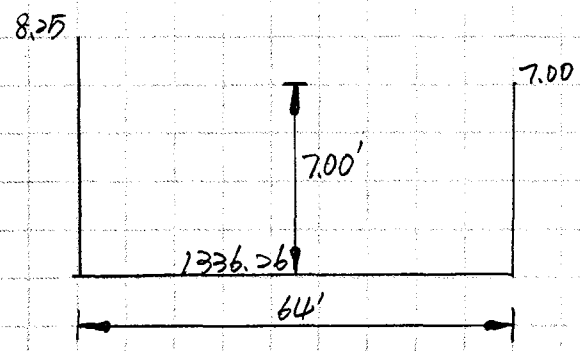
Sec. 14 Sta. 125+76.46 (13553.54)



Sec. 17 Sta. 122+05.21 (13924.79)



Sec. 15 Sta. 125+76.45 (13553.55)
Sta. 122+24.72 (13905.28)



Sec. 18 Sta. 121+85.72 (13944.28)

Greiner Engineering

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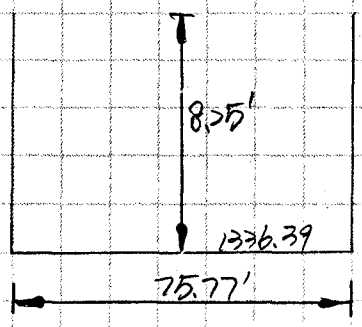
Job SCS RWCD Floodwall Reach 6 - E101012

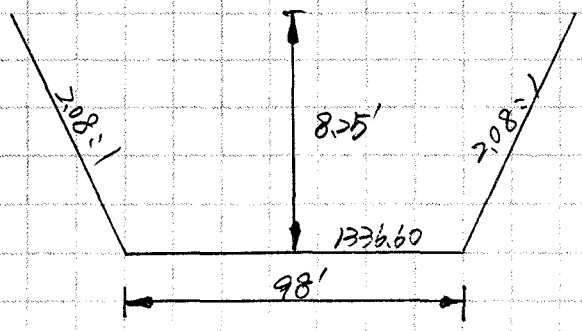
Description Comparative Design Studies
Cross Sections at Main Channel for Mod. #3

Calculated by B. Gary Sun Date 1/24/86 Sheet No. 4

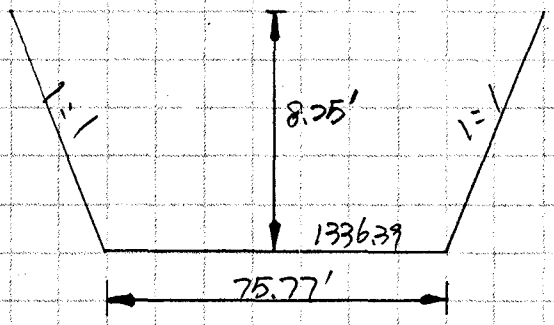
Checked by M.S.S. Date _____ of _____



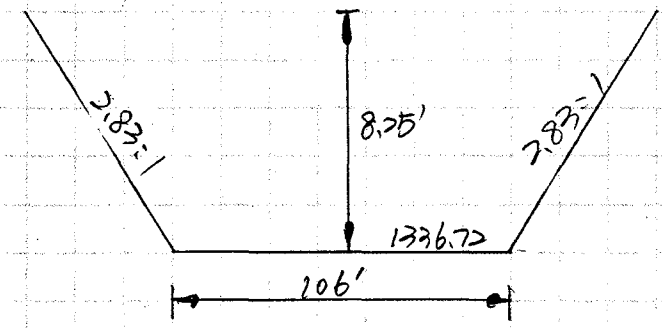
Sec. 19 Sta. 121+13.05 (14016.95)



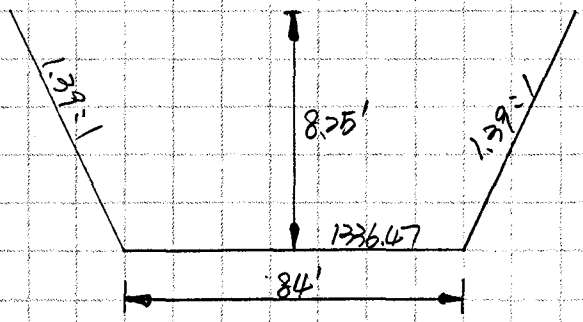
Sec. 22 Sta. 119+85.98 (14144.02)



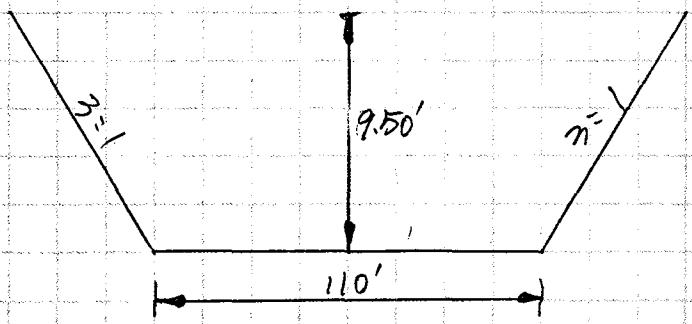
Sec. 20 Sta. 121+13.04 (14016.96)



Sec. 23 Sta. 119+02.72 (14227.28)



Sec. 21 Sta. 120+71.45 (14058.55)



Sec. 24 Sta. 118+75.72 (14254.28)
Sta. 93+97.84 (16732.16)

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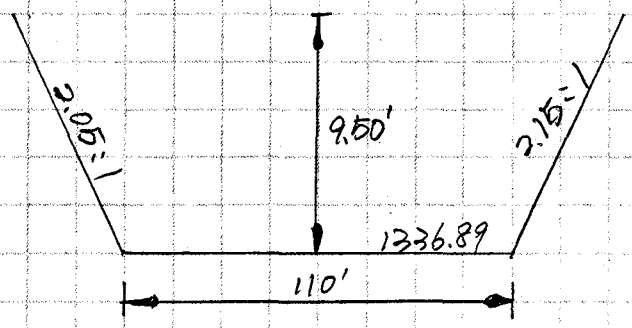
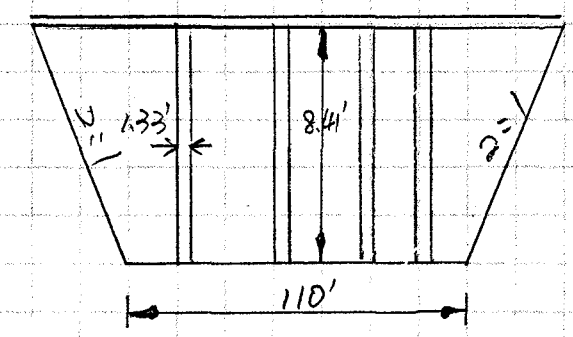
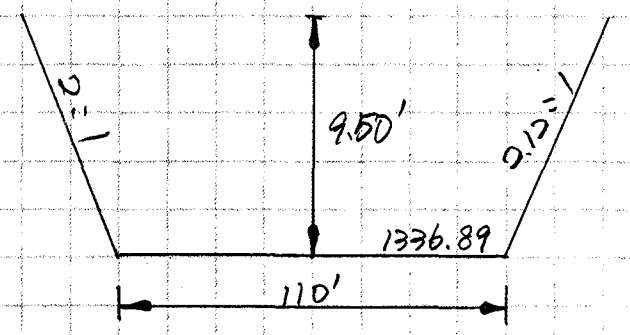
Job SCB RWCD Floodway Reach 6 - E101012
Description Comparative Design Studies
Cross Sections in Main Channel for Mod. No. 3
Calculated by B. Gary Sun Date 1/24/86 Sheet No. 5
Checked by M.S.S. Date _____ of _____



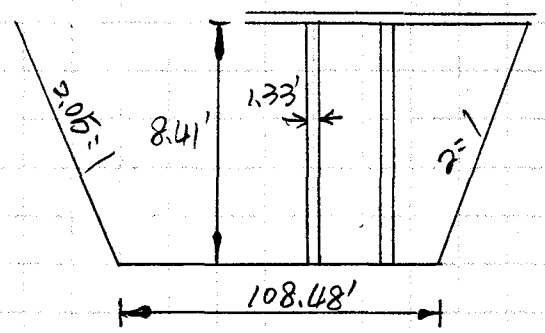
Sec. 25 Sta. 91+97.84 (16932.16)



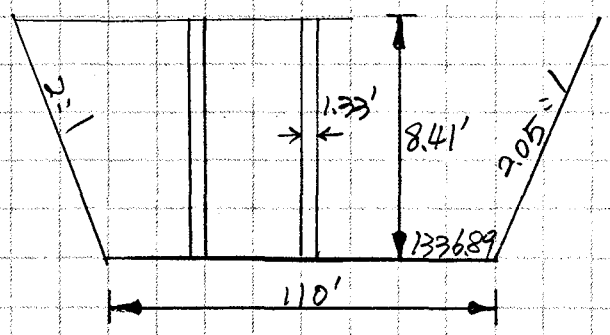
Sec. 28 Sta. 91+33.29 (16996.71)
Sta. 90+94.45 (17035.55)



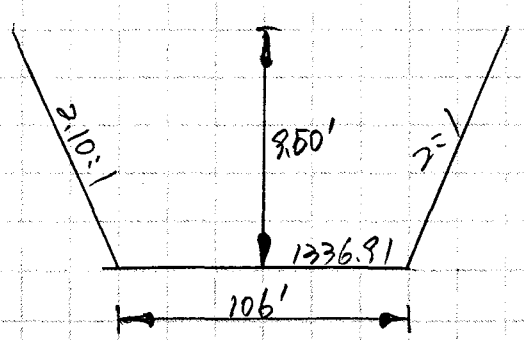
Sec. 26 Sta. 91+83.23 (16946.77)



Sec. 29 90+69.48 (17060.52)



Sec. 27 Sta. 91+58.26 (16971.74)



Sec. 30 90+44.51 (17085.49)

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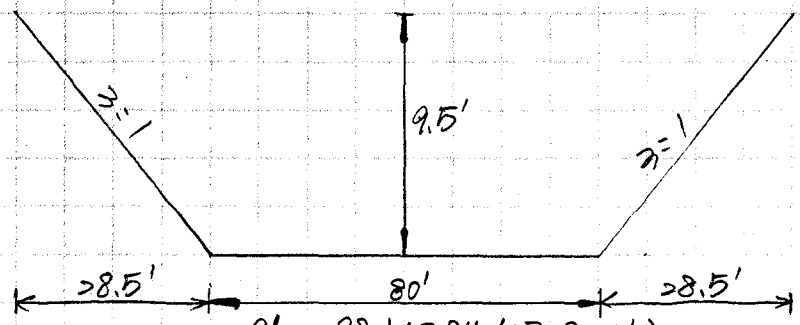
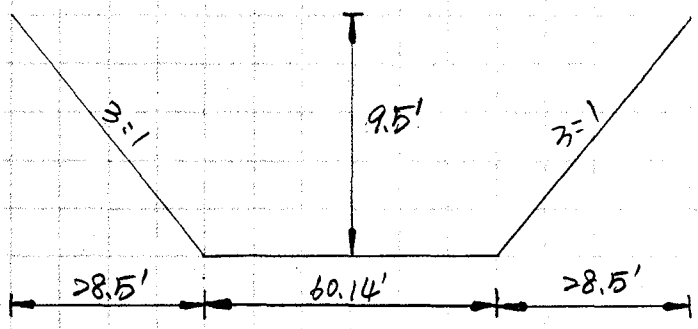
Phoenix 602 275-5400

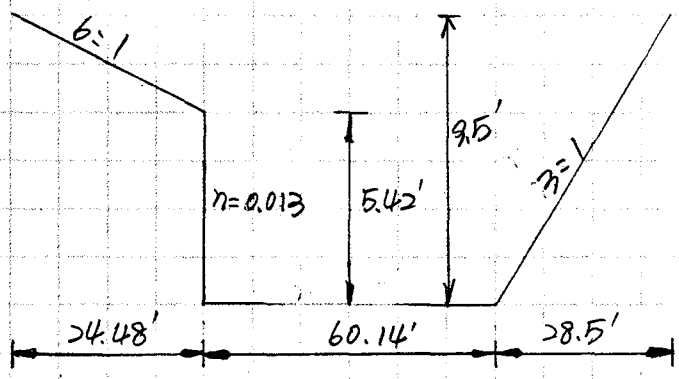
Cross Sections for using five barrel 8'x8' box culvert at East Adobe Road



Sec. 31 Sta. 88+47.84 (17282.16) Sta. 36+79.83 (22450.17)
Sta. 65+06.02 and Sta. 59+37.98
(19623.98) (20192.02)

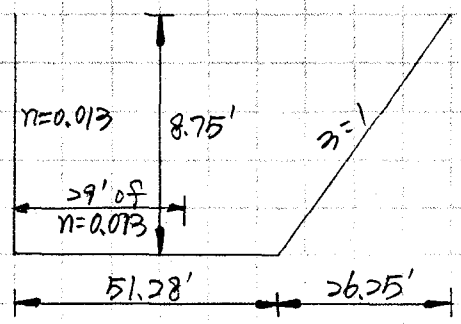


Sec. 32 Sta. 63+06.03 (19823.97)
Sta. 61+37.98 (19992.03)

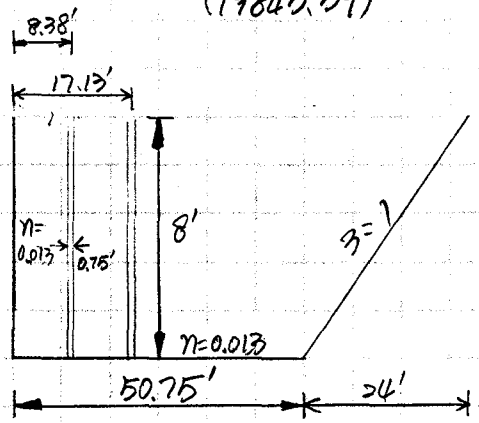


Sec. 33 Sta. 63+06.02 (calc. n = 0.024)
(19823.98)

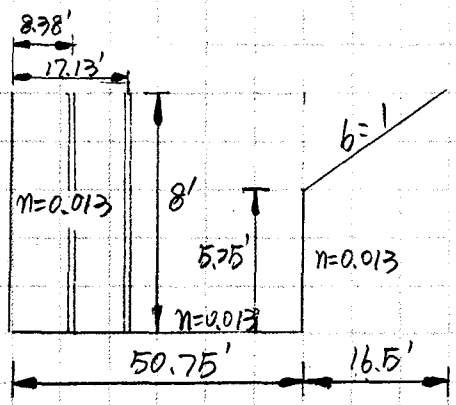
Cross Sections for using five barrel 8'x8' box culvert at E. Adobe



Sec. 34 Sta. 62+84.41 (calc. n = 0.020)
(19845.59)



Sec. 35 Sta. 62+73.02 (calc. n= 0.017)
(19856.98)



Sec. 36 Sta. 62+73.01 (calc. n= 0.015)
(19856.99)

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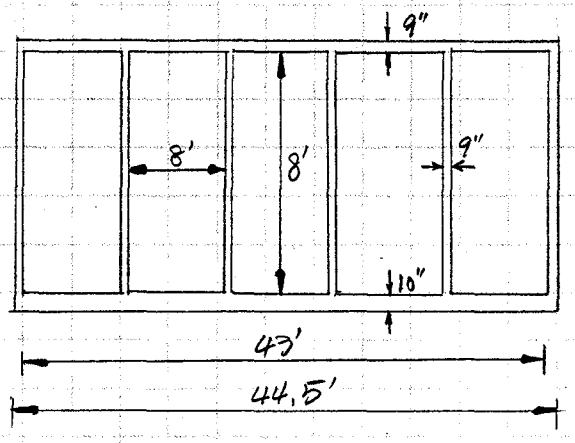
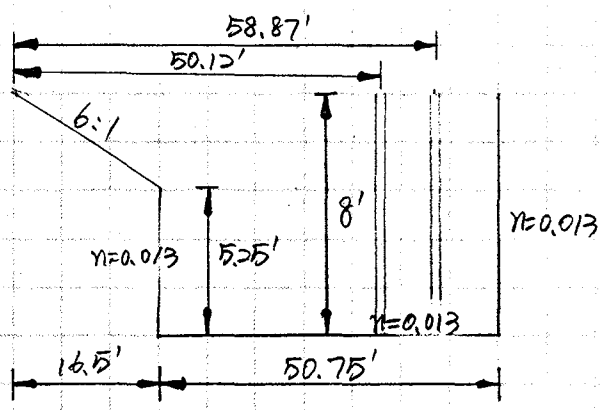
Phoenix 602 275-5400

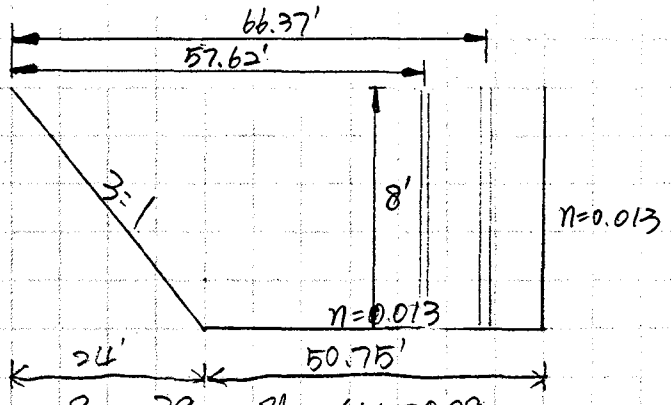
Cross Sections for using five barrel 8'x 8' box culvert at E. Adobe



Sec. 37 Sta. 62+59.59 and Sta. 61+84.41 (n=0.013)
(19870.41) (19945.59)



Sec. 38 Sta. 61+70.99 (calc. n=0.015)
(19959.01)



Sec. 39 Sta. 61+70.98 (calc. n=0.017)
(19959.02)

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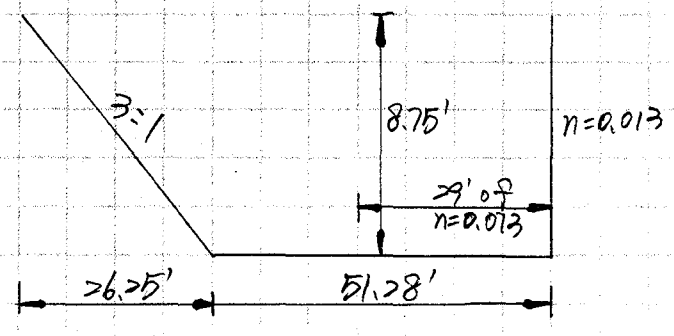
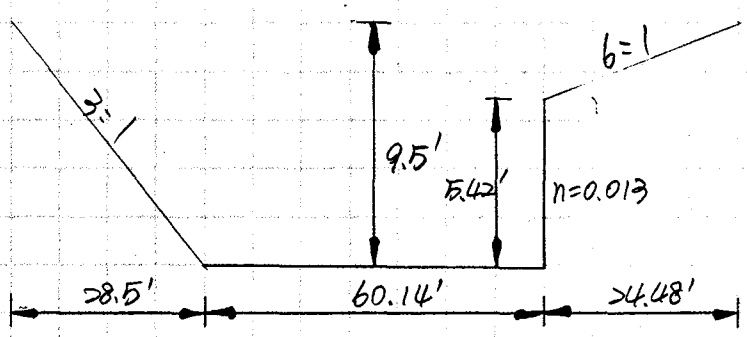
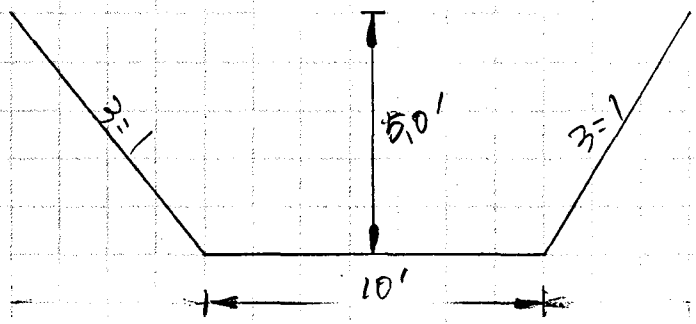
Cross Sections for using five barrel 8'x8' box culvert at E. Adobe Rd.



Sec. 40 Sta. 61+59.59 (calc. n= 0.020)
(19970.41)



Sec. 41 Sta. 61+37.98 (calc. n= 0.024)
(19992.02)



Sec. 42 Lateral Inlets

Greiner Engineering

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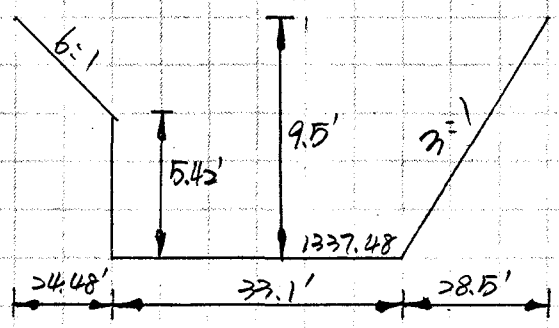
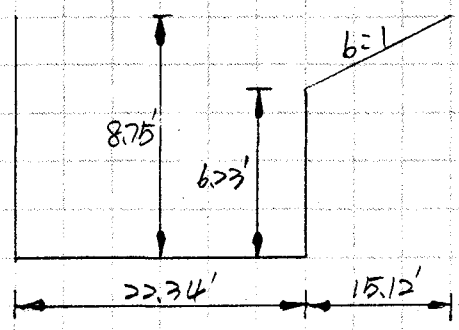
Phoenix 602 275-5400

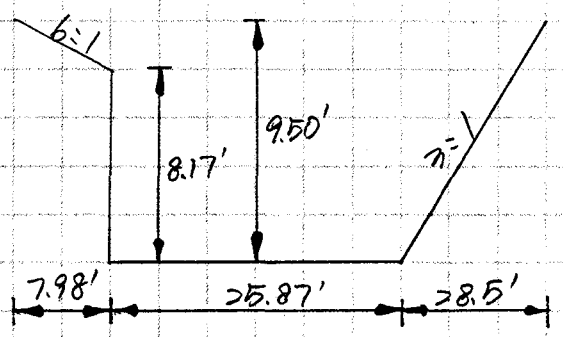
Job SCS RWCD Floodway Reach 6 – E101012
Description Comparative Design Modification No. 3
Cross Sections in Main Channel for Mod. No. 3
Calculated by B. Gary Sun Date 1/24/86 Sheet No. 10
Checked by M.S.S. Date _____ of _____



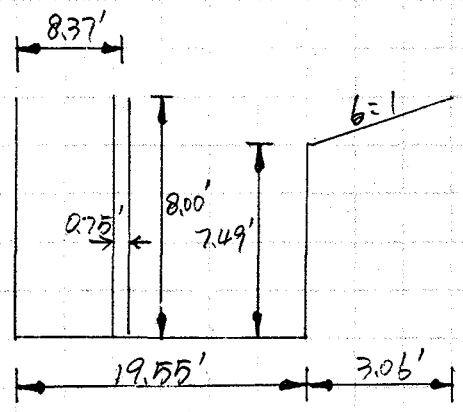
Sec. 44 Sta. 34+01.43 (>>728.57)



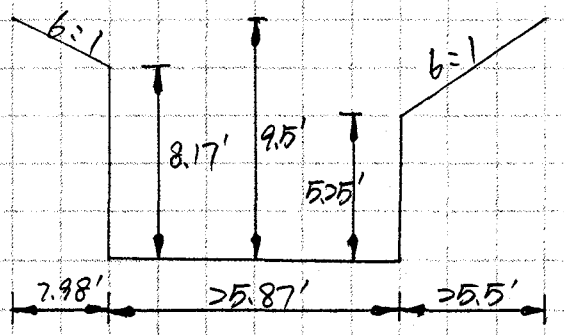
Sec. 47 Sta. 33+79.83 (>>750.17)



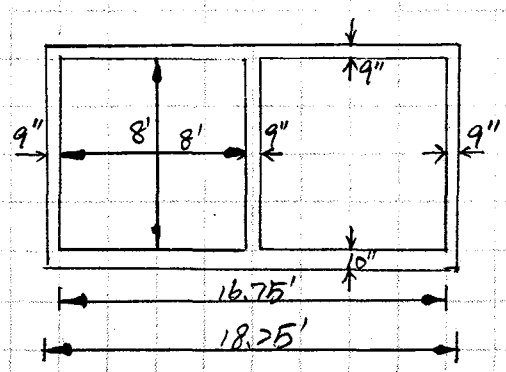
Sec. 45 Sta. 33+83.57 (>>746.43)



Sec. 48 Sta. 33+74.99 (>>755.01)



Sec. 46 Sta. 33+83.56 (>>746.44)



Sec. 49 Sta. 33+70.15 & Sta. 32+55.83
(>>759.85) (>>874.17)

Greiner Engineering

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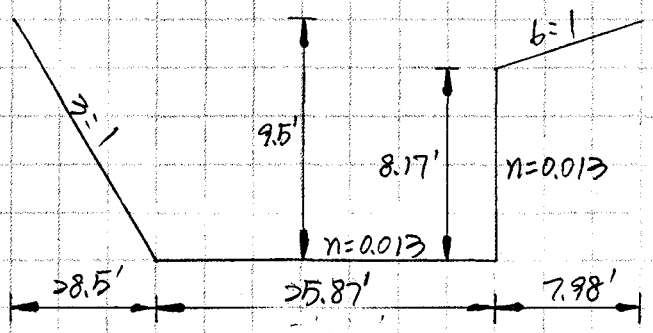
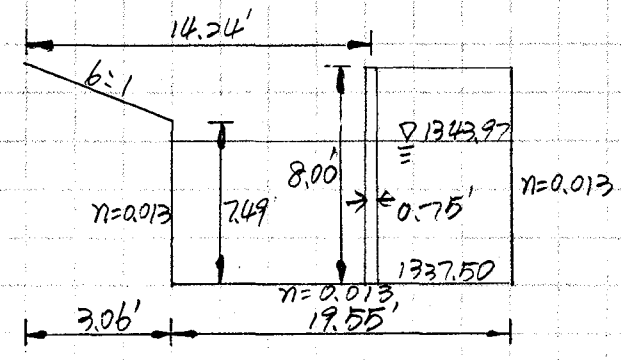
Job: SCS RWCD Floodway Reach 6 - E101012
Description: Comparative Design Studies
Cross Sections within Main Channel for Mod. No. 3
Calculated by: B. G. Sun Date: 1/24/86 Sheet No. 11
Checked by: M.S.S. Date: _____ of _____

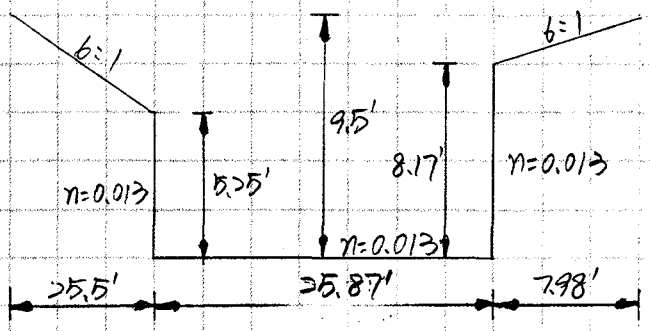
Cross Sections



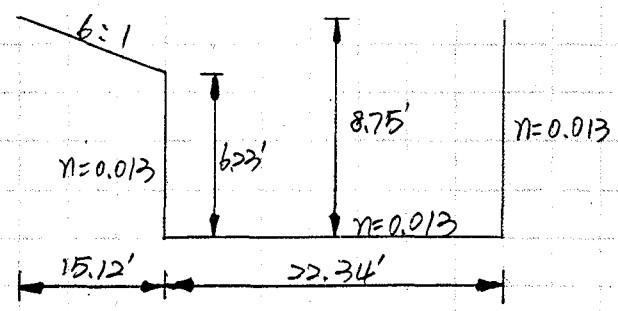
Sec. 53 Sta. 32+42.40 (37.50)



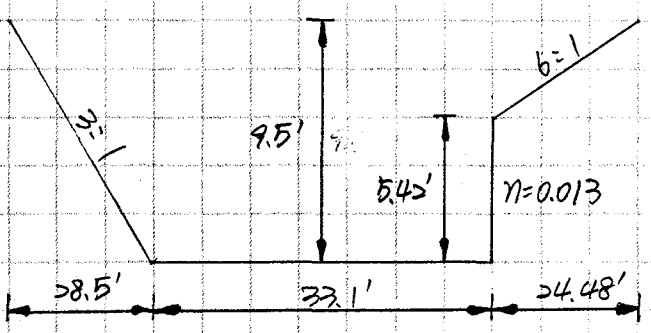
Sec. 50 Sta. 32+50.99 (37.50)



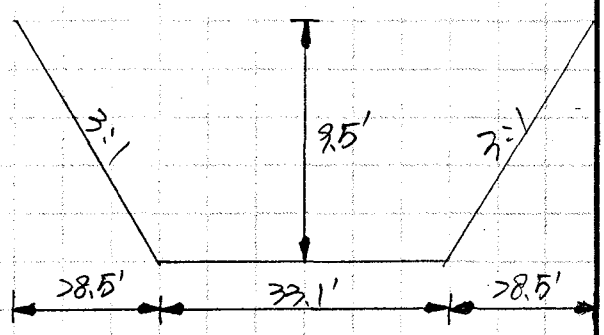
Sec. 52 Sta. 32+42.41 (37.50)



Sec. 51 Sta. 32+46.15 (37.50)



Sec. 54 Sta. 32+24.54 (37.50)



Sec. 43 Sta. 32+24.53 (22905.47)
Sta. 34+01.44 (22728.56)

Greiner Engineering

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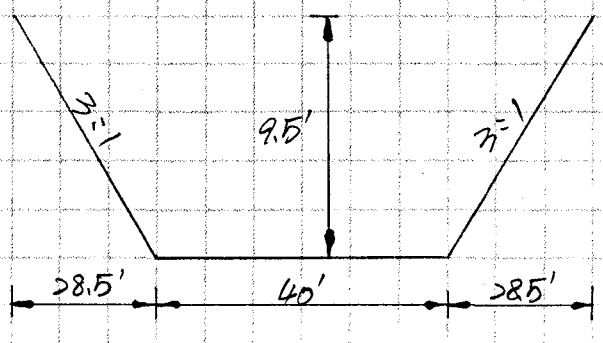
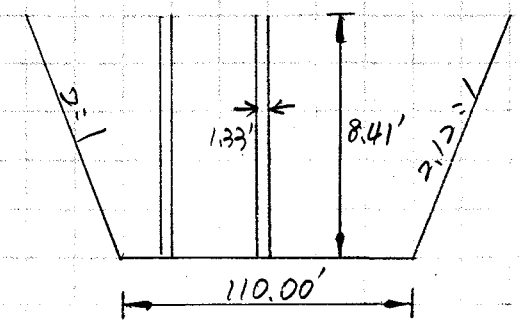
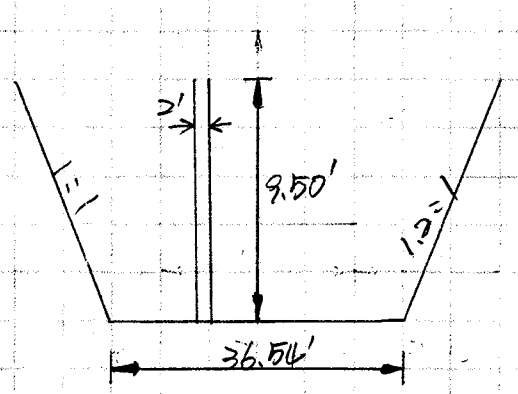
Cross Sections (Cont'd)



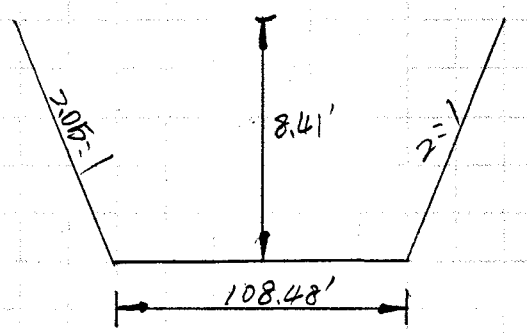
Sec. 55 Sta. 31+48.00 & 30+70.00
(2298.00) (3060.00)



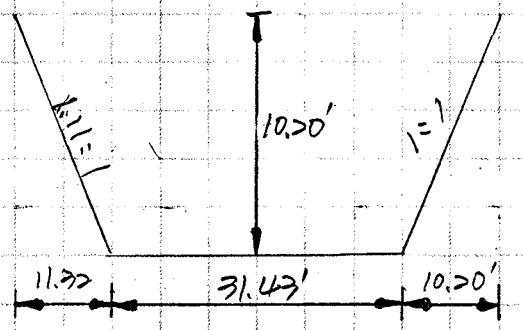
Sec. 86 Sta. 91+83.23 (16946.77)



Sec. 64 Sta. 156+63.18 (10466.82)



Sec. 89 Sta. 90+69.48 (17070.52)



Sec. 67 Sta. 155+50.00 (10580.00)

Greiner Engineering

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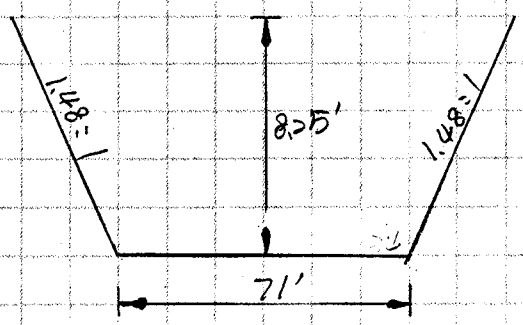
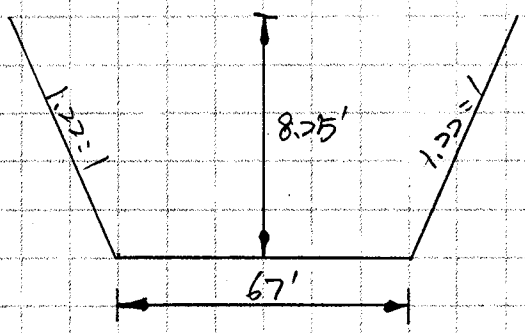
Phoenix 602 275-5400

Job SCS RWCD Floodway Reach 6 - E101012
Description Comparative Design Modification No. 3
Cross Sections for Trial #20
Calculated by B. Gary Sun Date 1/27/86 Sheet No. ____
Checked by M.S.S. Date ____ of ____



Sec. 56 Sta. 127+25.00 (13405.00)



Sec. 57 Sta. 127+00.00 (13430.00)

Greiner Engineering

Greiner Engineering Sciences, Inc.
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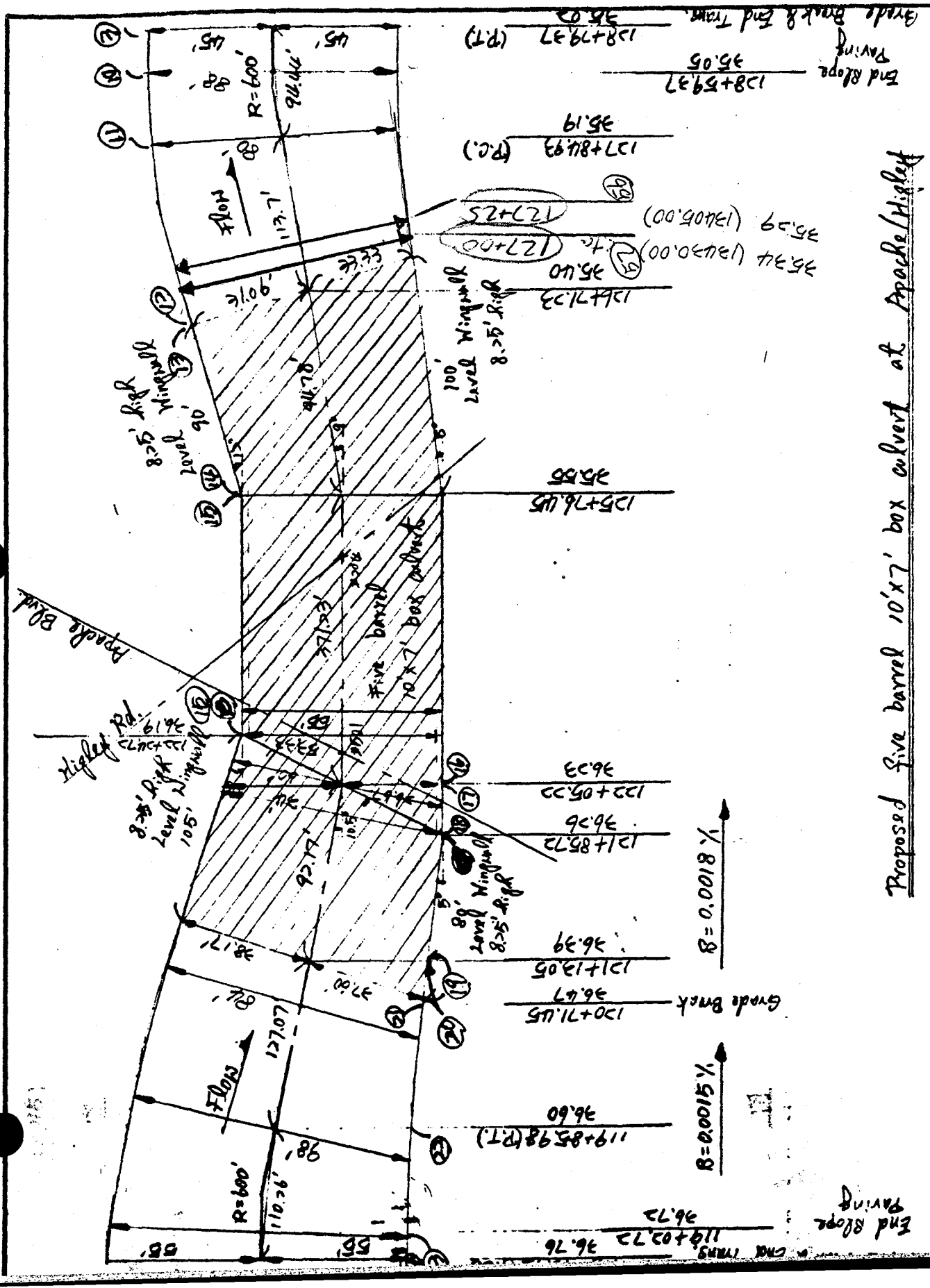
Phoenix 602 275-5400

Job SCS RNCD Floodway Reach 6 - E101012
Description Comparative Design Studies (Mod #:
Hydraulics for Main Channel
Calculated by B. Gary Run Date 1/24/86 Sheet No. 4
Checked by MSS Date _____ of _____



Greiner Engineering

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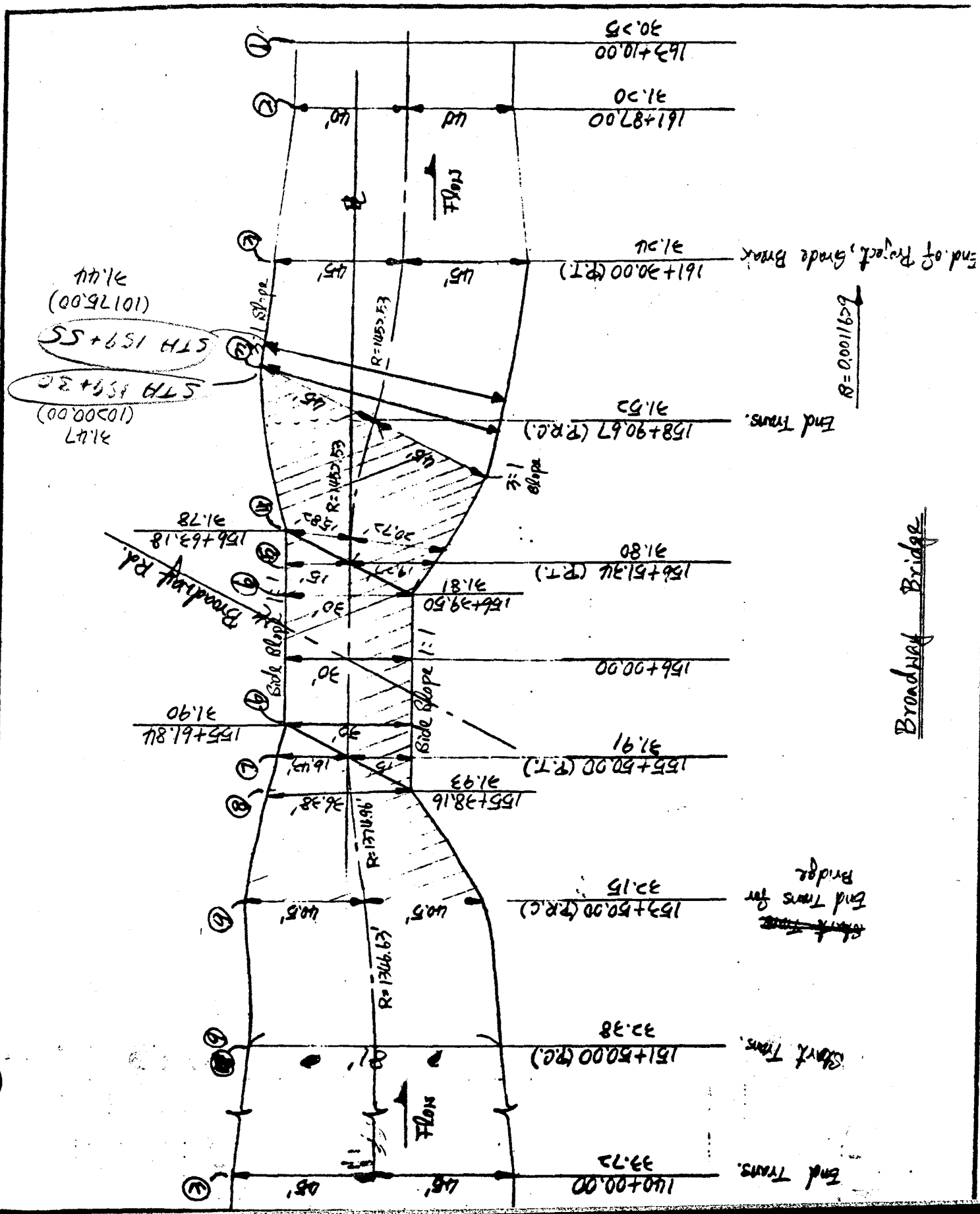
Tucson 602 327-3413
Phoenix 602 275-5400

Job: BCR RWCD Floodway Reach 6 - E101012
Description: Comparative Design Studies (Mod. #:
Hydraulics for Main Channel
Calculated by: B. Boyd Bin Date: 1/24/86 Sheet No. 5
Checked by: M.S.B. Date: _____ of _____



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Job SCS RWCD Floodway Reach 6 - E101012
Description Comparative Design Studies
Peak Flows in Main Channel
Calculated by B. Gary Run Date 2/3/86 Sheet No. ____
Checked by M.S.S. Date ____ of ____

Summary of Peak Flows in Main Channel
(Before Modification No. 3)

Station – Station		Q_{100}	50% of Q_{100}	Q_{10}
30+50.00 – 31+73.15	N. Brown	300 cfs	150 cfs	154 cfs
31+73.15 – 36+84.83	Brown Box	900 cfs	450 cfs	154 cfs
36+84.83 – 78+43.91	Adobe Rd.	1,200 cfs	600 cfs	193 cfs
78+43.91 – 88+89.51	Powerline	1,800 cfs	900 cfs	296 cfs
88+89.51 –	University Dr.	1,840 cfs	920 cfs	460 cfs
– 121+15.05	1/4 mi. S. Univ.	1,840 cfs	920 cfs	453 cfs
121+15.05 – 128+84.37	Apache Trail	1,900 cfs	950 cfs	721 cfs
128+84.37 –	S.E. of Higley	2,400 cfs	1,200 cfs	1,029 cfs
– 161+30.00	S. Broadway	2,400 cfs	1,200 cfs	1,014 cfs

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Phoenix 602 275-5400

Job: RCR RWCD Floodway Reach 6 - E101012

Description: Comparative Design Studies
ALT. No. 1 Trial #5

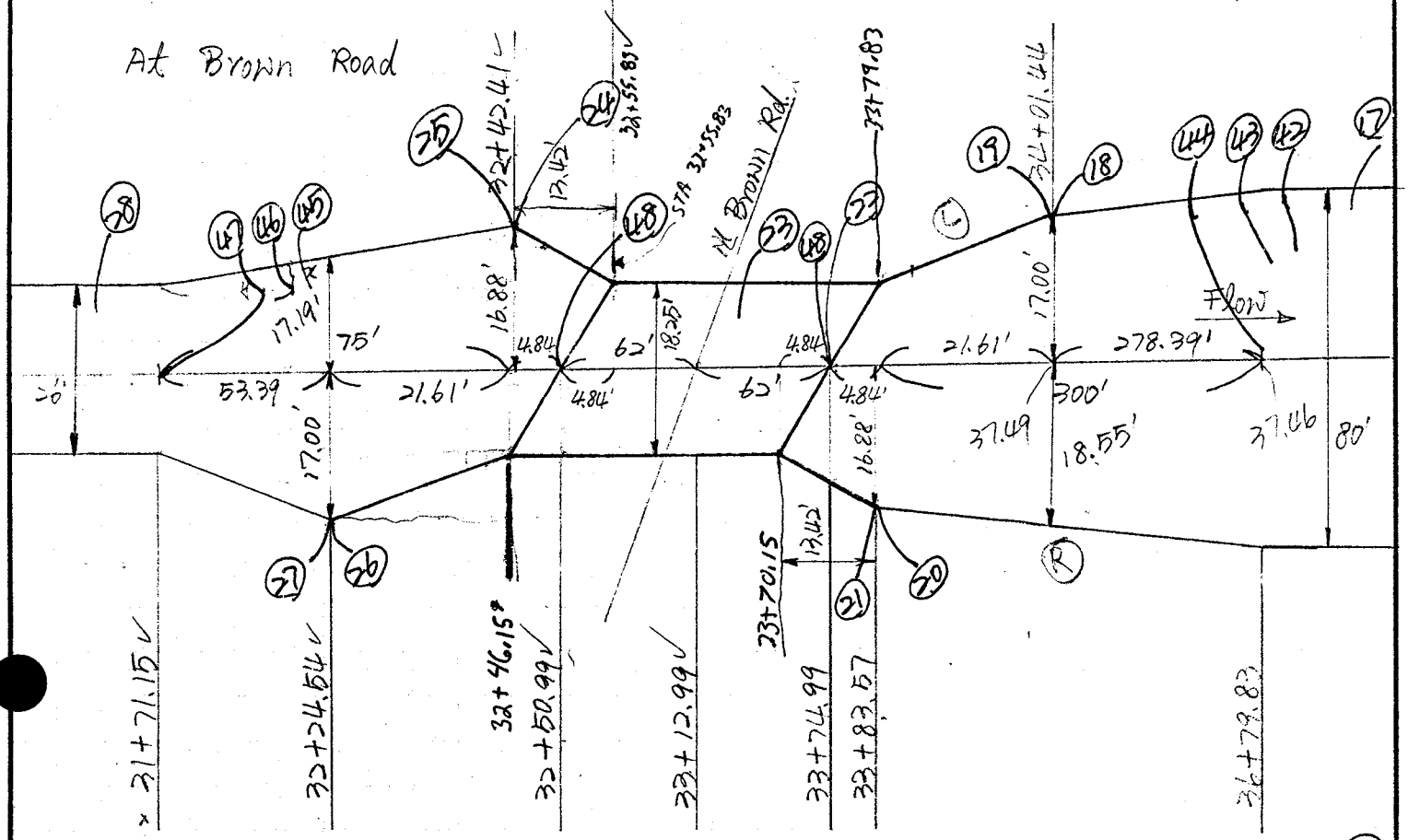
Calculated by: B. Gary Sun Date: 10/29/85 Sheet No. ____

Checked by: M.S.S. Date: ____ of ____

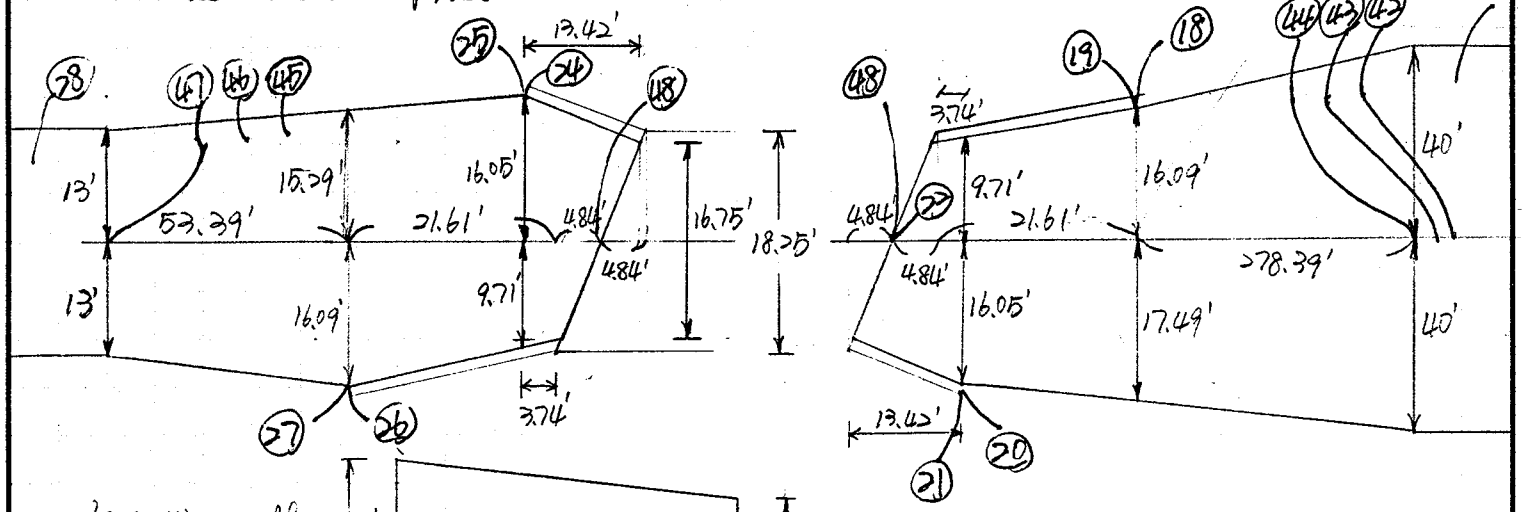
VOID 1/27/86
See Mod. No. 3

Proposed 2 barrel 8'x8' box culvert 30° skew 6:1 slope w/ wingwalls

At Brown Road



I.W.: Inside dimension of wall



Long Wing Wall 8.75' 5.42'

Short Wing Wall 8.75' 5.25'

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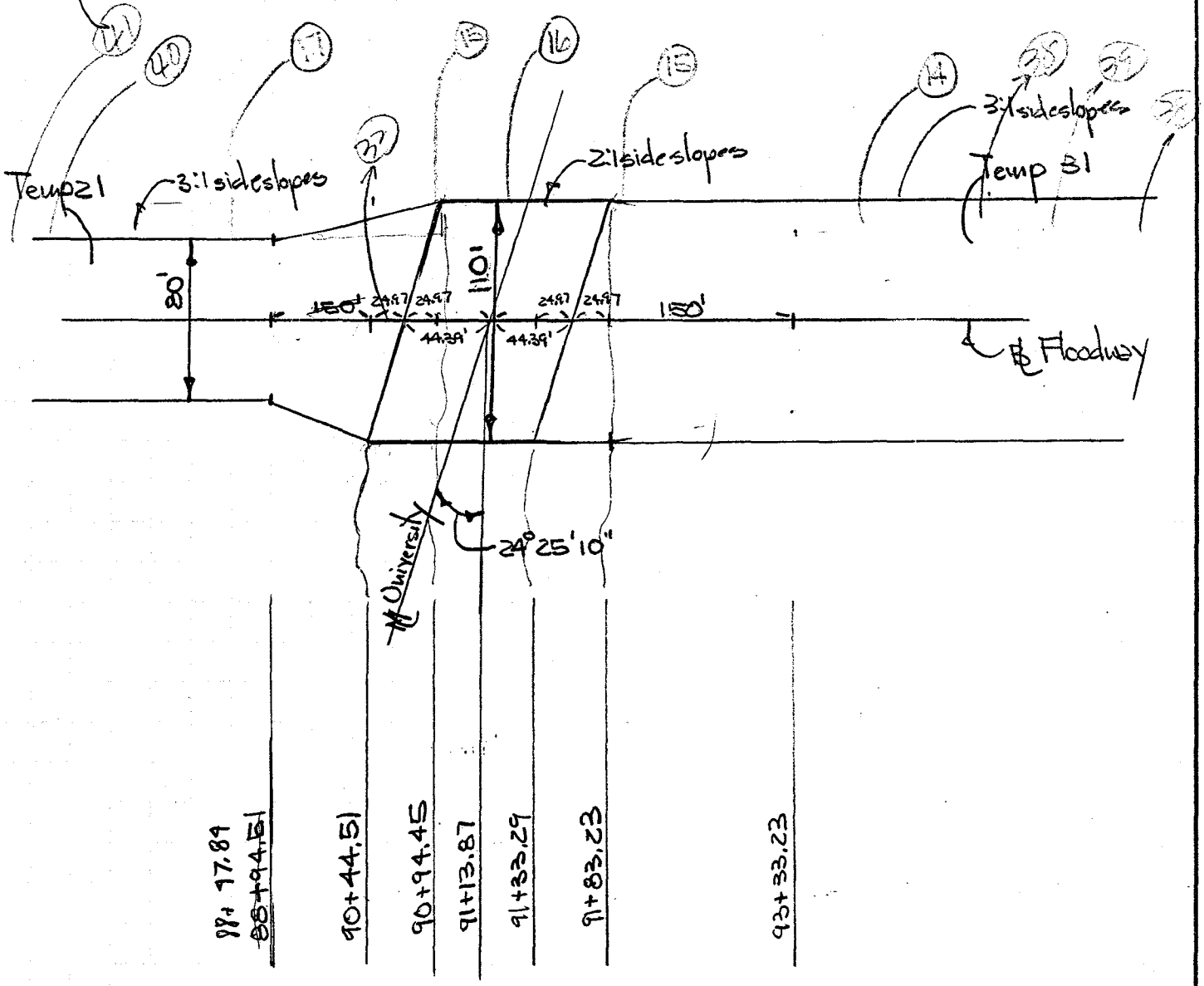
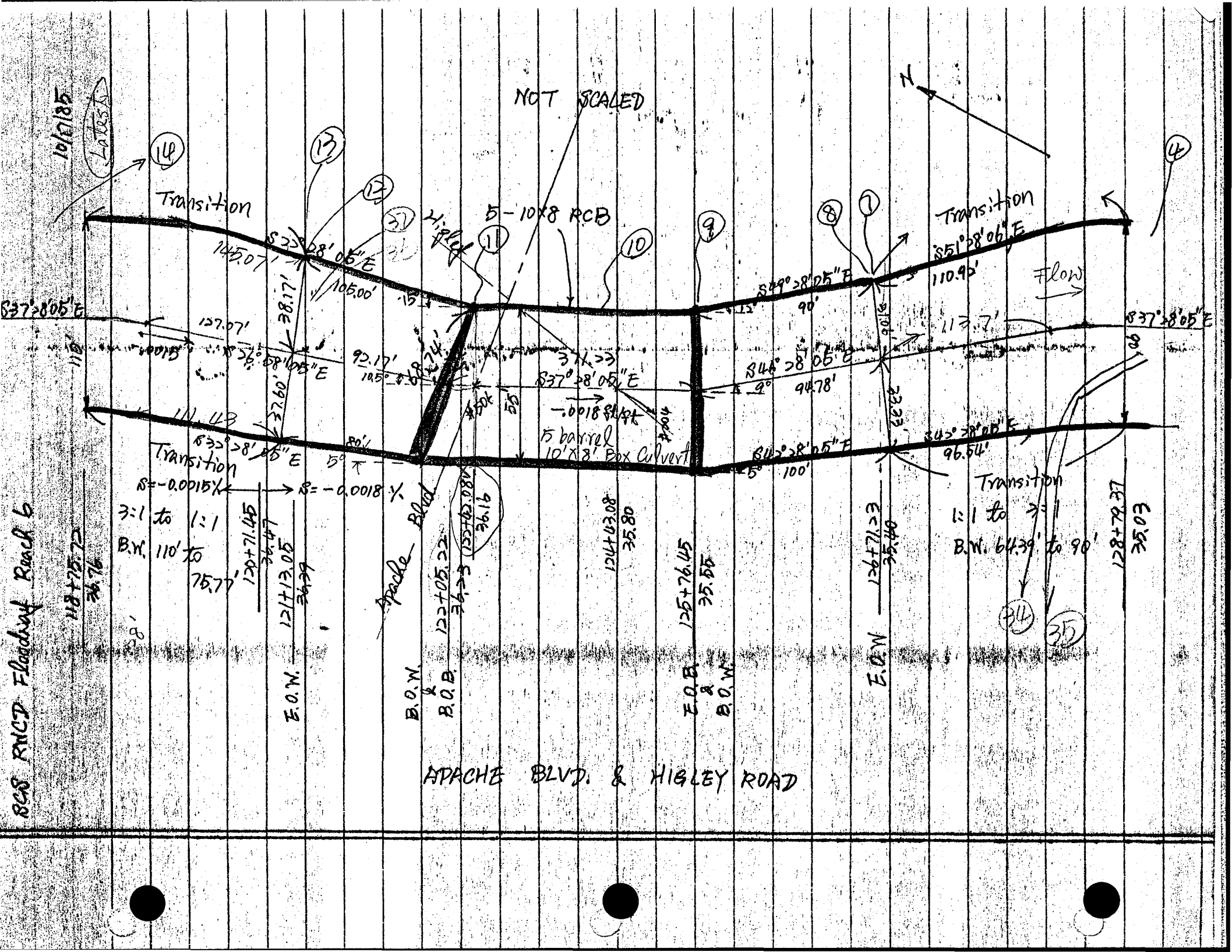
Phoenix 602 275-5400

Job RWCD Reach 6 E10012
Description Relin. Earthwork No. 1
Transitions
Calculated by M. Shapiro Date 10/5/85 Sheet No. 3
Checked by B. G. B. Date 2/11/86 of 8

Indicate section# for "WSPG" computer runs.

TTR 21 (indicates template # for "Dirt" program)




NOT SCALED
N
Flow
5-10x8 RCB
Transition
S37°28'05"E
145.07'
105.00'
38.17'
127.07'
92.17'
37.60'
111.48'
S32°28'05"E
-.0018 S/ft
5 barrel
10'x8' Box Culvert
S37°28'05"E
S49°28'05"E
90'
110.95'
S51°28'05"E
113.7'
S44°28'05"E
94.78'
S42°28'05"E
96.64'
S42°28'05"E
100'
S=-0.0015%
S=-0.0018%
3:1 to 1:1
B.W. 110' to 75.77'
1:1 to 3:1
B.W. 64.39' to 90'
Apache Blvd
E.O.W.
B.O.W. & B.O.B.
E.O.B. & B.O.W.
E.O.W.
118+75.72
36.76
120+71.45
36.47
121+13.05
36.39
122+05.22
36.23
123+03.08
36.16
124+03.08
35.80
125+76.45
35.55
126+71.23
35.49
128+78.37
35.03
APACHE BLVD. & HIGLEY ROAD
8CS RWCD Floodway Reach 6
10/17/85
Latest

Greiner Engineering

Greiner Engineering Sciences, Inc.

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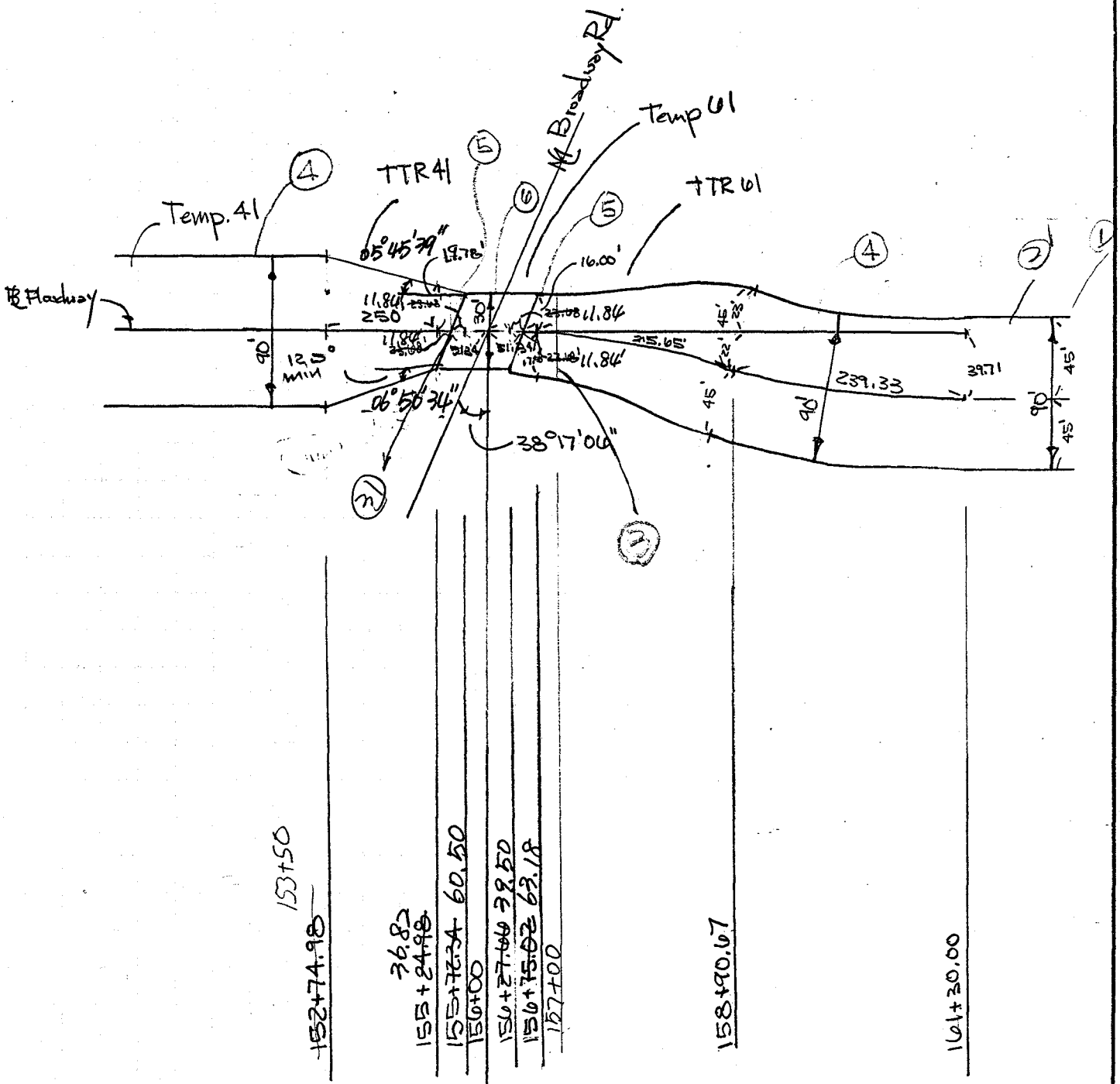
Phoenix 602 275-5400

Job RWCD Reach 6 E101012
Description Prelim. Earthwork No. 1 Transitions
Calculated by M. Shapiro Date 10/5/85 Sheet No. 7
Checked by B.G.S. Date 11/19/85 of 8

TTR 41 & 61



Greiner Engineering

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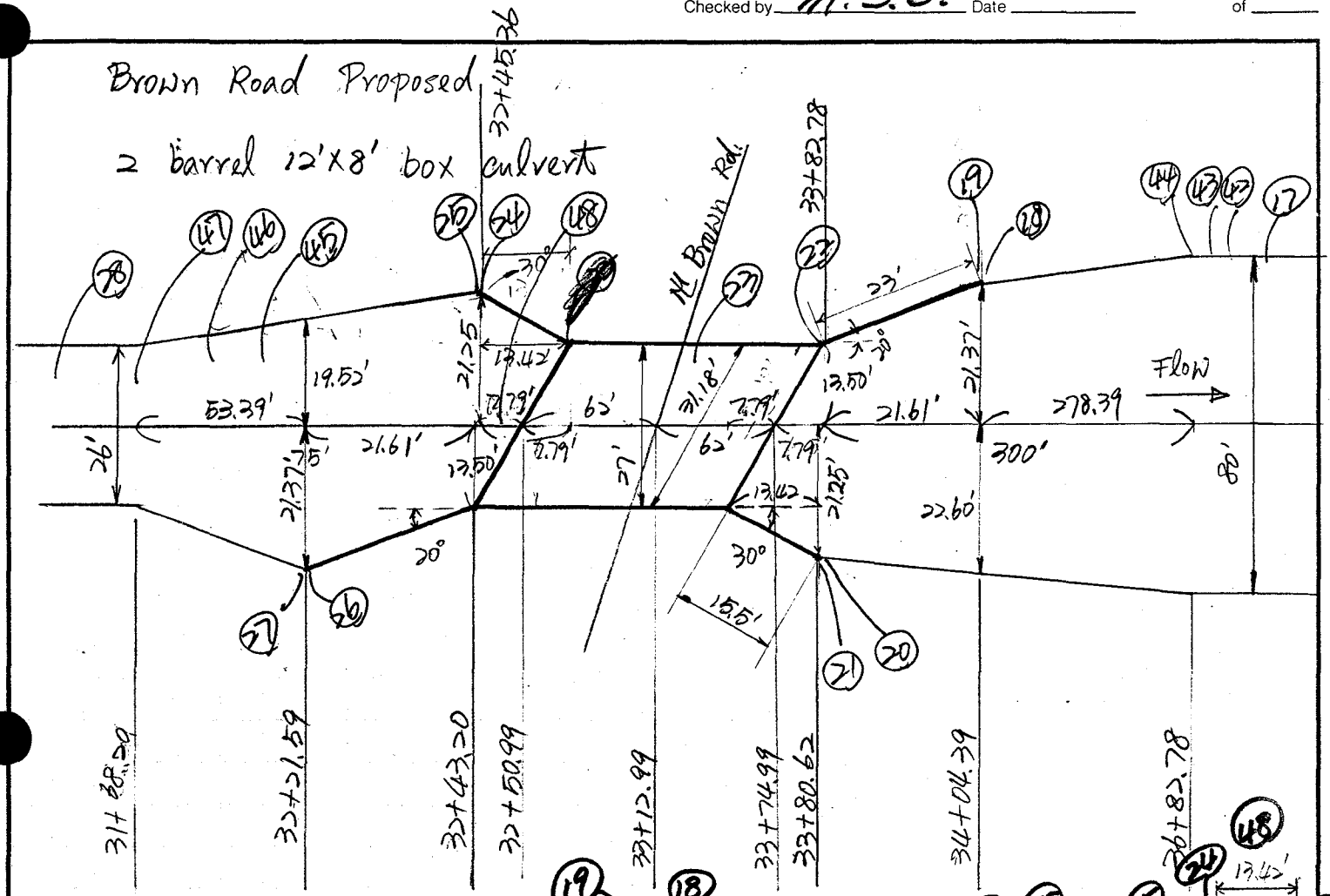
Tucson 602 327-3413
Phoenix 602 275-5400

Job: SCS RWCD Floodway Reach 6 - E10/012

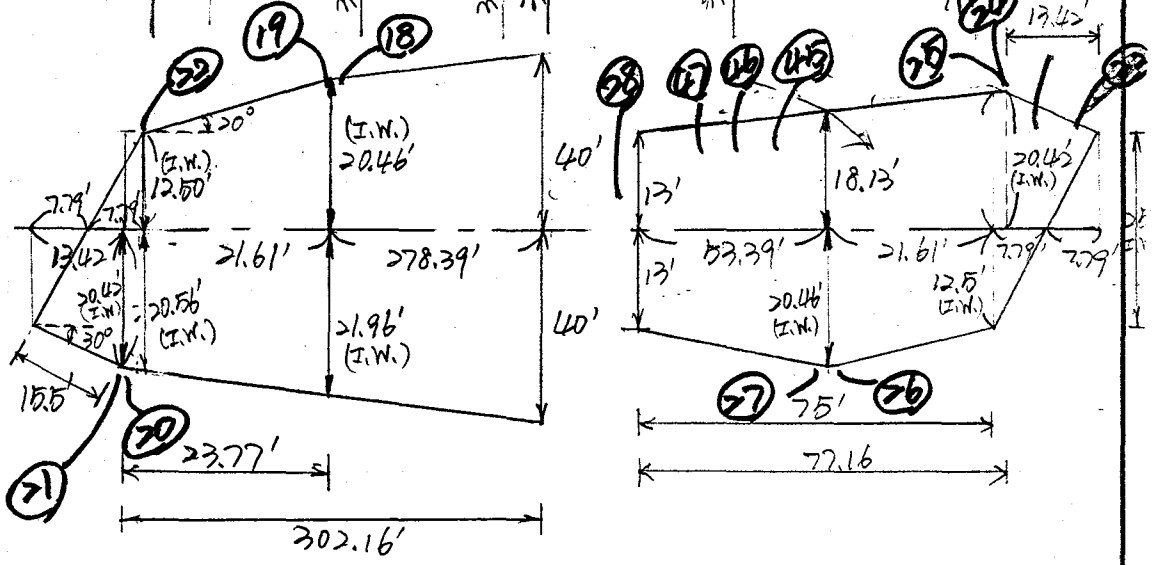
Description: Comparative Design Studies
ALT. No. 1 Trial #3 & #4

Calculated by: B. Gary Sun Date: 10/25/85 Sheet No. ____

Checked by: M.S.S. Date: ____ of ____



I.W.: Inside of wall



Long wing wall 9.04' 5.42'

Short wing wall 9.04' 5.25'

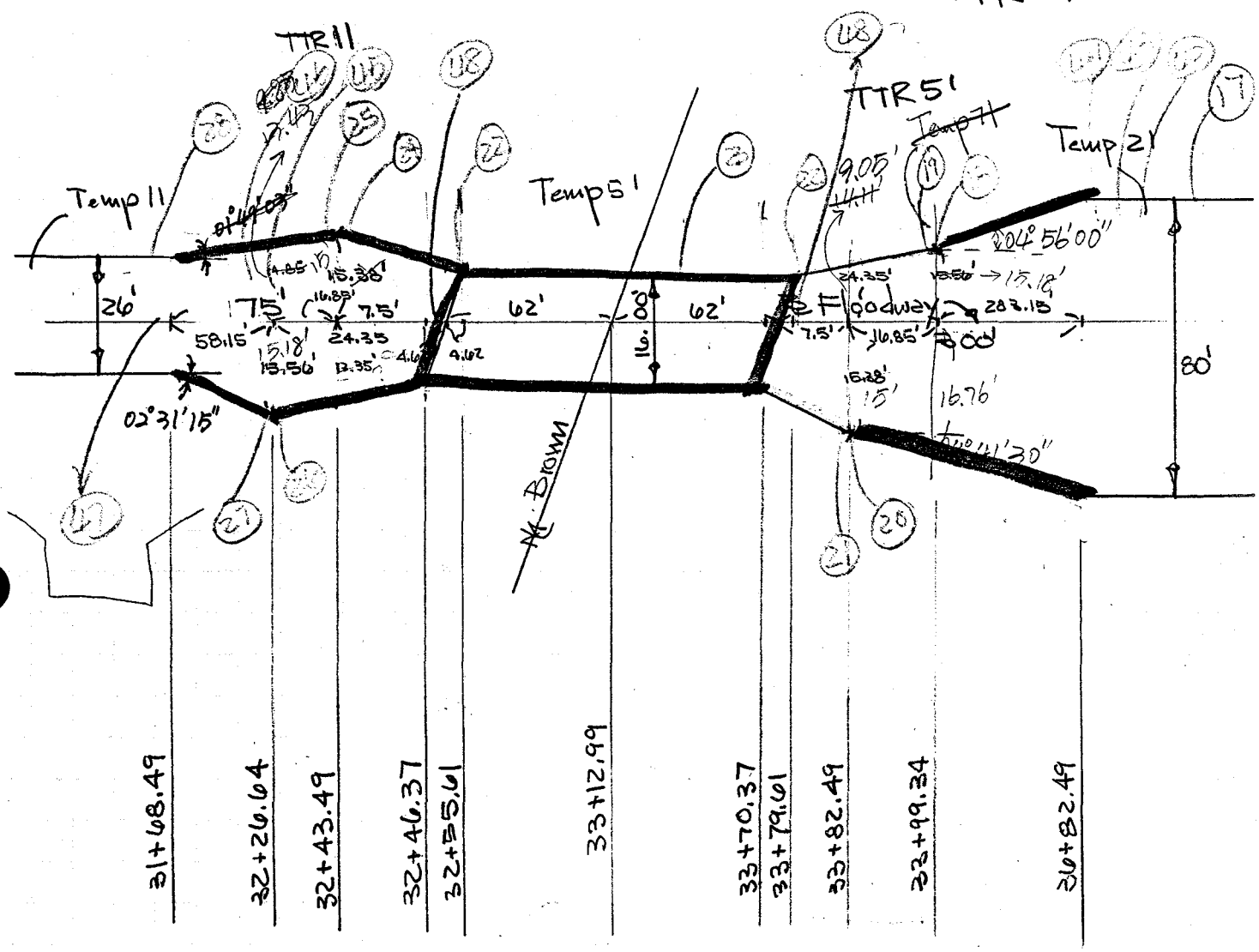
Greiner Engineering

Greiner Engineering Sciences, Inc.

Tucson 602 327-3413
Phoenix 602 275-5400

Job RWCD Reach 6 E10101R
Description Prelim Earthwork No. 1
Transitions
Calculated by M Shapiro Date 10/5/85 Sheet No. 1
Checked by B.G.B. Date 2/11/86 of 8

Trial #1 ONLY



Greiner Engineering

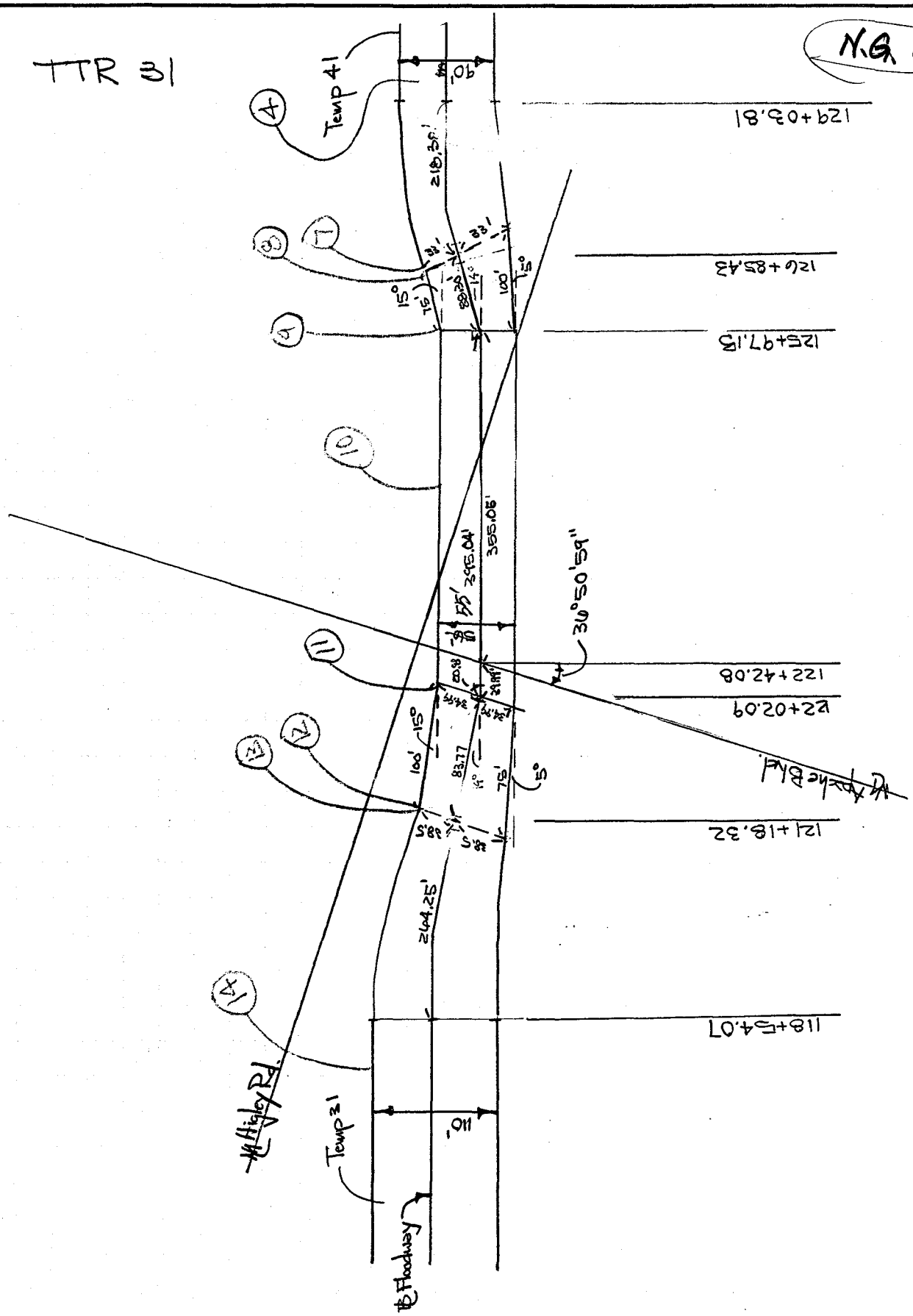
Greiner Engineering Sciences, Inc.

Tucson 602 327-3413
Phoenix 602 275-5400

Job RWCD Reach 6 E101012
Description Prelim. Earthwork No. 1
Transitions
Calculated by MShapiro Date 10/10/85 Sheet No. 5
Checked by B. G. B. Date 2/11/86 of 8

N.G. 10/17/85

TTR 31



Greiner Engineering

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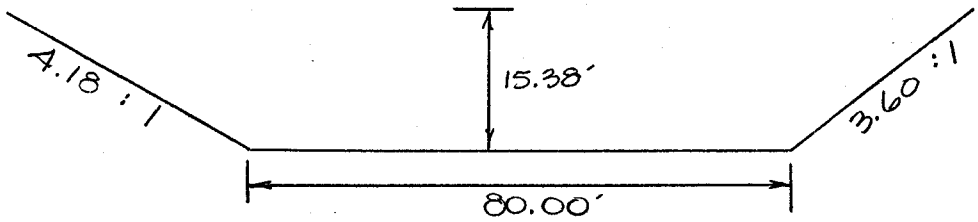
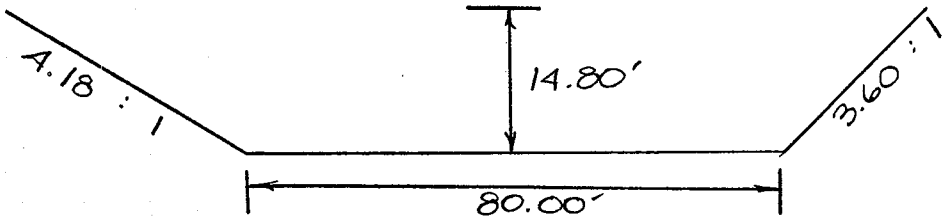
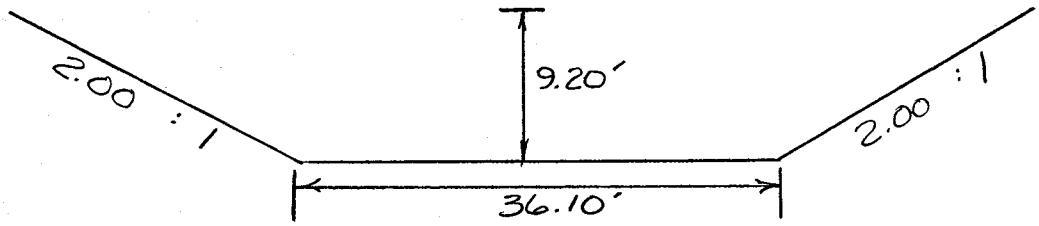


SECTION 1 (Sta. 163+10)



SECTION 2 (Sta. ~~163+53~~ 161+87)



SECTION 3 (Sta. 157+00.00)

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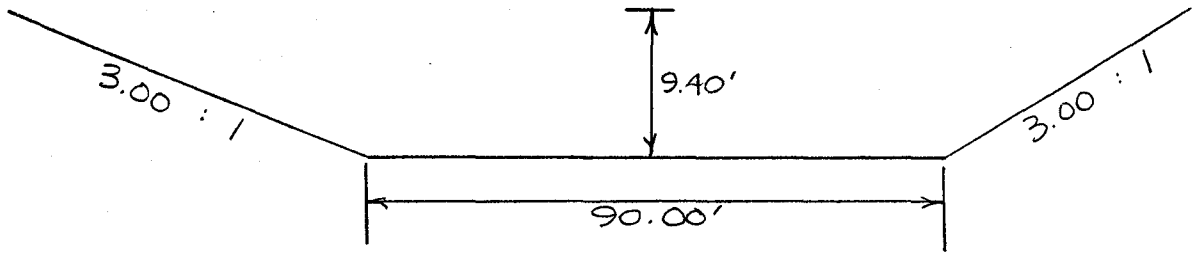
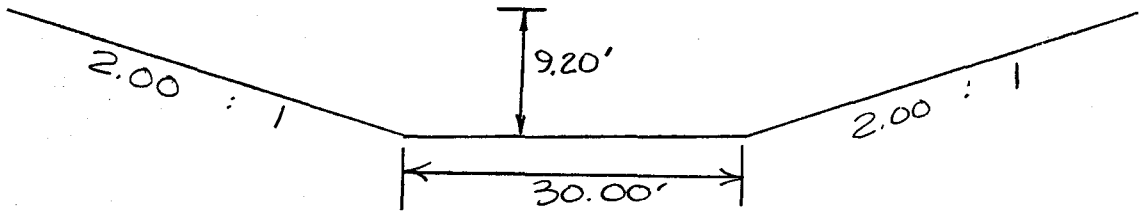
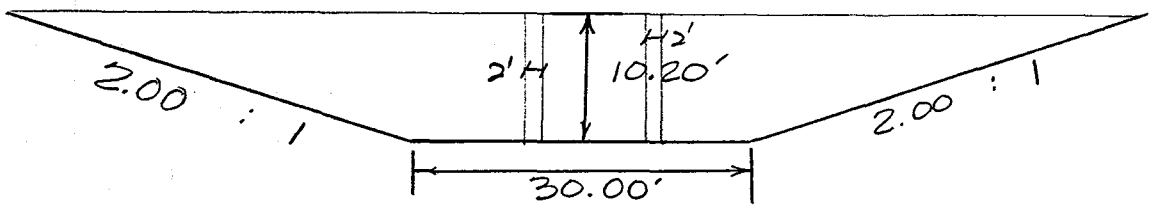
Sta. 161+30.00, 158+90.67, 155+74.98 & 128+79.37



SECTION 4

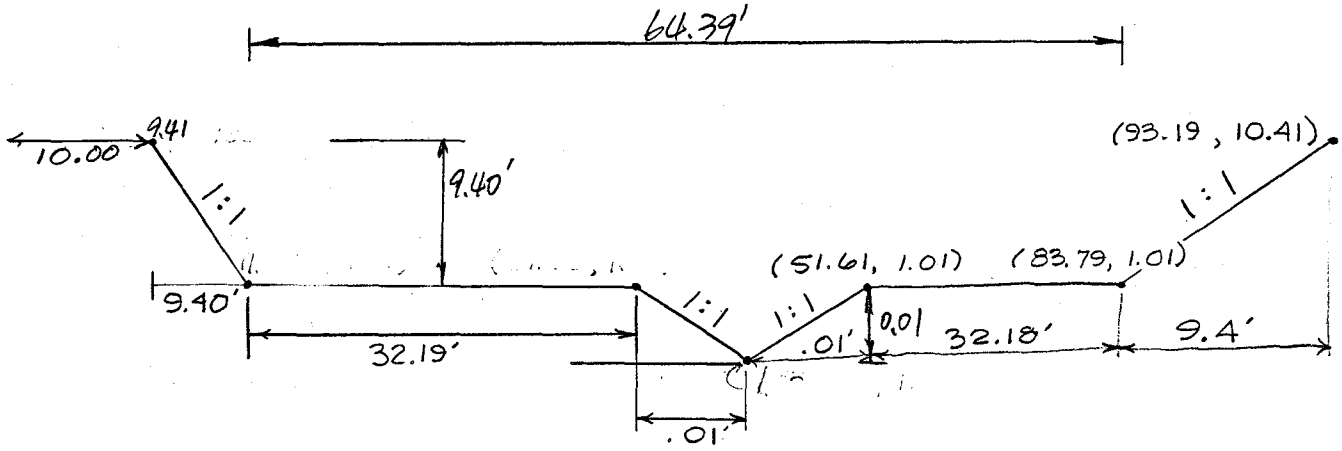


SECTION 5 (Sta. 156+51.34 & 155+48.66)

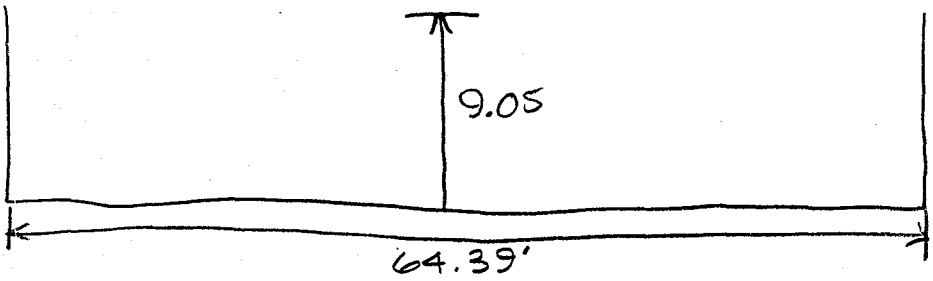


SECTION 6 (Sta. 156+51.34 & 155+48.66)

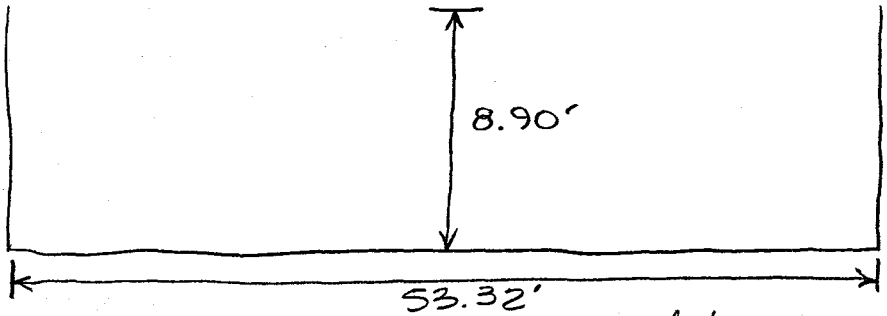
Broadway Road Bridge



SECTION 7 (Sta. 126+71.23)

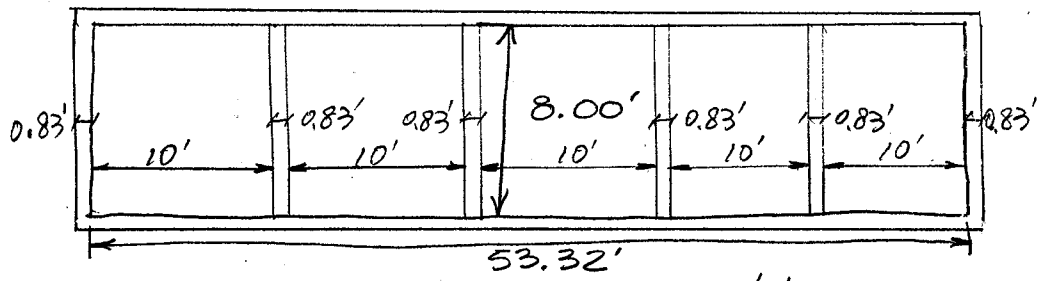


SECTION 8 (Sta. 126+71.23)

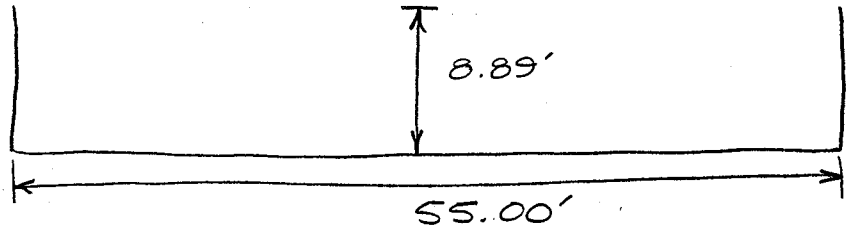


SECTION 9 (Sta. 125+76.45)

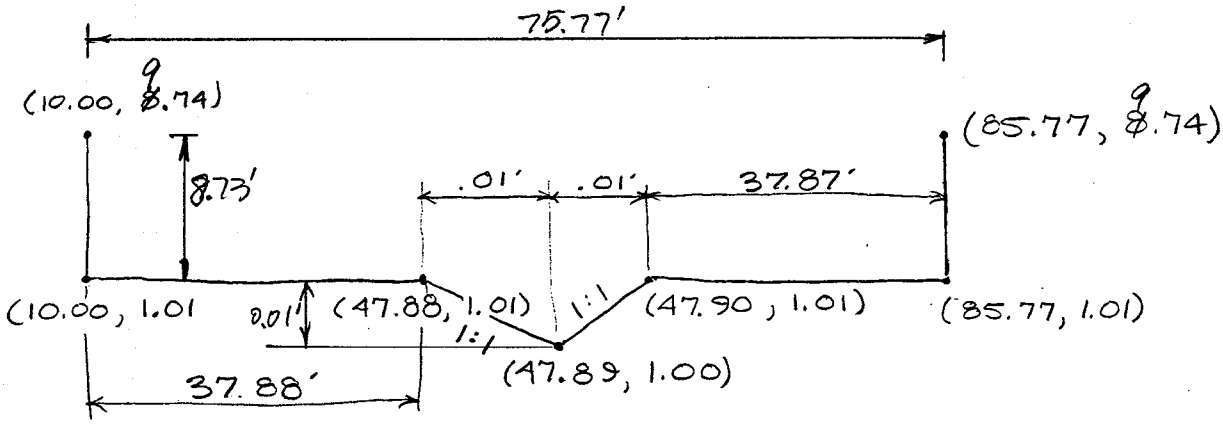
Apache & Higley Box Culvert 5 barrel 10'x8'



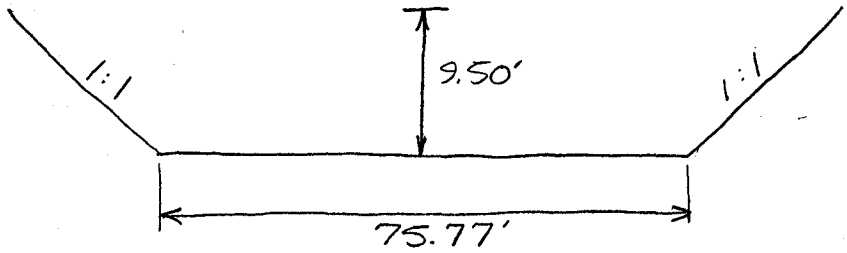
SECTION 10 (Sta. 125+76.45, 122+05.22)



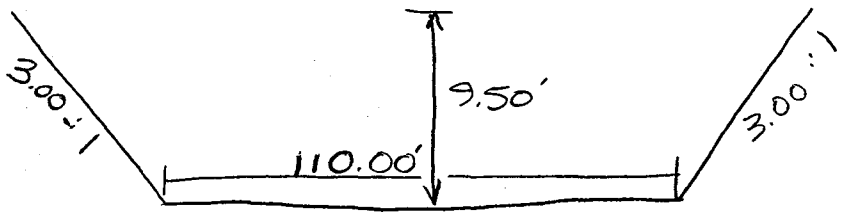
SEC. 11 (Sta. 122+05.22)



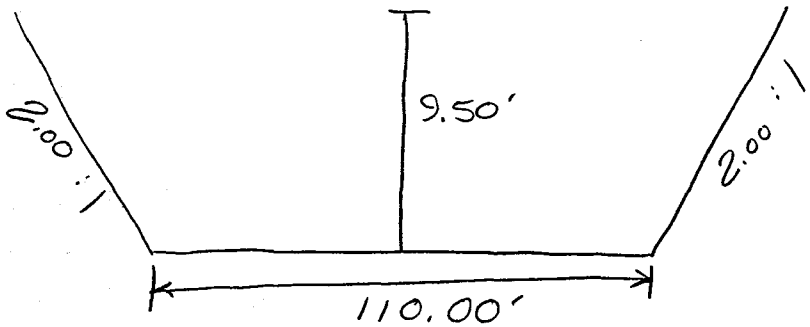
SEC 12 (Sta. 121+13.05)



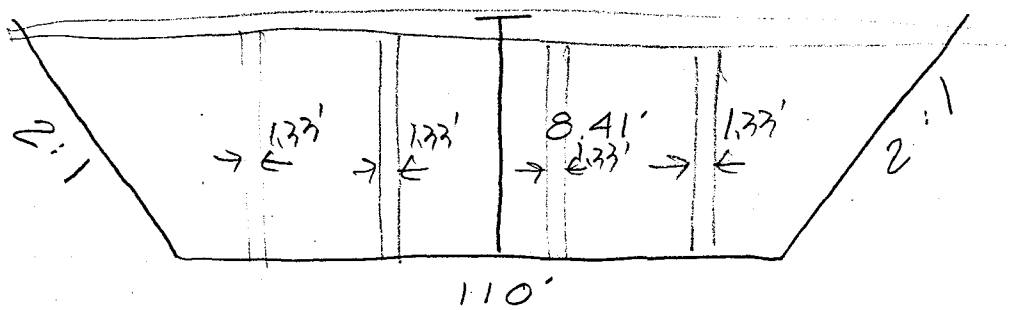
SEC 13 (Sta. 121+13.05)



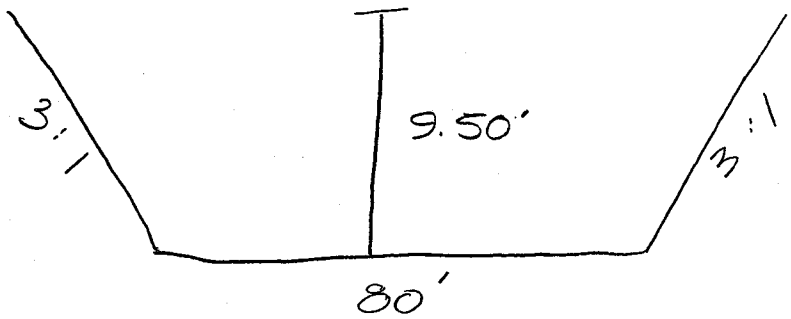
SEC 14 (Sta. 118+75.72 & 118+54.07)



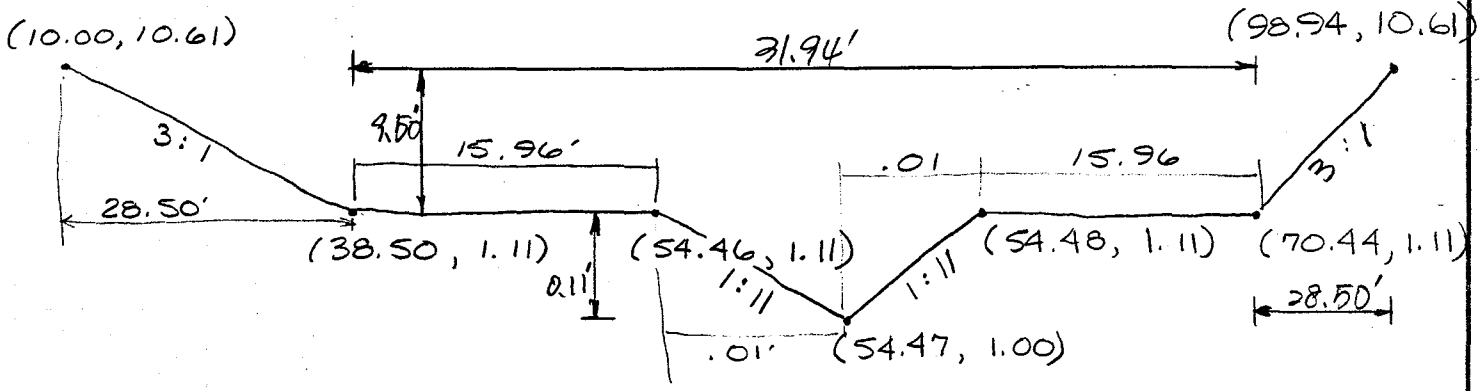
SEC 15 (Sta. 91+58.26 & 90+69.48



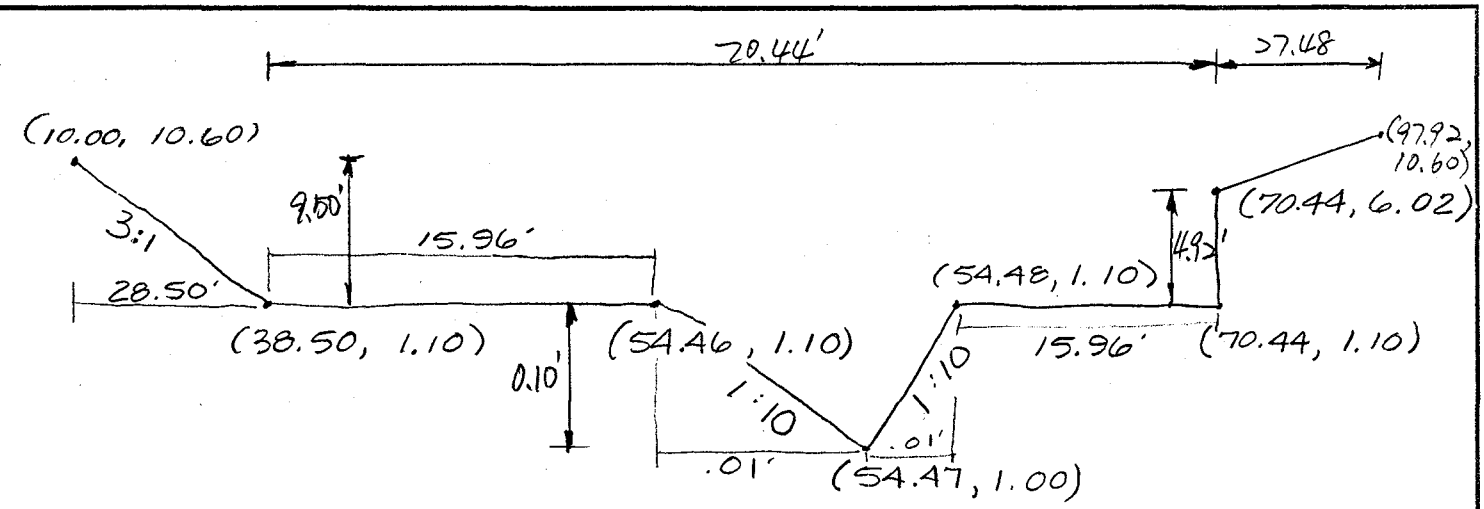
SEC. 16 (Sta. 91+58.26 & 90+69.48)



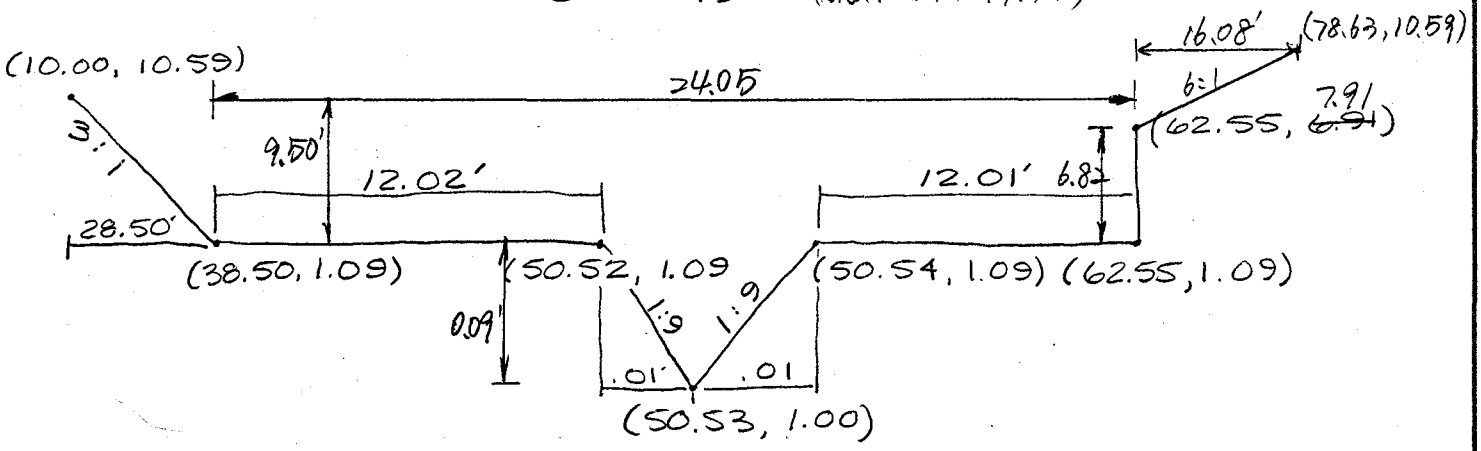
SEC 17 (Sta. 88+94.51, 88+47.84, 86+47.84, 78+95.00)



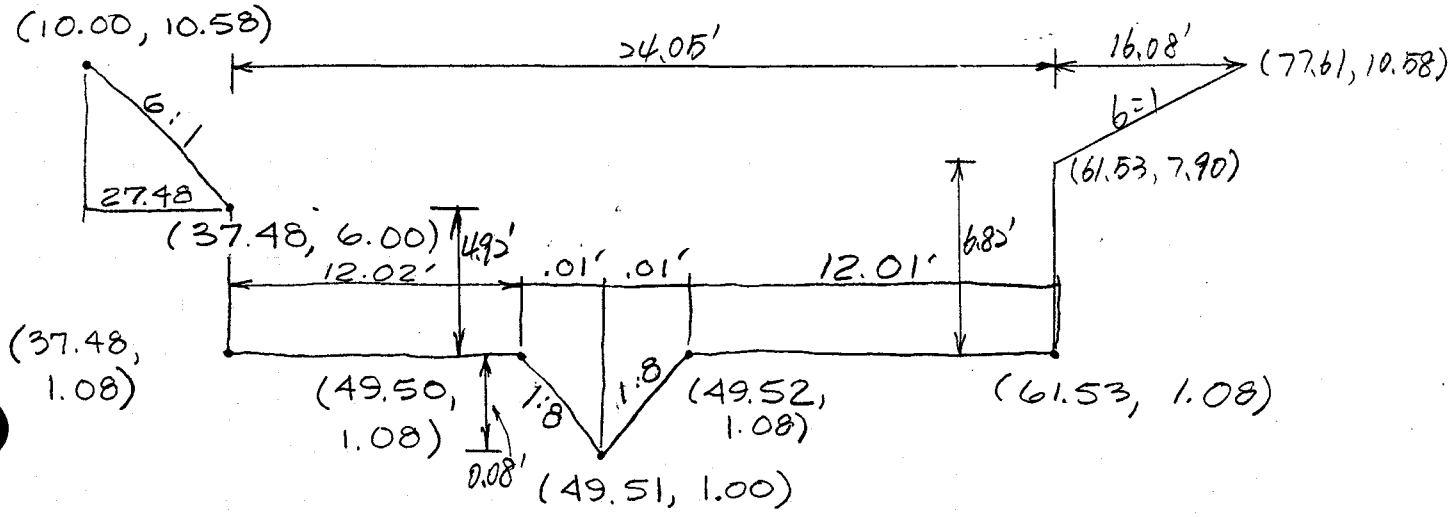
SEC 18 (Sta. 33+99.34)



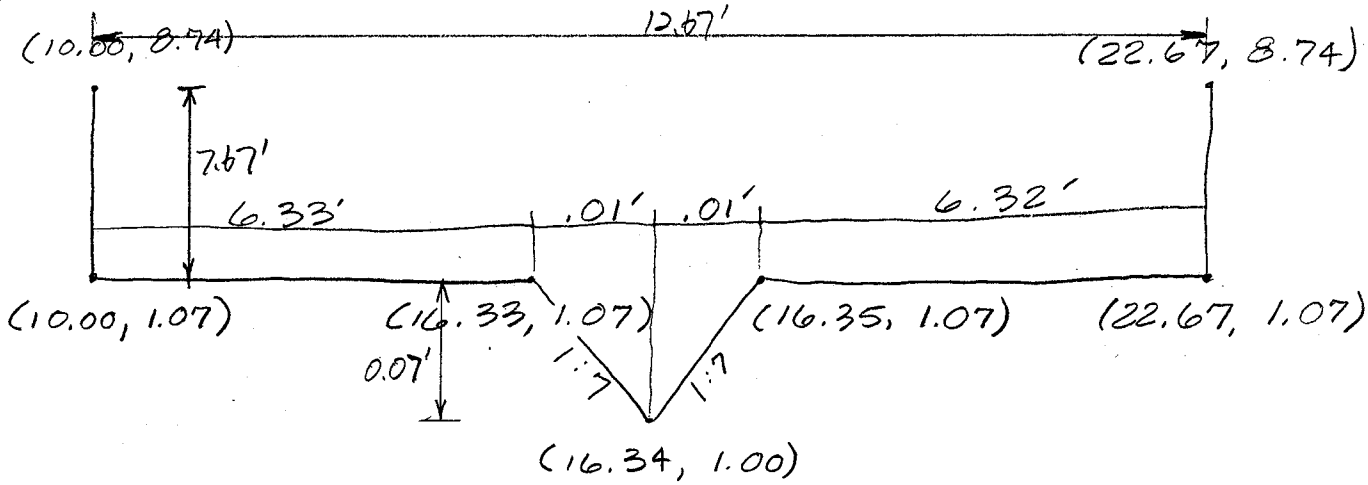
SEC 19 (Sta. 33+99.34)



SEC 20 (Sta. 33+82.49)

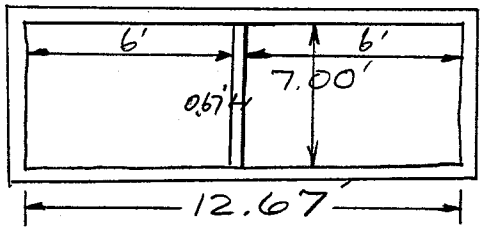


SEC 21 (Sta. 33+82.49)

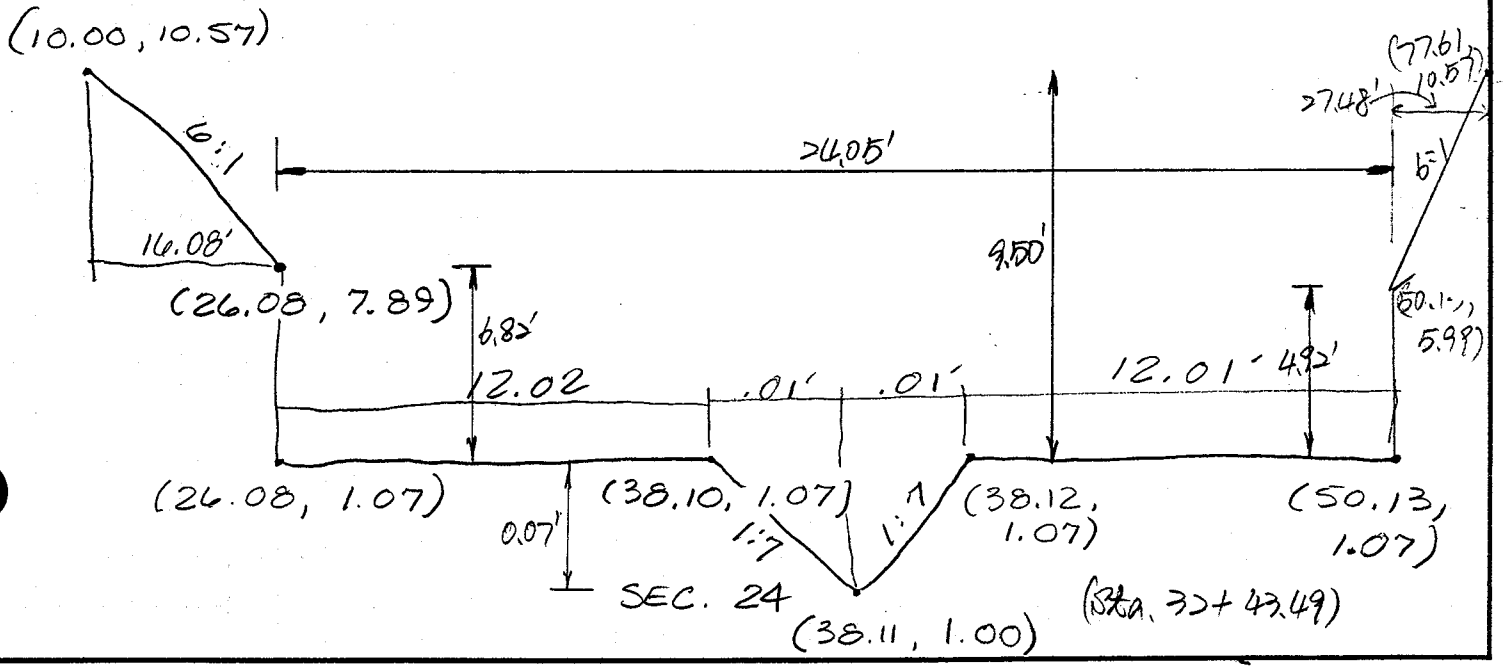


SEC. 22 (Sta. 33+75.00)

Proposed 2 barrel 6'X7' box culvert for Brown Road



SEC. 23 (Sta. 33+74.99 ~ 32+50.99)



SEC. 24 (Sta. 32+43.49)

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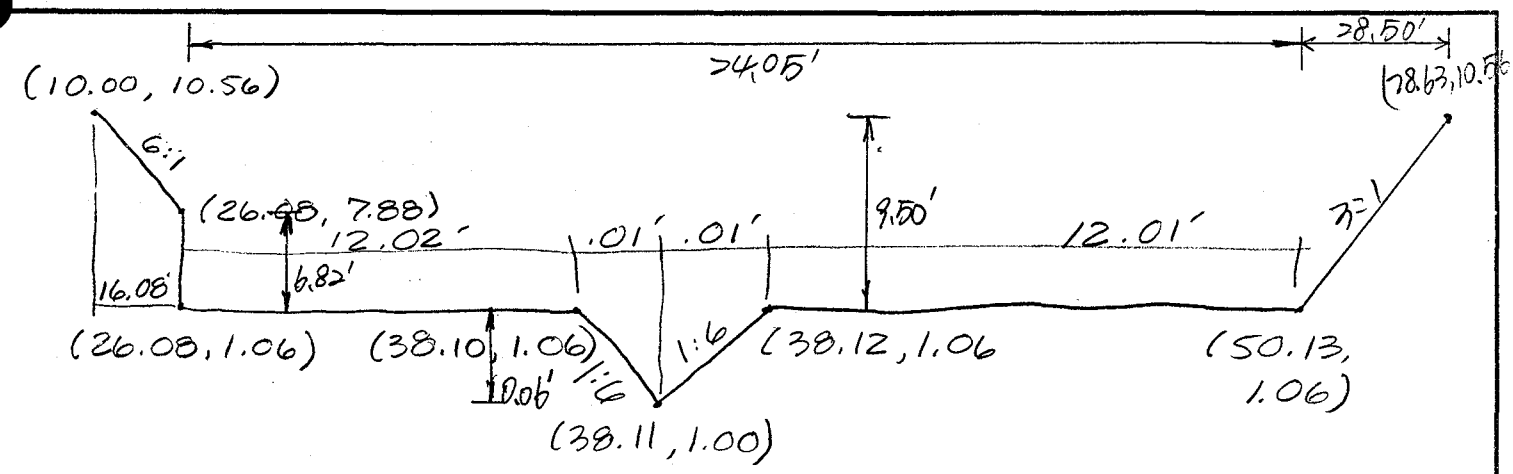
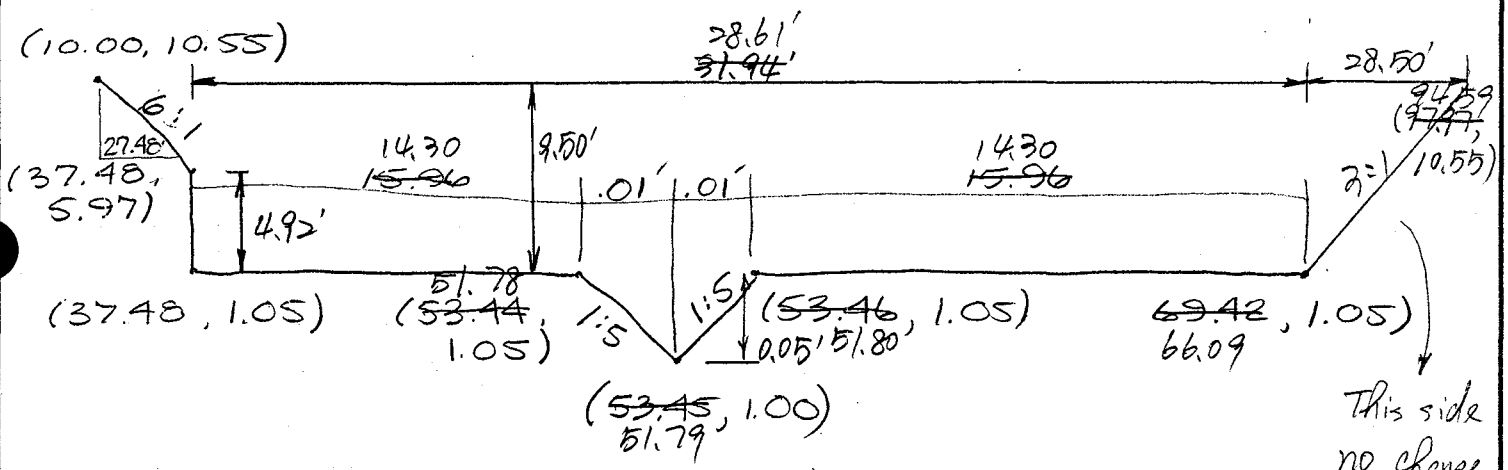
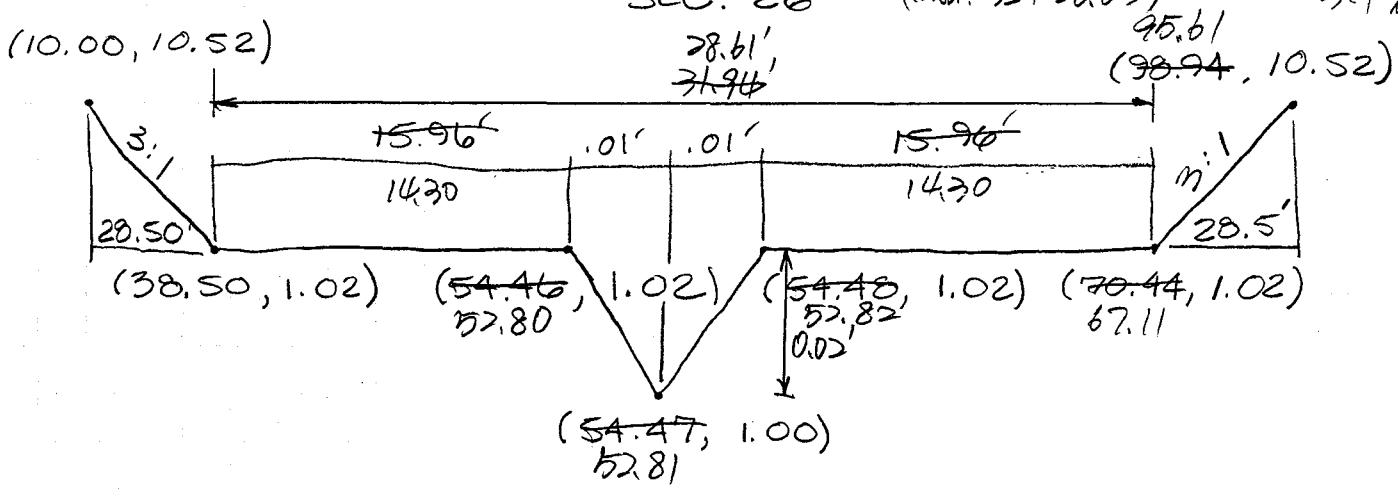


SEC. 25 (Sta. 32+43.49)

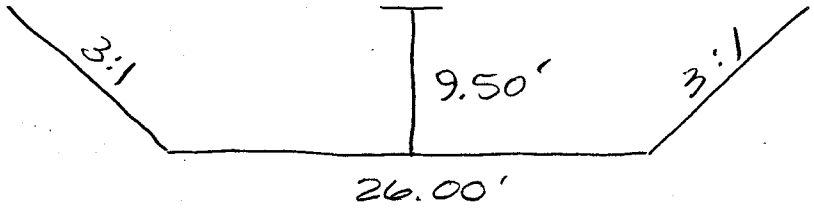


This side no change 3:1 to 3:1

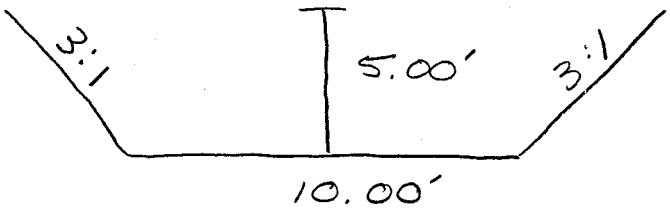
SEC. 26 (Sta. 32+26.63)



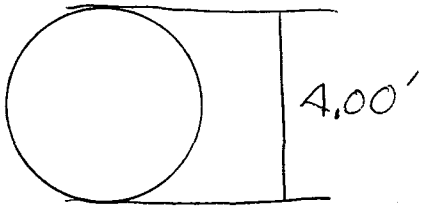
SEC. 27 (Sta. 32+22.63)



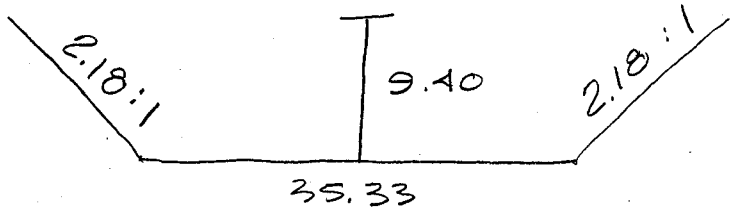
SEC 28 (Sta. 21+48.00)



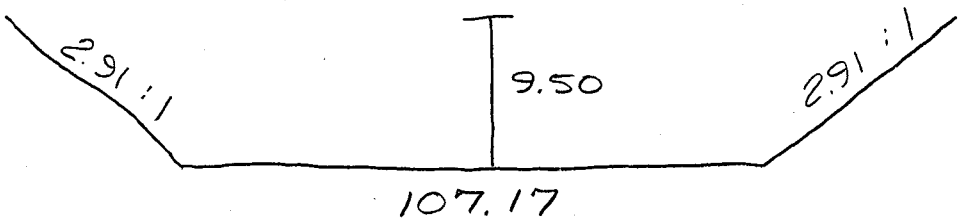
SEC 29 (Junction Side channel)



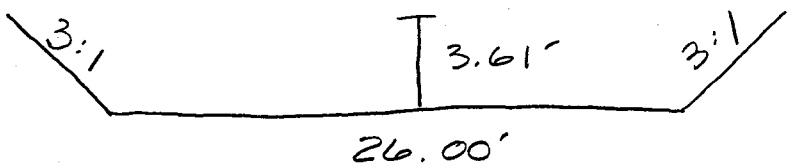
SEC 30 (Junction pipe)



SEC 31 (Sta. 155+00)



SEC 32 (Sta. 90+52.99)



SEC 33 (Sta. 30+50.00)

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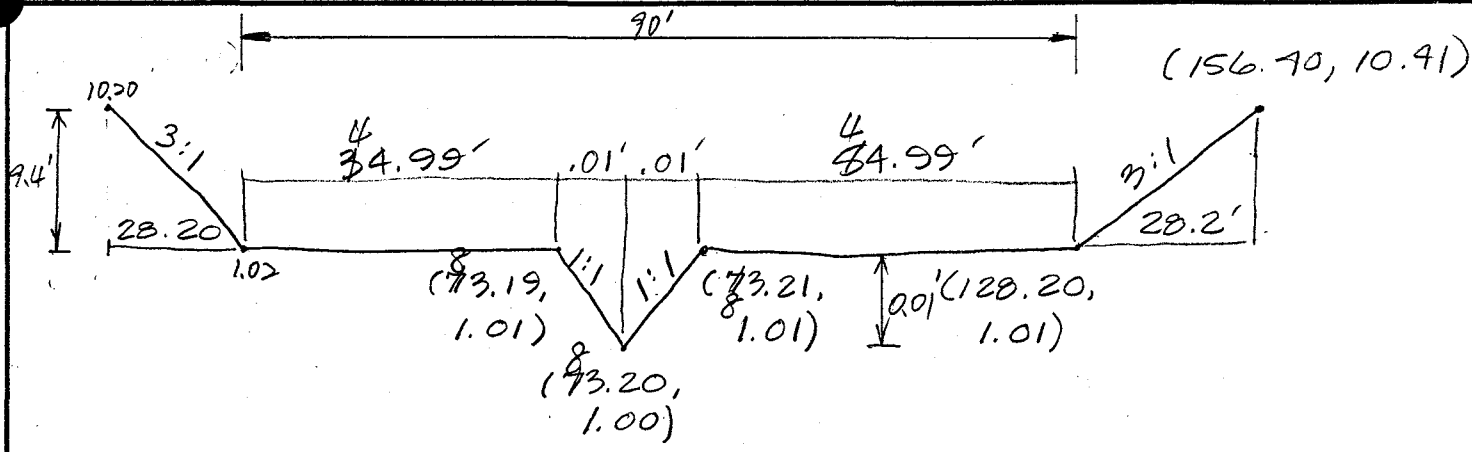
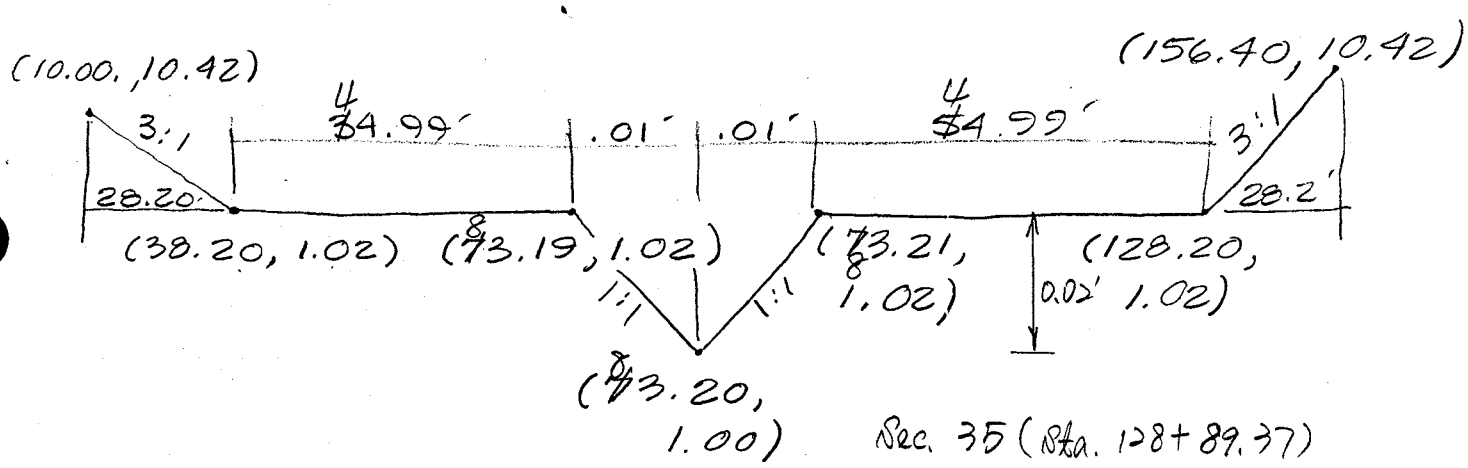
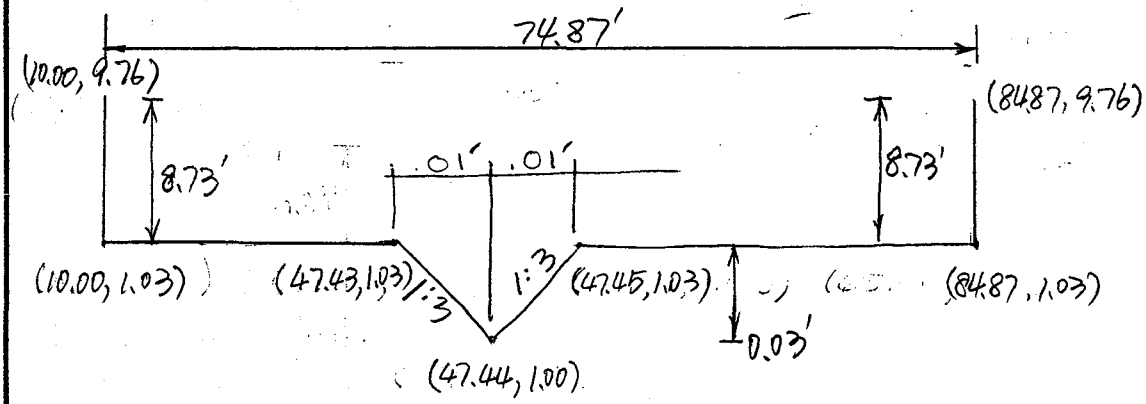
Tucson 602 327-3413
Phoenix 602 275-5400



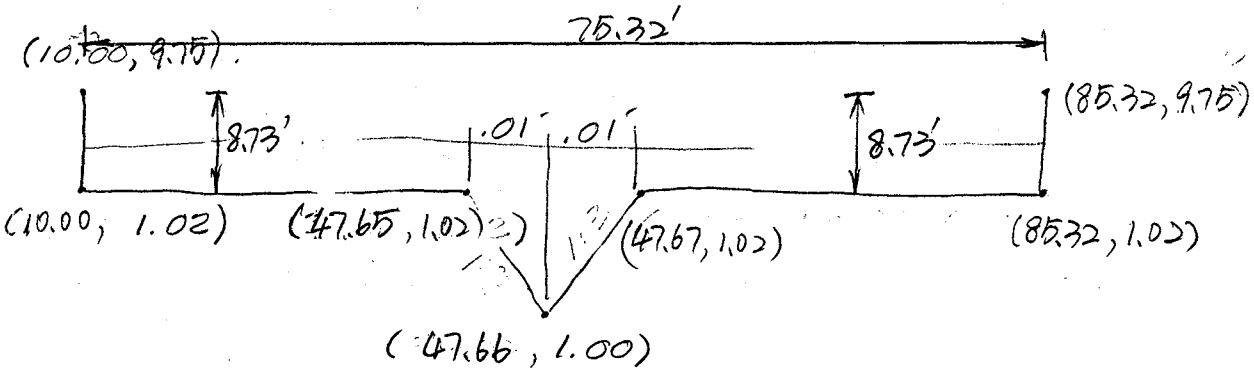
SEC 34 (Sta. 128+84.37)



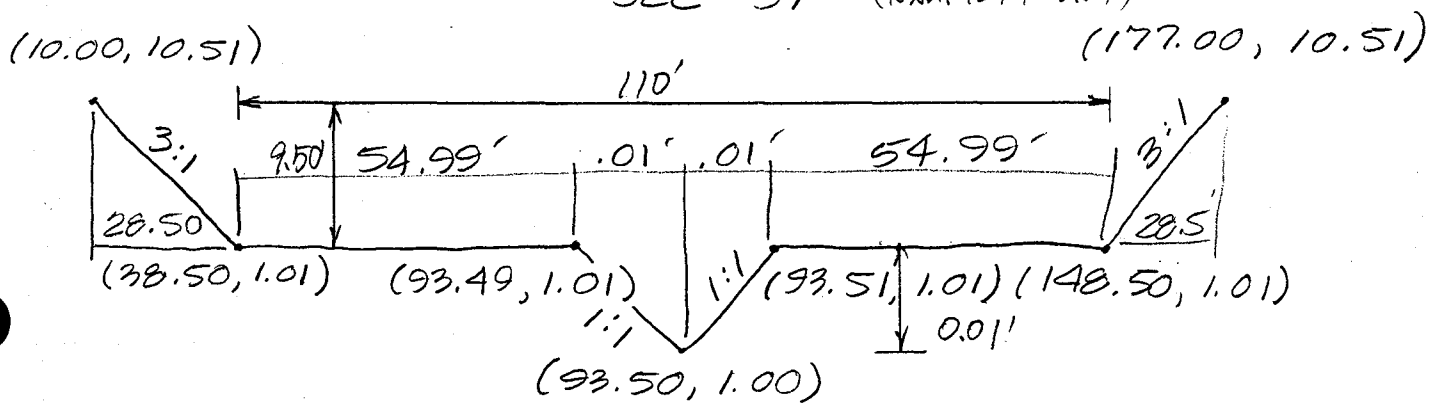
Sec. 35 (Sta. 128+89.37)



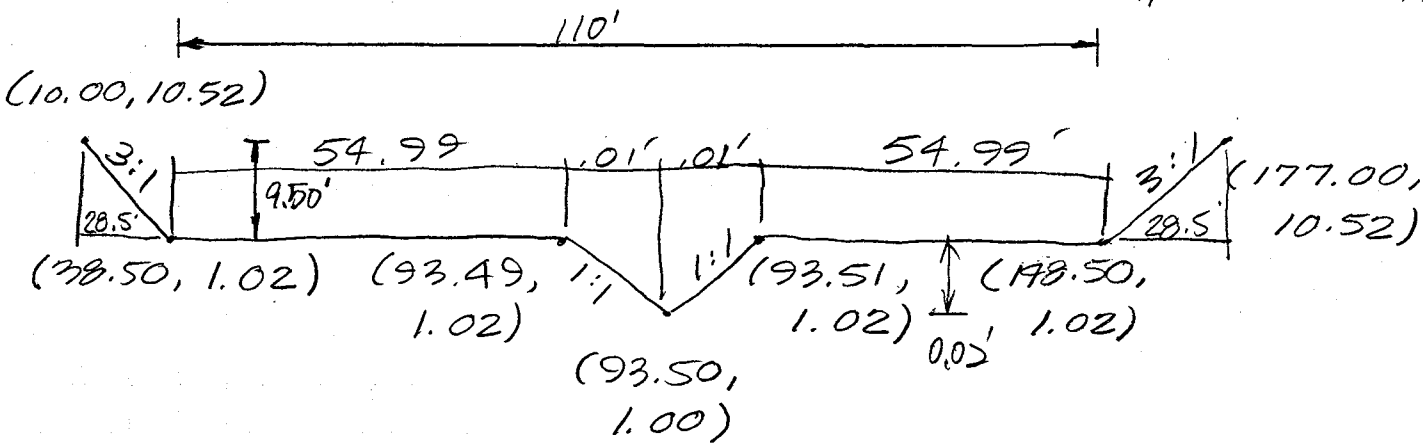
SEC 36 (Sta. 121+17.05)



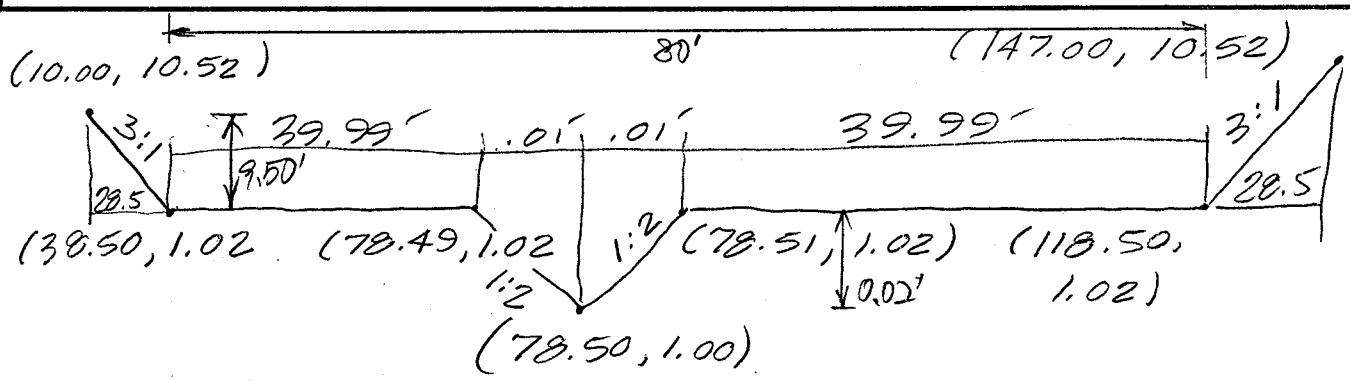
SEC 37 (Sta. 121+15.07)



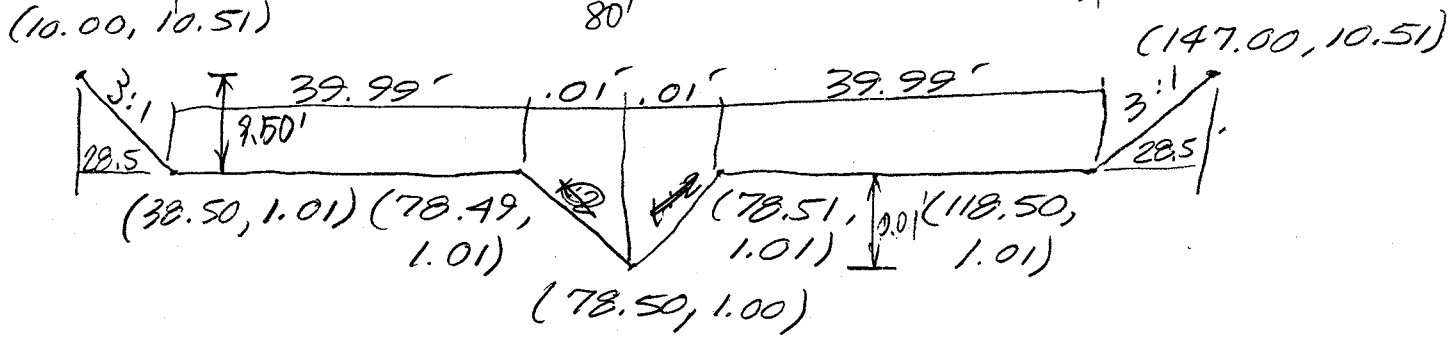
SEC 38 (Sta. 102+48.39, 95+97.84 & 93+97.84)



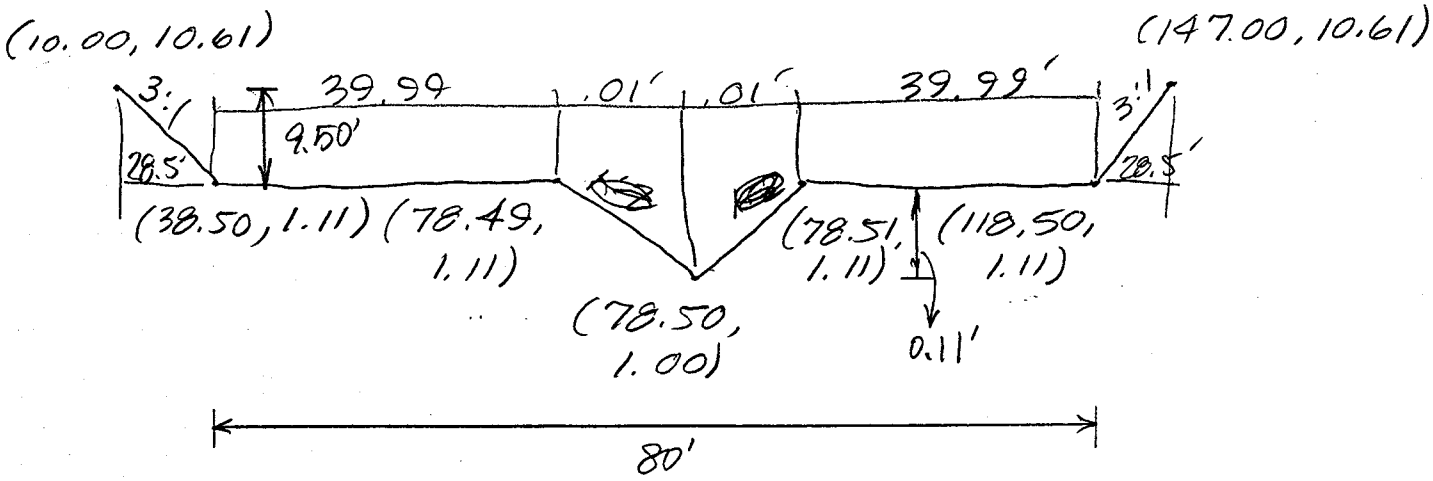
SEC 39 (Sta. 97+08.37)



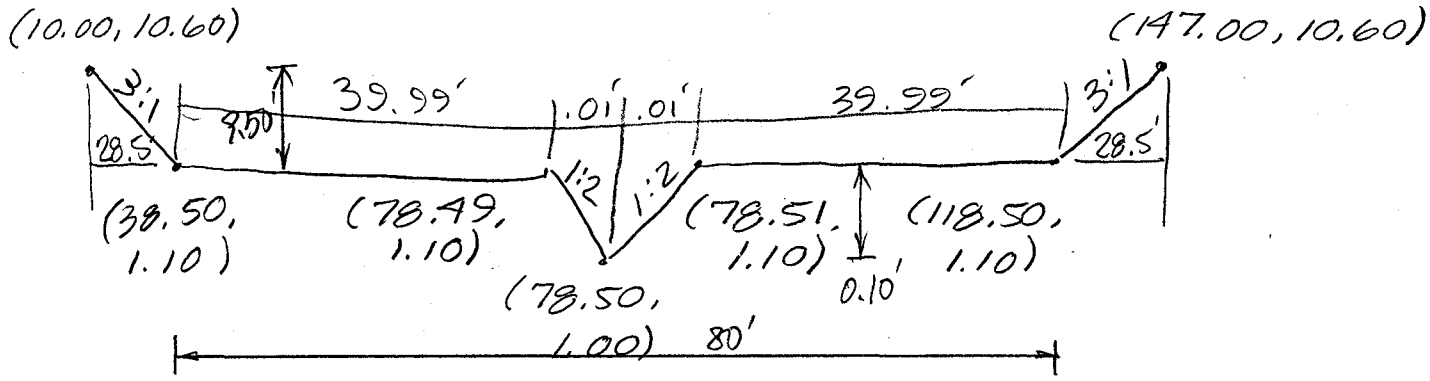
SEC 40 (Sta. 79+05.00)



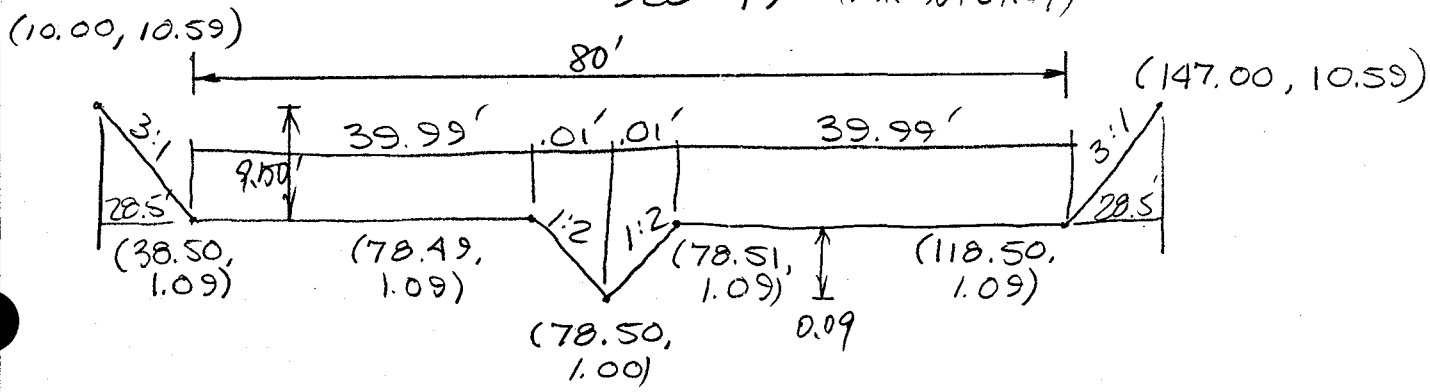
SEC 41 (Sta. 79+00.00)



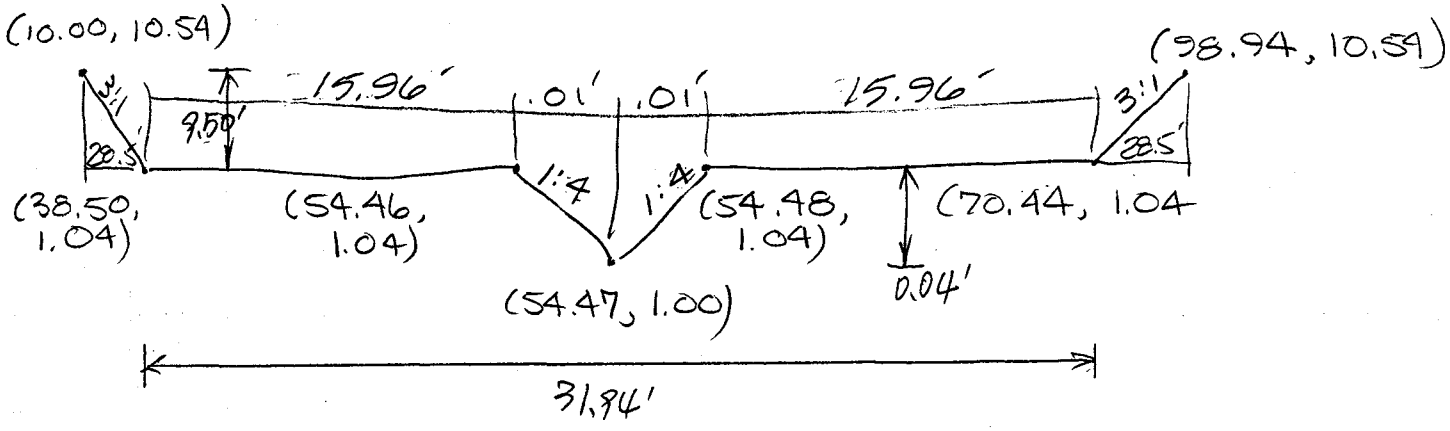
SEC 42 (Sta. 76+92.49)



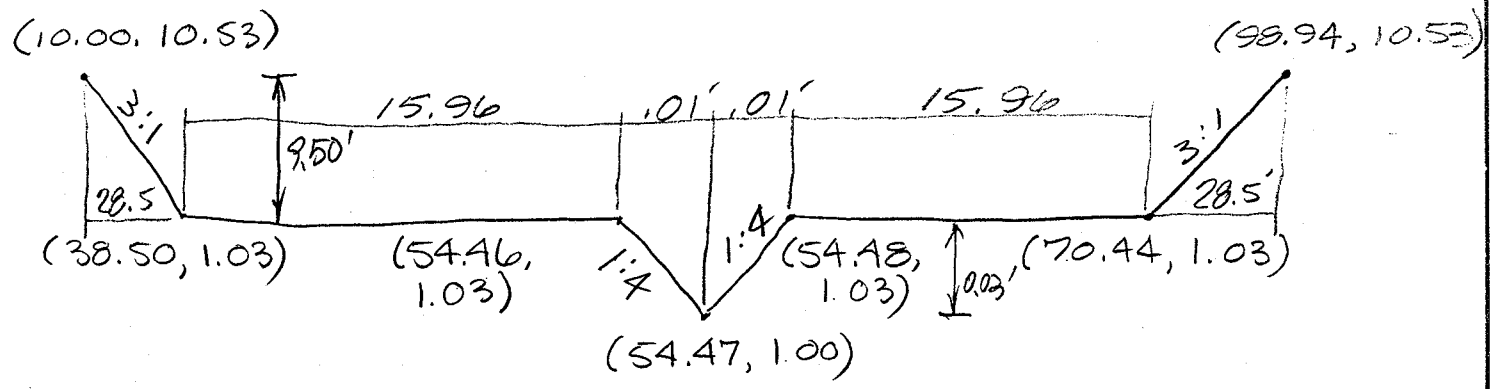
SEC 43 (Sta. 36+87.49)



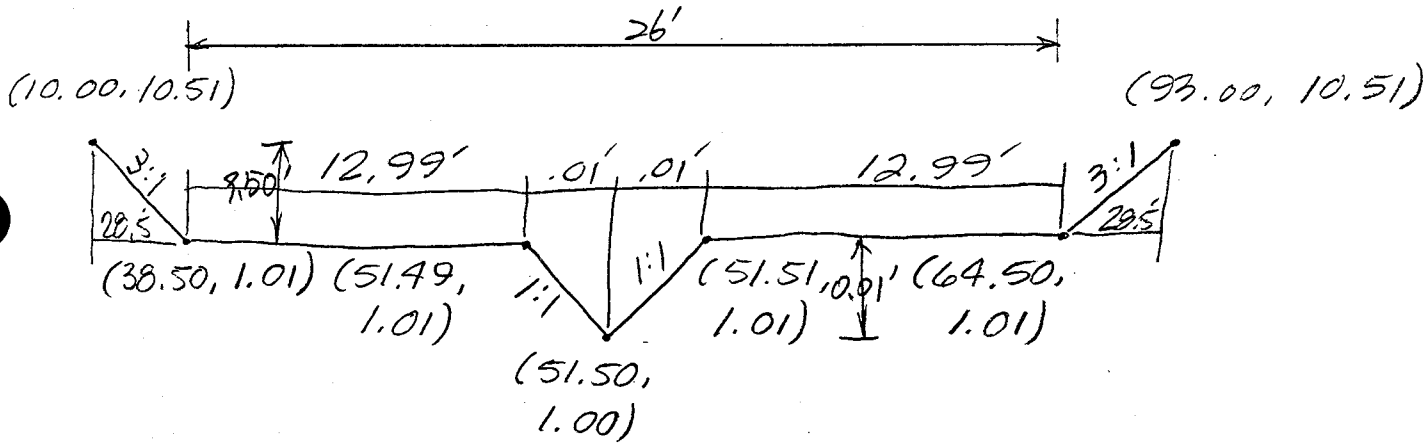
SEC 44 (Sta. 36+82.49)



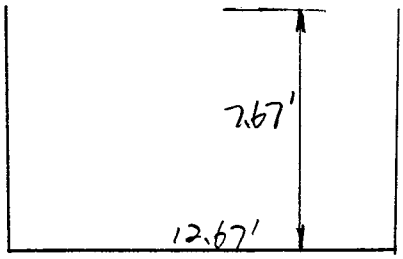
SEC 45 (Sta. 32+26.63)



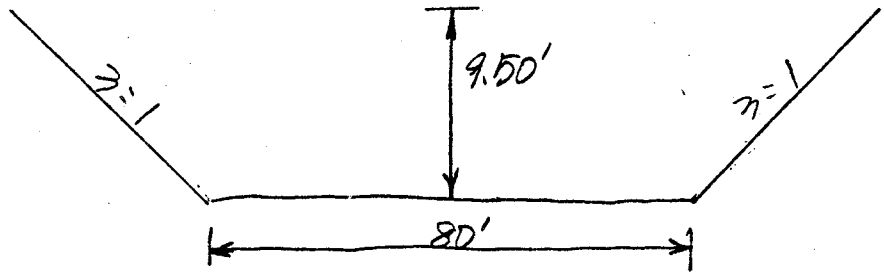
SEC 46 (Sta. 32+26.63)



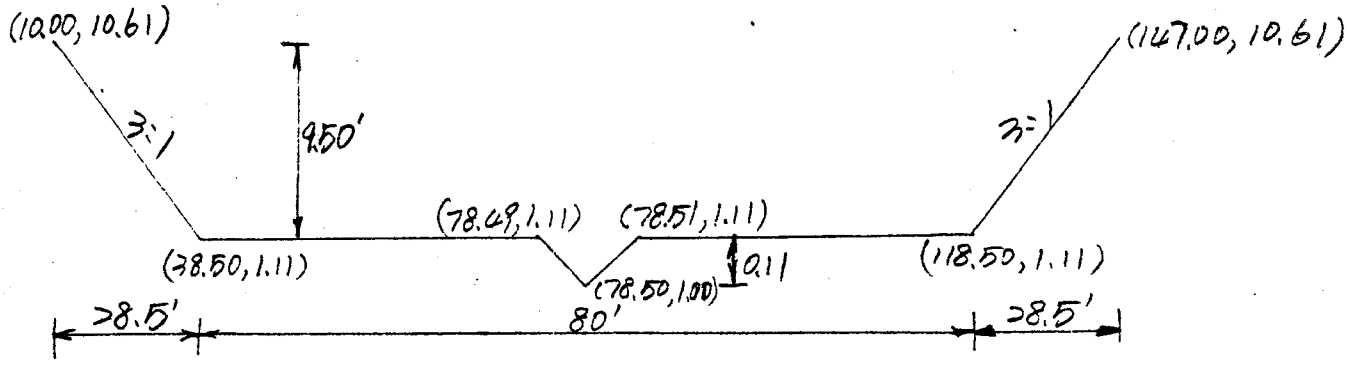
SEC 47 (Sta. 31+68.49)



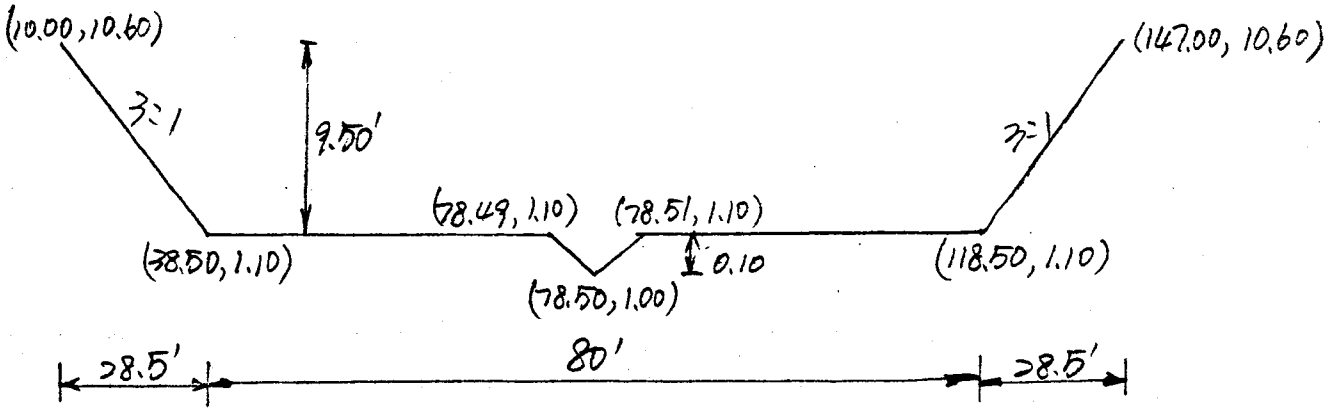
Sec. 48 (Sta. 33+75.00 & 32+50.99)



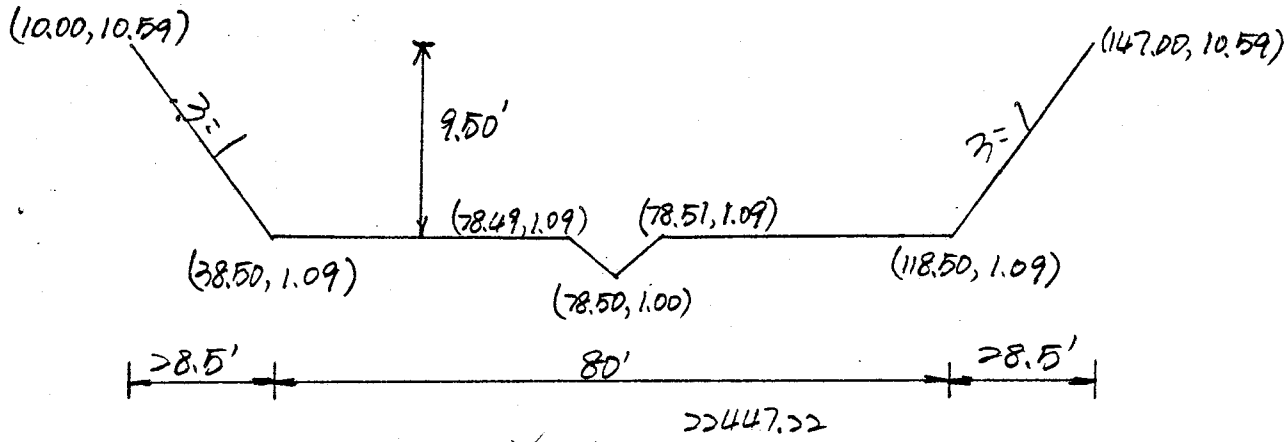
Sec. 17 (Sta. 88+94.51, 88+47.84, 86+47.84, 78+95.00)



Sec. 42 (Sta. 36+92.78) 22437.22

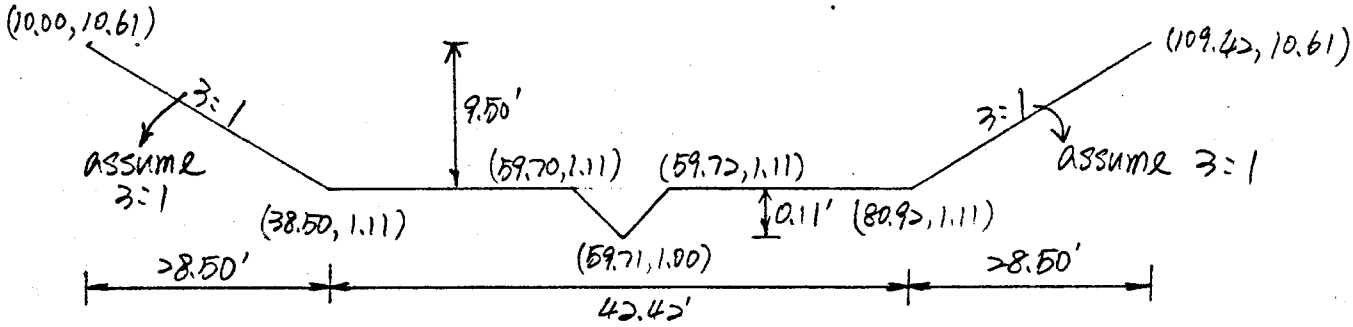


Sec. 43 (Sta. 36+87.78 22442.22



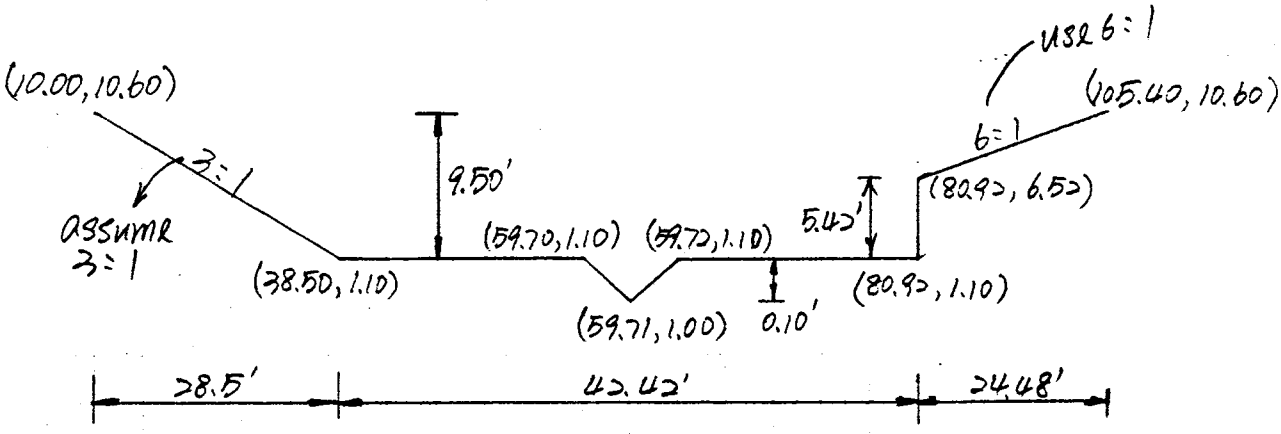
>>447.22

Sec. 4/4 (Sta. 36+82.78)



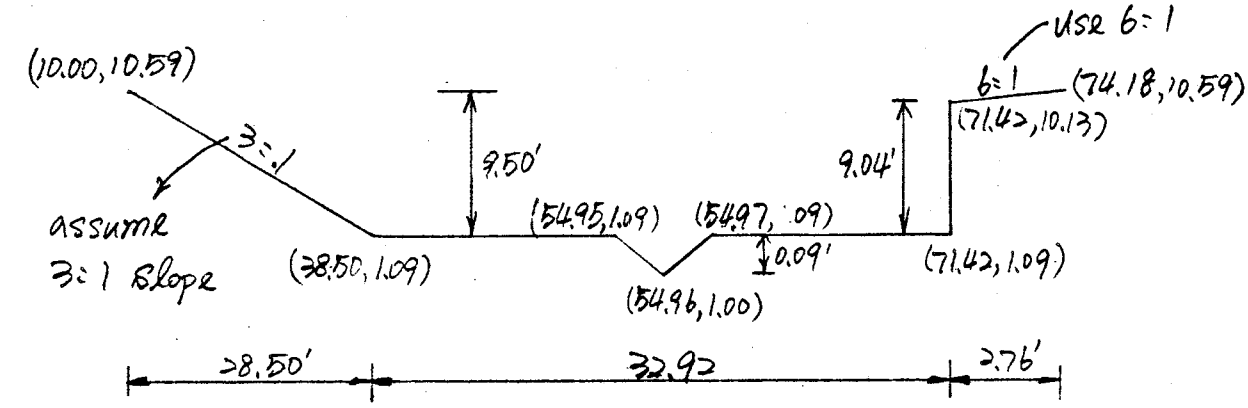
>>725.60

Sec. 18 (Sta. 34+04.40)



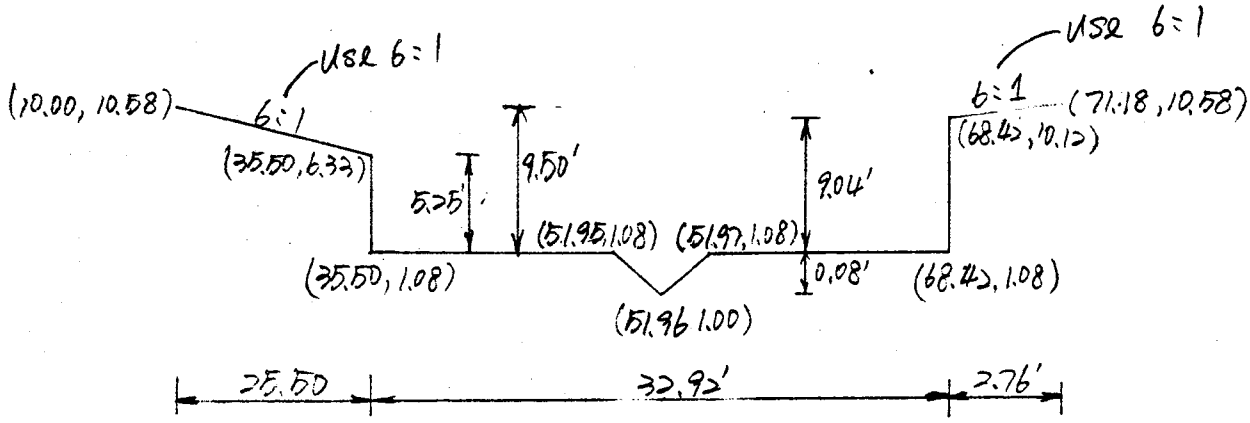
>>725.61

Sec. 19 (Sta. 34+04.39)



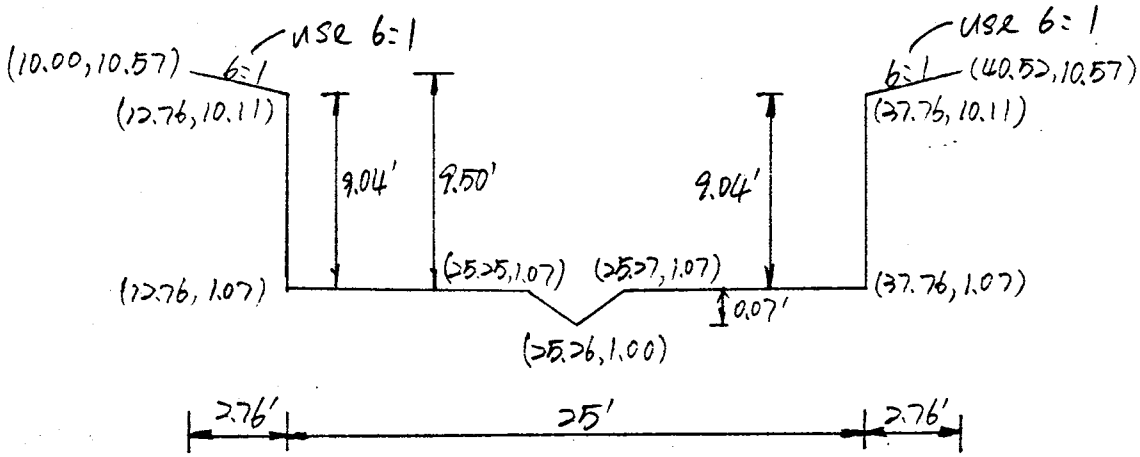
22749.37

Sec. 20 (Sta. 33+80.63)



22749.38

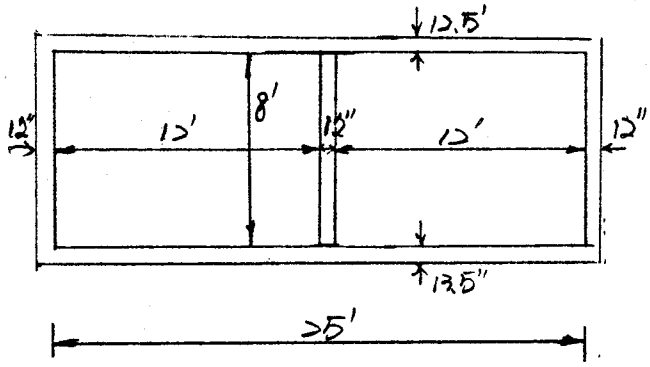
Sec. 21 (Sta. 33+80.62)



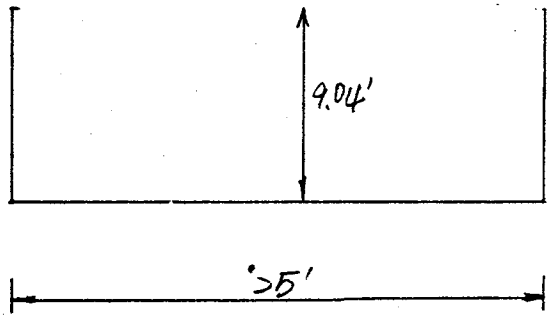
22755.00

Sec. 22 (Sta. 33+75.00)

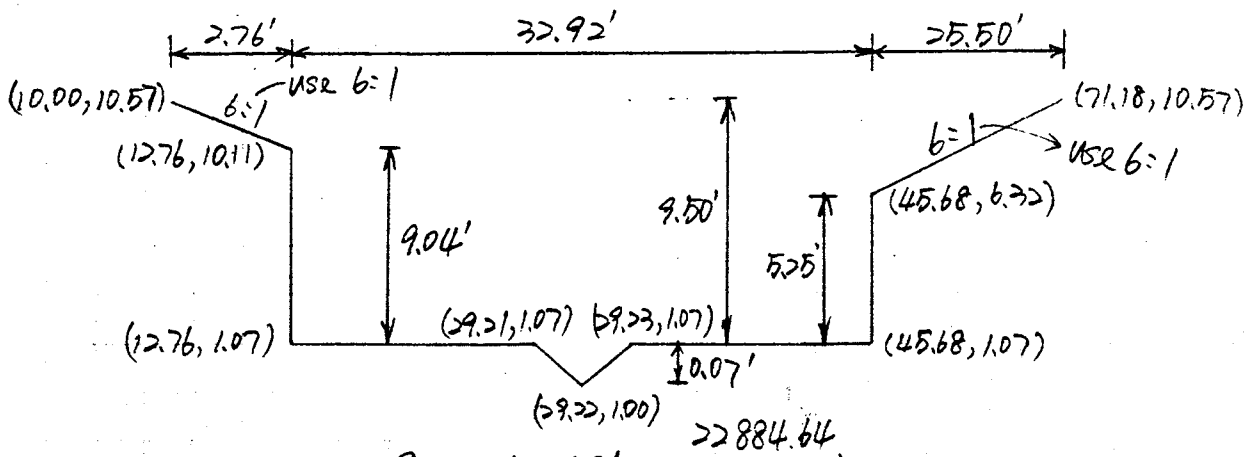
Proposed double barrel 12'×8' box culvert at Brown



Sec. 23 (Sta. 33+74.99 ~ 32+50.44) 22755.01 22879.01



Sec. 48 (Sta. 33+74.99, 32+50.99) 22755.01 22879.01



Sec. 24 (Sta. 32+45.36) 22884.64

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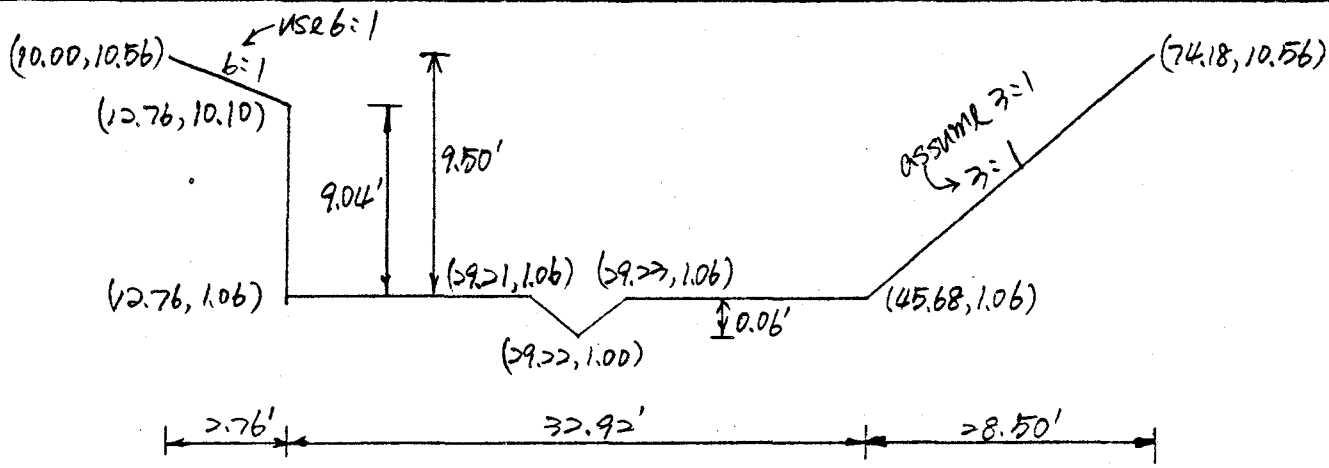
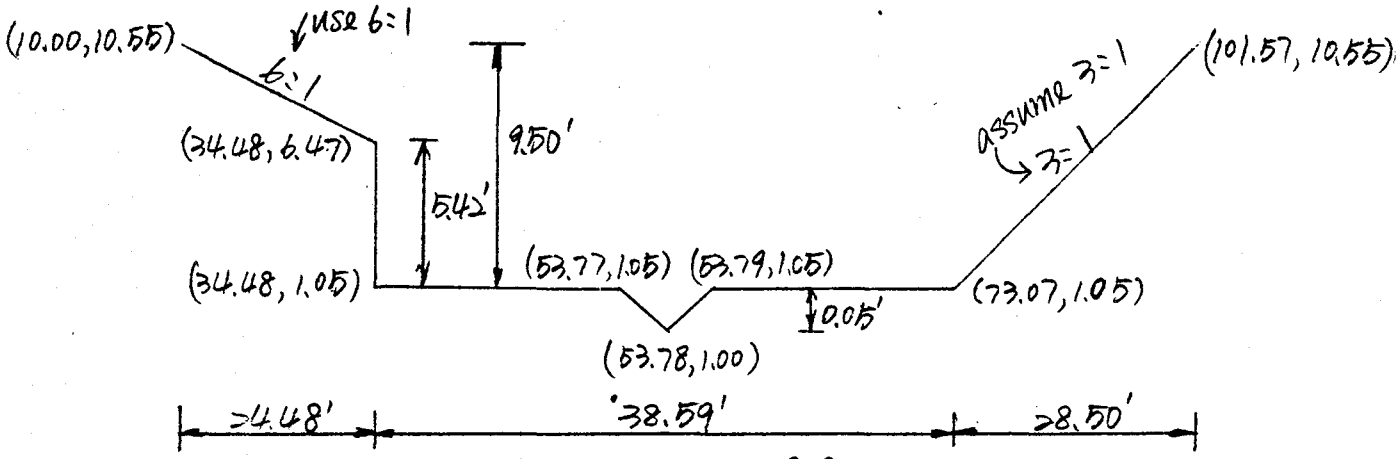


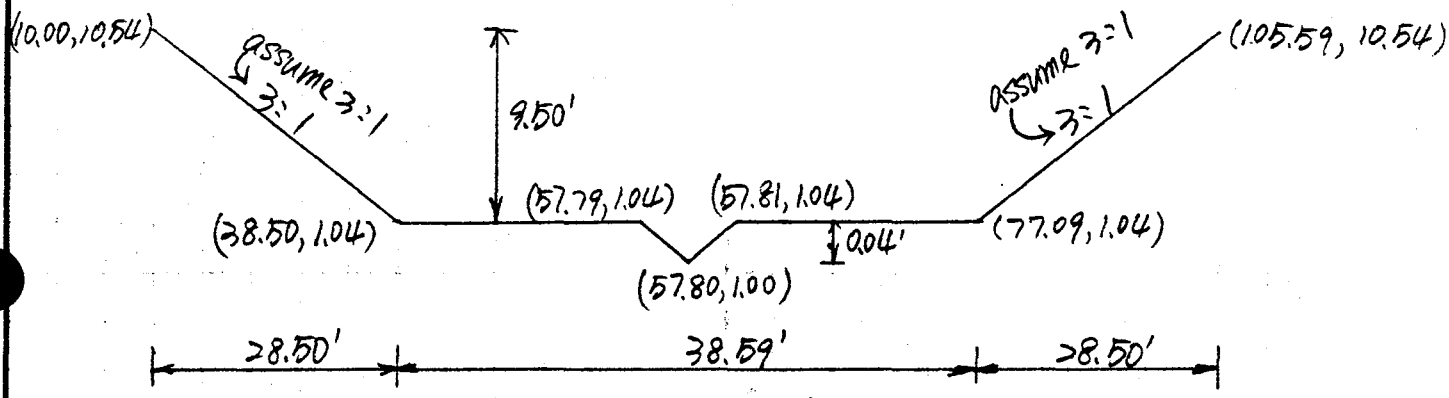
22884.65

Sec. 25 (Sta. 32+45.35)



22908.41

Sec. 26 (Sta. 32+21.59)



22908.42

Sec. 27 (Sta. 32+21.58)

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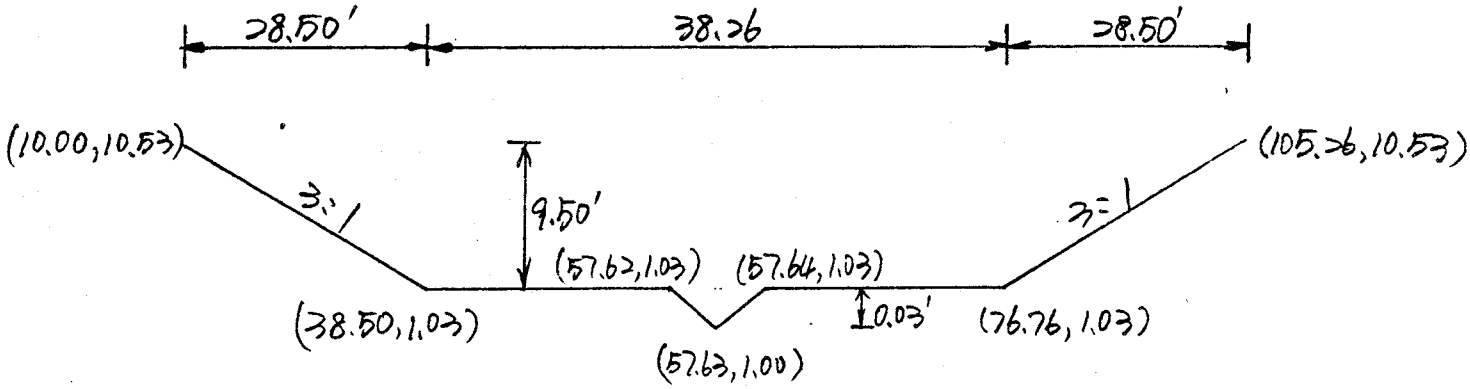
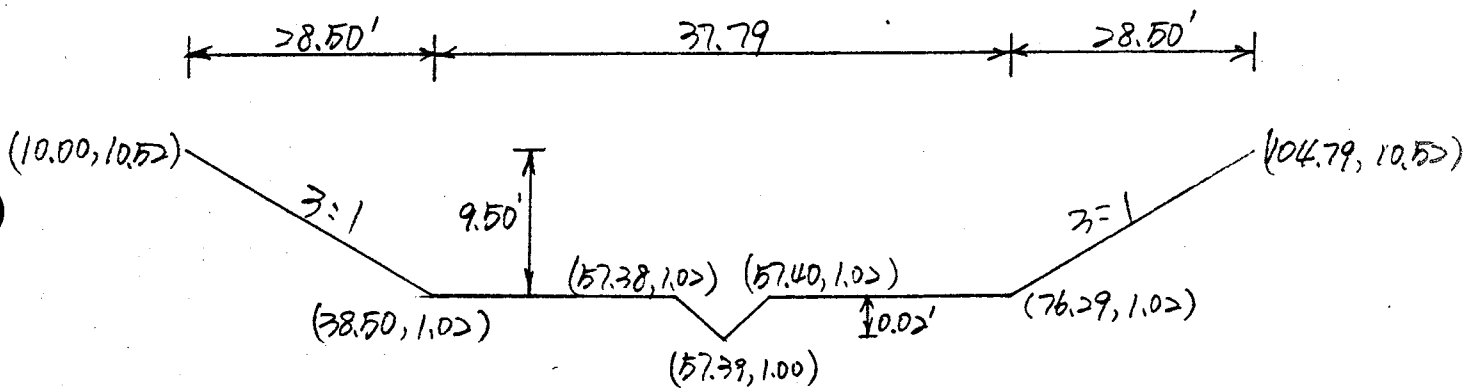
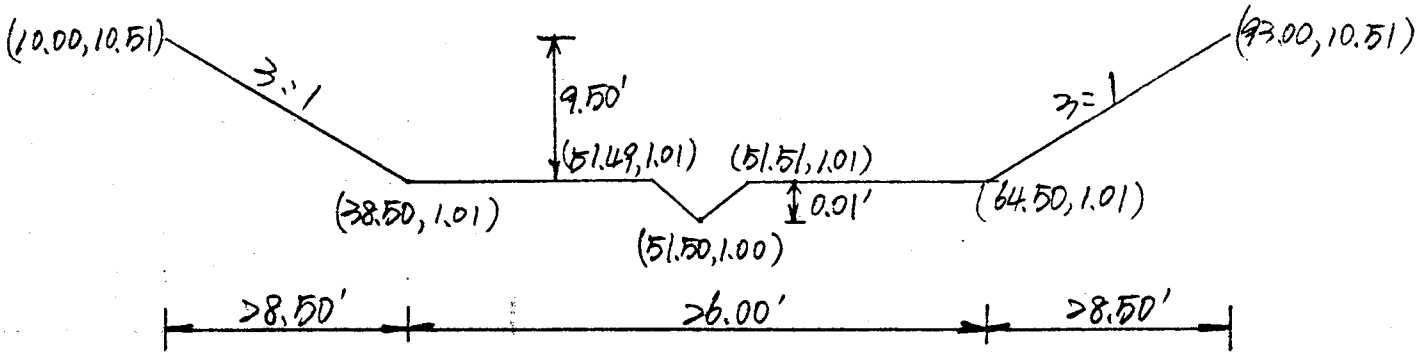


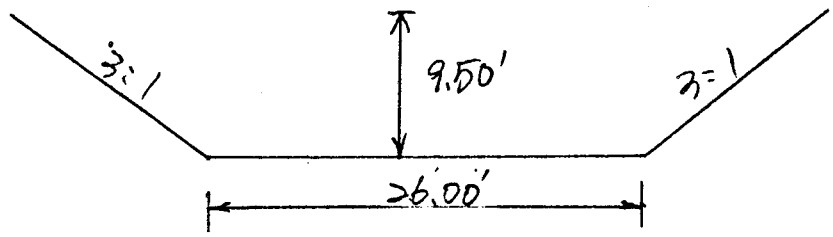
Sec. 45 (Sta. 32+19.58) >>910.42



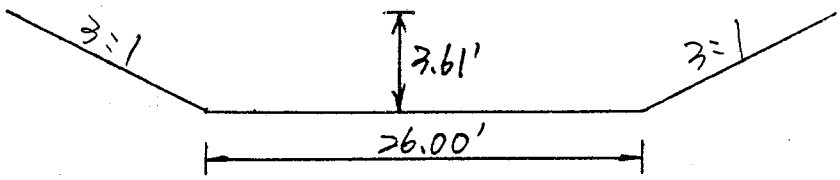
Sec. 46 (Sta. 32+17.58) >>912.42



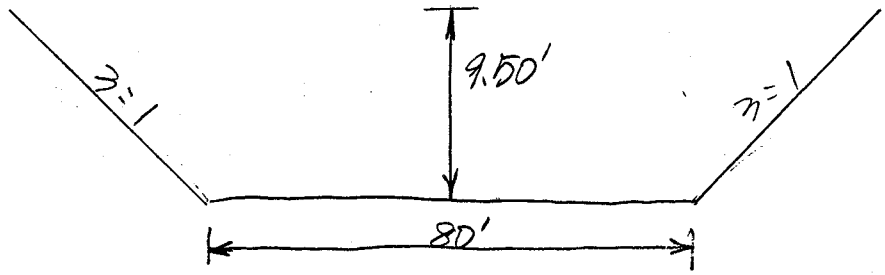
Sec. 47 (Sta. 31+68.20) >>961.80



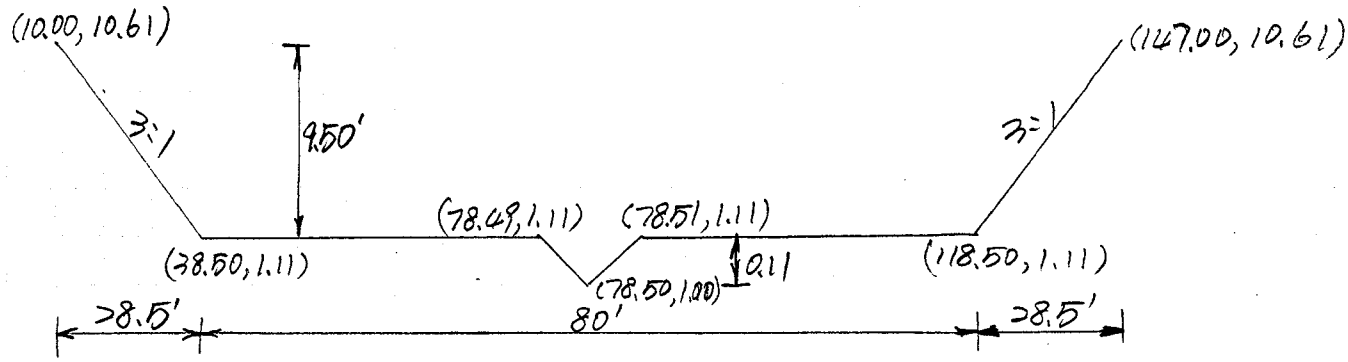
Sec. 28 (Sta. 31+48.00) 2298?.00



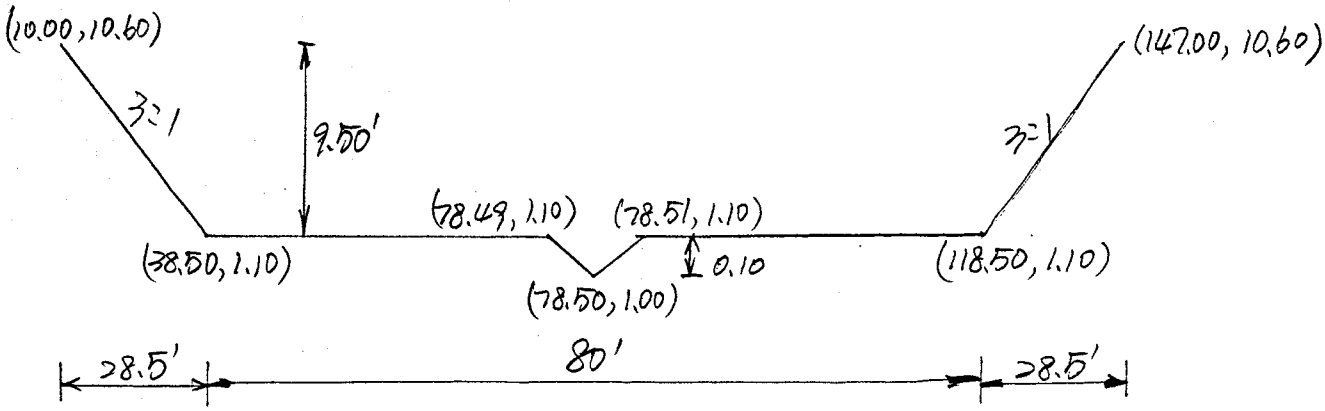
Sec. 33 (Sta. 30+50.00) 23080.00



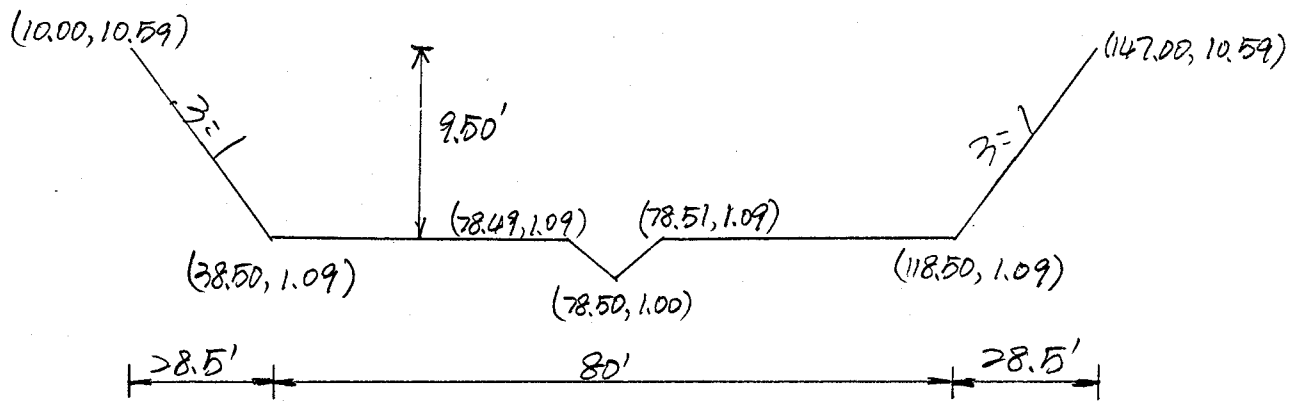
Sec. 17 (Sta. 88+94.51, 88+47.84, 86+47.84, 78+95.00)



Sec. 42 (Sta. 36+89.83 >>440.17)

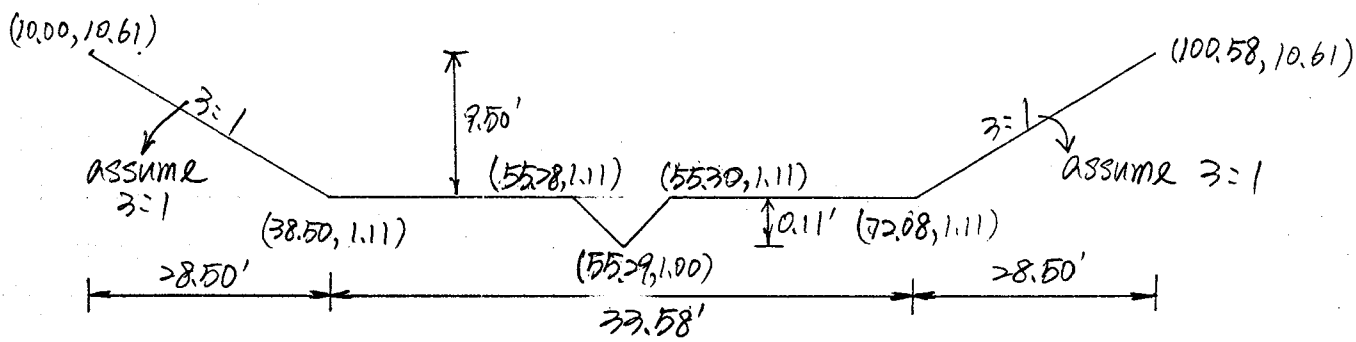


Sec. 43 (Sta. 36+84.83 >>445.17)



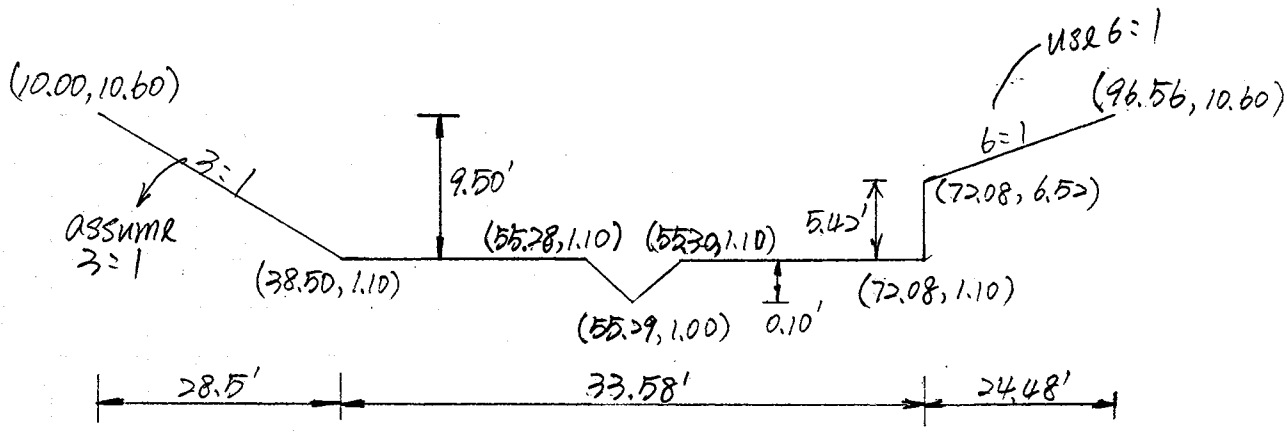
>>450.17

Sec. 44 (Sta. 36+79.83)



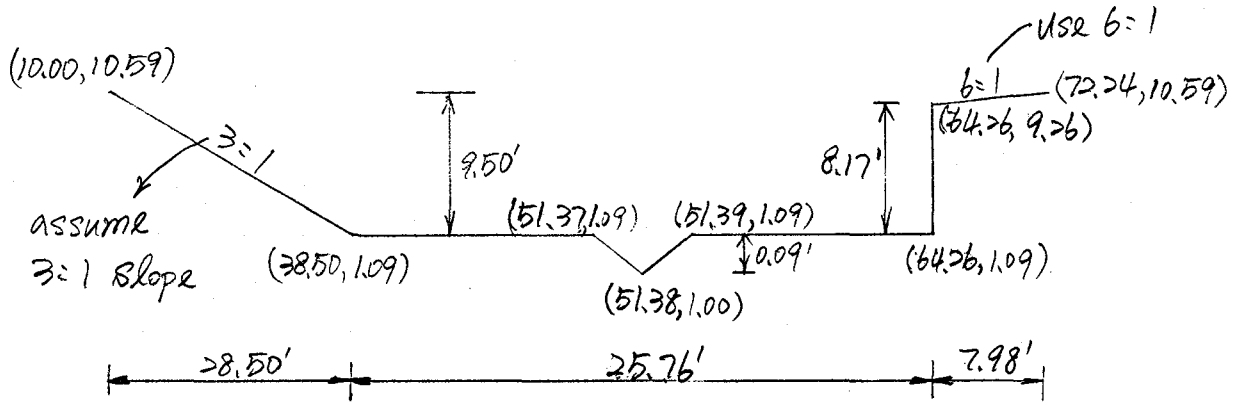
>>7>8.55

Sec. 18 (Sta. 34+01.45)

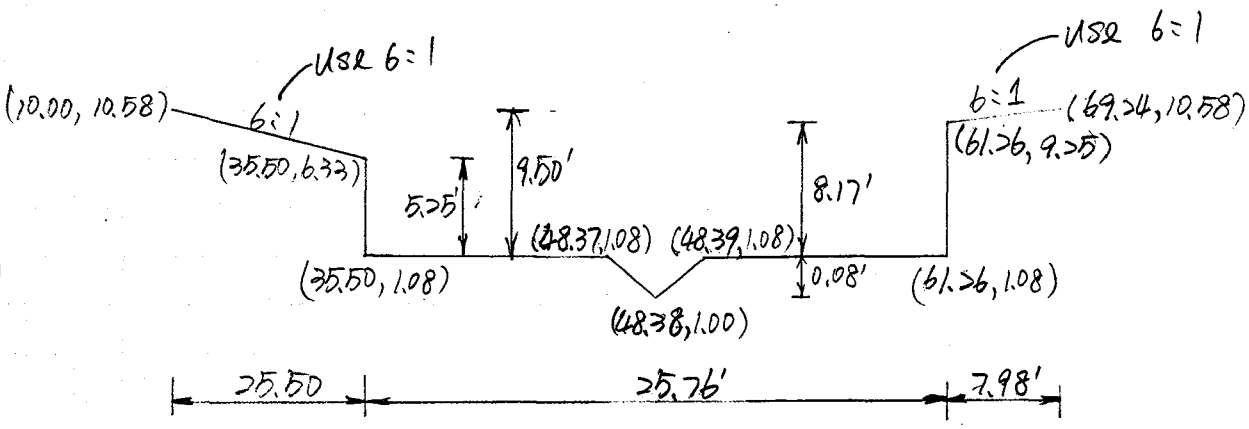


>>7>8.56

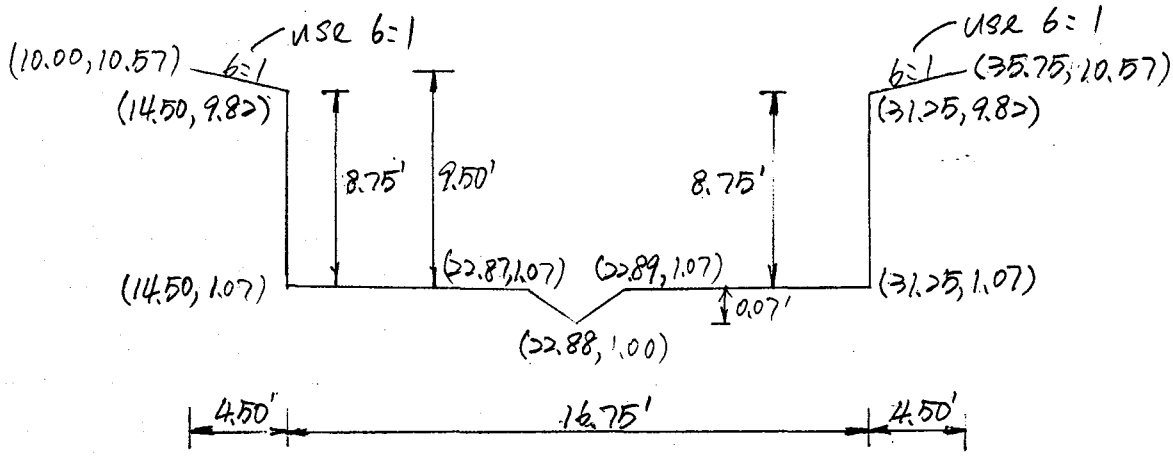
Sec. 19 (Sta. 34+01.44)



22746.42
Sec. 20 (Sta. 33+83.58)

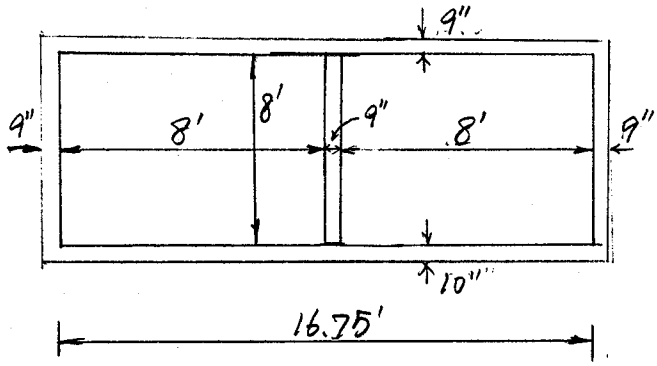


22746.43
Sec. 21 (Sta. 33+83.57)

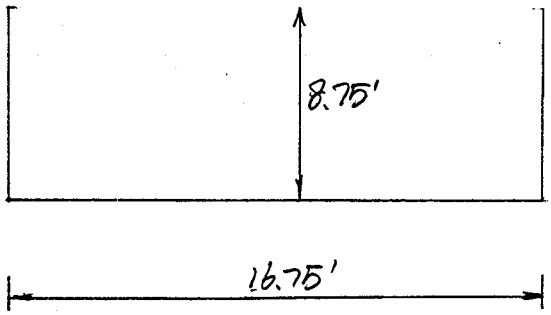


22755.00
Sec. 22 (Sta. 33+75.00)

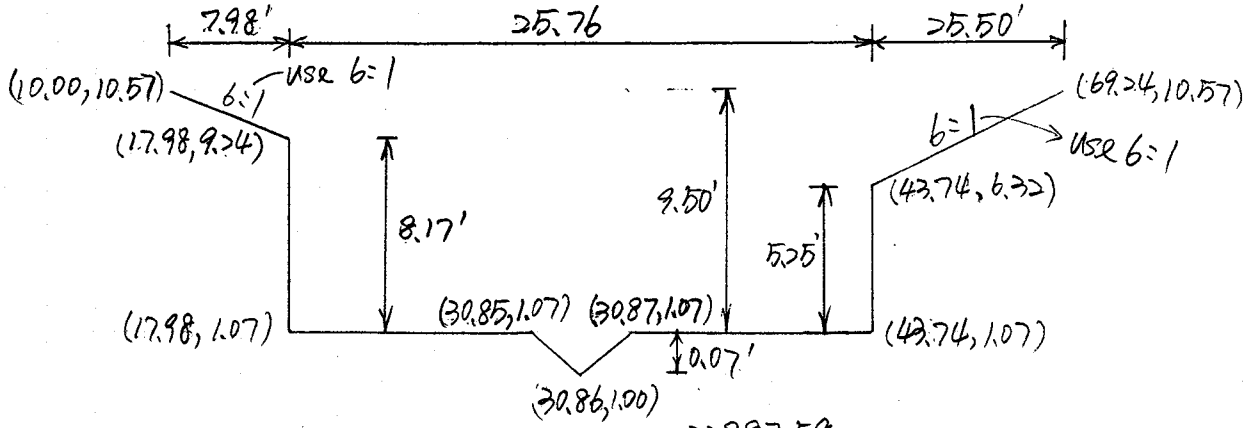
Proposed double barrel 8'x8' box culvert at Brown Rd.



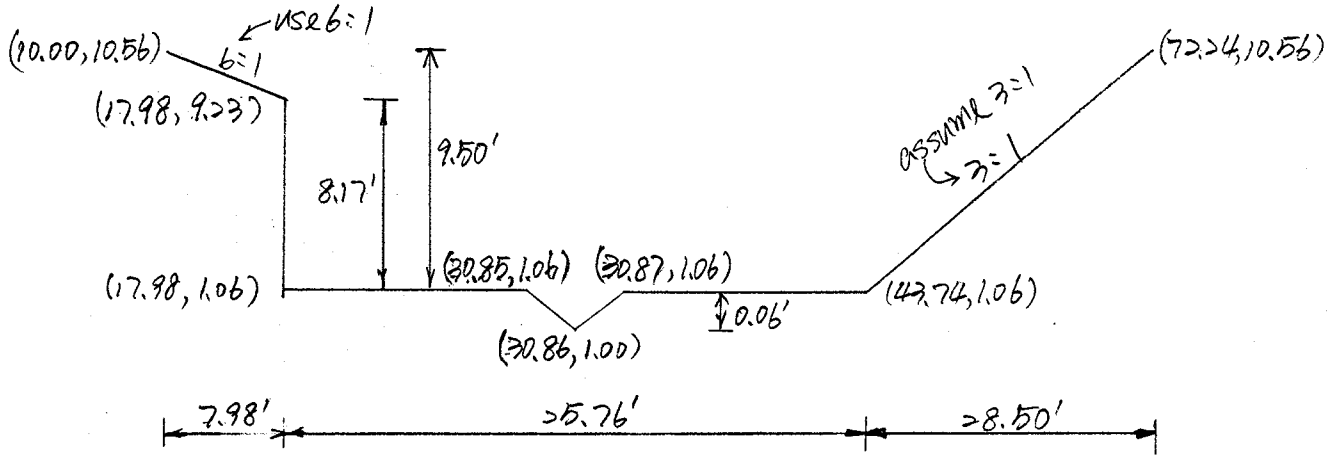
Sec. 23 (Sta. 33+74.99 (22755.01) ~ 32+50.99 (22879.01))



Sec. 48 (Sta. 33+74.99 (22755.01), 32+50.99 (22879.01))

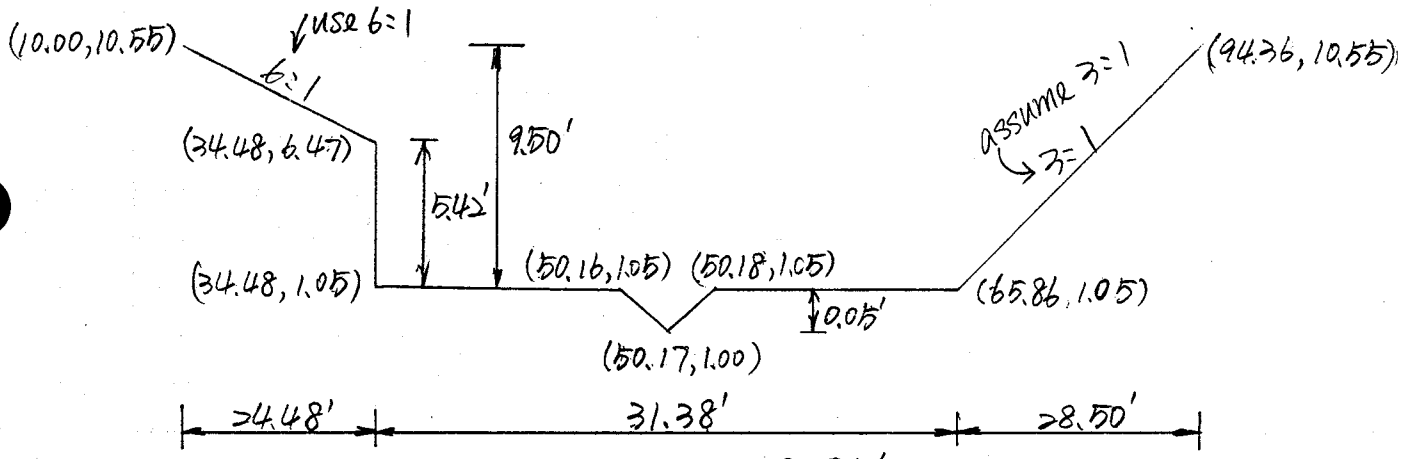


Sec. 24 (Sta. 32+42.41 (22887.59))



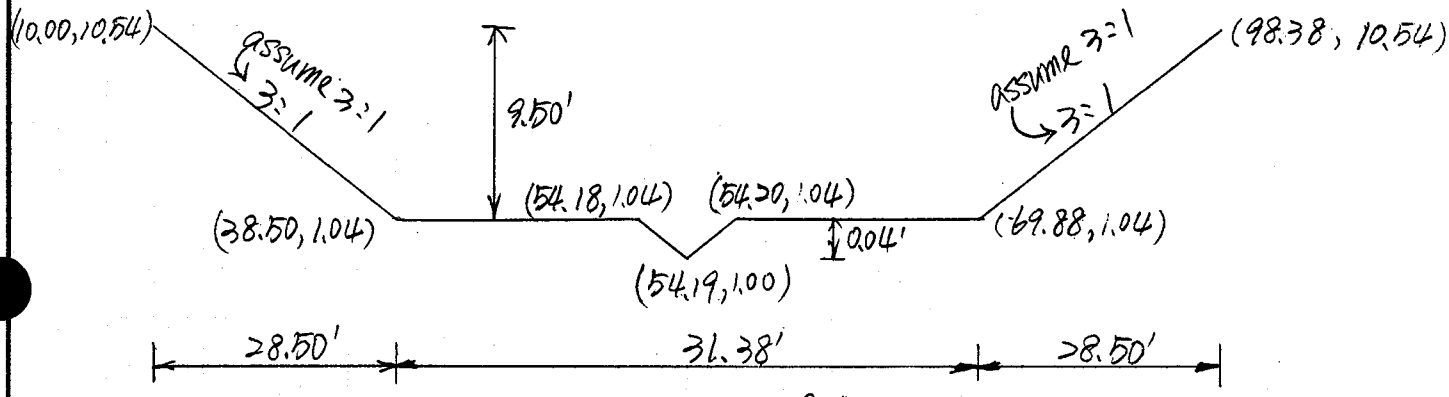
22887.60

Sec. 25 (Sta. 32+42.40)



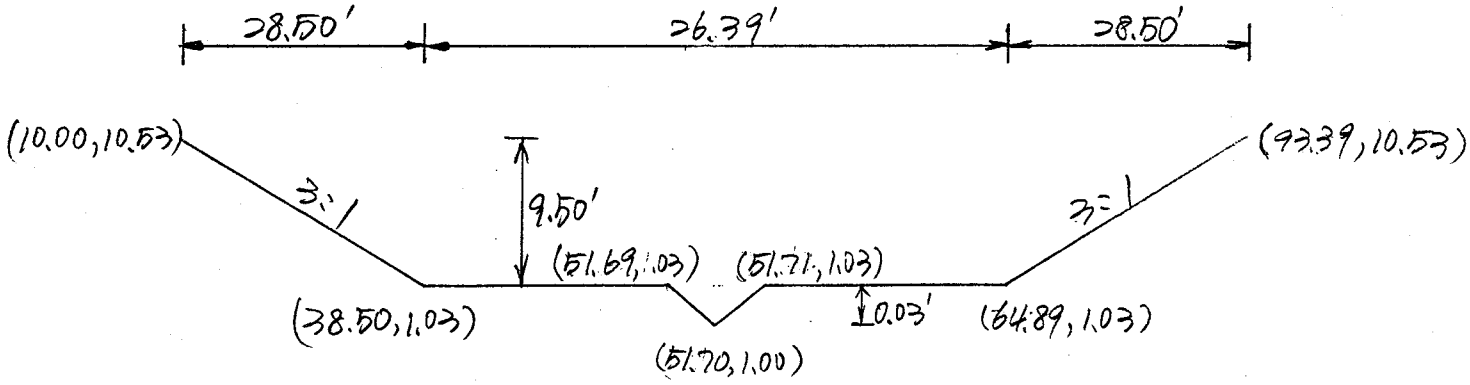
22905.46

Sec. 26 (Sta. 32+24.54)

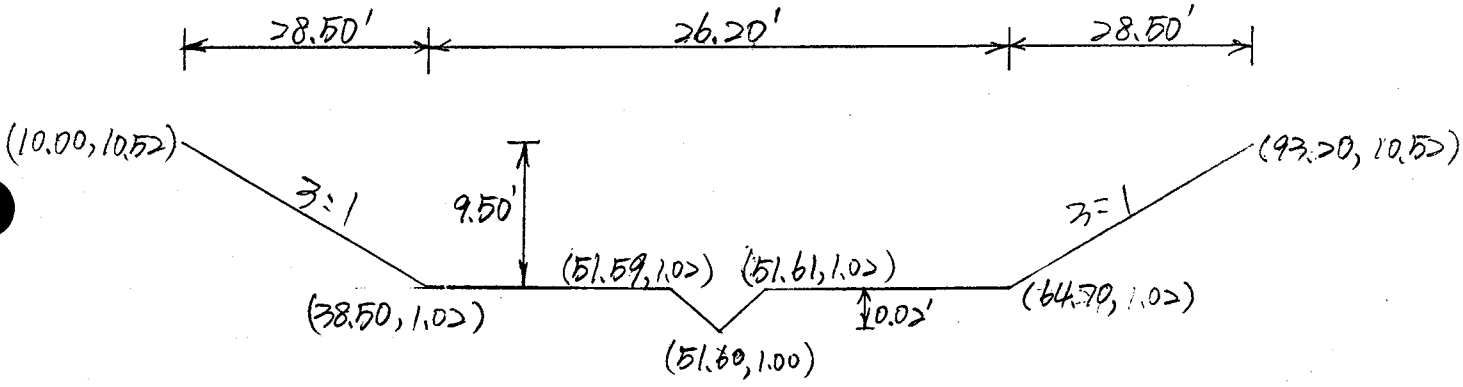


22905.47

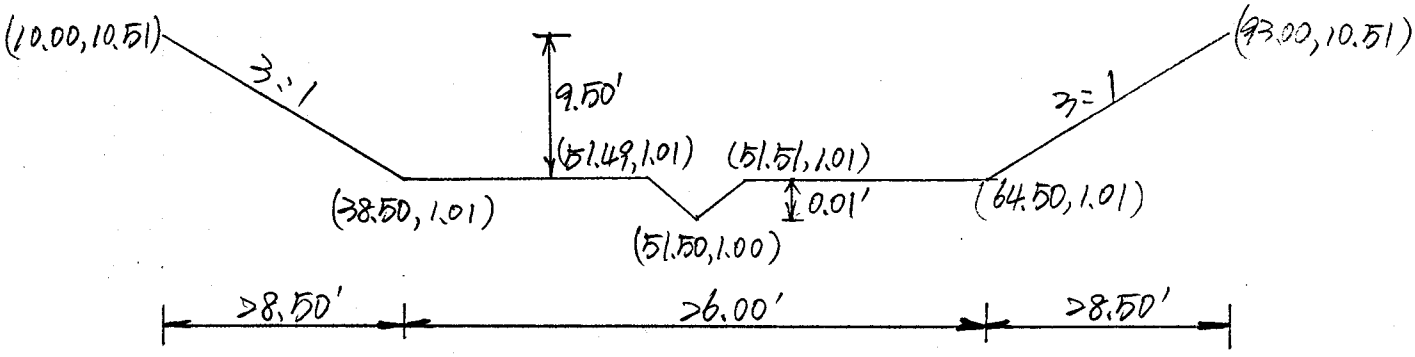
Sec. 27 (Sta. 32+24.53)



Sec. 45 (Sta. 31+75.15) >>954.85



Sec. 46 (Sta. 31+73.15) >>956.85



Sec. 47 (Sta. 31+71.15) >>958.85

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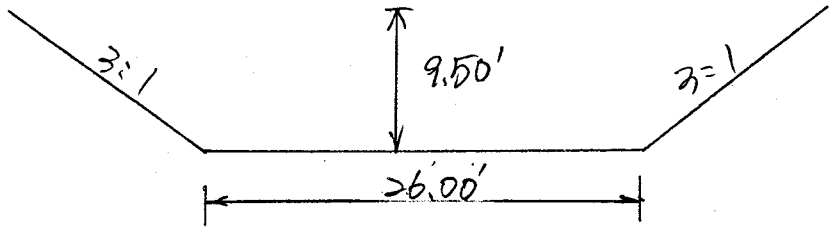
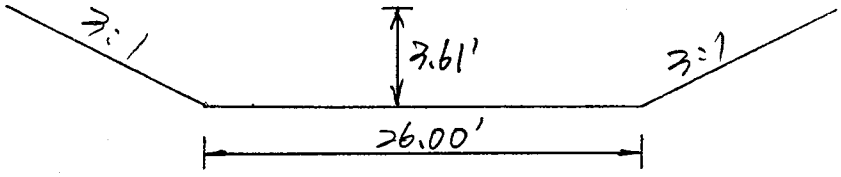


Sec. 28 (Sta. 31+48.00) 2298?.00



Sec. 33 (Sta. 30+50.00) 23080.00

3.	L BK
3.	R BK
26.	BASE
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0.023	N
0.814	DP
23.151788	AREA
31.14818803	WP
.7432788057	R
12.97293585	FPS
300.3466606	CFS

Greiner Engineering

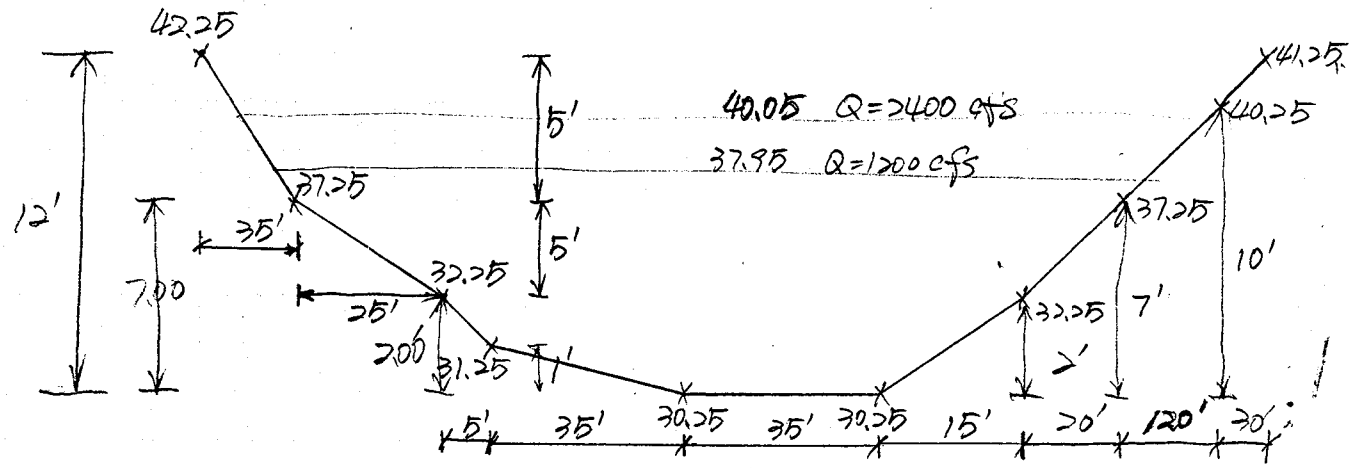
Greiner Engineering Sciences, Inc.

Tucson 602 327-3413
Phoenix 602 275-5400

Job SCS RWCD Floodway Reach 6 - E101012
Description Comparative Design Studies
Main Channel Backwater Alt. No. 1 Trial #6
Calculated by B. Gary Sun Date _____ Sheet No. _____
Checked by M.S.S. Date _____ of _____

Sta. 163+10.00 (SCS Section 15312)

n= 0.035



Sec. 1 Sta. 163+10.00 (9820.00)

Greiner Engineering

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Job SCS RWCD Floodway Reach 6 - E101012
Description Summary of Peak Flows Side Inlets
Calculated by B. Gary Sun Date 1/27/86 Sheet No. 1
Checked by M.S.S. Date _____ of 1

Summary of Peak Flows (Cont'd)

2. Design Flows for Major Side Inlets

Description	Design Flows	Spillway Width	Invert Elev.
① North of Brown Road at Sta. 30+70	196 cfs	14 ft	37.52
*② South of Brown Road at Sta. 35+18	201 cfs	50 ft	37.48
③ North of Adobe Road at Sta. 60+60	194 cfs	45 ft	37.22
④ South of Adobe Road at Sta. 64+03	116 cfs	40 ft	37.19
⑤ Powerline Easement at Sta. 80+04	cfs	ft	37.03
**⑥ North of University Drive at Sta. 89+11	600 cfs	80 ft	36.91
⑦ South of University Drive at Sta. 93+98	133 cfs	66 ft	36.85
***⑧ North of Apache Blvd. at Sta. 120+21	727 cfs	90 ft	36.53
⑨ South East of Higley Road at Sta. 128+06	500 cfs	66 ft	35.16
****⑩ Mesa Shadows East 42" S.D. at Sta. 143+66	220 cfs	30 ft	34.78
⑪ Mesa Shadows East Spillway at Sta. 150+98	17 cfs	8 ft	34.57

Notes:

* Q = 159 cfs for 54" Pipe South of Brown Road at Sta. 35+84.5 Inv. = 37.47

** Q = 20 cfs for 36" S.D. South of University Drive at Sta. 92+25 Inv. = 41.00

*** Q = 273 cfs for 72" S.D. Higley Road

**** Existing 42" Pipe capacity of 118 cfs is included Inv. = 39.46

Design Concept

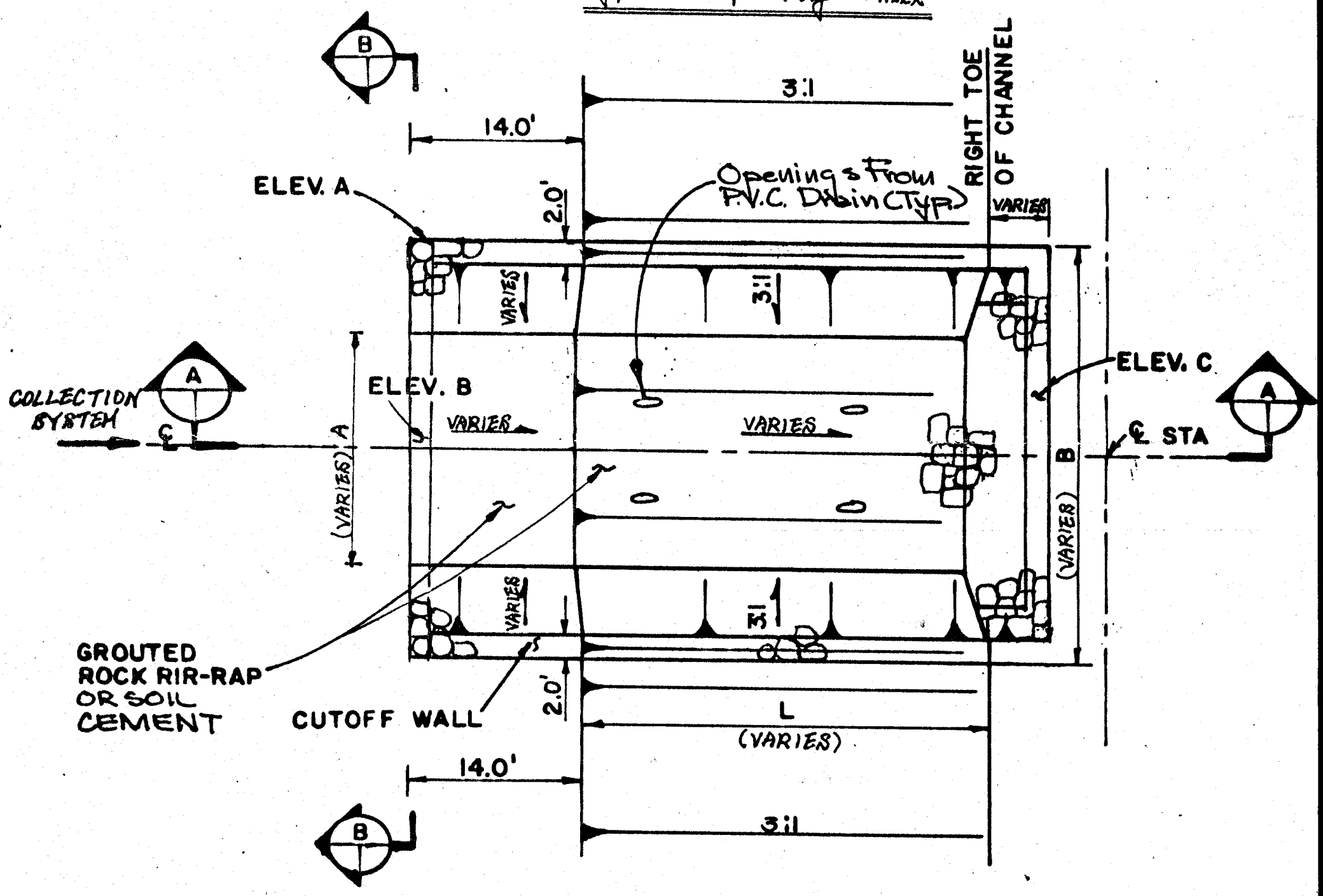
The side inlet structure was designed to drain the offsite floodwater into the RWCD floodway. The design flow is the 100-year, >4-hour storm event and is provided by the Soil Conservation Service (SCS). The range of design flows are from 17 cfs to cfs. The grade control structure with a drop spillway was used for the floodway major inlet structure. This inlet structure is placed in which the historic inlet was shown on the topographic site. The principal hydraulic elements of an inlet structure are the inlet drop, the inclined channel and the outlet drop spillway. The inlet drop consists of an overflow crest and a drop inlet with loose riprap, or grouted riprap or soilcement on a slope of 3:1 or flatter. The location of the inlet crest is limited by the right-of-way line of the floodway. The structure must be designed so that the full capacity can be discharged into the floodway. Under this consideration, the inclined earth channel with an minimum invert slope of 0.005 ft/ft is designed to provide positive drainage. The transition from the inlet to the outlet spillway is made gradually in order to reduce the head loss through the channel. The channel is a trapezoidal earth

channel with side slopes of 3:1 or flatter. The banks, with tops set at the same elevation as the nature ground, should provide adequate freeboard for full capacity in the structure. A maintenance road is placed across the channel with approaching slopes of 8:1. The invert to the outlet drop spillway is generally set low enough so that the flow at the spillway crest will have adequate freeboard to maintain floodwater inside the spillway. The outlet invert at the toe of spillway is set at the same invert of the floodway. The outlet drop spillway is a trapezoidal shaped grouted riprap or soil cement structure with side slopes of 3:1 and an invert slope of 3:1. The backwater analysis was made for all the inlet structures by using "WSPG" program for full- and no-flow conditions in the floodway.

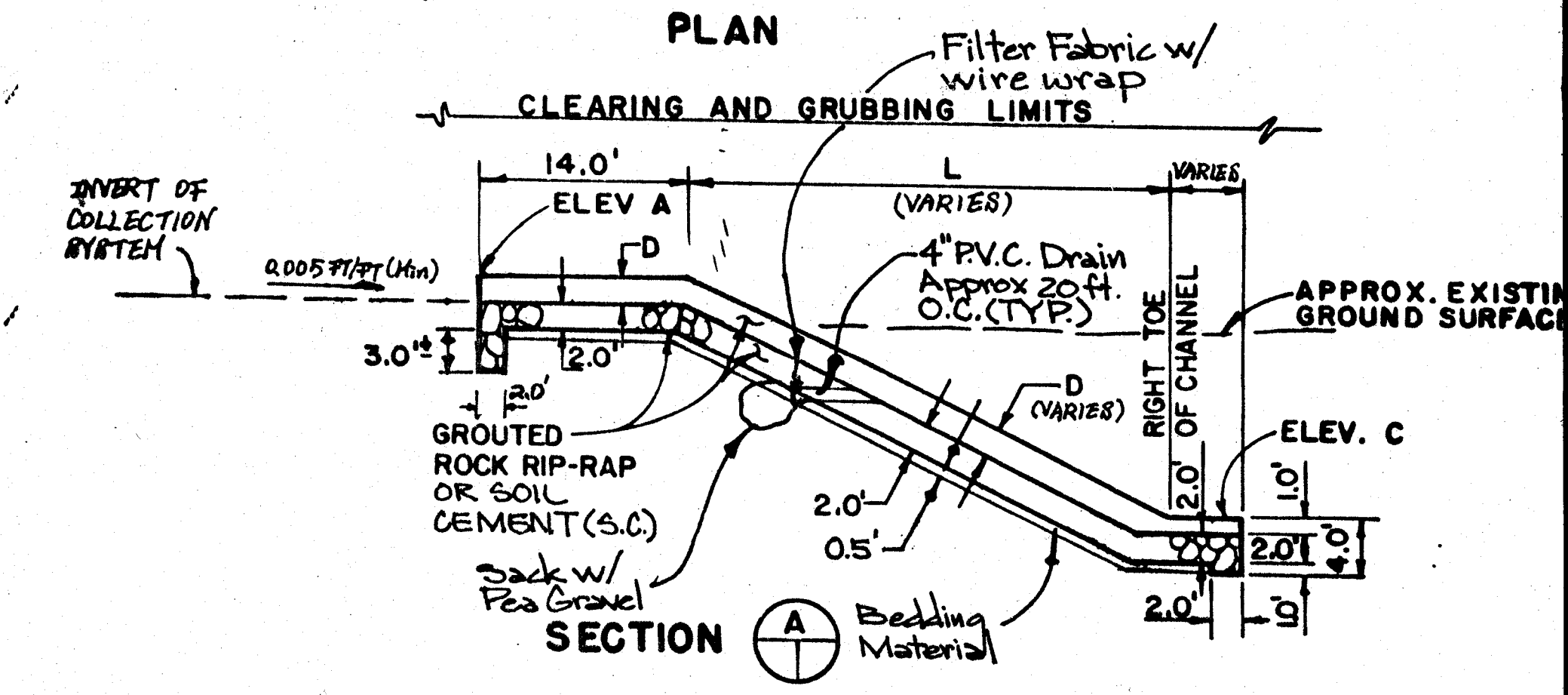
Addendum: 2/4/86

A large collection system is necessary to convey storm water into the spillway. The reason for this is that it is very hard to define the direction of overland flows with a relatively flat slope at the site. It is recommended to use this system in order to handle the runoff of this area. A structure details of typical spillway inlet is attached (An exception was made on the spillway of the northern terminus of project.).

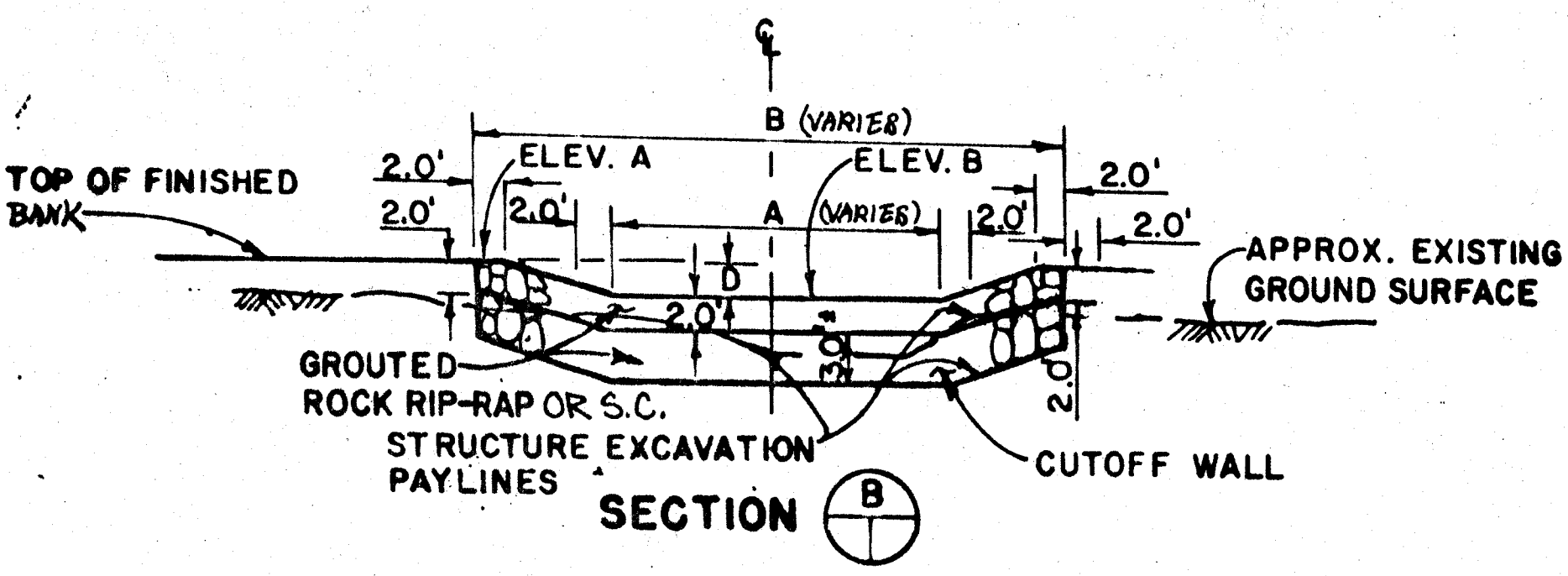
Typical Spillway Inlet



PLAN



SECTION



SECTION

Design Procedure

The following steps and criteria were followed in the design of the major inlet structures:

1. Determine the design flow for the 100-year, 24-hour storm event by making the hydrologic analysis for either the split of the floodwater on the roadway or the offsite discharge from the adjacent subdivision.
2. Establish the location of the inlet structure. Arbitrarily set the spillway width and determine the inverts through the structure. There are no criteria on transitions to side inlet structures unless the inlet is an actual channel.
3. A backwater analysis is performed for the design flow using the WSPG program for the full-flow condition in the floodway. Spillway width is adjusted if necessary to satisfy the freeboard requirements inside the inclined channel. Freeboard for a trapezoidal section channel should be provided as follows:

   Subcritical velocity: $0.2\,H_e$ where H_e = specific energy head $= d + \frac{V^2}{2g}$

   Supercritical velocity: $0.25\,d$ where d = calculated depth of flow

One foot of freeboard will not required within the collection system to the inlet structure.

Design Procedure (Cont'd)

4. If freeboard requirements have been met, another backwater analysis is performed for the no-flow condition in the floodway. The inclined channel should meet the freeboard requirements. If not, redesign the structure and repeat the previous third step.

5. After determining that the structure is adequate, an erosion analysis must be performed through the structure. Apron should be sized if necessary to protect the floodway. (See Section 8 for erosion protection)

Hydraulic Properties

The grade control structure with a drop spillway is easily designed, built, and operated. This type of side inlet structures has been performed successfully on all the major inlets at relatively low heads. Flows upstream from the crest of the spillway are generally at subcritical velocity, with critical velocity occurring when the water passes over the crest. Flows in the spillway are ordinarily maintained at supercritical stage (when no flow in floodway) until the floodway is reached. Most of inlet structures are maintained non-erosive velocities (under 3 ft/sec) before approaching the outlet drop spillway. From hydraulic analysis, grouted riprap or soil cement should be extended 14 feet from spillway crest to the upstream channel in order to prevent erosion of the channel floor. The criteria of freeboard are based on SCS "Engineering Design Standards for Far West States". Due to the constriction of the right-of-way of the floodway, it is impossible that the inclined channel can meet the criteria of 12.5° for transitions to fit the alinement to the outlet spillway. A grouted riprap apron, or soil cement apron is designed according to the outlet velocity at the entrance of the floodway for the no-flow condition.

Design Details

The floodway has twelve major inlet structures: 1- north of Brown Road (Q=196 cfs), 2- south of Brown Road (Q=360 cfs), 3- the powerline easement approximately 3/4 mile south of Brown Road (Q= cfs), 4- north of Adobe Road (Q= 194 cfs), 5- south of Adobe Road (Q= 116 cfs), 6- north of University Drive (Q= 600 cfs), 7- existing 36-inch storm drain pipe just south of University Drive Bridge (Q=20 cfs), 8- south of University Drive (Q= 133 cfs), 9- north of Apache Trail (Q=1000 cfs), 10- south east of Higley Road (Q= 500 cfs), 11- existing 42-inch storm drain pipe approximately 1,230 feet north of Broadway Road (Q=220 cfs), and 12- existing spillway at MESA SHADOW EAST approximately 500 feet north of Broadway Road (Q= 17 cfs).

The hydraulic designs of these structures are described as follows:

1. North of Brown Road at the northern terminus of the floodway (See Files NBROWN1.DAT, NBROWN1.OUT, QNBROWN1.OUT, NBR1.OUT, NBROWN2.DAT, NBROWN2.OUT & QNBROWN.OU (Sta. 30+70): The inlet structure has a 14 foot spillway width with a carrying capacity of 196 cfs. The spillway has 27 feet in length and the same invert slope as the inclined channel. The length of this channel is 158 feet with an invert slope of 0.0381 ft/ft. The channel has a series of reverse curves with radius of 135 feet and

Design Details (Cont'd)

1. (Cont'd) 95 feet from upstream to downstream respectively. The channel has a varying bottom width and depth, from 1.26 feet bottom and a 2.05 feet of depth at Sta. 29+15 to a 9.52 feet bottom and a 5.97 feet of depth at Sta. 30+05 to a 14 feet bottom and a 7.87 feet of depth at Sta. 30+43.36. Water surface profile computations show the structure to function adequately at the downstream of Sta. 30+05. The floodwater will overtop the banks at the upstream of Sta. 30+05 but should be picked up within the structure prior to the spillway crest. Erosion analysis will be done to protect the structure and the floodway. (See Section 8)

2. South of Brown Road at Sta. 35+18

The 54 inch storm drain pipe has the capacity of 159 cfs. The inlet structure is designed to discharge 201 cfs of floodwater with a 50 foot spillway width. Two alternates are exercised here. Alternate No. 1 is to remove part of the gunite channel and to extend the 54 inch pipe into the floodway. The gunite channel should be removed to the right-of-way of the Brown Road and a inlet structure is designed to have adequate capacity.

Design Details (Cont'd)

2. (Cont'd) The headwall of the 54 inch pipe is removed and a new manhole is placed. A 108 lineal feet of 54 inch pipe is installed from the manhole to the floodway with a positive slope of 0.0143 ft/ft. Also a bleed-off 18 inch pipe would be installed to the east and discharge into a drywell. The result of the STORM program showed the 54 inch pipe has a carrying capacity of 159 cfs. Water surface profile computations show that erosion analysis must be made between Sta. 10+69 and Sta. 11+64. Velocity of 4.91 fps should be used to size the apron. (See computer printouts in separate cover) Alternate No. 2 is a modified Alternate No. 1 with a negative slope from the manhole to the floodway and with a plunge basin containing weep holes in the floodway. (See Section 8 for details) No additional "STORM" run has been made for this alternate. A 50 foot retaining wall will required adjacent to the main channel bank due to grade differencial.

Design Details

4. North of East Adobe Road at Sta. 60+60

The recommended design flow at East Adobe Road is 310 cfs by SCS. The hydraulic analysis of the proposed roadway shows that the design flow of 194 cfs is recommended for the north inlet and the rest of 116 cfs should be used for the south inlet. Side inlet structure has two inlets. The south end inlet, which is adjacent to the north side of East Adobe Road, is designed to have a capacity of 110 cfs. The north east end inlet is located at the right-of-way of the floodway. Two water surface profile computations has been made for each condition (full- or no-flow condition). The first run is used a design flow of 194 cfs from Sta. 10+00 to Sta. 11+34.5 and used a design flow of 84 cfs for the upstream of Sta. 11+34.5 up to the north east end inlet. The second run is made for the south portion of the inlet with a capacity of 110 cfs and a given water surface elevation at the junction from the first run. A velocity of 5.0 fps should

Design Details (Cont'd)

4. (Cont'd) be used for the apron design. Addition erosion analysis should be done for the junction area which has a velocity of 4.25 fps. This structure has a 45 foot spillway width. (See Section 8)

5. South of East Adobe Road at Sta. 64+03

The inlet structure has a 40 foot spillway width and a design capacity of 116 cfs. Water surface profile computations show that a velocity of 4.40 fps should be used for apron design and erosion analysis should be done at Sta. 11+81 (V= 8.13 fps). This analysis shows additional 6 feet of channel protection needed at Sta. 11+81 to Sta. 11+75. (See Section 8)

6. North of University Drive at Sta. 89+11

The inlet structure has a 80 foot spillway width and a design capacity of 600 cfs. The inclined channel has an invert slope of 0.015 ft/ft in order to meet freeboard requirements. Water surface profile calculations show that a velocity of 6.05 fps should be used for apron design and erosion analysis should be done at Sta. 11+29 and Sta. 10+82. This analysis shows additional 6 ft of channel protection needed at Sta. 11+29 to Sta. 11+23. (See Section 8)

Design Details (Cont'd)

7. As-built 36 inch pipe just south of University Drive at Sta. 92+30

As per City of Mesa as-built plan for 36 inch pipe at University Drive, the maximum capacity of the pipe is found to be 20 cfs. Adjustment of minus 1.00 foot in elevations has been made to correspond to Greiner's datum. Installation of MAG detail no. 502 headwall with trashrack is recommended.

8. South of University Drive at Sta. 93+98

The inlet structure has a 66 foot spillway width and a design capacity of 133 cfs. A velocity of 2.96 fps should be used for apron design. (See Section 8)

11. As-built 42 inch pipe at Mesa Shadows East Sta. 143+66

As per City of Mesa as-built plan for 42 inch pipe, the maximum capacity of the pipe while full-flow condition in the floodway is found to be 118 cfs. No adjustment have been made in elevations. The inlet structure has a 30 foot spillway width and a design capacity of 220 cfs. Greiner's recommendation is to remove headwall and 16 lineal feet of 42 inch pipe and to rebuilt the headwall. A velocity of 5.77 fps

Design Details (Cont'd)

11. (Cont'd) should be used to design the apron at the floodway channel bottom. Also protection is needed at the outlet of the 42 inch pipe where the velocity is 18.39 fps. The inclined channel and maintenance road have to be protected due to this high velocity.

12. Mesa Shadows East Spillway at Sta. 150+98

This inlet structure has an 8 foot spillway width and a design capacity of 17 cfs. A velocity of 3.69 fps should be used for apron design.

The decision has been made by SCB to eliminate the design of major side inlets at the Apache/Higley intersection from the Comparative Design Study. (See memorandum dated 2/3/86) Therefore, Structures 9 and 10 will be designed in the preliminary design phase.

Major Inlet Structures

Description:

The Major inlet structures in Reach 6 approach the floodway at a right angle, which in the no-flow condition indicates that the flow discharges into a channel with no defined boundaries. After reviewing the available literature, there was no design guide which deals with this situation directly, particularly as it relates to the design of the outlet apron.

The following publications were examined for design information:

TR-25
Hydraulic Design of Stilling Basins and Energy Dissipators
Design of Urban Drainage Systems.
HEC14
HEC15
Highways in the River Environment
Design of Small Dams
Hydraulic Design Manual - L.A. County
SCS-Chute Spillways Engr. Handbook

Don Paulis was contacted on 1-14 and asked if he was aware of any literature on the subject of outlet aprons and he indicated that he did not know of any SCS publications which addressed the subject. Previous practice on other SCS projects has been to size the aprons based on the engineers experience and judgement.

The basic concept for the inlet structures (as per Harry) is to provide a loose rip rap inlet and a grouted rip rap outlet. The loose rip rap inlet presents a problem due to the 3:1 slope in the direction of flow. This condition is analyzed as a channel with bottom slope of 3:1 (33%) and the required rock sizes were found to unrealistically large.

This would indicate that the inlet side of the structures are not an appropriate place to call for loose riprap. As an example, HEC15 design chart (Chart 27) does not consider slopes as great as 33%. (20% max. in HEC15)

Recommendations: Based on the above statements and the apron dimensions shown on the plans for Reach 3, the following recommendations are made:

The side inlets proposed in Reach 3 approach the floodway at a right angle and have aprons that range from 10' to 35' in length. The dimensions are summarized as follows:

Spillway Width	Apron Length	Q
10'	12'	
25'	30'	
68'	35'	

Typically, the aprons are grouted rip rap for a distance and then loose rip rap to the end of the apron. The entire flow area is grouted on the floodway slope. It is recommended that previous SCS designs that have a record of successful performance under design conditions be used as a guide to arrive at appropriate apron dimensions for Reach 6.

In addition it is recommended that loose riprap NOT be used on the inlet side of the structure. The rip rap should be grouted or installed in wire baskets so that a realistic rock size can be used.

Additional Considerations: Another approach to the apron design would be to consider designing the apron such that the velocity at the end of the apron was within the allowable velocity for the floodway itself based on the tractive power method. This concept would involve several assumptions necessary to simplify the analysis.

1) Assume normal depth some distance downstream of the spillway.

2) Compute velocities based on normal depth, and an assumed apron width.

3) The length of apron required would be the distance for the velocity to reduce on a 0% grade to the allowable velocity in the floodway.

- Estimate of Quantities -

Major Inlet Structures.

General Notes:
Apron dimensions used are representative of ones in Reach 3.
Thickness of riprap blanket taken as 18" from Reach 3.
Filter material will be calculated as 6" sand bedding.
All riprap is grouted riprap. (Explanation in memo to file).

Major Inlet Structure N. of Univ. Drive Q = 600 cfs.
Coverage of riprap = 7188 ft^2 Depth = 18"
Assumed apron length = 35'
Volume of grouted riprap = 399 yd^3
Volume of bedding = 133 yd^3

Major Inlet Structure S. of Univ. Drive Q = 133 cfs
Coverage of RipRap = 10381 ft^2
Assumed Apron Length = 35'
Volume of grouted riprap = 577 yd^3
Volume of bedding = 192 yd^3

Major Inlet Structure at Sta 143+66 Q = 220 cfs
Coverage of riprap = 7155 ft^2
Assumed Apron Length = 30'
Volume of grouted riprap = 398 yd^3
Volume of bedding = 133 yd^3

Major Inlet Structure at Sta 150+98 Q=17.
Coverage of Rip Rap = 1750 ft²
Assumed Apron Length = 10'
Volume of grouted rip rap = 97 yd³
Volume of bedding = 32 yd³

Major Inlet Structure SE corner Apache/Higley Q = 96
Coverage of riprap = 6852 ft²
Assumed apron length = 30 ft.
Volume of grouted riprap = 381 yd³
Volume of bedding = 127 yd³

Major Inlet Structure N. of Adobe Rd. Q = 194
Coverage of rip rap = 9606 ft²
Assumed apron length = 30'
Volume of grouted riprap = 534 yd³
Volume of bedding = 178 yd³

Major Inlet Structure S. of Adobe Rd. Q = 116
Coverage of riprap = 5437 ft²
Assumed apron length = 30'
Volume of grouted riprap = 302 yd³
Volume of bedding = 101 yd³

Major Inlet Structure S. of Brown Rd. Q = 201
Coverage of Rip Rap = 6687 ft²
Assumed apron length = 30'
Volume of grouted riprap = 372 yd³
Volume of bedding = 124 yd³

Greiner Engineering

Greiner Engineering Sciences, Inc.

Tucson 602 327-3413
Phoenix 602 275-5400

Job: SCS RWCD Reach 6
Description: Erosion Protection for Major Inlet Structures
Calculated by: R Beck Date: 1-30-86 Sheet No. 1
Checked by: B.G.S. Date: _____ of 2

Major Inlet Structure N. of Univ. Drive Q_{100} = 600 cfs.

Coverage of loose riprap. 452 ft²
Coverage of grouted riprap. 6736 ft²
(Assumed apron length = 35')

Major Inlet Structure S. of Univ. Drive. Q = 133

Coverage of loose riprap = 3808 ft²
Coverage of grouted riprap 6573 ft².
(Assumed apron length = 35')

Major Inlet Structure at Sta 143+66 Q = 220 cfs
need [illegible]
[illegible]

Coverage of loose riprap = 2160 ft²
Coverage of grouted riprap = 4995 ft²
(Assumed apron length = 35')

Major Inlet Structure at Sta 150+98 Q = 17 cfs

Coverage of loose riprap = 630 ft²
Coverage of grouted riprap = 1120 ft²
(Assumed apron length = 10').

Major Inlet Structure SE corner Apache/Higley Q = 96

Coverage of loose riprap = 3381 ft²
Coverage of grouted riprap = 3471 ft²
(Assumed apron length = 30')

Greiner Engineering

Greiner Engineering Sciences, Inc.

Tucson 602 327-3413
Phoenix 602 275-5400

Job: SCS RWCD Reach 6
Description: Erosion Protection for Major Inlet Structures
Calculated by: R. Beck Date: 1-30-86 Sheet No. 2
Checked by: B.G.S. Date: of 2

Major Inlet Structure N. of Adobe Rd. Q = 194

Coverage of loose riprap = 5038 ft²
Coverage of grouted riprap = 4568 ft²
(Assumed apron length = 30').

Major Inlet Structure S. of Adobe Rd. Q = 116

Coverage of loose riprap. = 2104 ft²
Coverage of grouted riprap. 3333 ft²
(Assumed apron length = 30')

Major Inlet Structure S. of Brown Rd. Q = 201

Coverage of loose riprap. 1800 ft²
Coverage of grouted riprap. 4887 ft²
(Assumed apron length = 30').

Greiner Engineering

Greiner Engineering Sciences, Inc.

Tucson 602 327-3413
Phoenix 602 275-5400

Job

Description

Calculated by M.C. Date Sheet No. 1

Checked by B.G.B. Date of 1

Quantities and Costs for inlet structure North of University

Item	Quantity c.y.	unit cost $	Total Cost
Excavation	1478	1	1478
Riprap	736	40	29,440
Filter	197	8	1,576

GREINER ENGINEERING SCIENCES, INC.
RECORD OF TELEPHONE CONVERSATION

DATE: 1-14-86 TIME: 8 : AM E-101012
JOB NUMBER

PERSON CALLED: Don Paulis ADDRESS:

REPRESENTING: SCS. PHONE NUMBER: 241-5143

NAME OF CALLER: Randall Beck PHONE NUMBER: 2601551

ADDRESS: REPRESENTING: Greiner

DETAILS OF CONVERSATION:

I called to request information about spillway apron design for inlets approaching the floodway at a right angle. I asked for SCS publications that dealt with this topic and Don indicated that this type of spillway outlet is not covered in any of the SCS literature. His recommendation was to look at previous RWCD projects and see what was proposed. He indicated that the designs in previous projects were left up to the Engineers judgement and no analytical procedure was used.

REPLIES:

Randall Beck
(Name and Title)

Distribution

Anderson-Nichols
4120 North 20th Street
Phoenix, Arizona 85016
(602) 957-3681

Woodrow C. Scoutten, P.E.
Vice President

September 10, 1985

Ms. Kebba Buckley
Flood Control District of
Maricopa County
3335 West Durango Street
Phoenix, AZ 85009

Re: RWCD Reach 6 Hydrology
East Maricopa County Master Drainage Plan

Dear Ms. Buckley:

Enclosed is the information requested by the Soil Conservation Service's letter dated July 16, 1985 (copy attached). Their letter requested particular channel inflow design information for one location along the RWCD Reach 6.

We have remodeled the watershed for this area based on the selected alternative scheme and have enclosed a sketch displaying the new 100-year peak discharges along Reach 6.

If you have any questions or comments, please feel free to call myself or Darrel Wood.

Sincerely,

ANDERSON-NICHOLS & COMPANY, INC.

L Steve Miller

Steve Miller, P.E.
Project Engineer

SM/sld

enclosures

cc: Mr. Harry Millsaps
Soil Conservation Service

United States
Department of
Agriculture

Soil
Conservation
Service

Suite 200
201 E. Indianola Ave.
Phoenix, AZ 85012

July 16, 1985

Dan Sagramoso
Chief Engineer and General Manager
Flood Control District of Maricopa County
3335 West Durango Street
Phoenix, AZ 85012

RE: RWCD, Reach-6 Hydrology

Dear Dan:

From the results of our hydrology study of the subject area and the proposals of the Master Drainage Plan by Anderson/Nichols we propose that Greiner Engineering (our A&E design firm for this reach) design the inlets for RWCD, Reach 6 for the maximum inflow whether present or future condition.

In taking this approach, we will need additional information for the major inlet proposed in the Anderson/Nichols Master Drainage Plan which will enter 1150 cfs into the RWCD Floodway through a lined channel along the power line easement just south of Adobe Road.

The following information is requested by September 6, 1985, in order for Greiner Engineering for proceed with their design.

1. Exact channel alignment
2. Confirmed inflow rate (cfs)
3. All hydraulic characteristics of the channel (i.e., velocity, slope, depth of flow, etc.).
4. Channel invert elevations
5. Channel cross sections

If the information can not be provided by the requested date then we would propose to have Greiner Engineering design a temporary inlet to handle the present condition using a capacity of 200 cfs. Then when the Master Drainage Plan is implemented, the larger 1150 cfs inlet would be designed and installed by others.

Please let me know if you will be able to supply the required information.

Verne M. Bathurst
State Conservationist

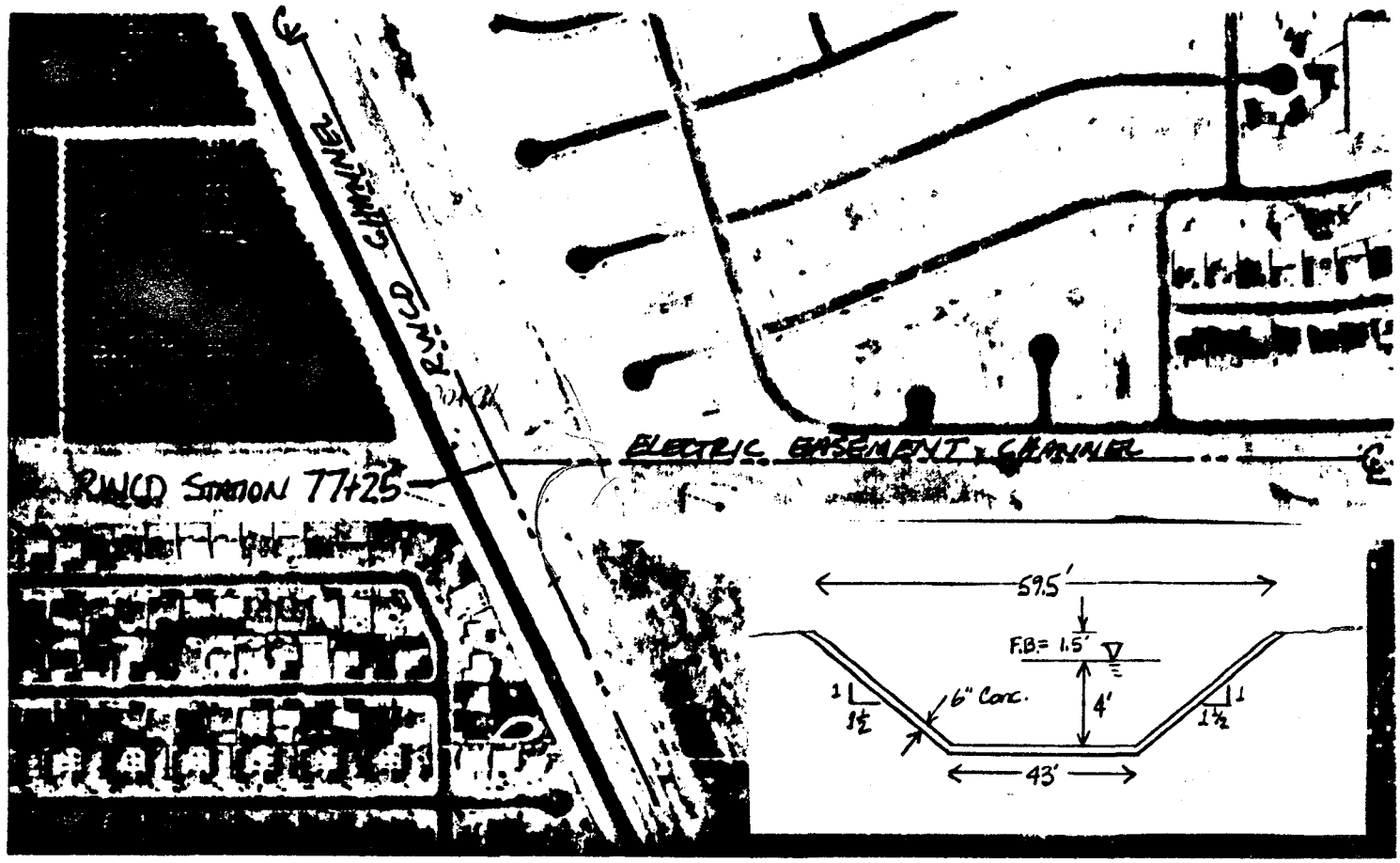
cc: Ralph Arrington, SCE
Bill Payne

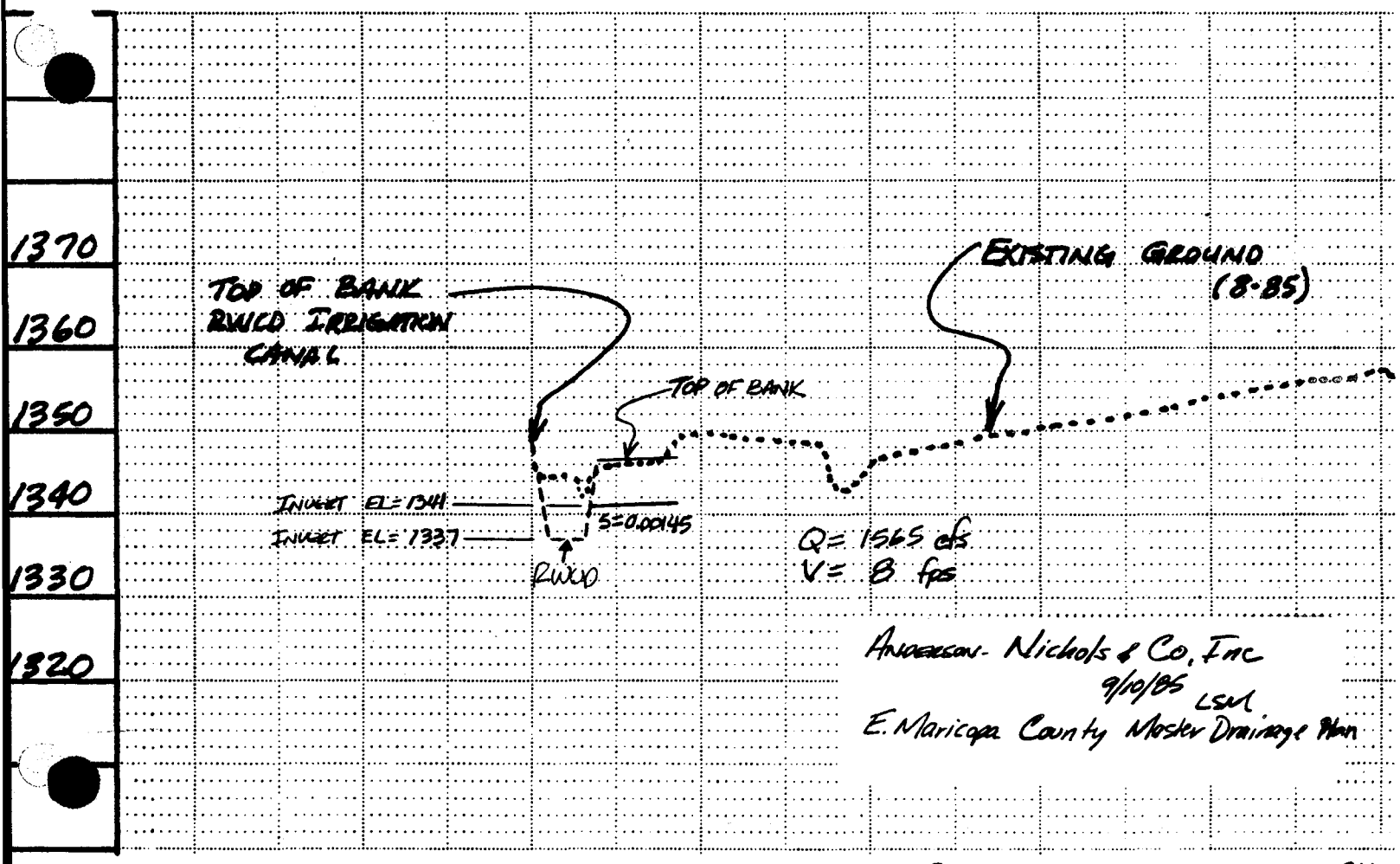
FLOOD CONTROL DISTRICT
'85

HYDRO

3 KEB KEB

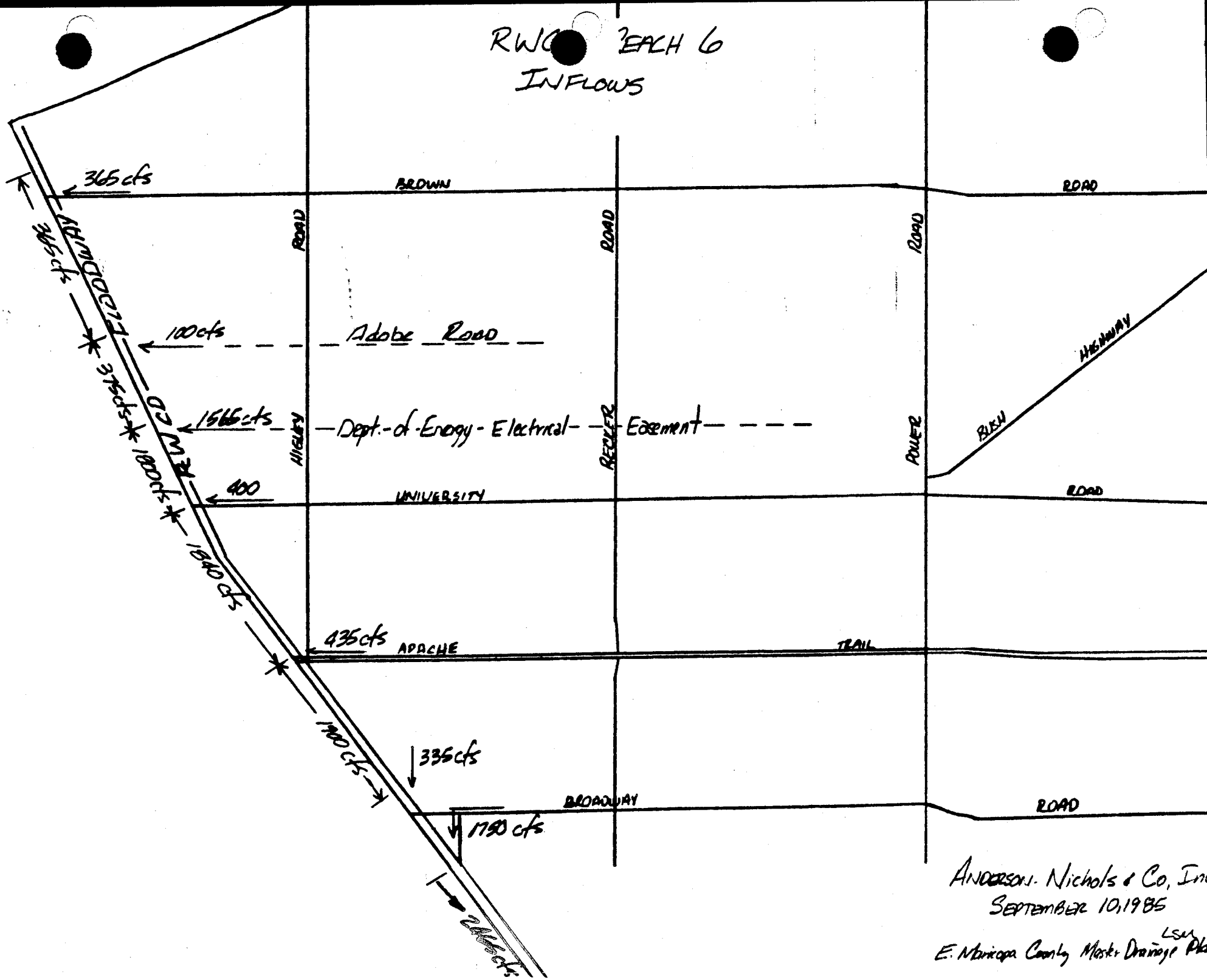
The Soil Conservation Service
is an agency of the
Department of Agriculture





Anderson-Nichols & Co, Inc
9/10/85 LSM
E. Maricopa County Master Drainage Plan

RWC REACH 6
INFLOWS



Anderson-Nichols & Co, Inc
September 10, 1985
LSM
E. Maricopa County Master Drainage Pla

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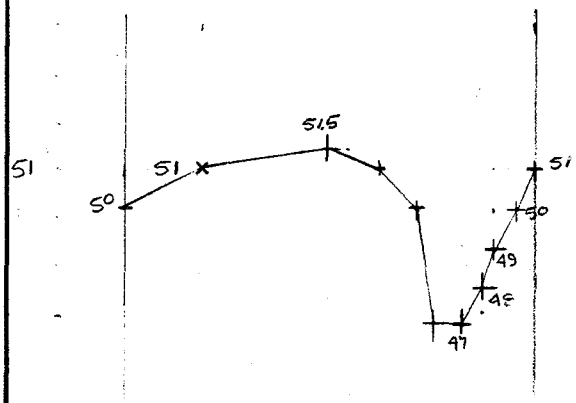
Job 1"=5' VERT. / 1" = 50" HORIZ.

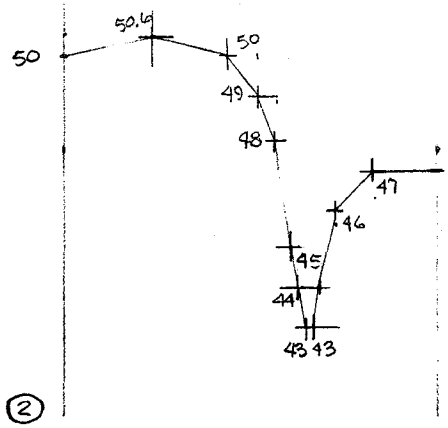
Description RWCD REACH 6

Calculated by D. Ryb-5/ Date 9/29/85 Sheet No. 1

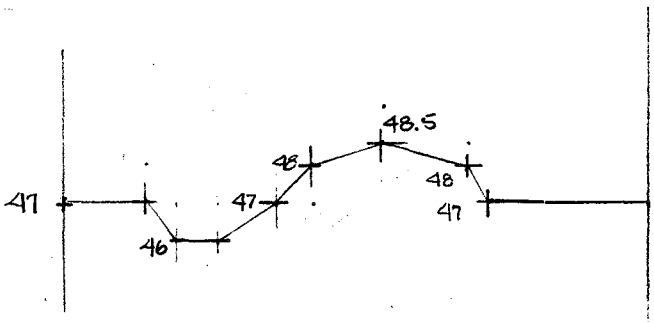
Checked by M.S.S Date of 3



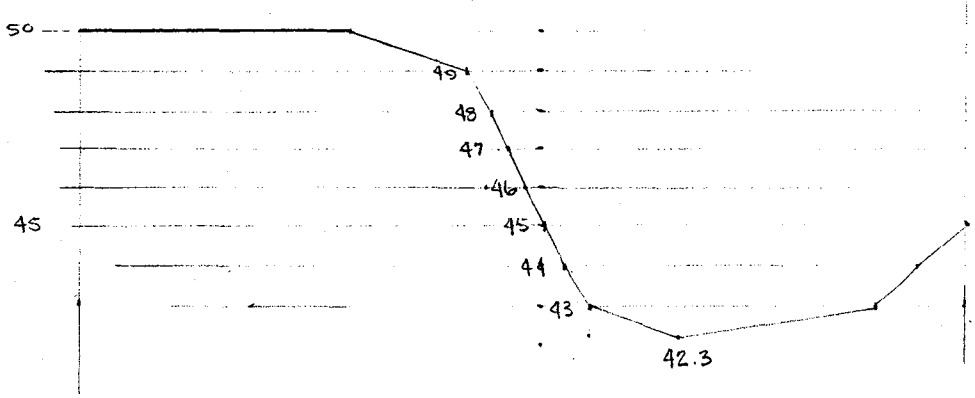
① 317' EAST OF ℄ ON BROWN RD.



② 72' EAST OF ℄ ON BROWN RD.



③ ADOBE ROAD



④ TRANSMISSION ESMT.

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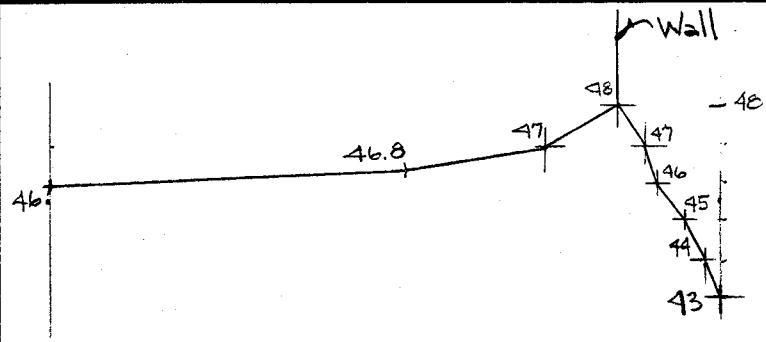
Job 1" = 5' VERT. / 1" = 50' HORIZ.

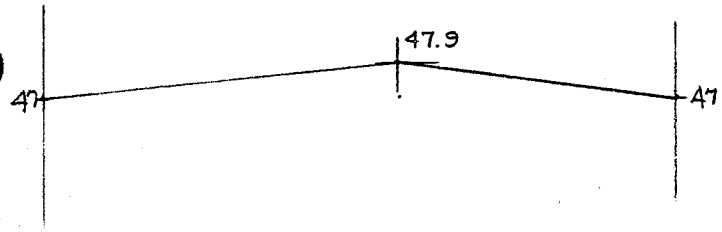
Description RUCD REACH 6

Calculated by D. Rudy Anderson Date 9/29/85 Sheet No. 2

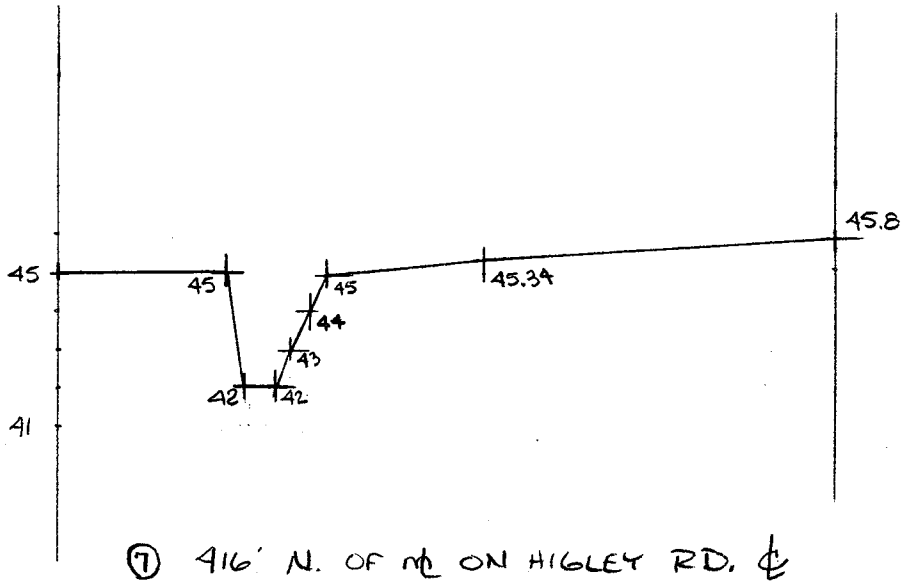
Checked by M.S.S. Date _____ of 3



(5) 270' EAST OF ℄ ON UNIVERSITY



(6) APACHE 345' E OF ℄



(7) 416' N. OF ℄ ON HIGLEY RD. ℄

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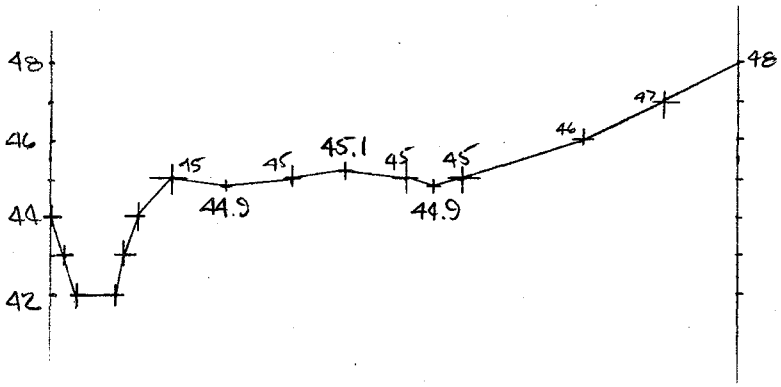
Job 1"=5' VERT. / 1"=50' HORIZ.

Description RWCD REACH 6

Calculated by D.R. Merber Date 9/29/85 Sheet No. 3

Checked by M.S.S. Date _____ of 3



(8) 295' N. OF ℄ ON HIGLEY RD. ℄

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Job RWCD Floodway Reach 6 - E101012
Description Comparative Design Studies

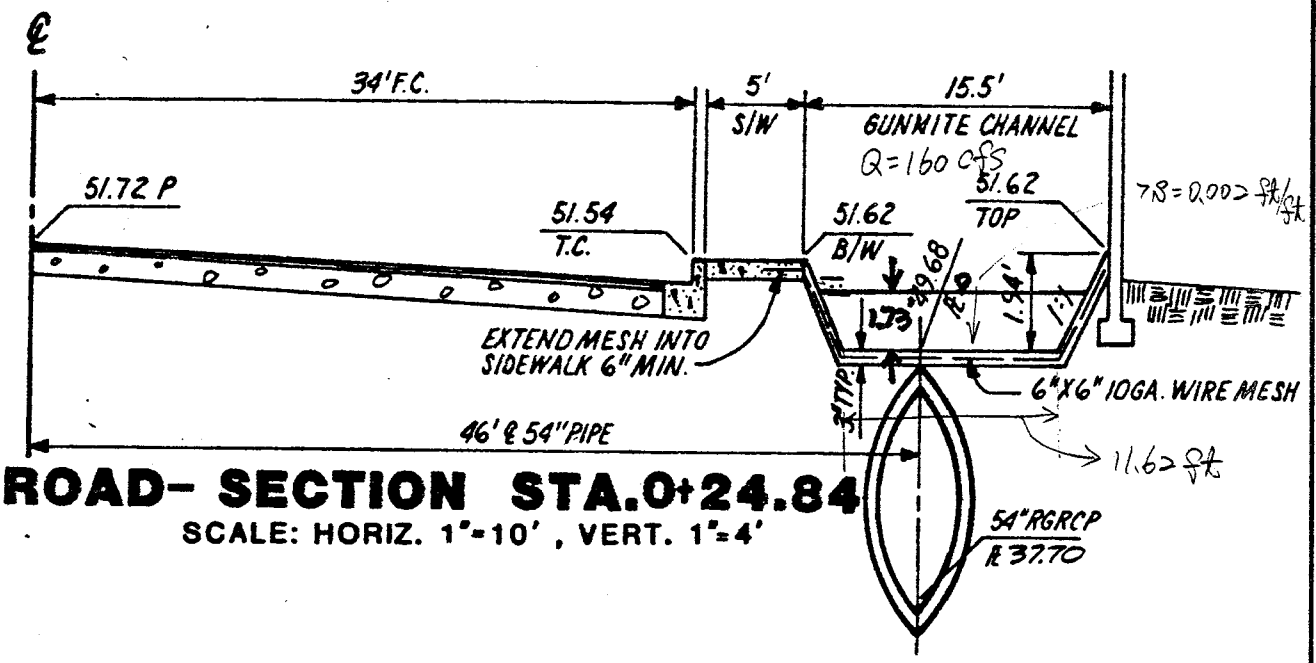
Calculated by Gary Sun Date 10/15/85 Sheet No. 1
Checked by M.S.S. Date _____ of _____

* Future Improvement (Sundance Groves)

Brown Road Sta. 0+24.84
d = 1.94'

```
ENTER X AND Y VALUES
      51.62
          0.
      49.68      10/23
       1.94
      49.68
      13.56      1.94'
      51.62
       15.5

      26.3064          =A
 17.10714862          =WP
       0.002          =SF
       0.015          =N

        160.          =Q
35.05200848
36.11415307

     155.272          =Q
35.05200848
35.04697985
```

```
ENTER X AND Y VALUES
      51.41
          0.
      49.68
       1.73
      49.68
      13.35
      51.41
      15.08
d=1.73 ft
      23.0955          =A
16.51317893          =WP
       0.002          =SF
       0.012          =N

        160.          =Q
28.88730693
28.89132245
```



BROWN ROAD- SECTION STA.0+24.84

SCALE: HORIZ. 1"=10', VERT. 1"=4'

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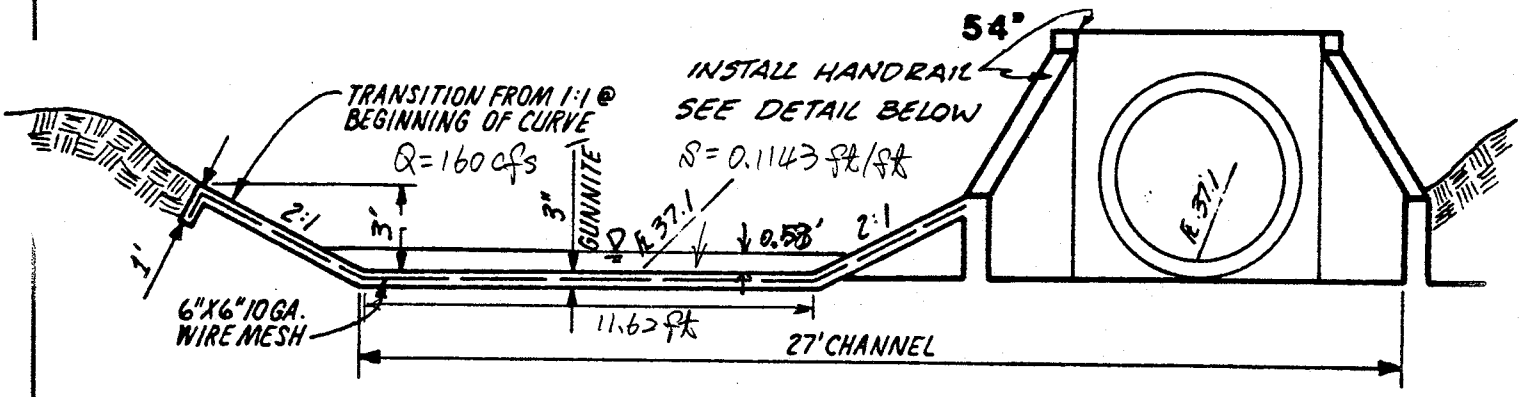
Job RWCD Floodway Reach 6 - E101012
Description Comparative Design Studies

Calculated by Gary Sun Date 10/15/85 Sheet No. 2
Checked by M.S.S Date _____ of _____



SECTION X-X

SCALE 1"=5'

Side Inlet from E. Brown Road to Floodway

```
ENTER X AND Y VALUES
      37.63
         0.
       37.1
       1.06
       37.1
      12.68     d=0.53'
      37.63
      13.74

     6.7204          =A
13.99023206          =WP
     0.1143          =SF
      0.013          =N

       160.          =Q
4.120998437
4.140200851
```

d=0.53 ft.

```
ENTER X AND Y VALUES
      37.68
         0.
       37.1
       1.16
       37.1
      12.78     d=0.58'
      37.68
      13.94

     7.4124          =A
14.21383885          =WP
     0.1143          =SF
[redacted]           =N

       160.          =Q
4.801344889
4.777154829

       161.          =Q
4.801344889
4.807012046
```

d=0.58 ft.

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Job SCS RWCD Floodway Reach 6 - E101012

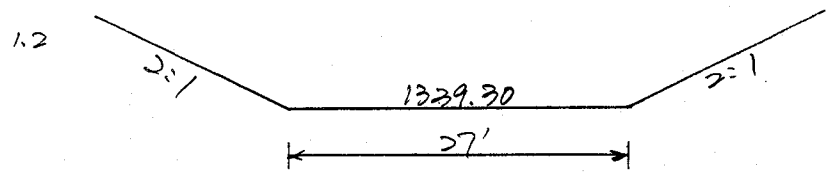
Description Comparative Design Studies
Future Improvements for Sundance Groves

Calculated by B. Gary Sun Date 10/23/85 Sheet No. 3

Checked by M.S.S. Date _____ of _____

Dirt Channel

$S_o = -0.0293$ (37.10 from H.W. to 39.30)
$n = 0.035$



$d = 2.0$ ft

2.	1.	1.3	1.32	1.4	1.42
0.	0.	0.	0.	0.	0
0.	0.	0.	0.	0.	0.
4.	2.	2.6	2.64	2.8	2.84
0.	0.	0.	0.	0.	0.
31.	29.	29.6	29.64	29.8	29.84
2.	1.	1.3	1.32	1.4	1.42
35.	31.	32.2	32.28	32.6	32.68

```
ENTER X AND Y VALUES
          1.42
            0.
            0.
          2.84
            0.
         29.84
          1.42
         32.68
```

$d = 1.42$ ft

```
       42.3728        =A
 33.35043306          =WP
        0.0293        =SF
         0.035        =N

          360.        =Q
 49.71021202
 49.53565677
```

Flow line elevation 39.30 (sheet 25 of 32)

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Job RWCD Floodway Reach 6 - E101012

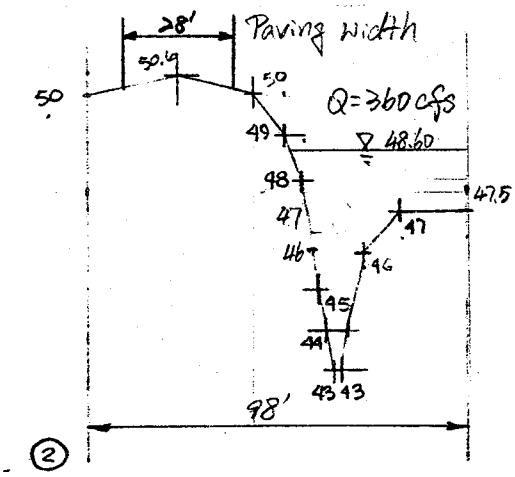
Description Comparative Design Studies
Hydraulics for Side Inlets

Calculated by Gary Sun Date 10/9/85 Sheet No. 4

Checked by MS-S Date _____ of _____

Cross Section #2: 72 ft. Lt. of ℄ of floodway on Brown Road
Near Sundance Groves

1. Determine mean n value = 0.035



72' EAST OF ℄
ON BROWN RD.

Q = 160 cfs

```
ENTER X AND Y VALUES
          48.6
            0.
           48.
           2.5
           45.
           6.5
           44.
           8.5
           43.
          10.5
           43.
          12.5
           46.
          18.5
           47.
          28.5
          47.2
          45.5
          48.6
          45.5

        109.85        =A
49.20238396        =WP
         0.002        =SF
         0.035        =N

          360.        =Q
187.6976965
189.5993036

          358.        =Q
187.6976965
188.5459741

          355.        =Q
187.6976965
186.9659799

          356.        =Q
187.6976965
187.4926447
```

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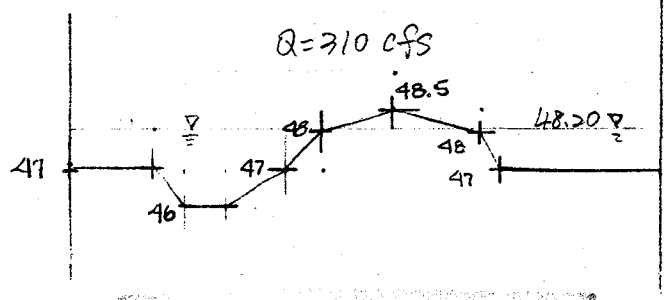
Job SCS RWCD Floodway Reach 6 - E101012
Description Comparative Design Studies

Calculated by B. Gary Sun Date 10/23/85 Sheet No. 5
Checked by M.S.S. Date _____ of _____

Adobe Road
$S_o = -0.0032$ (Sundance Groves Sheet 4 of 32)

E. ADOBE Road

Q=310 cfs



$Q = 310$ cfs

$S_o = 0.002$

$n = (0.035 \times 112) + (0.015 \times 40)/152$

$= 0.0297$

```
ENTER X AND Y VALUES
          48.2
            0.
           47.
            0.
           47.
           21.
           46.
           29.
           46.
           40.
           47.
           56.
           48.
           65.
          48.2
           75.
          48.2
           96.
           48.
          106.
           47.
          111.
           47.
          152.
          48.2
          152.

        151.2          =A
154.6518815          =WP
        0.002          =SF
        0.031          =N

         310.          =Q
148.9405359
144.6070879
```

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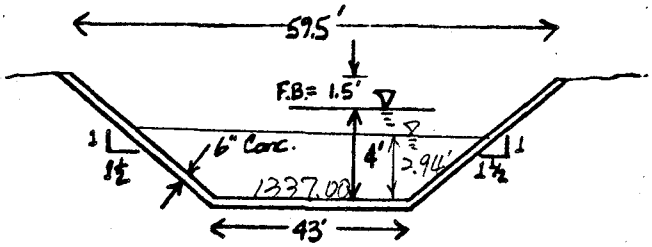
Job SCS RWCD Floodway Reach 6 - E101012

Description Comparative Design Studies

Calculated by B. Gary Sun Date 10/23/85 Sheet No. 6

Checked by M.S.S. Date _____ of _____

Electric Easement Channel (Anderson-Nichols letter Sep. 10, 1985)



Q = 1565 cfs

V = 8 fps n = 0.016 S = 0.00145

d = 4 ft.

Q = 1150 cfs n = 0.013 S = 0.00145

Existing condition ?

```
ENTER X AND Y VALUES
          2.94
Future      0.
            0.
         4.41
           0.
        47.41
         2.94
        51.82
d=2.94 ft
      139.3854          =A
   53.60032075          =WP
       0.00145          =SF
         0.013          =N

        1150.           =Q
   263.6668721
   264.2033878
```

Hydraulics for Side Inlets

1. At Brown Road:

Future (Sundance Groves): No freeboard on gunite channel for Q = 160 cfs. along Brown Road.

Present: Spread over west bank with Q = 360 cfs.

2. At E. Adobe Road:

Question on the way to drain Q = 310 cfs into RWCD floodway.

3. At Power line Easement:

Future: As Anderson-Nichols design Q = 1565 cfs V = 8 fps

n = 0.016 (calc.) (for a concrete lined channel) S = 0.00145 ft/ft

Trapezoidal concrete lined channel with 1.5 to 1 side slopes. 1.5 feet freeboard.

As per GER calculation:

Q = 1150 cfs V = 8.25 fps n = 0.013 S = 0.00145 ft/ft

same channel section 3.56 feet freeboard.

Present: Retension Basin

Hydraulics for Side Inlets (Cont'd)

4. At Apache Blvd. and Higley Rd.

Present: ① The way to drain $Q_{100} = 1000$ cfs coming into RWCD from E. Apache Blvd.
② New earth channel is not adequate to drain $Q_{100} = 500$ cfs from S.E. of Higley Road

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Job NCD RNCD Tucson Reach 8 Drainage

Description University Drive Existing S.D.
STORM run

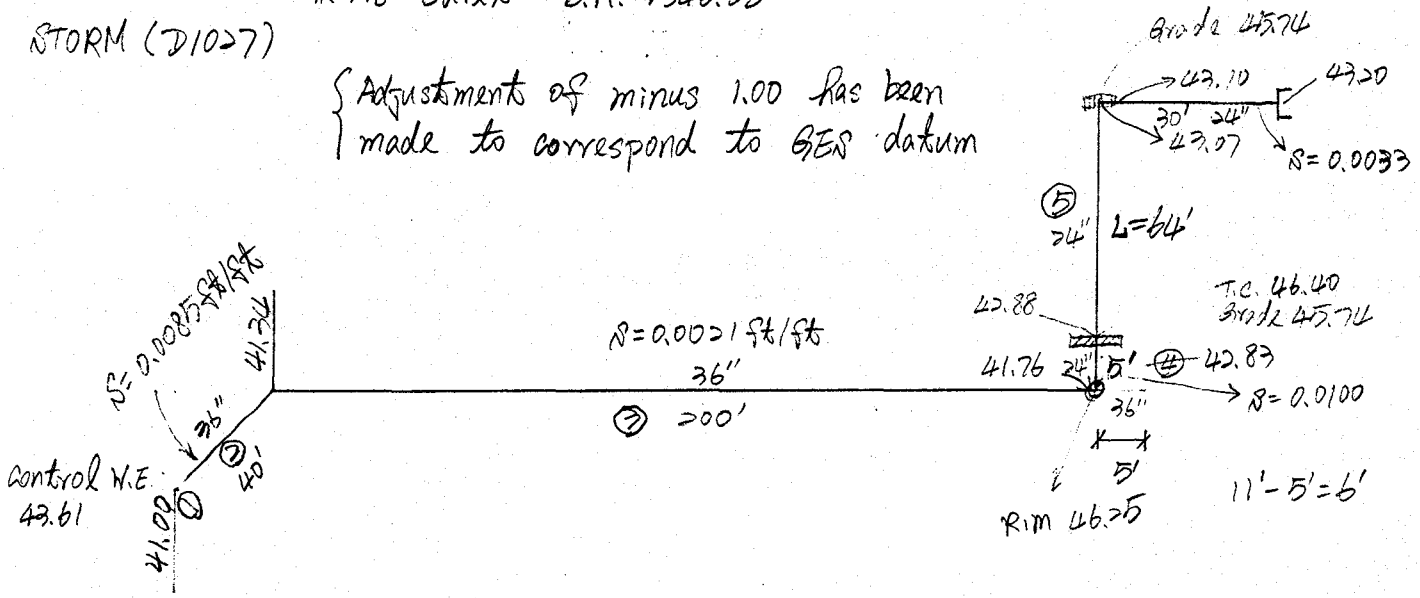
Calculated by B. Gary Sun Date 11/5/85 Sheet No. ____

Checked by M.S.S Date ____ of ____

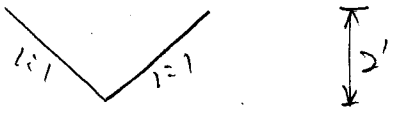
* As-Built B.M. 1346.55

STORM (D1027)

{ Adjustments of minus 1.00 has been made to correspond to GES datum



1.	L BK
1.	R BK
0.	BASE
0.0074	FPF
0.025	N
2.	DP
4.	AREA
5.656854249	WP
.7071067812	R
4.053681399	FPS
16.21472559	CFS



S= 0.0074 ft/ft
n= 0.025

Max. Q= 16.21 cfs

UDSD.DAT UDSD.OUT 11/5 9:15 AM

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Job RWCD Reach 6 E101012
Description Discharge through flume for inlet @ Sta. 150+98
Calculated by M. Shapiro Date 11/25/85 Sheet No. 1
Checked by B.G.S. Date _____ of _____

Per Kings Handbook page 5-43 Table 5-9

weir equa. $Q = CLH^{3/2}$ given: $Q = 17$ cfs
w/ freeboard $Q = 21$ cfs

$L_{flume} = 16$ ft

Trial 1 $H = .33'$ $C = 2.82$

$Q = 2.82(16)(.33)^{1.5}$
$= 8.55$ cfs < 21 cfs $\therefore$ N.G.

Trial 2 $H = .33'$ $C = 2.88$ $L = 103.5'$

$Q = (2.88)(103.5)(.5)^{3/2}$
$= 105.39$ cfs > 21 cfs $\therefore$ N.G.

Trial 3 $H = .40'$ $C = 2.86$ $L = 42'$

$Q = (2.86)(42)(.4)^{3/2}$
$= 30.39$ cfs > 21 cfs $\therefore$ N.G

Trial 4 $H = .37$ $C = 2.84$ $L = 26$ ft

$Q = (2.84)(26)(.37)^{3/2}$
$= 16.62$ cfs < 21 cfs $\therefore$ N.G

Trial 5 $H = .38$ $C = 2.85$ $L = 31$ ft

$Q = (2.85)(31)(.38)^{3/2}$
$= 20.7$ cfs ≥ 21 cfs $\therefore$ O.K.

Side Inlet at Terminus of Project North of Brown (Sta. 30+70.00)

1. Problem Set Up:

① As per SCS TR-20 Hydrology, the design flow for the inlet structure is 196 cfs, the design flow from terminus of floodway to Sta. 32+24.54 is 300 cfs and the proposed box culvert has the design flow of 900 cfs.

② Control Water Surface Elevation at Sta. 32+50.99 is 1343.97.

③ Change the bottom width of floodway from 26 ft to 40 ft.

④ Spillway width is 14 ft.

⑤ The inclined channel has two curve reaches with R=135 ft and R=95 ft, respectively. The point of reverse curve is at Sta. 29+93.

⑥ This structure has an exception design on the spillway. This spillway has a continuous invert slope (S_o = 0.038 ft/ft) from the inclined channel.

⑦ Run "TRAPØ1I" program for normal depth calculation at Sta. 31+48.00 for no flow condition in the floodway.

2. Results:

① Full flow Condition: (NBROWN1.DAT, NBROWN1.OUT & QNBROWN1.OUT)

(i) Protection needs at Sta. 32+24.54 ~ Sta. 32+42.41.

(ii) Overbank flow will occur at the curve reach between Sta. 28+85 ~ Sta. 29+93.

(iii) Meet the freeboard requirements considering the superelevations in the curve reach from Sta. 29+93 to Sta. 30+43.36.

② No Flow Condition: (NBR1.OUT, NBROWN2.DAT, NBROWN2.OUT & QNBROWN2.OUT)

(i) From result of "TRAPØ1I" program, the normal depth at Sta. 31+48.00 was 4.263 feet. (NBR1.OUT)

(ii) Erosion analysis will be performed between Sta. 28+85 and Sta. 29+93.

(iii) Meet the freeboard requirements considering the superelevations in the curve reach from Sta. 29+93 to Sta. 30+43.36.

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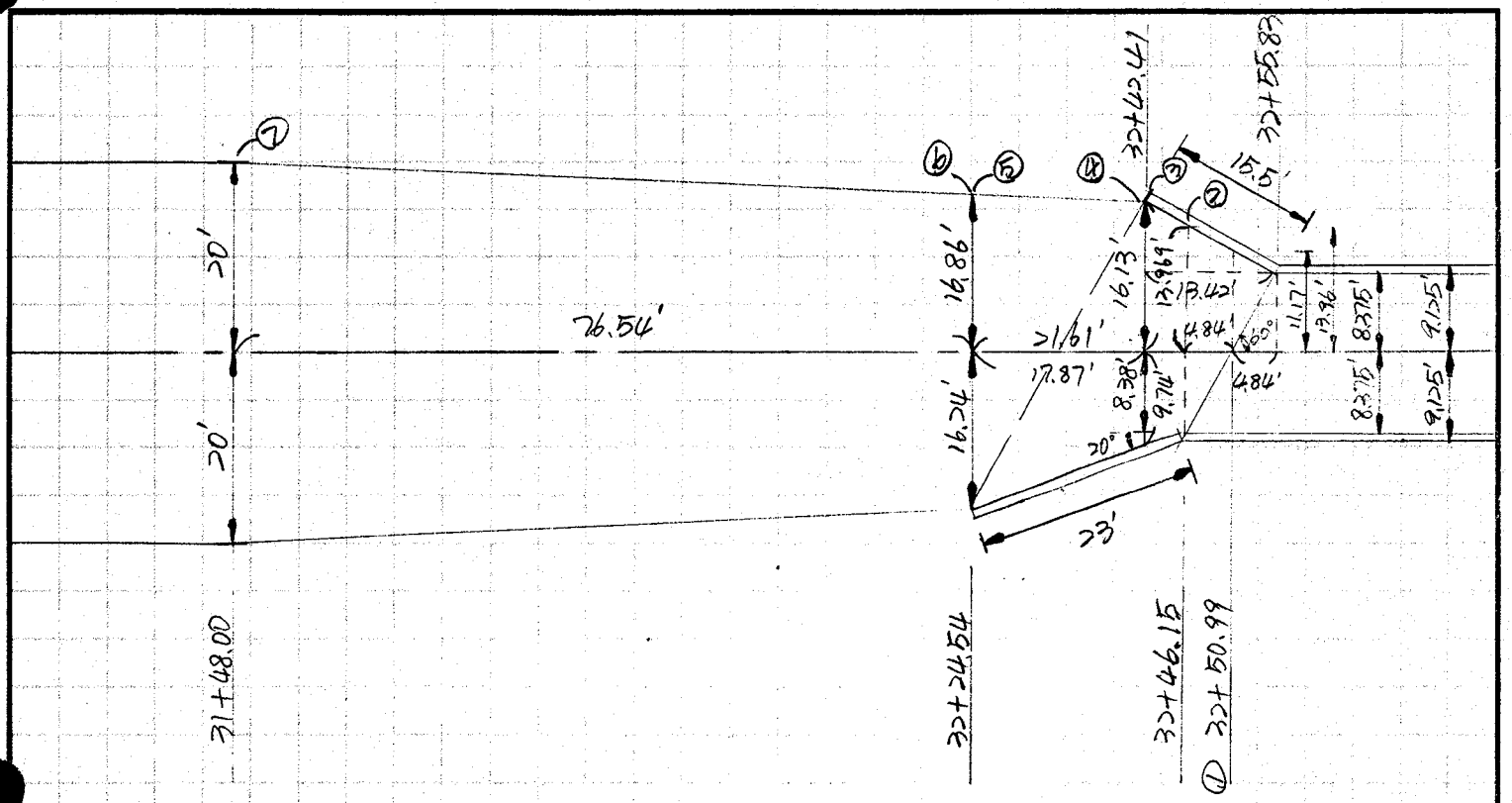
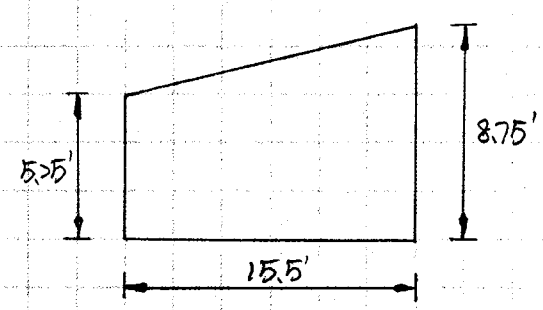
Job SCB RWCD Floodway Reach 6 - E101012

Description Comparative Design Studies
Side Inlet at Terminus of project (N. Brown

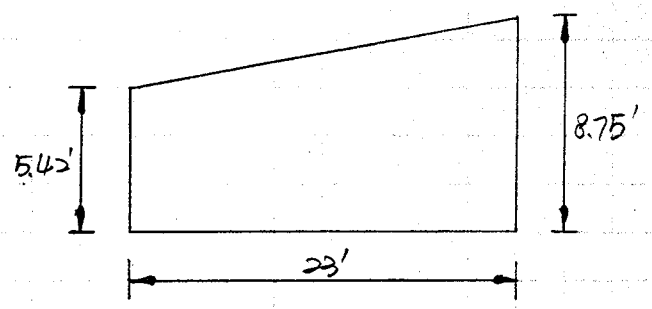
Calculated by B. Gard Sun Date 1/13/86 Sheet No. 3

Checked by M.S.S Date _____ of 5





Short Wingwall



Long Wingwall

Greiner Engineering

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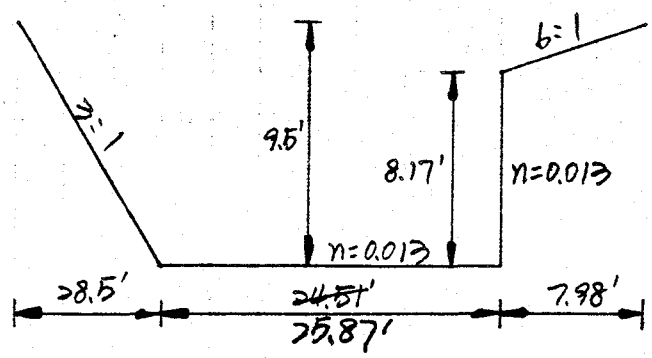
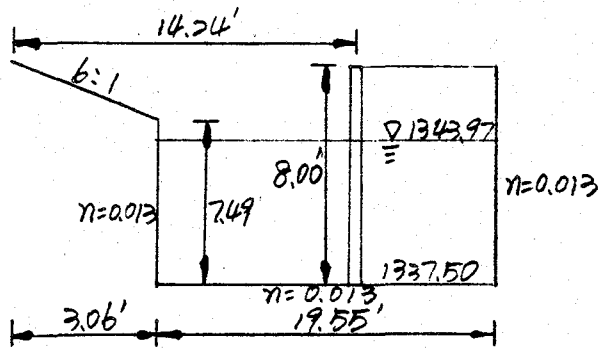
Job: BCS RWCD Floodway Reach 6 - E101012
Description: Comparative Design Studies
Side Inlet at Terminus (N. of Brown)
Calculated by: B. G. Run Date: 1/13/86 Sheet No. 4
Checked by: H.S.S. Date: _____ of 5

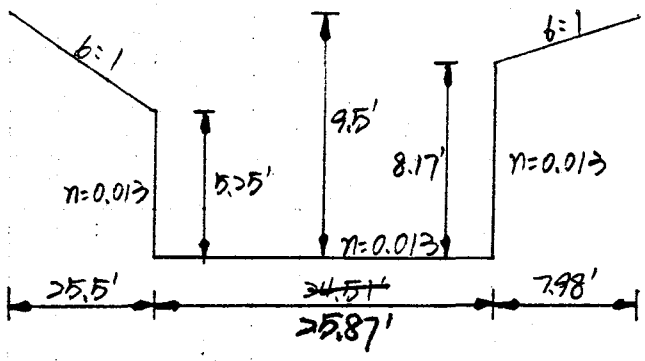
Cross Sections



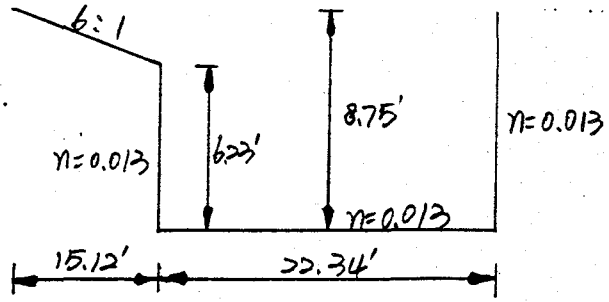
Sec. 4 Sta. 32+42.40 (37.50)



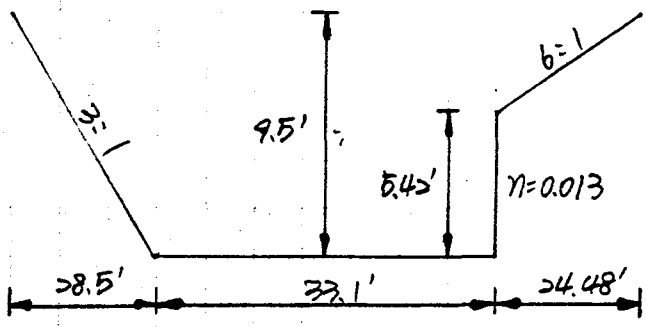
Sec. 1 Sta. 32+50.99 (37.50)



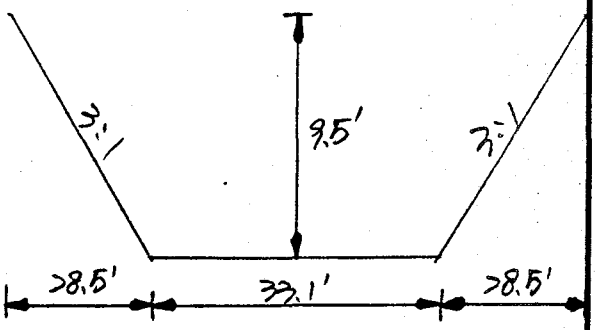
Sec. 3 Sta. 32+42.41 (37.50)



Sec. 2 Sta. 32+46.15 (37.50)



Sec. 5 Sta. 32+24.54 (37.50)



Sec. 6 Sta. 32+24.53 (37.50)

Greiner Engineering

Greiner Engineering Sciences, Inc.
Tucson 602 327-3413
Phoenix 602 275-5400

Job SCS RWCD Floodway Reach 6 - E101012
Description Comparative Design Studies
Peak Flows in Main Channel
Calculated by B. Gary Sun Date 2/3/86 Sheet No. ____
Checked by M.S.S. Date ____ of ____

Summary of Peak Flows in Main Channel
(Before Modification No. 3)

Station – Station	Q_{100}	50% of Q_{100}	Q_{10}
30+50.00 – 31+73.15 N. Brown	300 cfs	150 cfs	154 cfs
31+73.15 – 36+84.83 Brown Box	900 cfs	450 cfs	154 cfs
36+84.83 – 78+43.91 Adobe Rd.	1,200 cfs	600 cfs	193 cfs
78+43.91 – 88+89.51 Powerline	1,800 cfs	900 cfs	296 cfs
88+89.51 – University Dr.	1,840 cfs	920 cfs	460 cfs
– 121+15.05 1/4 mi. S. Univ.	1,840 cfs	920 cfs	453 cfs
121+15.05 – 128+84.37 Apache Trail	1,900 cfs	950 cfs	721 cfs
128+84.37 – S.E. of Higley	2,400 cfs	1,200 cfs	1,029 cfs
– 161+30.00 S. Broadway	2,400 cfs	1,200 cfs	1,014 cfs

Greiner Engineering

Greiner Engineering Sciences, Inc.
Tucson 602 327-3413
Phoenix 602 275-5400

Job SCR RWCD Floodway Reach 6 - E101012
Description Summary of Peak Flows
Main Channel
Calculated by B. Gary Sun Date 1/27/86 Sheet No. 1
Checked by M.S.S. Date _____ of _____

Modification No. 3

Summary of Peak Flows

1. Peak Flows Within Floodway Channel

Station — Station	Q_{100}	50% of Q_{100}	Q_{10}
30+70.00 - 32+19.53 N. Brown	300 cfs	150 cfs	154 cfs
32+19.53 - 36+84.83 Brown Box	900 cfs	450 cfs	154 cfs
36+84.83 - 78+43.91 Adobe Rd.	1,200 cfs	600 cfs	193 cfs
78+43.91 - 88+42.84 Powerline	1,800 cfs	900 cfs	296 cfs
88+42.84 - 118+70.72 University Dr.	1,840 cfs	920 cfs	460 cfs
118+70.72 - 1/4 mi S. of University	1,840 cfs	920 cfs	453 cfs
- 128+84.37 Apache Trail	1,900 cfs	950 cfs	721 cfs
128+84.37 - S.E. of Higley Road	2,400 cfs	1,200 cfs	1,029 cfs
- 161+30.00 S. of Broadway Rd.	2,400 cfs	1,200 cfs	1,014 cfs

Modification No. 3

Summary of Peak Flows (Cont'd)

2. Design Flows within Side Inlets

Description	Design Flows	Spillway Width	Invert Elev.
① North of Brown Road at Sta. 30+70	196 cfs	14 ft	37.52
*② South of Brown Road at Sta. 35+18	201 cfs	50 ft	37.48
③ North of Adobe Road at Sta. 60+60	194 cfs	45 ft	37.22
④ South of Adobe Road at Sta. 64+03	116 cfs	40 ft	37.19
⑤ Powerline Easement at Sta. 80+04	cfs	ft	37.03
**⑥ North of University Drive at Sta. 89+11	600 cfs	80 ft	36.91
⑦ South of University Drive at Sta. 93+98	133 cfs	66 ft	36.85
***⑧ North of Apache Blvd. at Sta. 120+21	727 cfs	90 ft	36.53
⑨ South East of Higley Road at Sta. 128+06	500 cfs	66 ft	35.16
⑩ Mesa Shadows East 42" S.D. at Sta. 143+66 (42" S.D. Pipe Q_{100} = 118 cfs)	220 cfs	30 ft	34.78
⑪ Mesa Shadows East Spillway at Sta. 150+98	17 cfs	8 ft	34.57

Notes:

* Q = 159 cfs for 54" Pipe South of Brown Road at Sta. 35+84.5 Inv. = 37.47

** Q = 70 cfs for 36" S.D. South of University Drive at Sta. 92+25 Inv. = 41.00

*** Q = 273 cfs for 72" S.D. Higley Road

9/11/85
Latest

RWCD REACH 6

INLET HYDROLOGY

SUMMARY OF PEAK DISCHARGE FOR DESIGN

Four separate alternatives were investigated during this analysis. These were as follows:

Alt. #1. Present 1985 Conditions, i.e. no channel upstream of Brown Road with present level of development and curve numbers.

Alt. #2. Year 2000 Conditions, with 1-inch storage assumed on new developments between 1985 and 2000 and with 200 and 300 cfs channel assumed upstream of Brown Road. This analysis also basically assumes a 70% to 30% split of runoff to the west and south, respectfully, for selected drainage areas. (See TR-20 Schematic Map).

Alt. #3. This alternate is the same as Alternate #2 described above except for subareas 3 & 4 shown on the Schematic Map, a 90% to 10% split of flows to the south and west, respectively is assumed. This latter split is an attempt to evaluate the effect of the Alta Mesa Develoment on flows originating to the north of Brown Road and east of Recker Road. The division of flows at Adobe and Higley Roads also were reversed over that assumed in Alternate #2. (See Schematic Map).

Alt. #4. This final alternate is again the same as the year 2000 conditions described above in Alternate 2 with the exception that a 100-year flood control channel is assumed upstream of Brown Road. This assumes that no flow overtops the RWCD Canal above Brown Road for any storm equal-to or less than the 100-year flood.

The results of these analyses, with reference to Peak Discharges, are shown on the attached table which compares the computed peaks to those estimated by Anderson-Nichols in their Master Drainage Plan Study and in Bob Bartel's Study which is presently being used for the design of the RWCD. There are major differences in the computed flows based on the various assumptions, especially for the RWCD and Side Inlets for the drainage areas lying north of University Drive. For instance at Brown Road, the design discharge for the RWCD Floodway itself can vary from a minimum of 460 cfs (Alt. 3) to a maximum of 1601 cfs (Alt. 4). The peaks for the side inlet at this location vary between 357 cfs and 862 cfs for the same two respective alternates.

For the Side Inlet at Brown Road it is recommended that the smaller value (i.e. 357 cfs) be used for design. This takes into account the effect of the Alta Mesa Subdivision on storm runoff originating to the east of Recker Road and north of Brown Road.

For the Floodway itself at Brown Road, it would be adequate to design the floodway for 460 cfs as computed under the assumptions of Alternate #3. However, the original design as developed by Bartel's in 1974 called for a design discharge of 1160 or 1200 cfs at this location. Based on Bartel's

data, some pre-design excavation by a developer has already occurred between Brown Road and Apache Trail; therefore, it is recommended that the 1200 cfs discharge be maintained from Brown Road downstream to the intersection of the Powerline Channel proposed by Anderson-Nichols in their Master Drainage Plan Study. The Powerline Channel is located about halfway beween Adobe Road and University Drive. The suggested discharge will also provide the needed capacity in this reach should a 100-year channel be installed upstream of Brown Road sometime in the future. The Anderson-Nichols flows for the RWCD Channel (date 9/10/85) should then be maintained downstream until exceeded by computed flows from Alternate #3.

For the remainder of the side inlets to the south of Brown Road it is again recommended that the Alternate #3 discharges be used for design, except for the Powerline Channel Inlet. At this location, it is recommended that Anderson-Nichols discharge of 1565 cfs be used. The final recommended discharges for each location is shown in Tabular form following the peak discharge comparison table. It should be recognized, however, that once the Master Drainage Plan is completed, the Inlet Structures at University and locations to the south, will be over-designed, as will the RWCD from Higley Road downstream to Leisure World.

Note, Alternate #3 discharges instead of Alternate #1, present condition 1985 discharges, were recommended since they show the effect of the Alta Mesa Subdivision. A revised Alternate #1 would be needed if "present condition" discharges are to be used. However, by comparing Alternates #1 and #2 it can be seen that there is not much difference in the estimated "present" and "future peaks with 1-inch of storage " when the same assumptions are made with reference to Alta Mesa. Therefore, Alternate #3, gives about the same peaks as would be obtained if Alternate #1 was revised to show the effect of Alta Mesa Development on present (1985) discharges.

Az.

H. Millsaps 6-7-85

Comparison of 100 yr. peak discharges — Future Condition, year 2000 w/1-inch storage on new developments & 85 (Present) condition

RWCD Reach-6, Inlet Hydrology

Location	1974 Calc. Design Peaks (Ignoring reach 6 ext. D.A.)	1985 Calc. (w/200 & 300 CFS Chan. on Reach 6 Ext. D.A.) Alt #2	Alt #3	1985 Calc. (w/ 100yr. Chan. on Reach-6 D.A.) Alt #4	1985 Calc. of Present (85) cond. No chan. Reach-6 Ext. D.A. Alt #1	1985 Calc. by And-Nichols for yr. 2000. Rec'd 4/29/85	A-N RW 9/10/85
BROWN ROAD							
Reach 6 EXT.	–	297	297	874	150		
From East (109)	1160	862	357	862	741	750	365
RWCD (110)	1160	867	460	1601	891	1150	365
ADOBE Rd. (½ mi. S. of Br. Rd)							
Inlet (119)		534	306	534	438	525	100
RWCD (110)	1160	1174	561	1594	1217	1500	375
3/4 mi. S. of Brown Rd.							
Inlet (121)	–	213	576	213	176	1150	1565
RWCD (120)	1160	1313	1090	1682	1347	1800	1800
UNIVERSITY DR.							
Inlet (128)	990	600	618	600	543	250	400
RWCD (122)	1965	1516	1562	1817	1539	1965	1840
1/4 mi. S. of UNVER. Dr.							
Inlet (12)	–	110	110	110	113	–	–
RWCD (129)	1965	1500	1530	1807	1510	1965	1840
APACHE TRAIL							
Inlet (133)	–	986	994	986	906	500	435
RWCD (147)	1965	1687	1876	1942	1720	2300	1900
S.E. of HIGLEY RD.							
INLET (142)	570	503	503	503	502	–	–
RWCD (148)	2290	2121	2374	2221	2158	2300	1900

2

COMPUTATION SHEET
SCS-ENG-523A Rev. 9-69

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

STATE Ariz. PROJECT RWCD Reach-6, Inlet Hydrology

BY H. Millsaps DATE 6-7-85 CHECKED BY DATE JOB NO.

SUBJECT Comparison of 100 yr. peak discharges — Future Condition, year 2000 w/1-inch storage on new developments & 85 (Present) condition

SHEET 2 OF 2

Location	1974 Calc. Design Peaks (Ignoring reach 6 ext. D.A.)	1985 Calc. (w/200 cfs chan. on Reach 6 Ext. D.A.) Alt #2	1985 Calc. (w/200 cfs chan. on Reach 6 Ext. D.A.) Alt #3	1985 Calc. (w/100yr. Chan. on Reach-6 D.A.) Alt #4	1985 Calc. of Present (85) cond. No chan. Reach 6 Ext. D.A. Alt #1	1985 Calc. by And-Nichols for yr. 2000.		
BROADWAY ROAD								
INLET (17)	—	324	* 220	324	306	70	222	
RWCD (149)	2290	2119	2361	2229	2152	—	—	
500 ft. S. of Broadway								
INLET (146)	750	1479	1486	1479	809		1750	
RWCD (151)	3050	3309	3350	3310	2674		2460	

* NOTE: D.A. decreased by 0.09 due to diversion into Broadway Rd. channel. Adjusted

$$Q = \frac{0.28 - 0.09}{0.28}(324) = 220 \text{ cfs}$$

...CALCULATION SHEET
SCS-ENG-523 Rev. 8-69

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

STATE	PROJECT		
ARIZONA	RWCD REACH 5, Inlet Hydrology		
BY: Hm	DATE: 8/19/85	CHECKED BY: Rev 9/11/85	DATE:
SUBJECT: RECOMMENDED PEAK DISCHARGE			JOB NO.:
			SHEET ____ OF ____

FOR DESIGN OF RWCD & SIDE INLETS

LOCATION	CALC. PEAKS	RECOMMENDED DESIGN DISCHARGE 1)	SOURCE
BROWN ROAD			
REACH 6 EXT	297	300	Reach 6 EXT STUDY
From East (109)	357	360	Alt #3, 1985 Study
RWCD	1160	1200	Bartel's 1974 STUDY
ADOBE ROAD (1/2 MI. S. of Br. Rd)			
Inlet (119)	306	310	Alt #3, 1985 Study
RWCD (110)	1160	1200	Bartel's 1974 Study
3/4 - MILE S. OF BR. ROAD			
Inlet (121)	~~1150~~ 1565	~~1150~~ 1600	Anderson - Nichols Study (Rev
RWCD (120)	~~1163~~ 1802	~~1200~~ 1800	~~Bartel's 1974 Study~~ Anderson - Nichols (Rev 9/85
UNIVERSITY DR			
Inlet (128)	618	620	Alt #3 1985 Study
RWCD (122)	~~1562~~ 1840	~~1550~~ 1840	~~Alt #3, 1985 Study~~ Anderson - Nichols (Rev 9/85)
1/4 - MILE S. OF UNIV. DR			
Inlet (12)	110	110	Alt #3 1985 Study
RWCD (129)	~~1550~~ 1840	~~1550~~ 1840	~~Alt #3, 1985 Study~~ Anderson - Nichols (Rev 9/85)
APACHE TRAIL			
Inlet (133)	994	1000	Alt #3, 1985 Study
RWCD (147)	1876	1900	Alt #3, 1985 Study
JUST S.E. OF HILLEY ROAD			
Inlet (142)	503	500	Alt #3 1985 Study
RWCD (148)	2374	2400	Alt #3, 1985 Study
BROADWAY ROAD			
Inlet (17)	220	220	Alt #3, 1985 Study Adj for D.A.
RWCD (149)	2361	2400	Alt #3, 1985 Study
500' S. OF BROADWAY Rd @ Southern Channel			
Inlet (146)	1486	1500	Alt #3 1985 Study
RWCD (151)	3350	3350	Alt #3, 1985 Study

1) SEE Attached Write-up.

COMPUTATION SHEET
SCS-ENG-523 Rev. 8-69

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

STATE	PROJECT		
ARIZONA	RWCD REACH 5, INLET HYDROLOGY		
BY: Hem / DATE: 9/4/85	CHECKED BY	DATE	JOB NO.
SUBJECT: ALT #3 10-YEAR DISCHARGES			SHEET ____ OF ____

LOCATION	CALC 10-YEAR DISCHARGE (CFS)
BROWN ROAD	
REACH 6 EXT	154
FROM EAST (109)	86
ADOBE ROAD (1/2-MI. S. of Br. Rd)	
Inlet (119)	89
RWCD (110)	193
3/4-MILE S. of Br. Road	
Inlet (121)	167
RWCD (120)	296
UNIVERSITY DR.	
Inlet (128)	296
RWCD (122)	460
1/4-MILE S. of UNIVER. DR.	
Inlet (12)	55
RWCD (129)	453
APACHE TRAIL	
Inlet (133)	490
RWCD (147)	721
JUST S.E OF HIGLEY ROAD	
Inlet (142)	358
RWCD (148)	1029
BROADWAY ROAD	
Inlet (17)	93 (Adj for reduced D.A.)
RWCD (149)	1014
500' S. OF BROADWAY RD.	
Inlet (146)	391
RWCD (151)	1317

RWCD REACH 6

INLET HYDROLOGY

SUMMARY OF PEAK DISCHARGE FOR DESIGN

Void 11/12/85
see Sep. 11, 1985
SEP 1 0 1985

Four separate alternatives were investigated during this analysis. These were as follows:

Alt. #1. Present 1985 Conditions, i.e. no channel upstream of Brown Road with present level of development and curve numbers.

Alt. #2. Year 2000 Conditions, with 1-inch storage assumed on new developments between 1985 and 2000 and with 200 and 300 cfs channel assumed upstream of Brown Road. This analysis also basically assumes a 70% to 30% split of runoff to the west and south, respectfully, for selected drainage areas. (See TR-20 Schematic Map).

Alt. #3. This alternate is the same as Alternate #2 described above except for subareas 3 & 4 shown on the Schematic Map, a 90% to 10% split of flows to the south and west, respectively is assumed. This latter split is an attempt to evaluate the effect of the Alta Mesa Develoment on flows originating to the north of Brown Road and east of Recker Road. The division of flows at Adobe and Higley Roads also were reversed over that assumed in Alternate #2. (See Schematic Map).

Alt. #4. This final alternate is again the same as the year 2000 conditions described above in Alternate 2 with the exception that a 100-year flood control channel is assumed upstream of Brown Road. This assumes that no flow overtops the RWCD Canal above Brown Road for any storm equal-to or less than the 100-year flood.

The results of these analyses, with reference to Peak Discharges, are shown on the attached table which compares the computed peaks to those estimated by Anderson-Nichols in their Master Drainage Plan Study and in Bob Bartel's Study which is presently being used for the design of the RWCD. There are major differences in the computed flows based on the various assumptions, especially for the RWCD and Side Inlets for the drainage areas lying north of University Drive. For instance at Brown Road, the design discharge for the RWCD Floodway itself can vary from a minimum of 460 cfs (Alt. 3) to a maximum of 1601 cfs (Alt. 4). The peaks for the side inlet at this location vary between 357 cfs and 862 cfs for the same two respective alternates.

For the Side Inlet at Brown Road it is recommended that the smaller value (i.e. 357 cfs) be used for design. This takes into account the effect of the Alta Mesa Subdivision on storm runoff originating to the east of Recker Road and north of Brown Road.

For the Floodway itself at Brown Road, it would be adequate to design the floodway for 460 cfs as computed under the assumptions of Alternate #3. However, the original design as developed by Bartel's in 1974 called for a design discharge of 1160 or 1200 cfs at this location. Based on Bartel's

data, some pre-design excavation by a developer has already occurred between Brown Road and Apache Trail; therefore, it is recommended that the 1200 cfs discharge be maintained from Brown Road downstream until exceeded by the computed flows from Alternate #3. This will also provide the needed capacity in this reach should a 100-year channel be installed upstream of Brown Road sometime in the future.

For the remainder of the side inlets to the south of Brown Road it is again recommended that the Alternate #3 discharge be used for design, except possibily at the Powerline Inlet located 3/4 mile south of Brown Road. At this location, it is recommended that Anderson-Nichols discharge of 1150 cfs be used, since they have proposed a flood control channel at this location. The final recommended discharges for each location is shown in Tabular form following the peak discharge comparison table. It should be recognized, however, that once the Master Drainage Plan is completed, the Inlet Structures at University and locations to the south, will be over-designed.

Note, Alternate #3 discharges instead of Alternate #1, present condition 1985 discharges, were recommended since they show the effect of the Alta Mesa Subdivision. A revised Alternate #1 would be needed if "present condition" discharges are to be used. However, by comparing Alternates #1 and #2 it can be seen that there is not much difference in the estimated "present" and "future peaks with 1-inch of storage " when the same assumptions are made with reference to Alta Mesa. Therefore, Alternate #3, gives about the same peaks as would be obtained if Alternate #1 was revised to show the effect of Alta Mesa Development on present (1985) discharges.

Az.

H. Millsaps 6-7-85

RWCD Reach-6, Inlet Hydrology

Comparison of 100 yr. peak discharges — Future Condition, year 2000 w/1-inch storage on new developments & 85 (Present) condition

Location	1974 Calc. Design Peaks (Ignoring reach 6 ext. D.A.)	1985 Calc. (w/200 & 300 CFS Chan. on Reach 6 Ext. D.A.) Alt #2	1985 Calc. (w/200 & 300 CFS Chan. on Reach 6 Ext. D.A.) Alt #3	1985 Calc. (w/100yr. Chan. on Reach-6 D.A.) Alt #4	1985 Calc. of Present (85) cond. No chan. Reach-6 Ext. D.A. Alt #1	1985 Calc. by And-Nichols for yr. 2000.
BROWN ROAD						750
Reach 6 EXT.	–	297	297	874	150	
From East (109)	1160	862	357	862	741	
RWCD (110)	1160	867	460	1601	891	
ADOBE Rd. (1/2 mi. S. of Br. Rd.)						525
Inlet (119)		534	306	534	438	
RWCD (110)	1160	1174	561	1594	1217	
3/4 mi. S. of Brown Rd.						1150
Inlet (121)	–	213	576	213	176	
RWCD (120)	1160	1313	1090	1682	1347	
UNIVERSITY DR.						250
Inlet (128)	990	600	618	600	543	
RWCD (122)	1965	1516	1562	1817	1539	
1/4 mi. S. of UNIVER. Dr.						–
Inlet (12)	–	110	110	110	113	
RWCD (129)	1965	1500	1530	1807	1510	
APACHE TRAIL						500
Inlet (133)	–	986	994	986	900	
RWCD (147)	1965	1687	1876	1942	1720	
S.E. of HIGLEY RD.						–
INLET (142)	570	503	503	503	502	
RWCD (148)	2290	2121	2374	2221	2158	

COMPUTATION SHEET
SCS-ENG-523A Rev. 9-69

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

STATE Ariz. | BY H. Millsaps | DATE 6-7-85 | PROJECT RWCD Reach-6, Inlet Hydrology | SHEET 2 OF 2

SUBJECT Comparison of 100 yr. peak discharges — Future Condition, Year 2000 w/1-inch storage on new developments & 85 (Present) condition

CHECKED BY | DATE | JOB NO.

Location	1974 Calc. Design Peaks (Ignoring reach 6 ext. D.A.)	1985 Calc. (w/200 cfs chan. on Reach 6 Ext. D.A.) Alt #2	1985 Calc. (w/200 cfs chan. on Reach 6 Ext. D.A.) Alt #3	1985 Calc. (w/100yr. Chan. on Reach-6 D.A.) Alt #4	1985 Calc. of Present (85) cond. No chan. Reach-6 Ext. D.A. Alt #1	1985 Calc. by And-Nichols for yr. 2000.
BROADWAY ROAD						70
INLET (17)	—	324	*324	324	306	
RWCD (149)	2290	2119	*2361	2229	2152	
500 Ft. S. of Broadway						—
INLET (146)	750	1479	1486	1479	809	
RWCD (151)	3050	3309	3350	3310	2674	

* NOTE: D.A. decreased by 0.09 due to diversion into Broadway Rd. channel. Adjusted

$$Q = \frac{0.28 - 0.09}{0.28}(324) = 220 \text{ cfs}$$

COMPUTATION SHEET
SCS-ENG-523 Rev. 8-69

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

STATE	PROJECT		
ARIZONA	RWCD REACH 5, Inlet Hydrology		
BY: Hm	DATE: 8/19/85	CHECKED BY:	DATE:
JOB NO.			
SUBJECT: RECOMMENDED PEAK DISCHARGES		SHEET ____ OF ____	

FOR DESIGN OF RWCD & SIDE INLETS

LOCATION	CALC. PEAKS	RECOMMENDED DESIGN DISCHARGE [1]	SOURCE
BROWN ROAD			
REACH 6 EXT	297	300	Reach 6 EXT STUDY
From East (109)	357	360	Alt #3, 1985 Study
RWCD	1160	1200	Bartel's 1974 STUDY
ADOBE ROAD (1/2-MI. S. of Br. Rd)			
Inlet (119)	306	310	Alt #3, 1985 Study
RWCD (110)	1160	1200	Bartel's 1974 Study
3/4-MILE S. OF BR. ROAD			
Inlet (121)	1150	1150	Anderson-Nichols Study
RWCD (120)	1160	1200	Bartel's 1974 Study
UNIVERSITY DR			
Inlet (128)	618	620	Alt #3 1985 Study
RWCD (122)	1562	1550	Alt #3, 1985 Study
1/4-MILE S. OF UNIV. DR			
Inlet (12)	110	110	Alt #3 1985 Study
RWCD (129)	1530	1550	Alt #3, 1985 Study
APACHE TRAIL			
Inlet (133)	994	1000	Alt #3, 1985 Study
RWCD (147)	1876	1900	Alt #3, 1985 Study
JUST S.E. OF HILLEY ROAD			
Inlet (142)	503	500	Alt #3, 1985 Study
RWCD (148)	2374	2400	Alt #3, 1985 Study
BROADWAY ROAD			
Inlet (17)	220	220	Alt #3, 1985 Study Adj for DA
RWCD (149)	2361	2400	Alt #3, 1985 Study
500' S. OF BROADWAY Rd			
Inlet (146)	1486	1500	Alt #3 1985 Study
RWCD (151)	3350	3350	Alt #3, 1985 Study

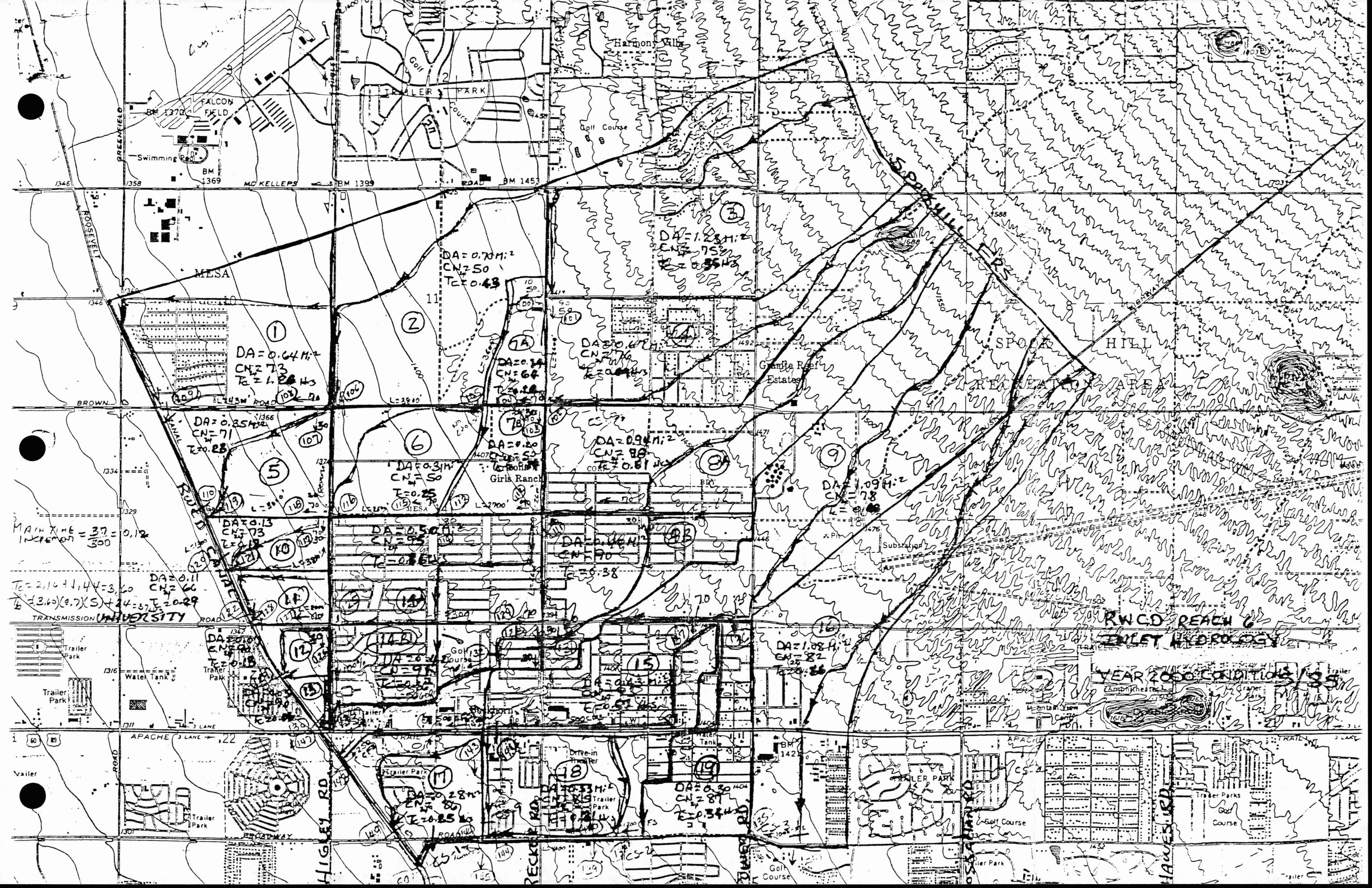
1) SEE Attached Write-up.

COMPUTATION SHEET
SCS-ENG-523 Rev. 8-69

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

STATE	PROJECT			
ARIZONA	RWCD REACH 5, INLET HYDROLOGY			
BY Hem	DATE 9/4/85	CHECKED BY	DATE	JOB NO.
SUBJECT ALT #3 10-YEAR DISCHARGES				SHEET ____ OF ____

LOCATION	CALC 10-YEAR DISCHARGE (CFS)
BROWN ROAD	
REACH 6 EXT	154
FROM EAST (109)	86
ADOBE ROAD (1/2-MI. S. of Br. Rd)	
Inlet (119)	89
RWCD (110)	193
3/4-MILE S. of Br. Road	
Inlet (121)	167
RWCD (120)	296
UNIVERSITY DR.	
Inlet (128)	296
RWCD (122)	460
1/4-MILE S. of UNIVER. DR.	
Inlet (12)	55
RWCD (129)	453
APACHE TRAIL	
Inlet (133)	490
RWCD (147)	721
JUST S.E OF HIGLEY ROAD	
Inlet (142)	358
RWCD (148)	1029
BROADWAY ROAD	
Inlet (17)	93 (Adj for reduced D.A.)
RWCD (149)	1014
500' S. OF BROADWAY RD.	
Inlet (146)	391
RWCD (151)	1317


RWCD REACH 6
INLET HYDROLOGY
YEAR 2000 CONDITIONS
SPOOK HILL
RECREATION AREA
SPOOK HILL HILLS
HIGHWAY
MESA
FALCON FIELD
Swimming Pool
TRAILER PARK
Golf Course
Harmony Villa
Granite Reef Estates
Girls Ranch
Substation
Drive-in Theater
Trailer Park
Water Tank
Mountain View Cemetery
Trailer Parks
MCKELLEPS ROAD
BROWN
APACHE TRAIL
UNIVERSITY
TRANSMISSION
BROADWAY
ROOSEVELT
GREENFIELD
HIGLEY RD
RECKER RD
ROWELL
CANAL
DA=0.64 Mi²
CN=73
DA=0.70 Mi²
CN=50
Tc=0.48
DA=1.28 Mi²
CN=75
DA=0.35 Mi²
CN=71
Tc=0.28
DA=0.31 Mi²
CN=50
DA=0.13
CN=73
DA=0.50 Mi²
DA=0.11
CN=66
DA=0.94 Mi²
CN=88
Tc=0.61 Hrs
DA=1.09 Mi²
CN=78
DA=1.08 Mi²
CN=82
DA=0.28 Mi²
CN=80
Tc=0.85 Hrs
DA=0.33 Mi²
DA=0.80
CN=87
Tc=0.34 Hrs
MAIN XING INCREMENT = 37/300 = 0.12
Tc=2.10+1.44=3.60
Tc=(3.60)(0.7)(S)+24=37
Tc=0.29

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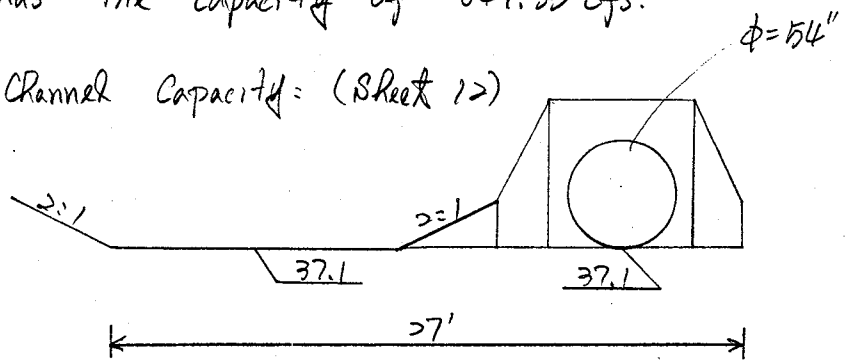
Job RWCD Floodway Reach 6 - E101012
Description Comparative Design Studies

Calculated by Gary Sun Date 10/2/85 Sheet No. 1
Checked by M.S.S. Date _____ of _____

* Review "Sundance Groves Drainage Report"

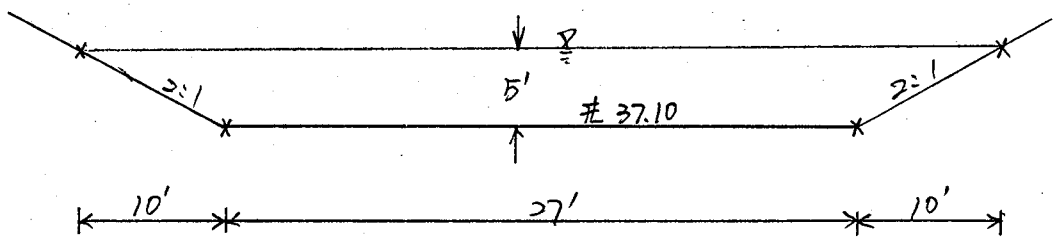
The dirt channel connecting the end of the 54" pipe and gunnite channel with the ditch on the East side of the R.W.C.D. floodway has the capacity of 847.55 cfs.

Channel Capacity: (Sheet 12)



$S = 0.002$

$n = 0.035$



$P = 27 + 2 \times \sqrt{10^2 + 5^2} = 49.36$ ft

$R = \frac{A}{P} = \frac{185}{49.36} = 3.748$ ft

$A = 27 \times 5 + 5 \times 10 = 185$ ft^2

$V = \frac{1.486}{0.035}(3.748)^{.667}(.002)^{.5}$

$= 4.583$ fps

$Q = VA = 847.92$ cfs #

1. Sundance Villas will retain its own runoff. (Volume = 167,840 ft^3)
2. Sundance Groves Retention Basin will be drained by means of a valved 12" R.G.R.C.P. into RWCD Floodway with $Q = 2.26$ cfs.
3. The 54" pipe (South side of Brown Road) has a capacity of 200 cfs.
4. The gunnite channel has the capacity of 155.27 cfs.
5. Use 10 year storm for all the design. Re-calculation needed.

"Drainage Study of Mini Park Area Plus Drainage Area North of E. Main Street"

Area North of E. Main Street:

1. Total drainage area = 49 ± acres, T_c = 50 min., C = 0.76

   I_{10} = 2.22 (?), I_{50} = 2.60 (O.K.) ⇒ Q_{10} = 82.7 cfs & Q_{50} = 96.8 cfs

2. Capacity of 4-36" C.M.P. is 145.2 cfs with S_o = 0.007.

3. A flat bottom channel section 18' wide with 1.5 to 1 side slopes was used. With d = 2.10' then Q = 100.4 cfs > 97 cfs.

4. SCS recommanded design discharge of 500 cfs.

   Assume d = 5.22 ft then P = 36.82 ft, A = 134.83 ft², Q = 501.61 cfs.

   Need information the diversion channel and maybe redesign it.

Apache Trail Casas & Mini Warehouses:

1. Retention basins shall not be more than 3.5' deep.

2. For 100 year storm use i = 8 in/hr (highest on chart)

3. Not provide any method of draining the retention volume.

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Job RWCD Floodway Reach 6 - E101012
Description Comparative Design Studies

Calculated by Gary Sun Date 10/4/85 Sheet No. ____
Checked by M.S.S. Date ____ of ____

"Hydrology and Hydraulics Report for Stoneybrook and Stoneybrook two"

1. Points 3 & 4: each has 9.7 cfs bypass
2. A 18" PVC S.D. 5' inside E. side of R.O.W. from C.B. at E. DIXON (278 L.F.) to the retention basin.
3. Use 6 dry wells to drain 6.37 ac-ft water in 36 hours. A 12" PVC will connect each well and extend to the floodway.

"Hydrology Report for Northpointe"

1. An undeveloped condition is analyzed (C=0.2) for Tracts "B" and "C".
2. Does School site basin have been approved? Also it needs a bleed-off system to the floodway.
3. No bleed-off system for two self-retaining Commercial areas.

Check the existing utilities:

1. Sheet 3 (Sta. 30+00 ~ 45+00)

   (i) Is 12" ACP water line installed?

   (ii) 54" R.G.R.C.P. S.D.?

2. Sheets 4 & 5 (Sta. 45+00 ~ 85+00)

   Adobe Road sewer M.H. locations & 12" PVC sewer to transmission easement.

3. Sheet 6 (Sta. 85+00 ~ 105+00)

   (i) Locate 4 M.Hs & 15" sewer near University

   (ii) Is future 15" PVC sewer line crossing R.W.C.D. installed?

4. Sheet 7 (Sta. 105+00 ~ 125+00)

   (i) Locate 3 M.Hs & 8" VCP sewer line near upstream of Apache.

   (ii) 12" ACP water line should be 20' & 24' west of M.L. of Higley.

   (iii) 12" ACP water line should be 47.5' north of M.L. of Apache.

   (iv) Missing 13' water line at 39.5' west of M.L. of Higley.

5. Sheet 8 (Sta. 125+00 ~ 145+00) Electrical line at Sta. 140+00?

6. Sheet 9 (Sta. 145+00 ~ 160+00)

   Is a 12" R.P.M.P. sewer or 10" sanitary sewer (F.C.D.) at Broadway Road crossing?

SHEET 3 - CHECK LOCATION OF POWER LINE (U.G. OR O.H.?)

- IS FENCE TO BE REMOVED?

SHEET 4 - O.H OR U.G. POWER LINE?

SHEET 6 - TELEPHONE LINE O.H. OR U.G.?

SHEET 7 - TELE. OH. OR U.G.?

- CHECK LOCATION OF TRANSFORMERS

SHEET 8 - U.G OR O.H. POWER LINES?

SHEET 9 - POWER LINES O.H. OR U.G.?

- IS POWER LINE REMOVED N. OF BROADWY?

Questions for City of Mesa 10-1-85

Brown Road

Need information on sewer line location after finding 3 manholes in the field on Brown Road.

Adobe Road

Cannot locate 2nd manhole in sewer line at end of Adobe. Is this MH buried?

University Dr.

Need information on 36" storm drain south of Univ. Has this been removed?

Apache

Cannot locate MHs North of Apache & West of canal.

Need info. on drain outlet (by transformers) which dumps into Canal from drainage West of Higley, N. of Apache.

A detailed investigation was made to identify the existing underground utilities, and vertify mapping.

Findings:

1. Brown Road:

① Proposed 54" R.G.R.C.P. and gunnit channel have not been installed or constructed.

② Find 3 sanitary sewer manholes on Brown Road.

③ Vertify the power line is an underground utility.

2. Adobe Road:

① Find the first manhole inside the west side of R.O.W.. Cannot locate the second manhole at end of Adobe Road.

3. Transmission Easement:

① Vertify a sewer manhole near the west side of R.O.W.

② Cannot vertify the other 2 manholes between Adobe Road and Transimission Easement.

4. Unversity Drive:

① Vertify 3 sewer manholes in field.

② Need information on 36" storm drain south of University Bridge.

③ Also need information on 36" pipe inlet east of Univ. Drive.

Findings (Cont'd):

5. Apache Blvd. and Higley Rd.

① Cannot locate 3 manholes at Sta. 137+00.

② Locate transformers.

③ Need information on drain outlet (by transformers) which dumps into Canal.

6. Broadway Road:

① Need information on underground power line near Sta. 140+00.

② Verify 10" sanitary sewer line and manhole on Broadway.

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Job: RWCD Reach 6
Description: Utility Conflicts Needing Further Investigation
Calculated by: R Beck Date: 1-10-86 Sheet No. 1
Checked by: B.B.R. Date: _____ of 1

Utility Conflicts

Any utilities located within a street R/W are not included.

Sta.	Utility	Depth	offset from ℄
138+53.81	Power Pole w/ buried cable	3'-5'	97' left
142+58.00	Power Pole w/ buried cable	3'-5'	
done 155+60.50	10" RPMP sewer	unknown	7' rt.
	Power pole w/ buried cable	3'-5'	124' left
144+54.00	42" PGRCP	unknown (needs as-built by surveyors	
92+00	30" RCP	4'-5'	

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Job RWCD - R6

Description Utility locations

Calculated by R. Beck Date 1-10-86 Sheet No. 1

Checked by MSS Date _____ of 8

RWCD Reach 6

Utility locations

as per cross-sections.

looking downstream:

STA. 32+42.41

OK	Electric (Buried)	depth = 3'	As-Built	46' Rt.
OK	Electric (Buried)	depth = 3'	As-Built	52' Rt.
OK	Water 12" ACP	depth = 4'		79' Rt.

STA 33+00.00

OK	Electric (Buried)	depth = 3'	As-Built	81' left
OK	18" VCP sewer	depth = 17'	As-Built	31' left
OK	4" Gas I.P.	depth = 3'		20' left
P.H.	6" ACP water	depth = 3'		10' rt.
OK	Electric (buried)	depth = 3'	As-Built	79' rt.

Sta 32+55.83

P.H.	Electric (Buried)	depth = 3'	20' rt.
OK	Electric (Buried)	depth = 3'	60' rt
OK	4" I.P. Gas	depth = 4'	75' rt.

Sta 32+50.99

OK	Electric (Buried)	depth = 3'	38' rt.
OK	12" ACP water	depth = 4'	70' rt.

Sta 32+46.15

OK	Electric (Buried)	depth = 3'	38' rt.
OK	12" ACP water	depth = 4'	70' rt.

Sta 33+12.99

P.H.	Electric (Buried)	depth =		93' left
~~P.H.~~	6" ACP water	depth = 3'		22' rt.
OK	4" I.P. Gas	depth = 4'		50' rt.
	18" VCP Sewer	depth = 17.5'	As-Built	64' rt.

due to unknown depth underneath pavement looks O.K.

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Job: SCS RWCD Reach 6

Description: Utility locations

Calculated by: R Beck Date: 1-10-86 Sheet No. 3

Checked by: B.G.S. Date: _____ of 8

Sta 63+00.00

ok 12" PVC sewer depth = 14.5' as-built 125' left

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ok STA 76+40.00
12" PVC sewer traverses floodway As-Built elev = 1329.42

Note: 12" PVC sewer runs from Sta 76+40.00 to Sta 63+47 parallel to east R/W 15' inside of floodway. Elevation varies from 1329.42 at Sta 76+40.00 to 1339.83 at Sta 63+47 As-Built

ok Sta 76+00.00
12" PVC sewer depth = ? 145' left

ok Sta 72+00.00
12" PVC sewer depth = ? 145' left

ok Sta 68+00
12" PVC sewer depth = ? 145' left.

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Job: SCS RWCD Reach 6
Description: Utility locations

Calculated by: R Beck Date: 1-10-86 Sheet No. 5
Checked by: B.G.B. Date: _____ of 8

STA 91+33.29

ok	12" ACP water	depth = 4'		97' left
ok	12" ACP water	depth = 4'		105' left
ok	15" ACP sewer	depth = 19'	As Built	112' left

STA 91+13.86

ok side street R/W	P.H.	12" ACP water	depth = 4'	52' left
	ok	12" ACP water	depth = 4'	96' left
	ok	Tele (Buried)	depth = 3.5 to 5 ft.	102' left
	ok	15" ACP sewer	depth = 19'	112' left

Sta 90+44.51

	ok	12" ACP water	depth = ?	100' rt.
ok street R/W	PH	Buried telephone	depth = 3-5'	55' rt
	PH	12" ACP water	depth = 4.5'	25' rt.
e street	PH	4"-6" gas	depth = 6'	20' rt.

Sta 90+94.45

in R/W	PH.	12" ACP water	depth = 4'	9' left
ok in R/W	PH	Buried telephone	depth = 3'-5'	55' left
ok in R/W	PH	12" ACP Water	depth = 6'	75' left
	ok	4"-6" gas	depth = 5'	90' left
		15" ACP Sewer	depth = 19'	

Sta 91+00

ok in R/W	PH	12" ACP water	depth = 4'	17' left
in R/W	PH	Buried telephone	3'-5' depth	48' left
	ok	12" ACP water	depth = 6'	70' left
	ok	4"-6" gas	depth = 5'	80' left
	ok	15" ACP sewer	depth = 19'	93' left

Sta 122+02.09

ok	12" ACP water	depth = 4'		32' left
ok	Tele (Buried)	depth = 3 to 5 ft.		43' left.
ok	12" ACP water	depth = 7.5'	As-Built	132' left

Sta 122+05.22 } Same as 122+02.99
Sta 122+00.00 }

Sta. 122+42.08

~~pft~~ ok (in R/W)	6" gas	depth = 4'		18' left
ok	12" ACP water	depth = 7.5'	As-Built	72' left
ok	Tele (Buried)	depth = 3 to 5 ft.		80' left
ok	12" ACP water	depth = 8'	As-Built	123' left

Sta 121+13.05

ok	12" ACP water	depth = ?	170' left.

Sta 120+00.00

ok	12" ACP water	depth = 4'	220' left

Sta 121+00.00

ok	12" ACP water.	depth = 4'	176' left.

Sta 117+00

ok	8" VCP	depth ≈ 9'	?

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Job SCS RWCD Reach 6
Description Utility locations

Calculated by R Beck Date 1-10-86 Sheet No. 7
Checked by B.G.S. Date of 8

Sta 125+00.00

ok in RW — 10" VCP sewer — depth = ? — 32' rt.
ok — 6" Gas — depth = 4' — 4' rt.

Sta 124+00.00

ok — 10" VCP sewer — depth = ? — 44' left
ok — 12" ACP water — depth = 5' — 70' left
ok — 6" gas — depth = 6' — 72' left

Sta 123+00.00

ok — 12" ACP water — depth = 5' — 77' left
ok — 6" gas — depth = 6' — 94' left

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Job: SCS RWCD Reach 6
Description: Utility locations
Calculated by: R Beck Date: 1-10-86 Sheet No. 8
Checked by: B.G.S. Date: of 8

Sta 156+00.00

PH	Power Pole w/ underground cables; depth = 3' ± 5'	123' rt.
ok	10" RPMP sewer depth = ?	43' left.

Sta 155+60.50

P.H.	Power Pole w/ underground cables depth = 3' to 5'	124' rt.
PH.	10" RPMP sewer depth = ?	7' rt.

Sta 155+36.82

ok	10" RPMP sewer depth = ?	67' rt.

Sta 155+00.00

ok	10" RPMP sewer depth = ?	100' rt.

Sta 152+00.00

ok	Power pole	35' left

Sta 147+00 to Sta 151+00

ok	power poles + overhead lines	36' left

Sta 142+00 to Sta 146+00

ok	power poles + overhead line	36' left

Sta 143+00.00

PH.	Power pole w/ buried cable 3'-5'	97' left

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Job RWCD-R6

Description Utility Locations.

Calculated by R. Beck Date 12-2 Sheet No. 1

Checked by M.S.S. Date of 6

RWCD Reach 6

Utility Locations

as per plan & profile

Utility Locations

Sta. (Baseline)	Description	Comments
32+77.99	12" ACP Waterline. Assumed depth = 4'	Runs parallel to Brown Rd. on North side 35' North of ℄ for a distance of 42' from West Floodway R/W.
32+72.99	18" VCP Sewer Line As-Built Depth = 17'	Runs parallel to Brown Rd. 26' North of ℄ for a distance of 125' from East Floodway R/W then for a distance of 65' perpendicular to Floodway ℄ to West Floodway R/W.
32+77.99	4" I.P. Gasline Assumed depth = 3'	Runs parallel to roadway 19' North of ℄ Brown Rd. for a distance of 200.' (R/W to R/W).
33+02.99	6" ACP Waterline Assumed depth = 3'	Underneath pavement 10' North of ℄ Brown Rd. for a distance of 192' (R/W to R/W).
32+65.99	Electric Line Assumed depth = 3'	Runs parallel to Brown Rd. on North side 47' N. of ℄ for a distance of 172' from E. R/W. Then runs south for a distance of 90' to west R/W.

Stationing referenced to Baseline

62 + 43.41	12" PVC Sewer line As-built depth = 14.5'	Begins at Sta 62+05.41 on west edge of floodway and runs diagonally to the east to Sta 63+15.41 on the east edge of floodway. Then parallels floodway 15' west of east edge of floodway to Sta 76+37.00 Then turns west & crosses floodway.
89+52.84	15" ACP sewer line As-built depth = 19'	Crosses floodway from west to east then turns south to Sta 91+20.87 at a distance of 10' west of east R/W of floodway.
90+57.32	12" ACP water line Assumed depth = 4'	Beginning at W. R/W runs N.E. for a distance of 45' then runs parallel to University 50' N. of ℄ for a distance of 190' then runs S.E. for a distance of 40' and ties into other 12" water line.
90+50.84	4"-6" Gas Assumed depth = 4'	Runs parallel to University 55' north of ℄ for a distance of 225' then runs southwest for a distance of 45' to west R/W line.
90+67.84	Buried telephone Assumed depth = 3' to 5'	Runs parallel to University 40' north of ℄ for a distance of 275' (R/W to R/W).
90+87.54	12" ACP Water Assumed depth = 4'	Runs parallel to University 21' N. of ℄, underneath pavement for a distance of 275' (R/W to R/W)
92+00.00	36" RCP Depth = 5'	Drains into floodway from Univ. Drive

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Job: SCS RWCD Reach 6

Description: Utility locations

Calculated by: R Beck Date: 12-2-85 Sheet No. 4

Checked by: B.G.B. Date: _____ of 6

Stationing referenced to baseline

117+01.07	8" VCP Sewer Assumed depth = ?	Runs perpendicular to floodway for a distance of 250' (R/W to R/W).
121+95.09	12" ACP Water Assumed depth = 4'	Runs parallel to Apache 45' N. of ℄ for a distance of 210' (R/W to R/W)
121+90.09	Buried telephone Assumed depth 3' to 5'	Runs parallel to Apache 50' N. of ℄ for a distance of 135' from East R/W line.
122+10.09	6" Gas Assumed depth = 4'	Runs parallel to Apache 10' N. of ℄ underneath pavement for a distance of 185' (R/W to R/W).
123+53.08	12" ACP water line Assumed depth = 4'	Runs along S. side of Apache 86' S. of ℄ Apache for a distance of 350' (R/W to R/W)
123+53.08.	12" ACP water line Assumed depth = 4'	Runs along Higley Rd. 27' W. of ℄ Higley Rd. for a distance of 465'. This line ties into line at Sta 123+53.08.
122+85.09	24" storm Drain Assumed depth = 4'	Crosses Higley Road 48' N. of ℄ Apache Blvd Ties into drainage ditch NW corner of intersection. 70' in length.

Stationing referenced to baseline

122+85.09	36"x 48" CMPA Assumed depth = 5'	Runs diagonally across Apache Blvd. for a distance of 110' from W. R/W line. Then runs north for a distance 45' and ties into drainage channel at NW corner of intersection.
124+68.08	10" VCP sewer Assumed depth = ?	Beginning at E. R/W Line runs parallel to Higley Rd. underneath pavement for a distance of 250' (R/W to R/W) located 10' E. of ℄ Higley Rd.
122+42.08	6" Gas Assumed depth = 4'	Beginning at W. R/W line runs east for a distance of 185' located 10' N. of ℄ Apache Blvd. (R/W to R/W).
125+00.08	6" H.P. Gas Assumed depth = 4'	Runs along Higley Rd. 32' East of ℄ for a distance of 268' from E. R/W.
138+53.81	Power line Assumed depth = 4'	Beginning at E. R/W line runs south for a distance of 120' then S.E. for 60' then ties into overhead line
142+58.00	Power line Assumed depth = 4'	Beginning at overhead line at sta 142+58.00 runs east for a distance of 100' to E. R/W.

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Job SCS RWCD Reach 6
Description Utility Locations

Calculated by R. Beck Date 12-2-85 Sheet No. 6
Checked by B.G.S. Date _____ of 6

Stationing referenced to baseline.

144+54.00	42" RGRCP Storm Drain Assumed depth = 5'	Drains into R/W from east.
148+13.00	Electric line Assumed depth = 4'	Runs from E. R/W line to the west for a distance of 15'
155+60.00	10" RPMP sewer Assumed depth = ?	Runs along Broadway 18' N. of ℄ of Broadway underneath pavement. (R/W to R/W)
155+60.00	Power Pole w/ Buried Elec. Cable Depth = 3'-5'	

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Job SCR RWCD Floodway Reach 6 - E101012
Description Summary for Backwater Analysis

Calculated by B. Gary Sun Date 2/6/86 Sheet No. 1
Checked by MSS. Date of 1

1. Review of computer programs which are considered applicable to this project for backwater analysis. Three water surface profile computer programs (HEC-2, WSP2 and WSPG) has been reviewed and evaluated. "WSPG" program was recommended by Greiner Engineering for water surface profile calculations. The details of the program should refer to Section 4.

2. As requested by SCR, comparison between HEC-2 and WSPG programs has been made. The runs have a straight reach approximate 640 feet with specified tailwater control elevation, discharge and Manning's "n" value. The results from both programs were virtually identical. Hence, "WSPG" program is highly recommended for backwater analysis in the floodway.

WSP2 Program

1. References Needed:

① SCS National Engineering Handbook, Section 4 "Hydrology"

② "Hydraulics of Bridge Waterways", Hydraulic Design Series No. 1, Bradley, J.N. Federal Highway Administration, Revised March 1978.

2. Questions:

① Can we use the Sep. 23, 1976, version of WSP2?

② Output

③ Changed the format on output for "TABLE OF VALUES FOR BPR EQUATION".

Meeting with Don Paulus at SCS office (10/15):

- Don't use WSP2 program.
- Comparison between HEC-2 and WSPG

WSP2 Program Input / Output Notes

INPUT:

1. If Reach 93350 has the same data as Reach 93147, you can use REACH2␣␣␣␣␣93147 following the REACH␣␣␣␣␣93350.
2. The program computes up to 15 water surface profiles for a combined total of 50 reach and road sections. However, a job can be extended beyond 50 sections by the LINK feature and beyond 15 profiles by the CHANGE feature.
3. The shape of each valley cross section can be defined by up to 48 horizontal and vertical points.
4. Results of computations from up to 20 cross sections can be save for later computations by using a TRIB card. The points can be entered in order or randomly.
5. A cross section can be divided into 6 segments max. At least one segment must be a channel segment. The segments must begin and end on points that appear in the section table.
6. Manning's n can be changed at user-specified values of hydraulic radius.

WSP2 Program Input/Output Notes

INPUT (Cont'd):

7. WSP2 can computer head losses through one bridge opening or up to 5 culvert openings with different configuration.
8. All profiles are computed in the upstream direction. Therefore, only subcritical flow can be analyzed.
9. When supercritical flow occurs, WSP2 uses the critical depth elevation at that section and continues upstream in this manner until subcritical flow recurs. WSP2 does not recompute downstream to determine supercritical flow elevations.
10. Locate valley sections about 50 to 100 ft. both upstream and downstream from road-type restrictions.
11. If velocities are between 6 and 11 fps, answers should be carefully examined to determine their adequacy. Answers that include velocities of 11 fps or more should be carefully vertified.

WSP2 (Max. 6 characters)

Limitations

- 25 bridge sections (BPR, CONTR, or COLV) Bridge cards that have the same road name are considered to be the same section.
- 50 cross sections max. (extended by LINK)
- Max. 6 characters for the name of roads and reaches.
- Max. 15 water surface profiles. (extended by CHANGE)
- Results of computations from up to 20 cross sections can be save for later computations by using a TRIB card.
- 48 horizontal and vertical points for each cross section.
- Max. 6 segments representing different characteristics for a cross section.
- Only subcritical flow can be analyzed. (All profiles are computed in the upstream direction.
- For the BPR bridge analysis procedure:
  1. the channel in the vicinity of the bridge must be nearly straight.
  2. cross sectional area of the stream must be fairly uniform.
  3. stream gradient between the exit and approach sections must be approximately constant.

Limitations (Cont'd)

④ flow must be free to contract and expand.

⑤ no appreciable scour can be present at the bridge.

⑥ flow must be subcritical

- WSP2 culvert analysis is limited to rectangular, circular, and standard arch shapes.

WSPG Program

Capabilities

- The flow in a system may alternate between supercritical, subcritical or pressure flow in any sequence.
- Data must always be processed first by WEDIT (the edit program) and then if no errors by WSPG (the processing program).
- A reach may have a straight or curving horizontal alignment.
- Allow you to describe Junction Structure, Transition Structure, or Bridge and Wall Entrance and Exit in input file.
- Plot water surface profile and channel geometry.
- Water surface profile computations listing.

WSPG Program (Cont'd)

Limitations

- 200 elements max.
- Max. 50 intermediate points for a reach element.
- Critical depth cannot exceed 100 ft.
- Friction slope < 1
- Undulating bottoms cannot be calculated properly in an irregular shaped section.
- Not accept vertical drops in invert elevations. slope < 10.0
- The system outlet must have the lowest station number and succeeding stations be in ascending order.
- Open channel processing is limited to a depth 10 ft above the height of the channel wall.
- The input data must consist of a minimum of 3 elements (system outlet, system headwork and any other element).
- Suggest no more than 3 profiles.
- Only one "n" value per element.

HEC-2 Program

Capabilities

- A data edit program EDIT-2 is available.
- Produce cross section and profile plots in interactive or batch modes. The vertical and horizontal scales of a profile may be specified.
- Computations proceed upstream for subcritical flow or downstream for supercritical flow.
- The water surface elevation for the beginning cross section may be:
  1. as critical depth
  2. as a known elevation
  3. by the slope area method
- The reach lengths for the left overbank, right overbank and channel used in computations are specified.
- Tributary stream profiles computations
- Split Flow Option
- Printer plots of any or all of the stream cross sections to any scale.

HEC-2 Program (Cont'd)

Limitations

- Flow is one dimensional, gradually varied and steady.
- River channels have small slope. $S < 0.1$
- Do not determine the position of the hydraulic jump or energy losses associated with the jump.
- Max. 14 profiles
- Max. 100 points for a cross section

Greiner Engineering

Greiner Engineering Sciences, Inc.

Tucson 602 327-3413
Phoenix 602 275-5400

Job SCS RWCD Floodway Reach 6 - E101012

Description Comparative Design Studies

Calculated by Gary Sun Date 10/16/85 Sheet No. ____

Checked by M.S.S. Date ____ of ____

Subject: RWCD Reach 6 Comparison between HEC-2 and WSPG

Test problem: Approx. 640 foot floodway near University Bridge

Assumptions:

- Straight reaches
- Q = 1550 cfs and n = 0.035
- HGL = 44.36 at Sta. 94+33.23

Conclusions:

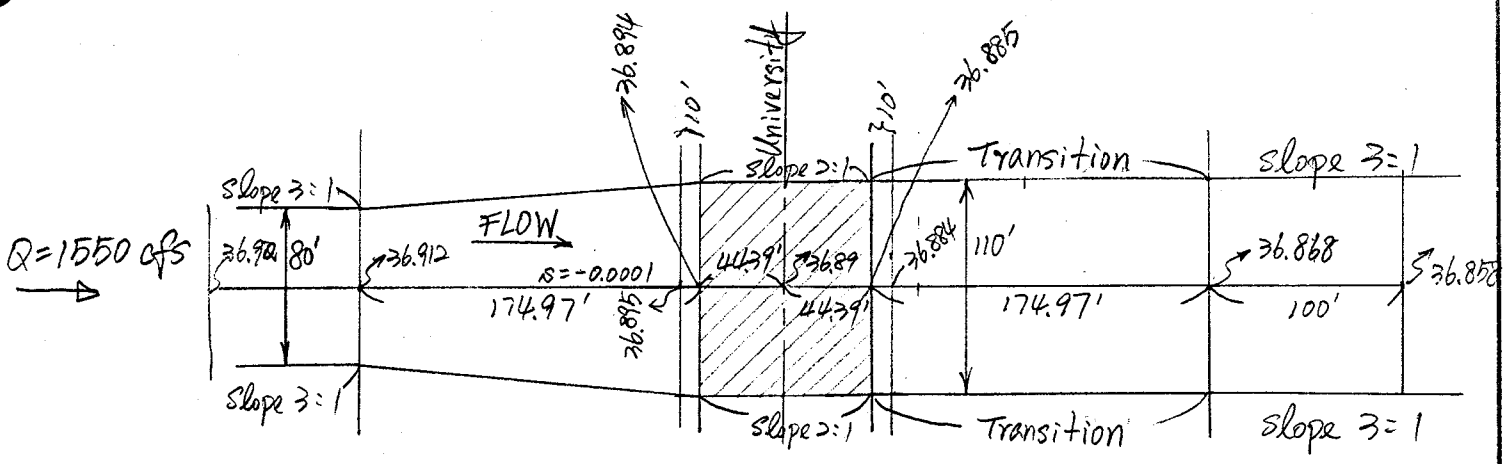
- The results from both programs were virtually identical.
- Recommend using WSPG for Backwater Analysis.

Greiner Engineering

Greiner Engineering Sciences, Inc.

Tucson 602 327-3413
Phoenix 602 275-5400

Job RWCD Floodway Reach 6 - E101012
Description Comparative Design Studies
HEC-2 Program Testing
Calculated by Gary Bun Date 10/15/85 Sheet No. ____
Checked by M.S.S. Date ____ of ____



6+38.72 | 88+94.51 (5+38.72) | (7+73.75) 90+69.48 | 90+69.48 (3+63.75) | (2+74.97) 91+58.26 | 91+68.26 (2+64.97) | 93+33.23 (0+00.00) 1+00.00 | 94+33.23 (0+00.00)

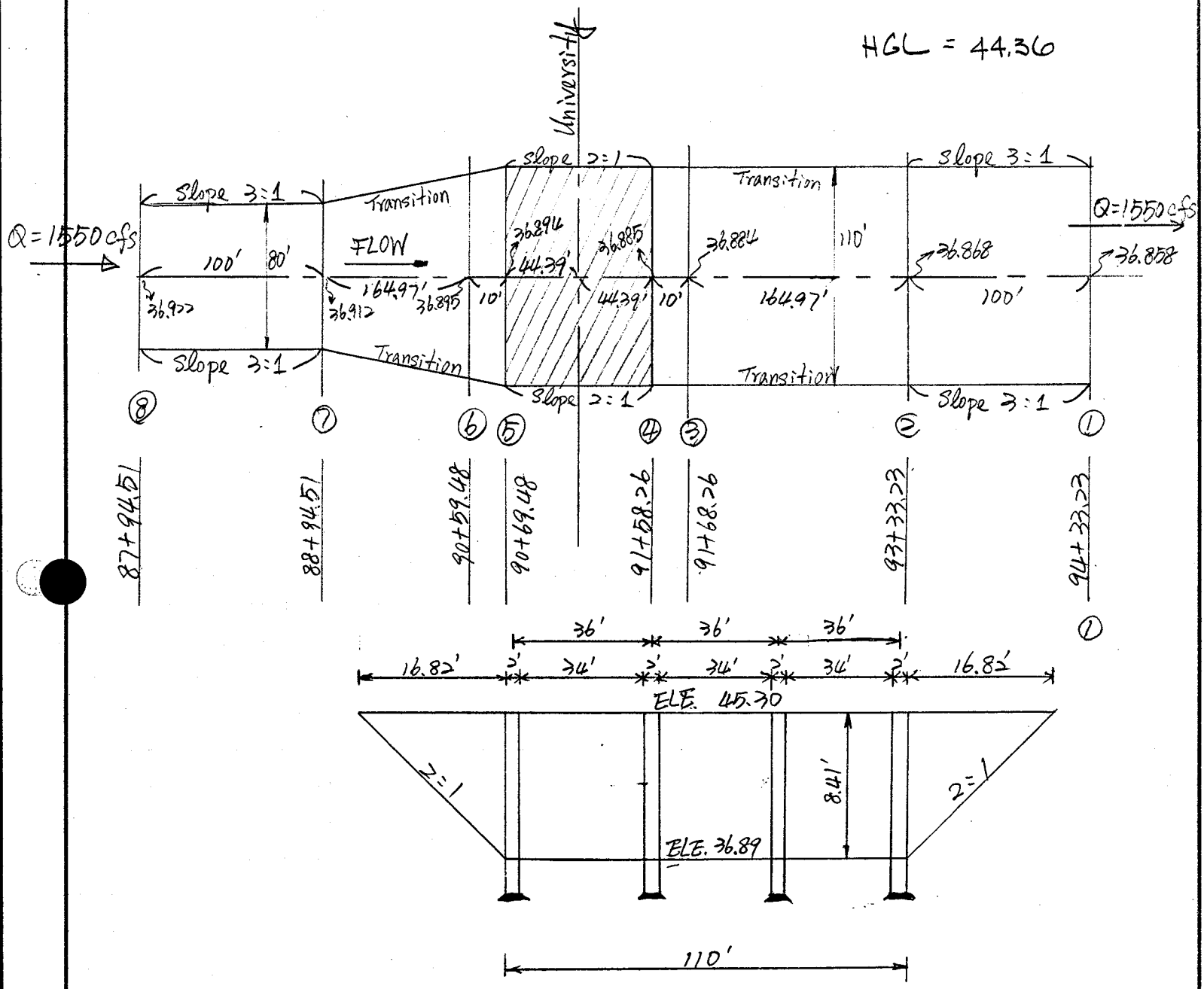
	8	16	24	32	40	48	56	64	72	80
T1		RWCD FLOODWAY REACH 6 - E101012								
T2		AT UNIVERSITY BRIDGE								
T3		NORMAL BRIDGE METHOD								
J1								1550	44.37	
NC		.035	.035	.035						
X1	0.	4.	0.	167.						
GR	46.37	0.	36.87	28.5	36.87	138.5	46.37	167.		
NC					.3	.5				
X1	164.97	4.	0.	148.	164.97	164.97	164.97			
GR	46.38	0.	36.88	19.	36.88	129.	46.38	148.		
X1	174.97				10.	10.	10.			
BT										
X1	263.75				88.78	88.78	88.78			
X2							1			
X1	273.75				10.	10.	10.			
X1	438.72									

Greiner Engineering

Greiner Engineering Sciences, Inc.

Tucson 602 327-3413
Phoenix 602 275-5400

Job SCS RWCD Floodway Reach 6 - E101012
Description Comparative Design Studies
Test HEC-2 & WSPG Program
Calculated by Gary Sun Date 10/16/85 Sheet No.
Checked by M.S.S. Date of



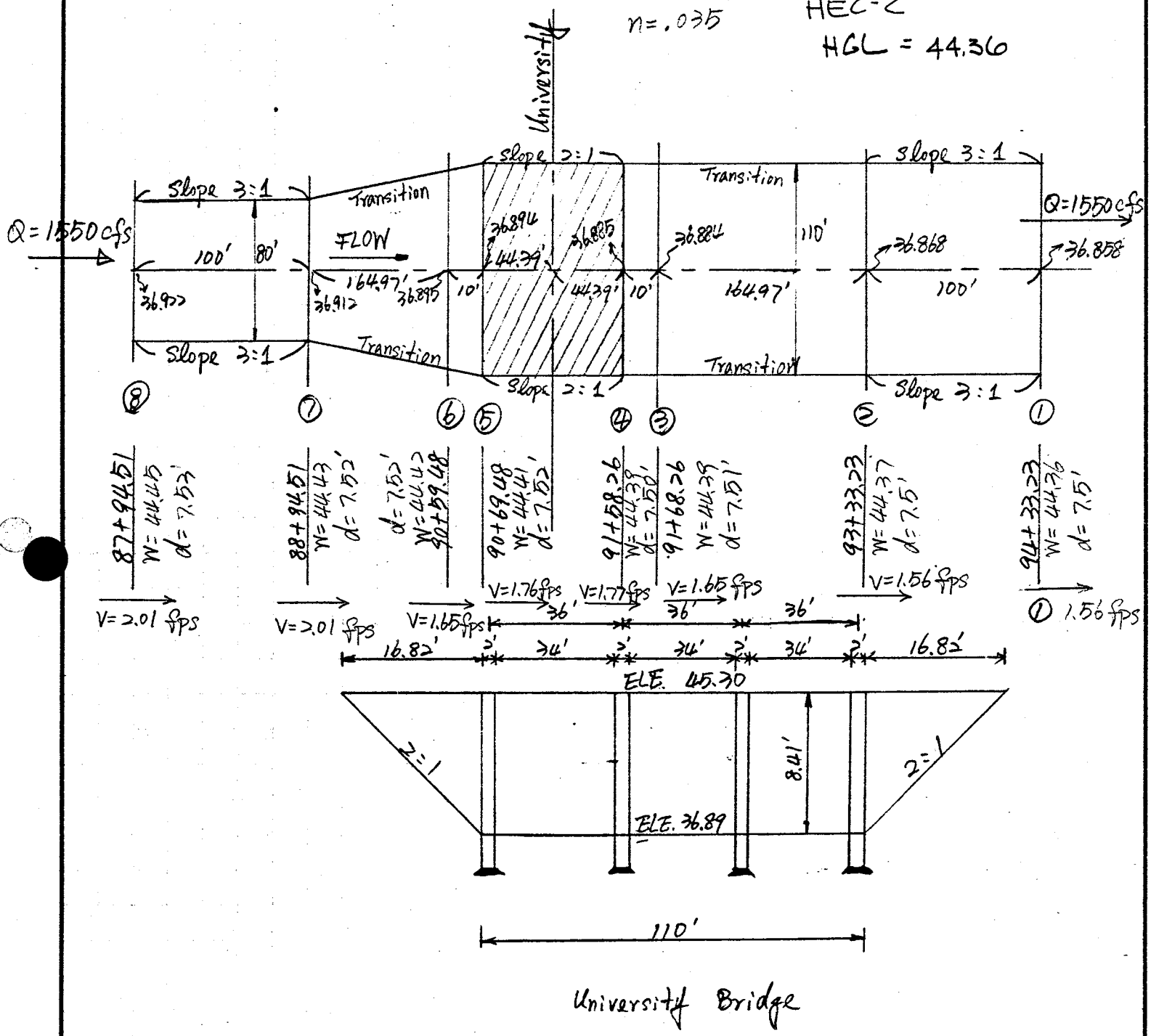
University Bridge

Greiner Engineering

Greiner Engineering Sciences, Inc.

Tucson 602 327-3413
Phoenix 602 275-5400

Job SCS RWCD Floodway Reach 6 - E101012
Description Comparative Design Studies
Test HEC-2 & WSPG Program
Calculated by Gary Sun Date 10/16/85 Sheet No. ____
Checked by M.S.S. Date ____ of ____

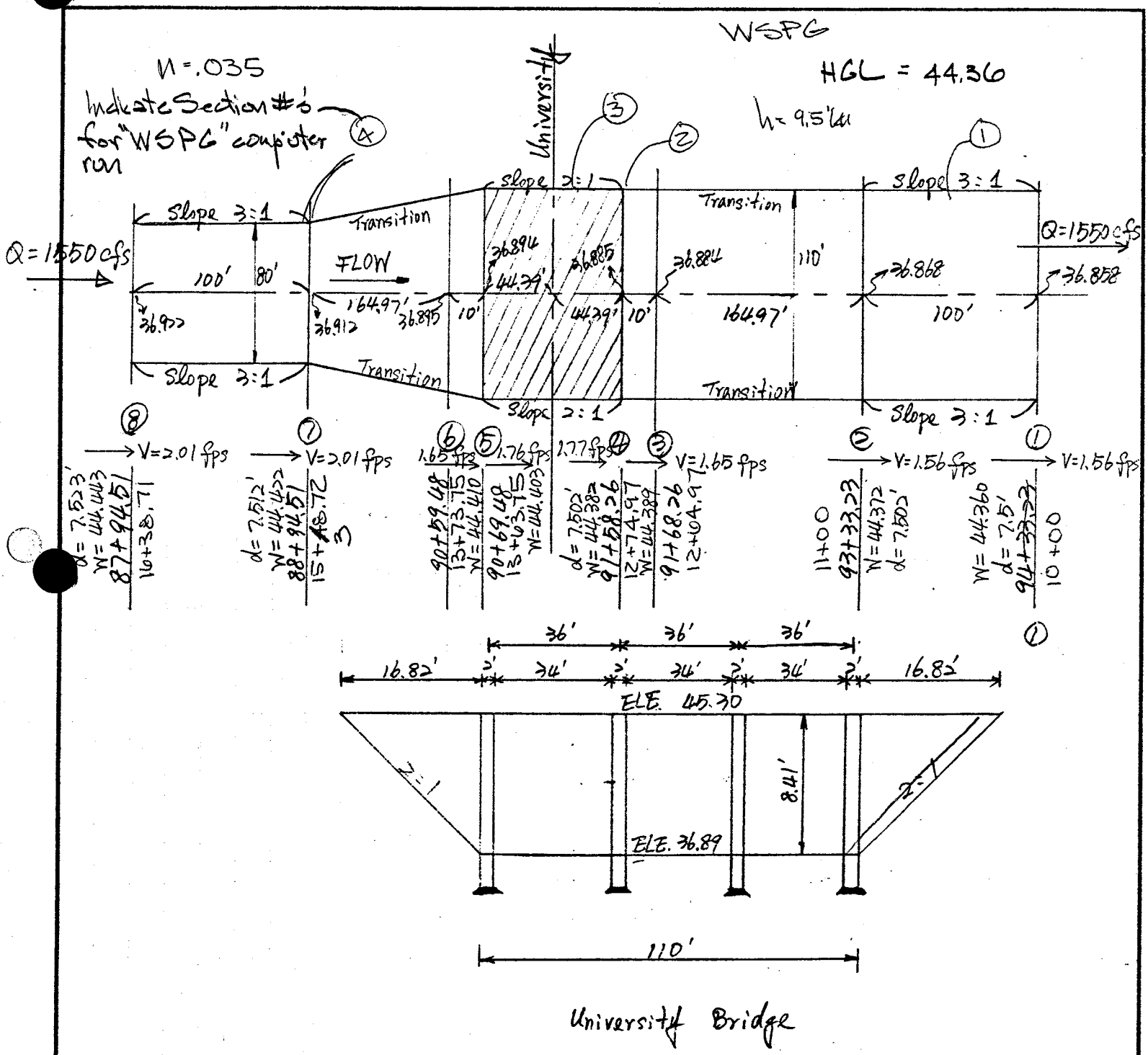


Greiner Engineering

Greiner Engineering Sciences, Inc.

Tucson 602 327-3413
Phoenix 602 275-5400

Job: SCS RWCD Floodway Reach 6 - E101012
Description: Comparative Design Studies
Test HEC-2 & WSPG Program
Calculated by: Gary Snn Date: 10/16/85 Sheet No. ____
Checked by: M.S.S Date: ____ of ____



University Bridge

INPUT FILE FOR HEC-2

```
ER! SLIST T1RWCD
T1      SCS RWCD FLOODWAY REACH 6 AT UNIVERSITY BRIDGE
T2      USE NORMAL BRIDGE METHOD
T3      USE OF X2 CARD AND GR CARDS TO REPRESENT BRIDGE STRUCTURE
J1                                                      1550.   44.36
NC  .035    .035    .035      .1      .3
X1433.23      4.      0.    167.
GR 46.36      0.   36.86    28.5   36.86   138.5   46.36    167.
NC                            .3      .5
X1333.23      4.      0.    167.    100.    100.    100.
GR 46.37      0.   36.87    28.5   36.87   138.5   46.37    167.
X1168.26      4.      0.    148.  164.97  164.97  164.97
X3   10.                                                48.21   48.21
GR 46.38      0.   36.88     19.   36.88     129.   46.38    148.
X1158.26     18.      0.  143.64     10.      10.     10.
X2                         45.3   48.21
GR 45.30      0.   36.89   16.82   45.30   16.82   45.30   18.82   36.89   18.82
GR 36.89   52.82   45.30   52.82   45.30   54.82   36.89   54.82   36.89   88.82
GR 45.30   88.82   45.30   90.82   36.89   90.82   36.89  124.82   45.30  124.82
GR 45.30  126.82   36.89  126.82   45.30  143.64
X1 69.48                          88.78   88.78   88.78
X2                         45.3   48.21
X1 59.48      4.      0.  143.64     10.      10.     10.
X3   10.                                                48.21   48.21
GR 45.30      0.   36.89   16.82   36.89  126.82   45.30  143.64
X1894.51      4.      0.    137.  164.97  164.97  164.97
GR 46.41      0.   36.91    28.5   36.91   108.5   46.41    137.
NC                            .1      .3
X1794.51      4.      0.    137.    100.    100.    100.
GR 46.42      0.   36.92    28.5   36.92   108.5   46.42    137.
EJ


ER
```

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```
OK, SLIST 01RWCD
1

     THIS RUN EXECUTED  16  OCT  85  09:12:21
 ************************************************
   HEC2 RELEASE DATED NOV 76 UPDATED  AUG1977
   ERROR CORR -  01,02
   MODIFICATION -  50,51,52,53
 ************************************************

 T1       SCS RWCD FLOODWAY REACH 6 AT UNIVERSITY BRIDGE
 T2       USE NORMAL BRIDGE METHOD
 T3       USE OF X2 CARD AND GR CARDS TO REPRESENT BRIDGE STRUCTURE

 J1  ICHECK    INQ       NINV      IDIR      STRT      METRIC    HVINS     Q
     WSEL      FQ

        0.        0.        0.        0.  0.000000      0.00       0.0    1550.
    44.360     0.000

 NC      0.035     0.035     0.035     0.100     0.300     0.000       0
.000       0.000     0.000     0.000

 X1    433.230     4.000     0.000   167.000     0.000     0.000       0
.000       0.000     0.000     0.000
 GR     46.360     0.000    36.860    28.500    36.860   138.500      46
.360    167.000     0.000     0.000
 NC      0.000     0.000     0.000     0.300     0.500     0.000       0
.000       0.000     0.000     0.000

 X1    333.230     4.000     0.000   167.000   100.000   100.000     100
.000       0.000     0.000     0.000
 GR     46.370     0.000    36.870    28.500    36.870   138.500      46
.370    167.000     0.000     0.000

 X1    168.260     4.000     0.000   148.000   164.970   164.970     164
.970       0.000     0.000     0.000
 X3     10.000     0.000     0.000     0.000     0.000     0.000       0
.000      48.210    48.210     0.000
 GR     46.380     0.000    36.880    19.000    36.880   129.000      46
.380    148.000     0.000     0.000

 X1    158.260    18.000     0.000   143.640    10.000    10.000      10
.000       0.000     0.000     0.000
 X2      0.000     0.000     0.000    45.300    48.210     0.000       0
.000       0.000     0.000     0.000
 GR     45.300     0.000    36.890    16.820    45.300    16.820      45
.300      18.820    36.890    18.820
 GR     36.890    52.820    45.300    52.820    45.300    54.820      36
.890      54.820    36.890    88.820
 GR     45.300    88.820    45.300    90.820    36.890    90.820      36
.890     124.820    45.300   124.820
 GR     45.300   126.820    36.890   126.820    45.300   143.640       0
.000       0.000     0.000     0.000
```

```
 X1     69.480      0.000      0.000      0.000      88.780      88.780      88
.780      0.000      0.000      0.000
 X2      0.000      0.000      0.000     45.300      48.210       0.000       0
.000      0.000      0.000      0.000


 X1     59.480      4.000      0.000    143.640      10.000      10.000      10
.000      0.000      0.000      0.000
 X3     10.000      0.000      0.000      0.000       0.000       0.000       0
.000     48.210     48.210      0.000
 GR     45.300      0.000     36.890     16.820      36.890     126.820      45
.300    143.640      0.000      0.000


 X1    894.510      4.000      0.000    137.000     164.970     164.970     164
.970      0.000      0.000      0.000
 GR     46.410      0.000     36.910     28.500      36.910     108.500      46
.410    137.000      0.000      0.000
 NC      0.000      0.000      0.000      0.100       0.300       0.000       0
.000      0.000      0.000      0.000


 X1    794.510      4.000      0.000    137.000     100.000     100.000     100
.000      0.000      0.000      0.000
 GR     46.420      0.000     36.920     28.500      36.920     108.500      46
.420    137.000      0.000      0.000
 EJ      0.000      0.000      0.000      0.000       0.000       0.000       0
.000      0.000      0.000      0.000
1
 *PROF 1

 CCHV=   0.100 CEHV=   0.300
 *SECNO 433.230
    SECNO    DEPTH     CWSEL     CRIWS     WSELK     EG        HV        HL        OLOS
S   BANK ELEV
    Q        QLOB      QCH       QROB      ALOB      ACH       AROB      VOL       TWA
  LEFT/RIGHT
    TIME     VLOB      VCH       VROB      XNL       XNCH      XNR       WTN       ELMI
N      SSTA
    SLOPE    XLOBL     XLCH      XLOBR     ITRIAL    IDC       ICONT     CORAR     TOPW
ID     ENDST

    433.23     7.50     44.36      0.00     44.36     44.40      0.04      0.00      0.
00    46.36
     1550.       0.     1550.       0.        0.      994.       0.        0.
0.     46.36
      0.00     0.00      1.56      0.00     0.035     0.035     0.035     0.000    36.
86     6.00
  0.000116       0.        0.        0         0         0         0      0.00   155.
00   161.00
0
 CCHV=   0.300 CEHV=   0.500
 *SECNO 333.230
    333.23     7.50     44.37      0.00      0.00     44.41      0.04      0.01      0.
00    46.37
     1550.       0.     1550.       0.        0.      994.       0.        2.
0.     46.37
      0.02     0.00      1.56      0.00     0.035     0.035     0.035     0.035    36.
87     6.00
  0.000116     100.      100.      100.         0         0         0      0.00   155.
01   161.00
0
 *SECNO 168.260

 3495 OVERBANK AREA ASSUMED NON-EFFECTIVE,ELLEA=       48.21 ELREA=       48.21
    168.26     7.51     44.39      0.00      0.00     44.43      0.04      0.02      0.
00    46.38
```

```
 3495 OVERBANK AREA ASSUMED NON-EFFECTIVE,ELLEA=       48.21 ELREA=       48.21
    168.26     7.51    44.39     0.00     0.00    44.43     0.04     0.02     0.
00    46.38
     1550.       0.    1550.       0.       0.     939.       0.       6.      1
.     46.38
      0.05     0.00     1.65     0.00    0.035    0.035    0.035    0.035    36.
88     3.98
  0.000124     165.     165.     165.        0        0        0     0.00   140.
04   144.02
0
 *SECNO 158.260

 3265 DIVIDED FLOW

 3370 NORMAL BRIDGE,NRD=  0 MIN ELTRD=   48.21 MAX ELLC=   45.30
    158.26     7.50    44.39     0.00     0.00    44.44     0.05     0.00     0.
00    45.30
     1550.       0.    1550.       0.       0.     878.       0.       6.
1.    45.30
      0.05     0.00     1.77     0.00    0.035    0.035    0.035    0.035    36.
89     1.82
  0.000234      10.      10.      10.        0        0        0     0.00   132.
00   141.82
0
 *SECNO 69.480

 3265 DIVIDED FLOW
    SECNO    DEPTH    CWSEL    CRIWS    WSELK       EG       HV       HL     OLOS
S   BANK ELEV
    Q        QLOB      QCH     QROB     ALOB      ACH     AROB      VOL      TWA
  LEFT/RIGHT
    TIME     VLOB      VCH     VROB      XNL     XNCH      XNR      WTN     ELMI
N      SSTA
    SLOPE    XLOBL     XLCH    XLOBR  ITRIAL      IDC    ICONT    CORAR     TOPW
ID     ENDST


 3370 NORMAL BRIDGE,NRD=  0 MIN ELTRD=   48.21 MAX ELLC=   45.30
     69.48     7.52    44.41     0.00     0.00    44.46     0.05     0.02     0.
00    45.30
     1550.       0.    1550.       0.       0.     879.       0.       8.
1.    45.30
      0.06     0.00     1.76     0.00    0.035    0.035    0.035    0.035    36.
89     1.79
  0.000233      89.      89.      89.        0        0        0     0.00   132.
05   141.85
0
 *SECNO 59.480

 3495 OVERBANK AREA ASSUMED NON-EFFECTIVE,ELLEA=       48.21 ELREA=       48.21
     59.48     7.53    44.42     0.00     0.00    44.46     0.04     0.00     0.
00    45.30
     1550.       0.    1550.       0.       0.     940.       0.       8.
1.    45.30
      0.06     0.00     1.65     0.00    0.035    0.035    0.035    0.035    36.
89     1.78
  0.000123      10.      10.      10.        0        0        0     0.00   140.
08   141.86
0
 *SECNO 894.510
    894.51     7.52    44.43     0.00     0.00    44.50     0.06     0.03     0.
01    46.41
     1550.       0.    1550.       0.       0.     773.       0.      11.
2.    46.41
      0.09     0.00     2.01     0.00    0.035    0.035    0.035    0.035    36.
91     5.91
  0.000202     165.     165.     165.        1        0        0     0.00   125.
```

```
CCHV=   0.100 CEHV=   0.300
 *SECNO 794.510
    794.51     7.53    44.45     0.00     0.00    44.52     0.06     0.02     0.
00    46.42
     1550.       0.    1550.       0.       0.     772.       0.      13.
2.     46.42
      0.10     0.00     2.01     0.00    0.035    0.035    0.035    0.035    36.
92     5.91
  0.000202     100.     100.     100.        0        0        0     0.00   125.
18   131.09
0
1
 PROFILE FOR STREAM  USE OF X2 CARD AND GR CA

 PLOTTED POINTS (BY PRIORITY)-E-ENERGY,W-WATER SURFACE,I-INVERT,C-CRITICAL W.S.,
L-LEFT BANK,R-RIGHT BANK,M-LOWER END STA

 ELEVATION-FT     36.       38.       40.       42.       44.       46.       48.
      50.       52.       54.
    SECNO   CUMDIS-FT
   433.23      0.  C   I    .         .         .         . E       . L       .
          .         .         .         .
             10.  C   I    .         .         .         . E       . L       .
          .         .         .         .
             20.  C   I    .         .         .         . E       . L       .
          .         .         .         .
             30.  C   I    .         .         .         . E       . L       .
          .         .         .         .
             40.  C   I    .         .         .         . E       . L       .
          .         .         .         .
             50.  C   I    .         .         .         . E       . L       .
          .         .         .         .
             60.  C   I    .         .         .         . E       . L       .
          .         .         .         .
             70.  C   I    .         .         .         . E       . L       .
          .         .         .         .
             80.  C   I    .         .         .         . E       . L       .
          .         .         .         .
             90.  C   I    .         .         .         . E       . L       .
          .         .         .         .
  333.23    100.  C   I    .         .         .         . E       . L       .
          .         .         .         .
            110.  C   I    .         .         .         . E       . L       .
          .         .         .         .
            120.  C   I    .         .         .         . E       . L       .
          .         .         .         .
            130.  C   I    .         .         .         . E       . L       .
          .         .         .         .
            140.  C   I    .         .         .         . E       . L       .
          .         .         .         .
            150.  C   I    .         .         .         . E       . L       .
          .         .         .         .
            160.  C   I    .         .         .         . E       . L       .
          .         .         .         .
            170.  C   I    .         .         .         . E       . L       .
          .         .         .         .
            180.  C   I    .         .         .         . E       . L       .
          .         .         .         .
            190.  C   I    .         .         .         . E       . L       .
          .         .         .         .
            200.  C   I    .         .         .         . E       . L       .
          .         .         .         .
            210.  C   I    .         .         .         . E       . L       .
          .         .         .         .
```

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B = BRIDGE ENTRANCE OR EXIT

Y = WALL ENTRANCE OR EXIT

2. STATIONS FOR POINTS AT A JUMP MAY NOT BE PLOTTED EXACTLY

1

14112 G.B.

```
1378.01    .I                C
           WE                H .    TX
1391.05    .                 .
1404.08    .                 .
1417.12    .                 .
1430.15    .                 .
1443.19    .                 .
1456.22    .                 .
1469.26    .                 .
1482.29    .                 .
1495.33    .                 .
1508.36    .                 .
1521.40    .                 .
1534.43    .                 .
1547.47    .I                  C
           X                 H .    R
1560.50    .                 .
1573.54    .                 .
1586.57    .                 .
1599.61    .                 .
1612.64    .                 .
1625.68    .                 .
1638.71    .I                  C
           X                 H.    R
                .         .         .         .         .         .         .
0               36.86     37.82     38.77     39.73     40.68     41.64     42.
60      43.55   44.51     45.46     46.42
```

N O T E S

1. GLOSSARY

I = INVERT ELEVATION

C = CRITICAL DEPTH

W = WATER SURFACE ELEVATION

H = HEIGHT OF CHANNEL

E = ENERGY GRADE LINE

X = CURVES CROSSING OVER

PRINTED IN U.S.A.

10-16-85

```
                 .         .         .         .         .         .         .
       .         .         .         .
     1000.00    .I             .   C
               X                    H .    R
     1013.03    .
                                      .
     1026.07    .
                                      .
     1039.10    .
                                      .
     1052.14    .
                                      .
     1065.17    .                          .
                                      .
     1078.21    .
                                      .
     1091.24    .
                                      .
     1104.28    .I                 C
               X                    H .    TX
     1117.31    .
                                      .
     1130.35    .
                                      .
     1143.38    .
                                      .
     1156.42    .
                                      .
     1169.45    .
                                      .
     1182.49    .
                                      .
     1195.52    .
                                      .
     1208.56    .
                                      .
     1221.59    .
                                      .
     1234.63    .
                                      .
     1247.66    .
                                      .
     1260.70    .
                                      .
     1273.73    .
                                      .
     1286.77    .IBBBBBBBBBBBBBBBBBBBCBBBBBBBBBBBBBBBBBBBBBBBBBBBBBBBBBBBBBBBBBBBBBBBBBBBBBB
BBBBBBBBBBBBBBBWEBBBBBBBBBBBBBBBBBBBH .    BX
     1299.80    .I                   C
               WE        H            .    R
     1312.84    .
                                      .
     1325.87    .
                                      .
     1338.91    .
                                      .
     1351.94    .
                                      .
     1364.98    .IBBBBBBBBBBBBBBBBBBBCBBBBBBBBBBBBBBBBBBBBBBBBBBBBBBBBBBBBBBBBBBBBBBBBBBBBBB
```

PRINTED IN U.S.A

```
OK, SLIST 0_Q.WSPG.TEST
 ** WARNING NO. 2 ** - WATER SURFACE ELEVATION GIVEN IS LESS THAN OR EQUALS INVE
RT ELEVATION IN HDWKDS, W.S.ELEV = INV + DC
1THE SP GROUP                                   WATER SUFACE PROFILE PROGRAM
                                          PAGE   1
                                                      VERSION 03.00

 INPUT FILE :  Q.WSPG.TEST
                                          DATE 10/16/85

                                          TIME 12:37:01
                                                WATER SURFACE PROFILE LISTING

 TEST PROGRAM FOR HEC-2 COMPARISON THROUGH UNIVERSITY BRIDGE


 10-16-85

0 STATION    INVERT   DEPTH     W.S.        Q       VEL   VEL     ENERGY   SUPER
  CRITICAL           HGT/   BASE/    ZL   NO  AVBPR
             ELEV    OF FLOW    ELEV                          HEAD   GRD.EL.   ELE
V    DEPTH             DIA    ID NO.       PIER
0 L/ELEM      SO                                            SF AVE     HF
            NORM DEPTH                    ZR
*******************************************************************************
*************************************************
0  1000.00    36.86     7.500    44.360    1550.0    1.56    0.038    44.398   0.
00    1.804              9.50  110.00  3.00   0   0.0
0   100.00  0.00010                                       .000120     0.01
                7.819                   3.00
0  1100.00    36.87     7.502    44.372    1550.0    1.56    0.038    44.410   0.
00    1.804              9.50  110.00  3.00   0   0.0
0TRANS STR  0.00006                                       .000120     0.02
                                        3.00
0  1274.97    36.88     7.509    44.389    1550.0    1.65    0.042    44.431   0.
00    1.814              9.50  110.00  2.00   0   0.0
0BRIDGE EXIT
                                        2.00
0  1274.97    36.88     7.502    44.382    1550.0    1.77    0.048    44.430   0.
00    1.905              8.41  110.00  2.00   4   2.0
0    88.78  0.00011                                       .000230     0.02
                9.471                   2.00
0  1363.75    36.89     7.513    44.403    1550.0    1.76    0.048    44.451   0.
00    1.905              8.41  110.00  2.00   4   2.0
0BRIDGE ENTRANCE
                                        2.00
0  1363.75    36.89     7.520    44.410    1550.0    1.65    0.042    44.452   0.
00    1.814              9.50  110.00  2.00   0   0.0
0TRANS STR  0.00011                                       .000160     0.03
                                        2.00
0  1538.72    36.91     7.512    44.422    1550.0    2.01    0.063    44.485   0.
00    2.205              9.50   80.00  3.00   0   0.0
0    99.99  0.00010                                       .000200     0.02
                9.161                   3.00
0  1638.71    36.92     7.523    44.443    1550.0    2.01    0.063    44.506   0.
00    2.205              9.50   80.00  3.00   0   0.0
1

1 TEST PROGRAM FOR HEC-2 COMPARISON THROUGH UNIVERSITY BRIDGE
```

```
                                  1000.00   36.86    1
                44.36
0 ELEMENT NO   2 IS A REACH                *         *     *
                        U/S DATA   STATION    INVERT  SECT              N
                          RADIUS  ANGLE  ANG PT  MAN H
                                  1100.00   36.87    1             0.035
                            0.00   0.00    0.00     0
0 ELEMENT NO   3 IS A TRANSITION           *         *     *
                        U/S DATA   STATION    INVERT  SECT              N
                                  1274.97   36.89    2             0.035
0 ELEMENT NO   4 IS A BRIDGE EXIT                          *
                        U/S DATA   STATION    INVERT  SECT
                                  1274.97   36.89    3
0 ELEMENT NO   5 IS A REACH                *         *     *
                        U/S DATA   STATION    INVERT  SECT              N
                          RADIUS  ANGLE  ANG PT  MAN H
                                  1363.75   36.89    3             0.035
                            0.00   0.00    0.00     0
0 ELEMENT NO   6 IS A BRIDGE ENTRANCE                      *
                        U/S DATA   STATION    INVERT  SECT             FP
                                  1363.75   36.89    2             0.035
0 ELEMENT NO   7 IS A TRANSITION           *         *     *
                        U/S DATA   STATION    INVERT  SECT              N
                                  1538.72   36.91    4             0.035
0 ELEMENT NO   8 IS A REACH                *         *     *
                        U/S DATA   STATION    INVERT  SECT              N
                          RADIUS  ANGLE  ANG PT  MAN H
                                  1638.71   36.92    4             0.035
                            0.00   0.00    0.00     0
0 ELEMENT NO   9 IS A SYSTEM HEADWORKS                     *                    *
                        U/S DATA   STATION    INVERT  SECT
            W S ELEV
                                  1638.71   36.92    4
                0.00
 NO EDIT ERRORS ENCOUNTERED-OK TO BEGIN PROCESSING DATA WITH WSPG
```

```
OK, SLIST 0_WSPG.TEST
1THE SP GROUP                                   WATER SURFACE PROFILE EDIT PROG
                                          PAGE   1
                                                     VERSION 03.00

 INPUT FILE :  WSPG.TEST
                                          DATE 10/16/85

                                          TIME 10:37:52
                                            WATER SURFACE PROFILE - CHANNEL DEFINIT
ION LISTING
0 CARD  SECT  CHN   NO OF  AVE PIER  HEIGHT 1  BASE    ZL    ZR    INV   Y(1)  Y(
2)  Y(3)  Y(4)  Y(5)  Y(6)  Y(7)  Y(8)  Y(9)  Y(10)
  CODE   NO   TYPE  PIERS   WIDTH    DIAMETER  WIDTH              DROP


  CD      1    1      0       0.00      9.50  110.00   3.00  3.00  0.00

  CD      2    1      0       0.00      9.50  110.00   2.00  2.00  0.00

  CD      3    1      4       2.00      8.41  110.00   2.00  2.00  0.00

  CD      4    1      0       0.00      9.50   80.00   3.00  3.00  0.00

1THE SP GROUP                                   WATER SURFACE PROFILE EDIT PROG
                                          PAGE   1
                                                     VERSION 03.00

 INPUT FILE :  WSPG.TEST
                                          DATE 10/16/85

                                          TIME 10:37:52
0                                         WATER SURFACE PROFILE - TITLE CARD LISTIN
G
0HEADING LINE NO 1 IS -

0                                 TEST PROGRAM FOR HEC-2 COMPARISON THROUGH UNIVERS
ITY BRIDGE
0HEADING LINE NO 2 IS -

0

0HEADING LINE NO 3 IS -

0                                 10-16-85

1THE SP GROUP                                   WATER SURFACE PROFILE EDIT PROG
                                          PAGE   2
                                                     VERSION 03.00

 INPUT FILE :  WSPG.TEST
                                          DATE 10/16/85

                                          TIME 10:37:52
0                                         WATER SURFACE PROFILE - ELEMENT CARD LIST
ING
0 ELEMENT NO   1 IS A SYSTEM OUTLET     *         *     *

                         U/S DATA   STATION    INVERT  SECT
```

```
ER! SLIST WSPG.TEST
T1 TEST PROGRAM FOR HEC-2 COMPARISON THROUGH UNIVERSITY BRIDGE
T3 10-16-85
SO   1000.00  36.86  1                                44.36
R    1100.00  36.87  1       .035
TS   1274.97  36.89  2       .035
BX                   3       .035
R    1363.75  36.89  3       .035
BE                   2       .035
TS   1538.72  36.91  4       .035
R    1638.71  36.92  4       .035
SH                   4
CD   1  1              9.5   110.00 3.0  3.0
CD   2  1              9.5   110.00 2.0  2.0
CD   3  1   4   2.00   8.41  110.00 2.0  2.0
CD   4  1              9.5    80.00 3.0  3.0
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PRINTED IN U.S.A.

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          550.  C    I    .    .    .    . WE    . L    .
          .     .    .    .
          560.  C    I    .    .    .    . WE    . L    .
          .     .    .    .
          570.  C    I    .    .    .    . WE    . L    .
          .     .    .    .
          580.  C    I    .    .    .    . WE    . L    .
          .     .    .    .
          590.  C    I    .    .    .    . WE    . L    .
          .     .    .    .
          600.  C    I    .    .    .    . WE    . L    .
          .     .    .    .
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          .     .    .    .
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          .     .    .    .
   794.51 640.  C    I    .    .    .    . WE    . L    .
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     THIS RUN EXECUTED  16  OCT  85  09:12:27
*************************************************
  HEC2 RELEASE DATED NOV 76 UPDATED  AUG1977
  ERROR CORR -  01,02
  MODIFICATION -  50,51,52,53
*************************************************
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          220.   C    I     .          .          .         . E        . L        .
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          230.   C    I     .          .          .         . E        . L        .
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          260.   C    I     .          .          .         . E        . L        .
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 168.26   270.   C    I     .          .          .         . E        . L        .
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 158.26   280.   C    I     .          .          .         . E    L   .          .
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          300.   C    I     .          .          .         . E    L   .          .
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          310.   C    I     .          .          .         . E    L   .          .
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  69.48   370.   C    I     .          .          .         . E    L   .          .
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  59.48   380.   C    I     .          .          .         . E    L   .          .
      .          .          .          .
          390.   C    I     .          .          .         . E     L  .          .
      .          .          .          .
          400.   C    I     .          .          .         . E     L  .          .
      .          .          .          .
          410.   C    I     .          .          .         . E      L .          .
      .          .          .          .
          420.   C    I     .          .          .         . E      L .          .
      .          .          .          .
          430.   C    I     .          .          .         . E      L .          .
      .          .          .          .
          440.   C    I     .          .          .         . E       L.          .
      .          .          .          .
          450.   C    I     .          .          .         . E       L.          .
      .          .          .          .
          460.   C    I     .          .          .         . E       L.          .
      .          .          .          .
          470.   C     I    .          .          .         . E        L          .
      .          .          .          .
          480.   C     I    .          .          .         . E        L          .
      .          .          .          .
          490.   C     I    .          .          .         . E        L          .
      .          .          .          .
          500.   C     I    .          .          .         . E        .L         .
      .          .          .          .
          510.   C     I    .          .          .         . E        .L         .
      .          .          .          .
          520.   C     I    .          .          .         . E        .L         .
      .          .          .          .
          530.   C     I    .          .          .         . E        . L        .
      .          .          .          .
 894.51   540.   C     I    .          .          .         . WE       . L        .
```

Greiner Engineering

Greiner Engineering Sciences, Inc.

Tucson 602 327-3413
Phoenix 602 275-5400

Job SCR RWCD Floodway Reach 6 - E10/012

Description Powerline Easement Channel

Calculated by B. Gary Sun Date 11/6/85 Sheet No. ____

Checked by M.S.S. Date ____ of ____

1. Three alternates

① One for a bridge over a concrete channel.

② One with a box culvert with a straight headwall.

③ One with transitions to a dip section for a maintenance road.

All alternates had the inlet entering the floodway with a 115 foot radius and using the invert elevation as proposed by Anderson-Nichols.

Greiner Engineering

Greiner Engineering Sciences, Inc.

Tucson 602 327-3413
Phoenix 602 275-5400

Job SCS RWCD Floodway Reach 6 - E101012

Description Powerline Easement Channel Alt. No. 1 14' wide 80' long Bridge

Calculated by B. Gary Sun Date 11/11/85 Sheet No. ____

Checked by M.S.S. Date ____ of ____

1. Problem Set Up

VOID - 11/19/85

① Downstream Control Water Surface Elevation

(i) For 100 year 24 hour storm $Q_{100} = 1200$ cfs W.E. = 43.94

(ii) Empty Floodway.

② Curve reaches between Sta. 10+98.88 and Sta. 12+26.81 with R = 114.86 ft.

③ At Sta. 11+51.81 set Inv. Elev. at 41.00 and S = 0.00145 ft/ft as per Anderson-Nichols recommended. for upstream stations

④ Use 14' long 80' wide concrete bridge.

⑤ n = 0.013 for concrete lined channel.

⑥ Q = 1150 cfs in powerline easement channel.

Greiner Engineering

Greiner Engineering Sciences, Inc.

Tucson 602 327-3413
Phoenix 602 275-5400

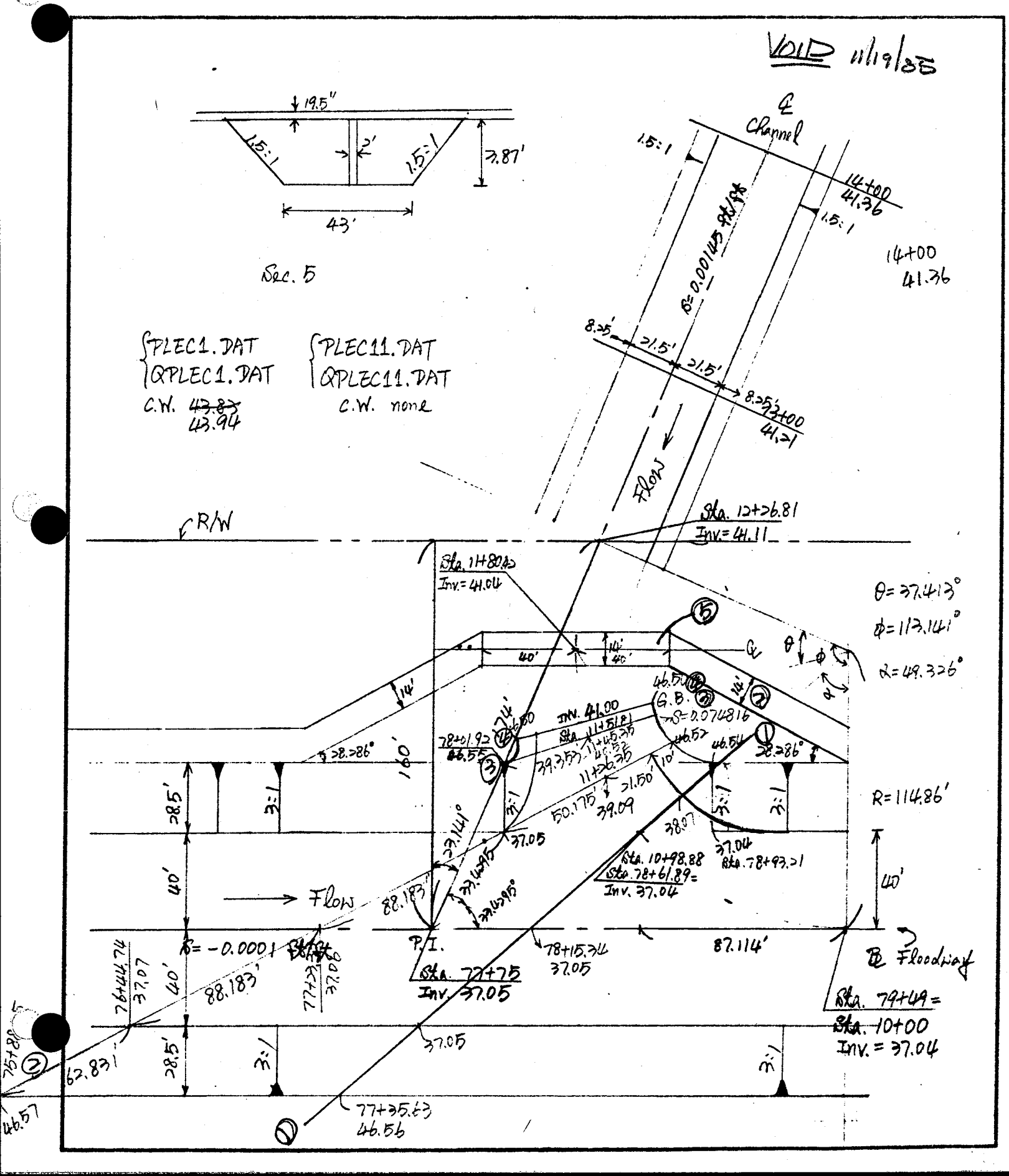
Job SCC RWCD Floodway Reach 6 - E101012

Description Power Line Easement Channel
Alt. #1 14' Wide 80' long Bridge

Calculated by B. Gary Burn Date 11/6/85 Sheet No ____

Checked by MSS Date ____ of ____

VOID 11/19/85



Greiner Engineering

Greiner Engineering Sciences, Inc.

Tucson 602 327-3413
Phoenix 602 275-5400

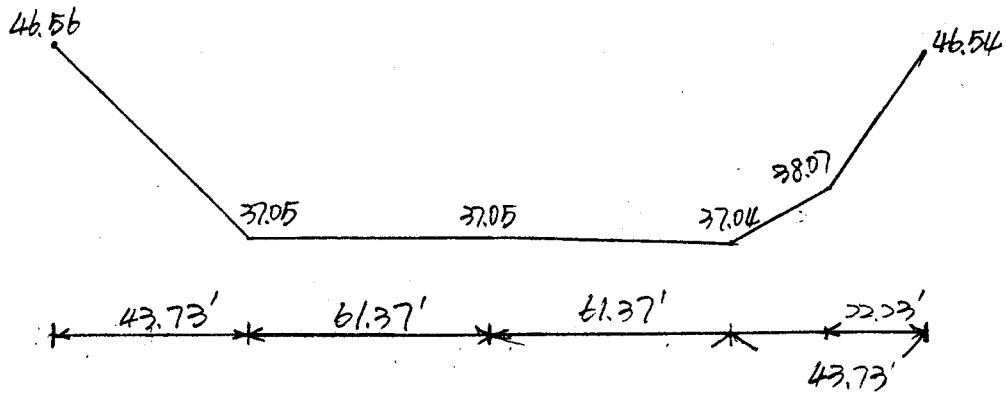
Job: BCS RWCD Floodway Reach 6 - E101012

Description: Power Line Easement Channel Alt. #1 14' wide 80' long Bridge

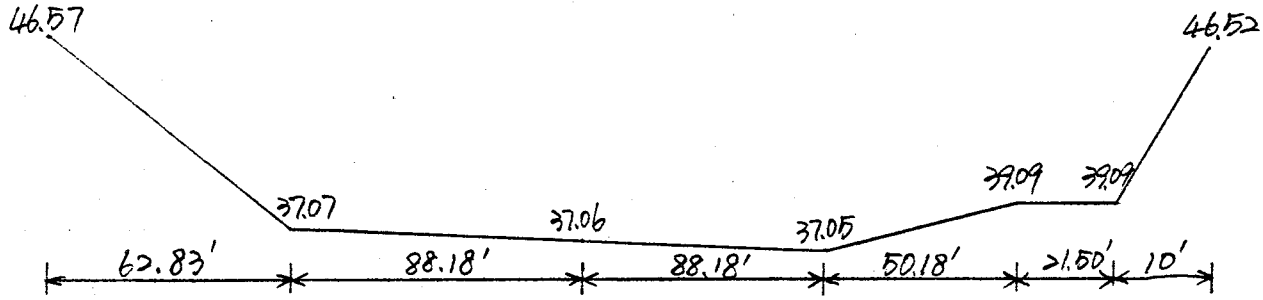
Calculated by: B. Gayl Sun Date: 11/6/85 Sheet No. ____

Checked by: M.S.S. Date: ____ of ____

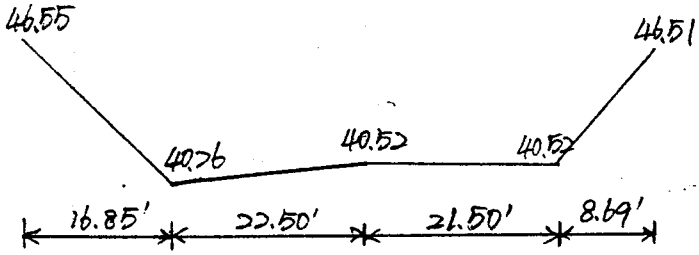
Void 11/19/85



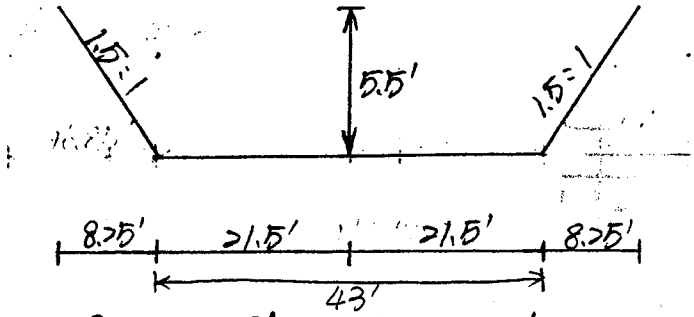
Sec. 1 Sta. 10+98.88
(Sta. 78+61.89)



Sec. 2 Sta. 11+26.35



Sec. 3. Sta. 11+45.35



Sec. 4 Sta. 11+51.81, etc.

PLEC1.DAT

Page 1 of 4 Date 11/05/85

Name B. Gary Sun

Project Power Line Easement Channel

HYDRAULIC ANALYSIS COMPUTER PROGRAM
(FORM NO. 1) SCS RWCD Floodway Reach 6

T1 SCS RWCD FLOODWAY REACH 6 COMPARATIVE DESIGN STUDIES ~~DATA NO 1~~
T2 POWER LINE EASEMENT CHANNEL WITH 80 FOOT BRIDGES
T3 ALTERNATE 1 11-06-85

	ELEM TYPE	STA 1	INV 1	CROSS SECT IDENT NO FROM FORM NO. 2 & 3	LATERAL ONE	LATERAL TWO	n f_p/K_o	Q_3	Q_4	WS ELEV. AT SO AND OR BI INV 3	RADIUS OF CURVE INV 4	Δ OF CURVE ϕ_3 Δ° CONF	Δ POINT ϕ_4 Δ° CONF
1	SO	1098.88	37.04	1						43.83			
2	TS	1126.35	37.05	2			.019						
3	TS	1145.35	40.26	3			.013						
4	TS	1161.81	41.00	4			.013				114.86		
5	R	1173.42	41.02	4			.013				114.86		
6	BX			5									
7	R	1187.42	41.05	5			.013				114.86		
8	BE			4									
9	R	1216.81	41.11	4			.013				~~114.86~~		
10	R	1300.00	41.21	4			.013						
11	SH			4						44.15			
12													
13													
14													
15													
16													
17													
18													
19													
20													

Page 2 of 4 Date 11/5/85

Name B. Gary Sun

Project SCS RWCD Floodway Reach 6
Power Line Easement Channel

HYDRAULIC ANALYSIS COMPUTER PROGRAM
(FORM NO. 2)

	CARD CODE	CROSS SECT. IDENT. NO.	CHAN TYPE	NO. OF PIERS	AVE WIDTH OF PIERS	HEIGHT OR DIAMETER	BASE WIDTH Y(PR. 1)	Z_L Y(PR. 2)	Z_R Y(PR. 3)	INV. CROSS FALL (In.) Y(PR. 4)	Y(PR. 5)	Y(PR. 6)	Y(PR. 7)	Y(PR. 8)	Y(PR. 9)	Y(PR. 10)
1	CD	1	5													
2	CD	2	5													
3	CD	3	5													
4	CD	4	1			15.50	43.00	1.50	1.50							
5	CD	5	3	1	2.00	3.87	43.00	1.50	1.50							
6	CD															
7	CD															
8	CD															
9	CD															
10	CD															
11	CD															
12	CD															
13	CD															
14	CD															
15	CD															
16	CD															
17	CD															
18	CD															
19	CD															
20	CD															

Page 3 Of 4 Date 11/5/85

Name B. Gary Sun

Project BCB RWCD Floodway Reach 6

Power Line Easement Channel

HYDRAULIC ANALYSIS COMPUTER PROGRAM

(FORM NO. 3)

	CARD CODE	CROSS SECT. IDENT. NO.	MJ	PO	Pt. 1(x,y) X(1)	Pt. 1(x,y) Y(1)	Pt. 1(x,y) X(1)	Pt. 1(x,y) Y(1)	Pt. 1(x,y) X(1)	Pt. 1(x,y) Y(1)	Pt. 1(x,y) X(1)	Pt. 1(x,y) Y(1)	Pt. 1(x,y) X(1)	Pt. 1(x,y) Y(1)
1	PTS	1	6		0.00	19.52	43.73	0.01	105.10	0.10	166.47	0.00	187.97	1.03
2	PTS			210	0.20	19.50								
3	PTS	2	7		0.00	19.52	62.83	0.02	151.01	0.10	239.19	0.00	289.37	2.04
4	PTS			310	0.87	2.043	20.87	9.47						
5	PTS	3	5		0.00	6.29	16.85	0.00	39.35	0.26	60.85	0.26	69.54	6.25
6	PTS													
7	PTS													
8	PTS													
9	PTS													
10	PTS													
11	PTS													
12	PTS													
13	PTS													
14	PTS													
15	PTS													
16	PTS													
17	PTS													
18	PTS													
19	PTS													
20	PTS													
21	PTS													

Page 4 of 4 Date 11/5/85.

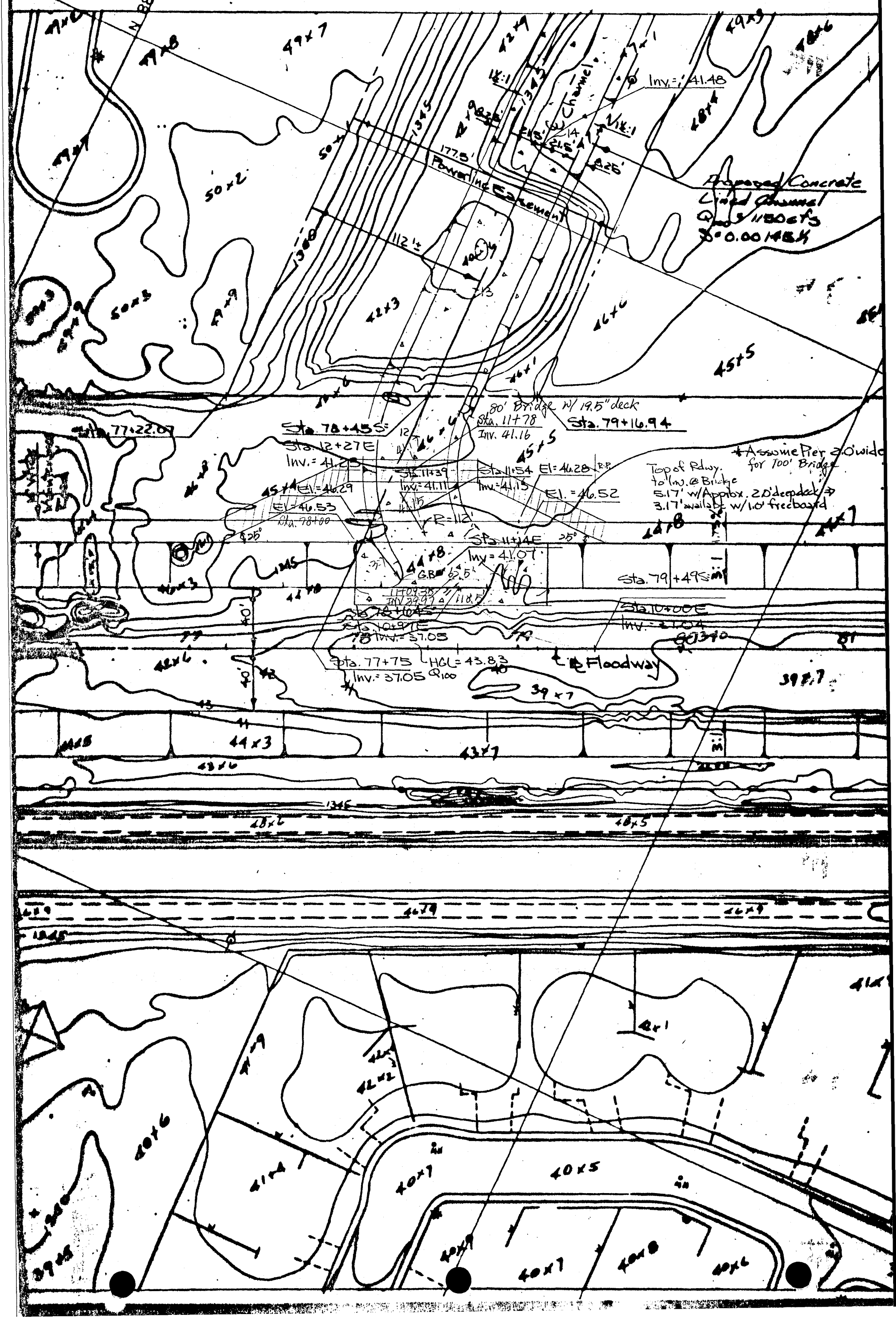
Name B. Gary Sun.

Project SCS RWCD Floodway Reach 6
Power line easement channel

HYDRAULIC ANALYSIS COMPUTER PROGRAM
(FORM NO. 4)

	Q Card		Q at System Headworks	Q Factor
1	Q		1150.0	1
2	Q		.	.
3	Q		.	.
4	Q		.	.
5	Q		.	.
6	Q		.	.
7	Q		.	.
8	Q		.	.
9	Q		.	.
10	Q		.	.
11	Q		.	.
12	Q		.	.
13	Q		.	.
14	Q		.	.
15	Q		.	.
16				
17				
18				
19				
20				
21				
22				
23				
24				
25				

ALT. NO. 1 (N.B. see sketch)



Greiner Engineering

Greiner Engineering Sciences, Inc.

Tucson 602 327-3413
Phoenix 602 275-5400

Job SCS RWCD Floodway Reach 6 - E101012

Description Powerline Easement Channel
Alt. No. 2 5 barrel 8'x5' box culvert

Calculated by B. Garit Sun Date 11/12/85 Sheet No. ____

Checked by M.S.S. Date ____ of ____

1. Problem Set Up

Void 11/19/85

① Downstream Control Water Surface Elevation

(i) For 100 year 24 hour storm $Q_{100} = 1200$ cfs W.E. = 43.94

(ii) Empty Floodway

② Curve reaches between Sta. 10+98.88 and Sta. 12+26.81 with R = 1148.6 ft.

③ Set Inv. Elev. 41.00 at Sta. 11+51.81 and S = 0.00145 ft/ft as per Anderson-Nichols recommended.

④ Use 5 barrel 8'x5' box culvert with headwalls.

⑤ n = 0.013 for concrete lined channel.

⑥ Q = 1150 cfs in Poweline Easement Channel

Greiner Engineering

Greiner Engineering Sciences, Inc.

Tucson 602 327-3413
Phoenix 602 275-5400

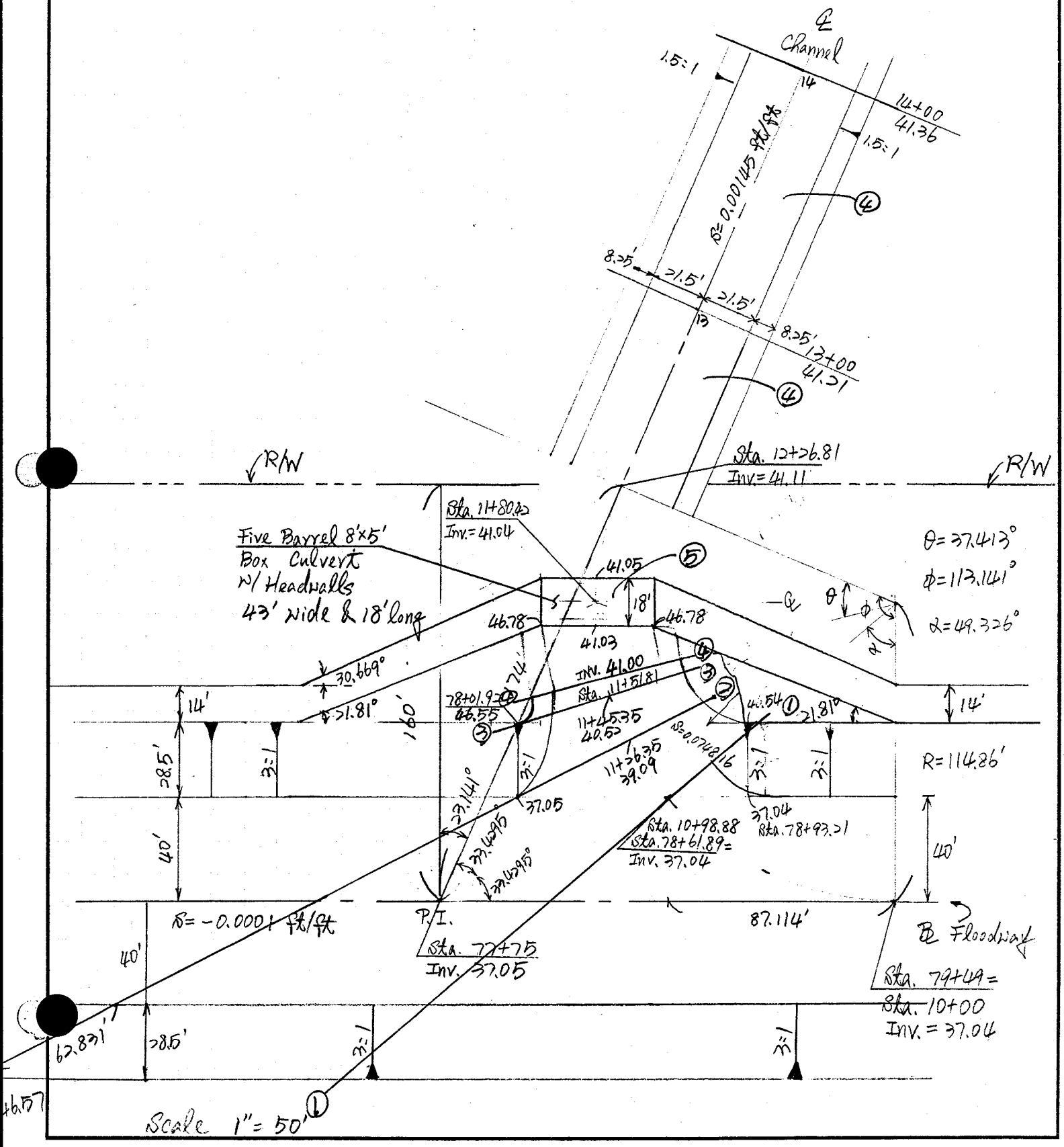
Job: SCS RWCD Floodway Reach 6 - E101012

Description: Powerline Easement Channel
Alt. #2 5 barrel 8'x5' box culvert w/headwalls

Calculated by: B. Gary Sun Date: 11/7/85 Sheet No. ____

Checked by: M.S.S. Date ____ of ____

Void 11/19/85



Greiner Engineering

Greiner Engineering Sciences, Inc.

Tucson 602 327-3413
Phoenix 602 275-5400

Job SCS RWCD Floodway Reach 6 - E101012

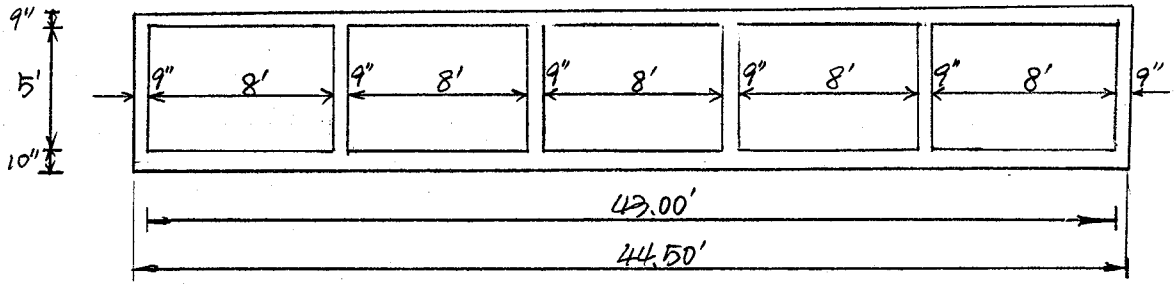
Description Channel for Powerline Easement
5 barrel 8'x5' box culvert w/ Headwalls

Calculated by B. Gary Sun Date 11/7/85 Sheet No. ____

Checked by M.S.S Date ____ of ____

Cost Estimate (Alt. #2)

Void 11/19/85



5 barrel 8'x5' box culvert w/ Headwalls (L=18')

Box:

Concrete — 3.510 C.Y./L.F x 18 L.F. = 63.18 C.Y.

Steel — 582.50 LBS/L.F. x 18 L.F. = 10,485 LBS.

Headwall (CW2 right angle barrel)

Concrete — Inlet (5.50+1.13x4) + Outlet (5.27+1.13x4) = 10.03 + 9.79 = 19.81 C.Y.

Steel — Inlet (433+106.4x4) + Outlet (420+106.4x4) = 858.6 + 845.6 = 1,704.2 LBS.

Total:

Concrete — 82.99 C.Y. x $165/C.Y. = $ 13,693.35

Steel — 12,189.2 LBS. x $.38 /LBS. = $ 4,631.90

$ 18,325.25

PROJECT: RWCD Reach 6 - Channel for Powerline Easement

DESIGNER: M. Shapiro

DATE: 11/6/85

HYDROLOGIC AND CHANNEL INFORMATION

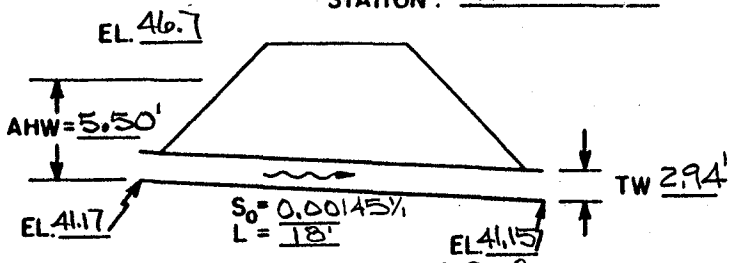
Q_1 = ____ TW_1 = ____

Q_2 = 1150 cfs TW_2 = 2.94'

(Q_1 = DESIGN DISCHARGE, SAY Q_{25}
Q_2 = CHECK DISCHARGE, SAY Q_{50} OR Q_{100})

SKETCH

STATION: 11+78E



MEAN STREAM VELOCITY = 8.26 fps

MAX. STREAM VELOCITY = 8.26 fps

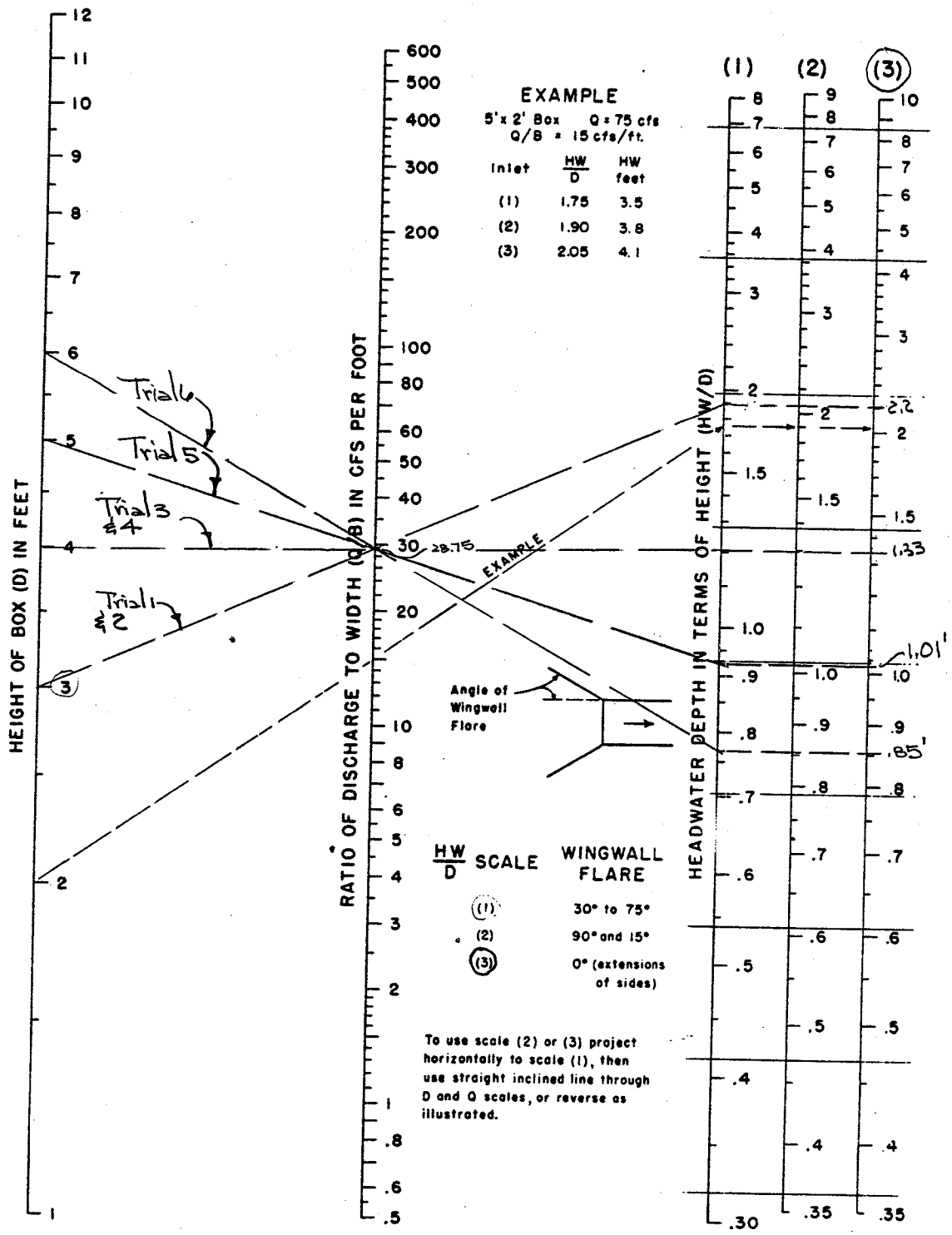
CULVERT DESCRIPTION (ENTRANCE TYPE)	Q	SIZE	HEADWATER COMPUTATION: INLET CONT. $\frac{HW}{D}$	HW	OUTLET CONTROL HW=H + h_o - LS_o: K_e	H	d_c	$\frac{d_c+D}{2}$	TW	h_o	LS_o	HW	CONTROLLING HW	OUTLET VELOCITY	COST	COMMENTS
4 barrel box culvert w/headwalls	1150	3'x10'	2.20	6.6'	0.2											N.G.
5 barrel box culvert w/headwalls	1150'	3'x8'	2.20	6.6'	0.2											N.G.
4 barrel box culvert w/headwalls	1150	4'x10'	1.33	5.32'	0.2	8.6										N.G.
5 barrel box culvert w/headwalls	1150	4'x8'	1.33	5.32'	0.2	5.6										N.G.
5 barrel box culvert w/headwalls	1150	5'x8'	1.01	5.05'	0.2	2.14'	2.28	3.64	2.94	3.64	0.03	5.75	5.75	5.79	18,350	N.G.
5 barrel box culvert w/headwalls	1150	6'x8'	0.85	5.10'	0.2	2.10'	2.28	4.14	2.94	4.14	0.03	6.21	6.21	4.82		N.G.

Try modeling w/ WSPG.

SUMMARY & RECOMMENDATIONS:

Figure 7

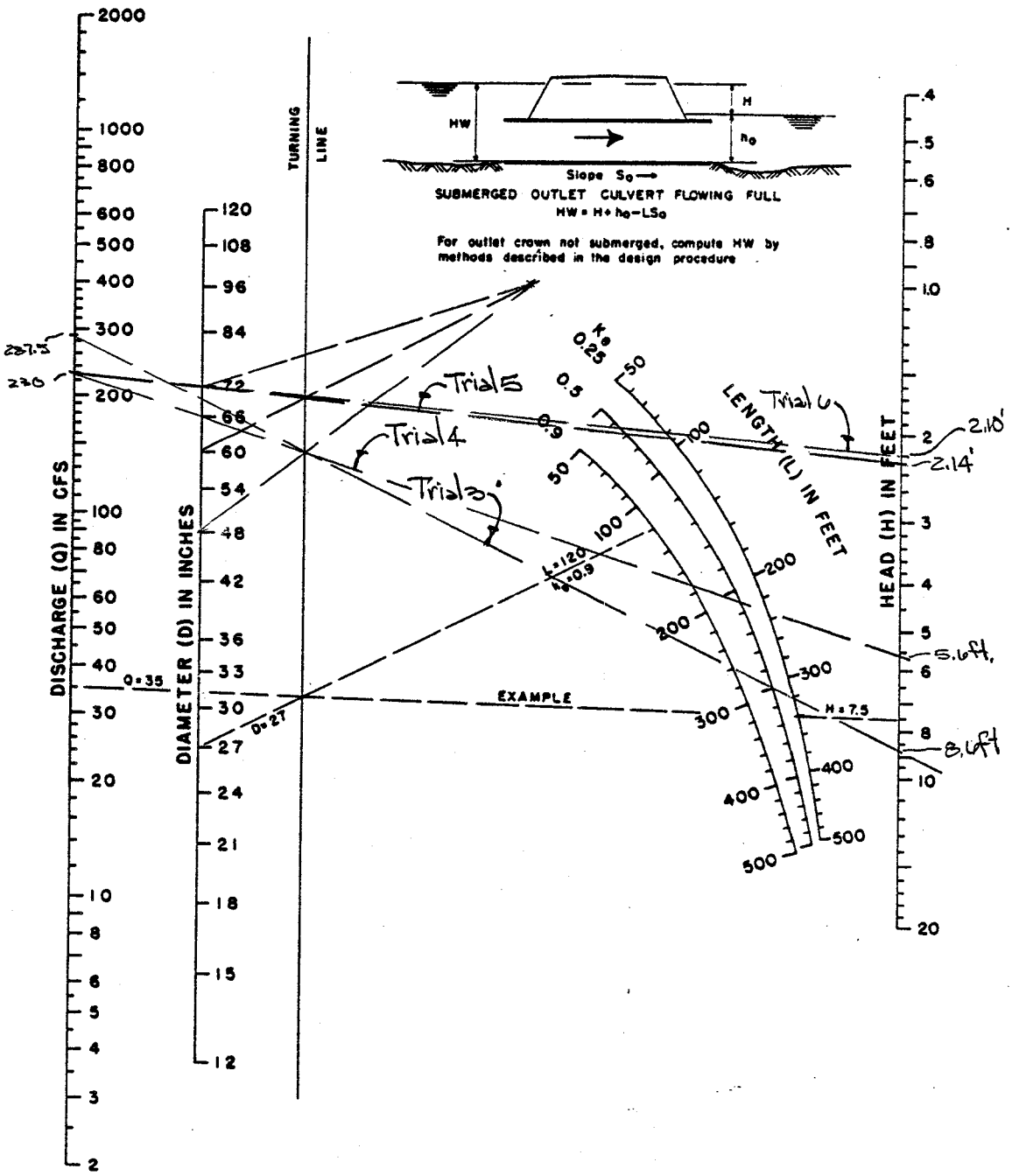
CHART I



HEADWATER DEPTH FOR BOX CULVERTS WITH INLET CONTROL

BUREAU OF PUBLIC ROADS JAN. 1963

CHART 11



HEAD FOR
STANDARD
C. M. PIPE CULVERTS
FLOWING FULL
n = 0.024

BUREAU OF PUBLIC ROADS JAN. 1963

Greiner Engineering

Greiner Engineering Sciences, Inc.

Tucson 602 327-3413
Phoenix 602 275-5400

Job RWCD Reach 6 E101012

Description Channel for Powerline Easement

Calculated by M. Shapiro Date 11/6/85 Sheet No. 1

Checked by B.G.S. Date _____ of 1

Void 11/19/85

$D_c \Rightarrow$ King Handbook P8-11 Eq. 8-55 for Trapizoidal Sections

$$D_c = \frac{V_c^2}{g} - \frac{b}{2z} + \sqrt{\frac{V_c^4}{g^2} + \frac{b^2}{4z^2}}$$

$$z = \frac{1.5}{1} = 1.5$$

$$D_c = \frac{(8.26)^2}{32.2} - \left(\frac{43}{2(1.5)}\right) + \sqrt{\frac{(8.26)^4}{(32.2)^2} + \frac{43^2}{4(1.5)^2}}$$

$$= 2.119 - 14.33 + \sqrt{14.490 + 205.444}$$

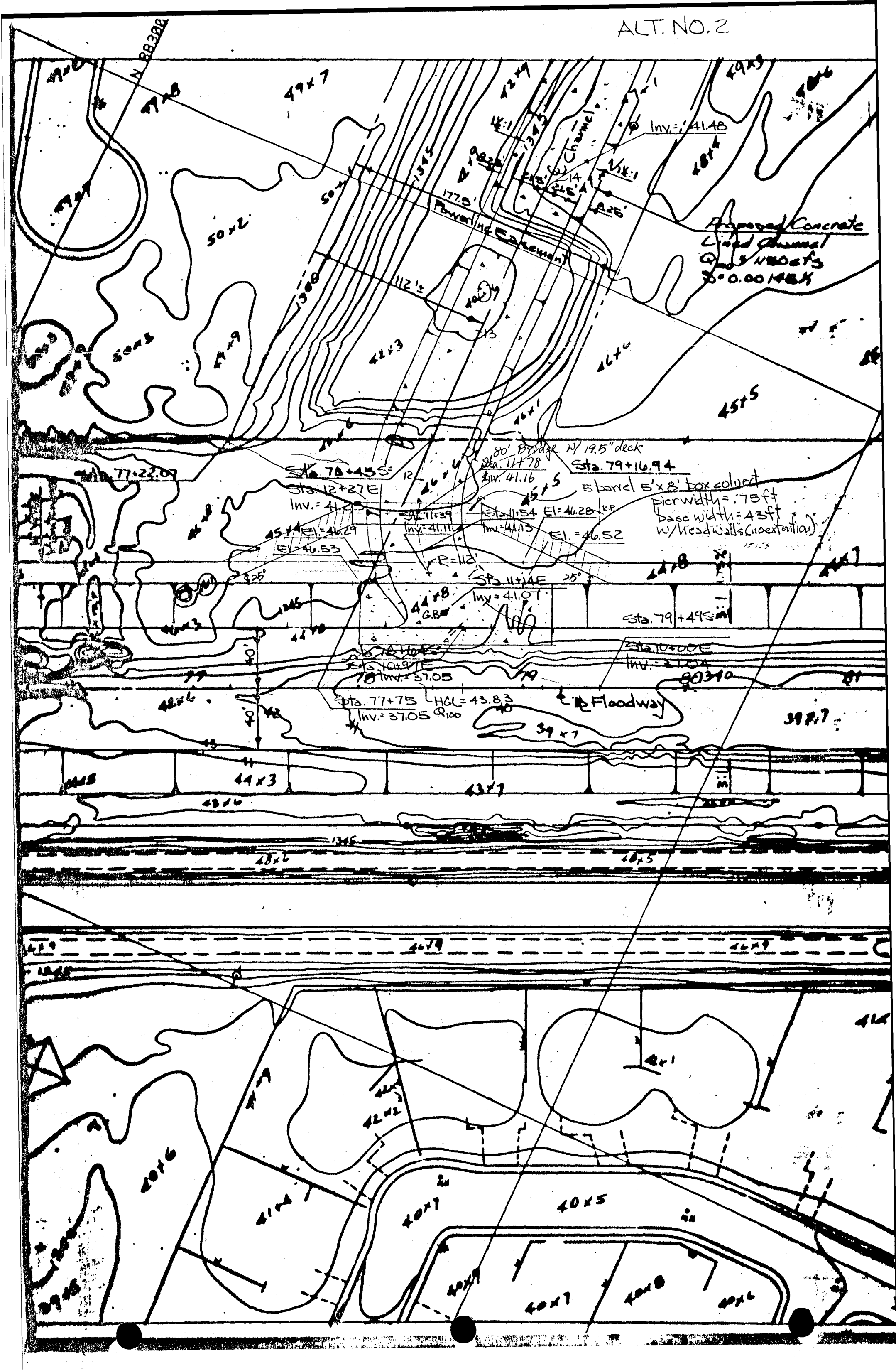
$$D_c = 2.28 \text{ ft}$$

$h_o = \frac{d_c + D}{2}$ or Tw whichever is greater

$$\frac{d_c + D}{2} = \frac{2.28 + 5}{2} = 3.64 > 2.94 \therefore \text{ use } 3.64 \text{ ft}$$

1.5	L BK
1.5	R BK
43.	BASE
0.00145	FPF
0.013	N
2.94	DP
139.3854	AREA
53.60032075	WP
2.600458319	R
8.257391756	FPS
1150.959853	CFS

ALT. NO. 2


N. BRADD
Inv. = 41.48
Channel
Proposed Concrete Lined Channel
Q100 = 1180 cfs
S = 0.00148
177.5'
Powerline Easement
112.5'
80' Bridge w/ 19.5" deck
Sta. 79+16.94
Sta. 78+45S
Sta. 12+27E
Inv. = 41.25
Sta. 11+78
Inv. 41.16
5 barrel 5'x8' box culvert
pierwidth = .75 ft
base width = 43 ft
w/headwalls (no extention)
Sta. 11+39
Inv. = 41.11
Sta. 11+54
El = 46.28
Inv. = 41.13
El. = 46.52
El. = 46.29
El. = 46.53
R = 112'
Sta. 11+14E
Inv = 41.07
Sta. 79+49S
Sta. 10+00E
Inv. = 37.04
Sta. 10+97E
Inv. = 37.05
Sta. 77+75
Inv. = 37.05
HGL = 43.83
Q100
Floodway

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Job SCB RWCD Floodway Reach 6 - E101012
Description Powerline Easement Channel Alt. No. 3 Dip Section
Calculated by B. Gary Sun Date 11/12/85 Sheet No. ____
Checked by M.S.S. Date ____ of ____

1. Problem Set Up

Void 11/19/85

① Downstream Control Water Surface Elevation

For Q=1200 cfs W.E. = 43.94

② 14' long 425' Wide Dip Section with 8 to 1 side slopes.

③ Angle point of 66.86° at Sta. 11+60.00

④ Q=1150 cfs in Powerline Easement Channel.

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Job SCS RWCD Floodway Reach 6 - E101012
Description Powerline Easement Channel
Alt #3 Dip Section
Calculated by B. Gayle Nun Date 11/9/85 Sheet No. 1
Checked by M.S.S. Date N.G. of

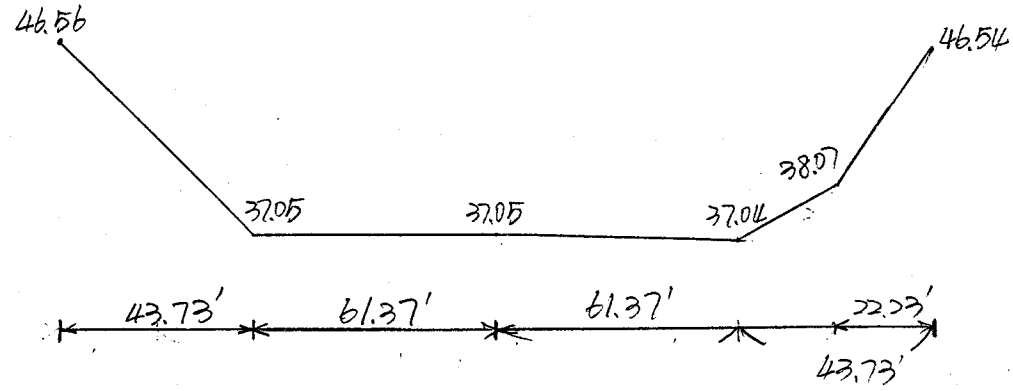
Q_{100}

PLEC311.DAT

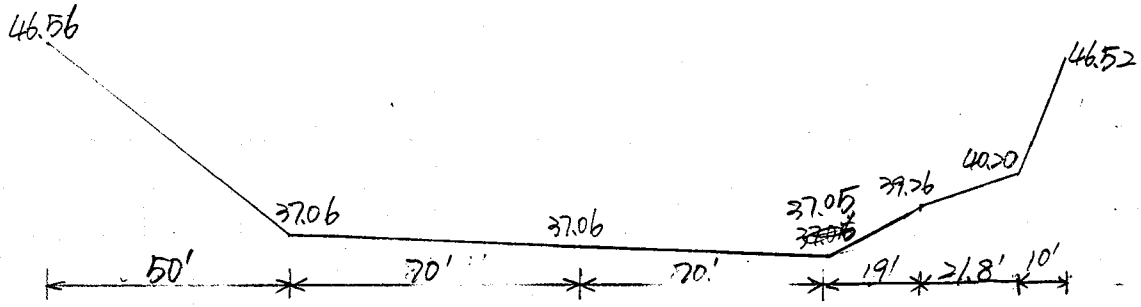
Void 11/19/85

at 78+61.89 43.94

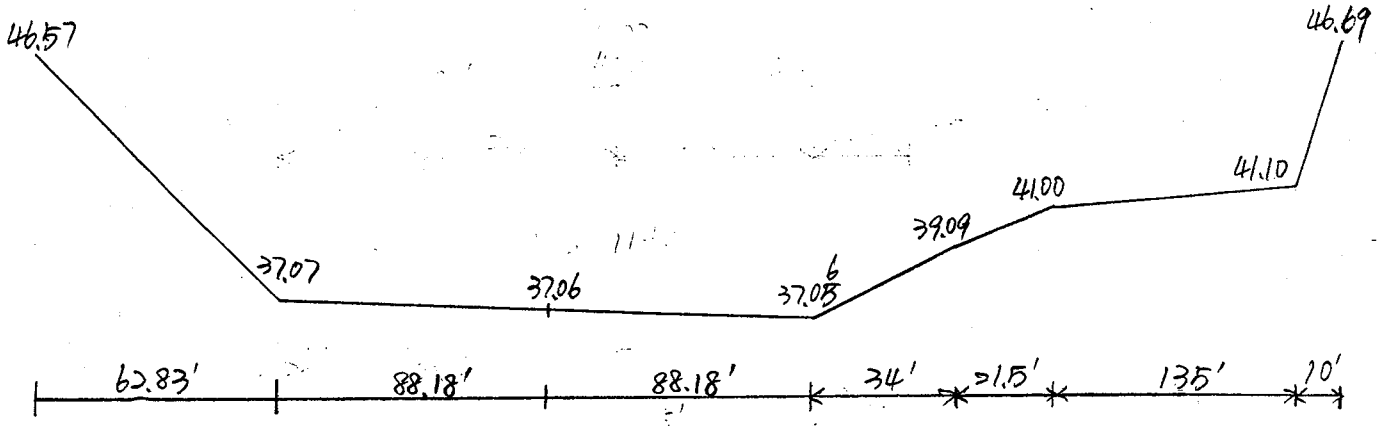
78+95.00 43.938
36+89.83 44.299



Sec. 1 Sta. 10+98.88
(Sta. 78+61.89)



Sec. 2 Sta. 11+17.85



Sec. 3 Sta. 11+26.35

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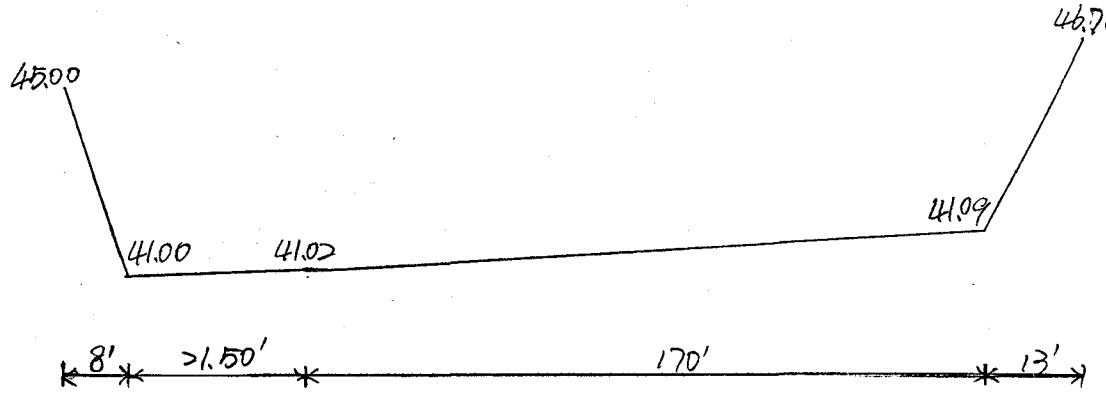
Job: SCS RWCD Floodway Reach 6 - E101012

Description: Powerline Easement Channel Alt. #3 Dip Section

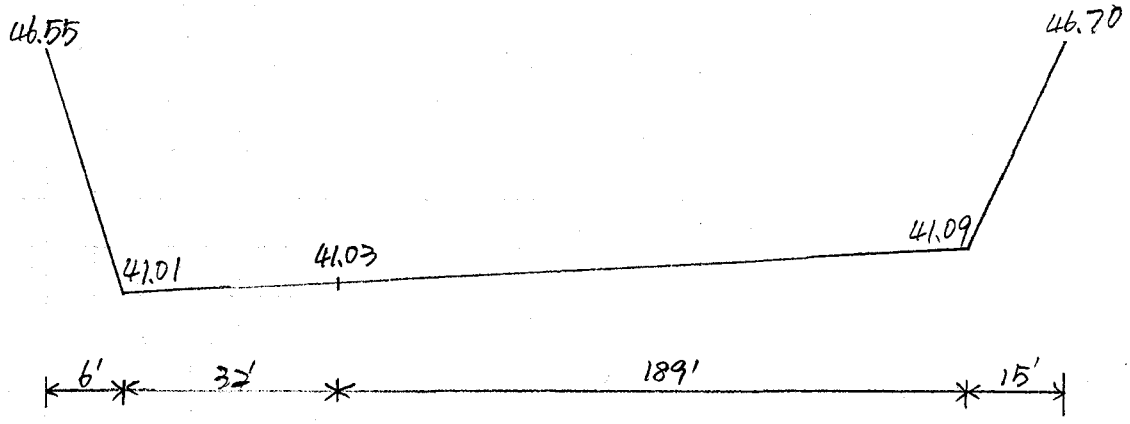
Calculated by: D. Bayh Sun Date: 11/9/85 Sheet No. 2

Checked by: M.S.S. Date: N.G. of

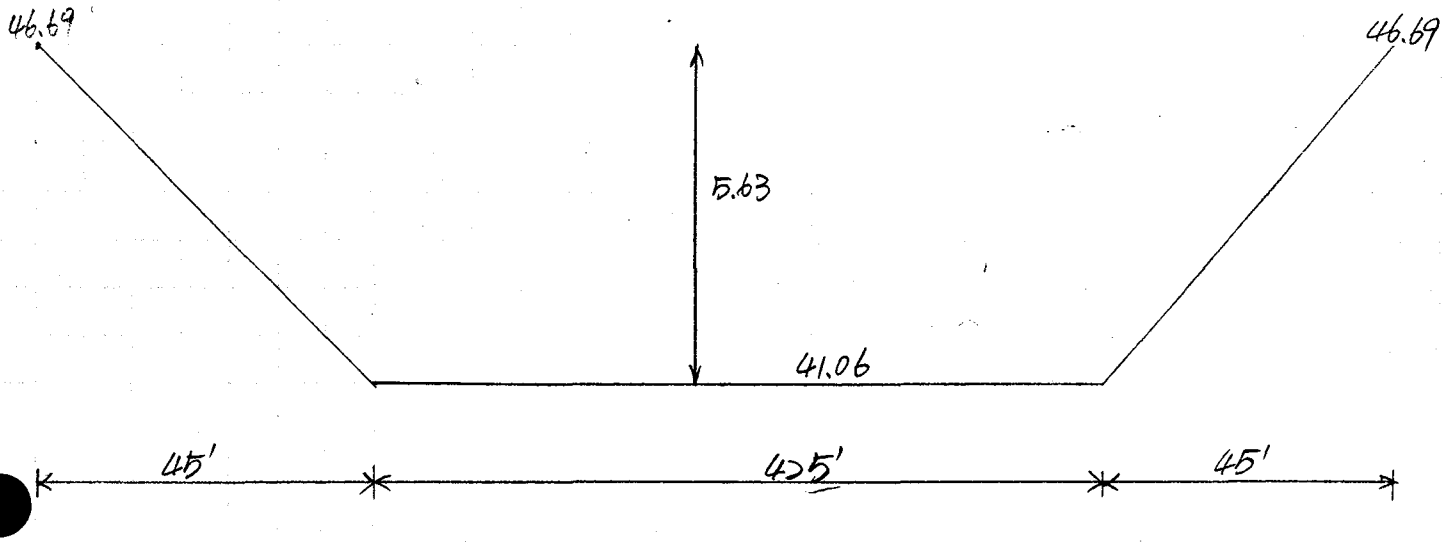
Void 11/12/85



Sec. 4 Sta. 11+46.81



Sec. 5 Sta. 11+51.81



Sec. 6 Sta. 11+73.42 & 11+87.42

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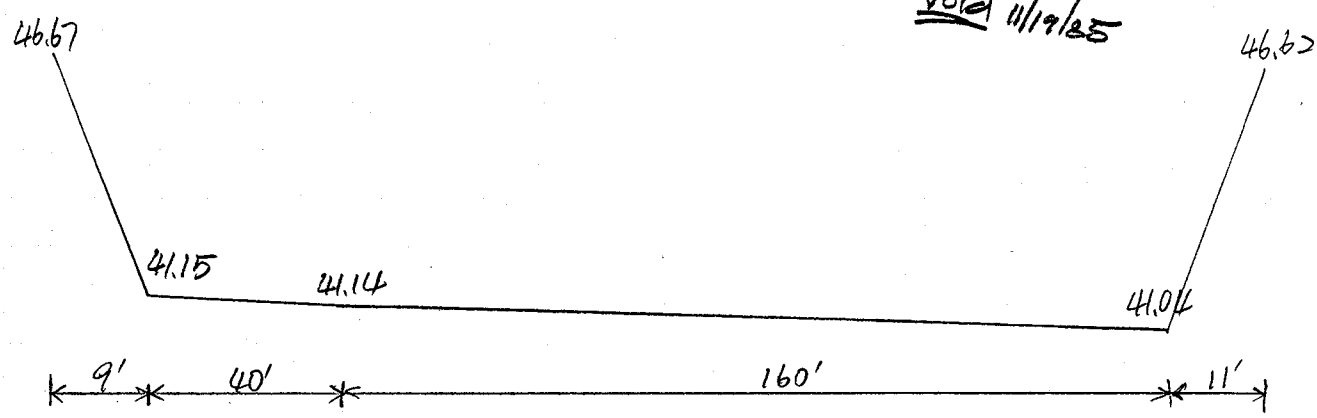
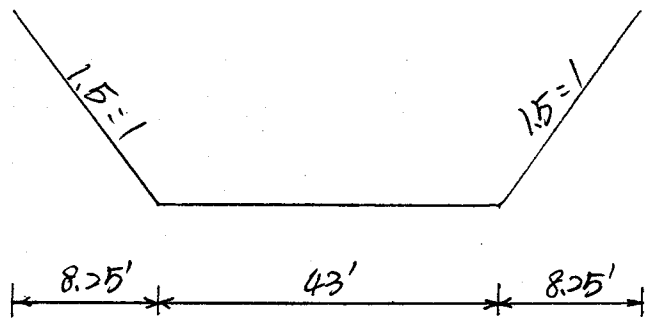
Job: SCS RWCD Floodway Reach 6 - E/0/012
Description: Powerline Easement Channel Alt. #3 Dip Section
Calculated by: B. Gary Sun Date: 11/9/85 Sheet No. 3
Checked by: M.S.S. Date: N.G. of

Void 11/19/85



Sec. 7 Sta. 12+26.81



Sec. 8 Sta. 12+44.00

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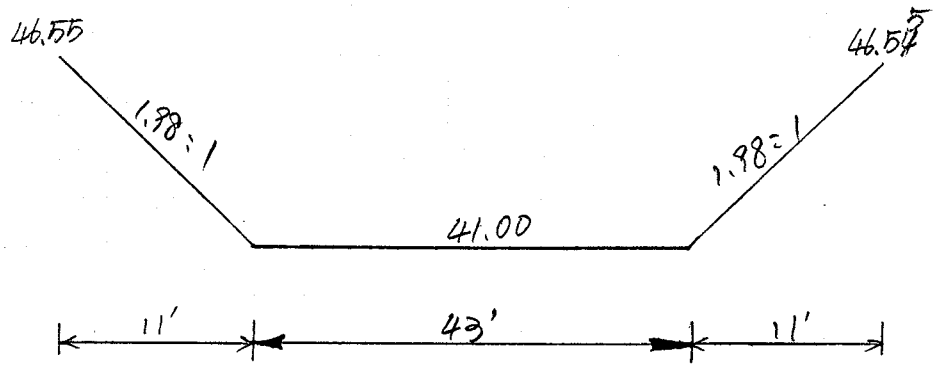
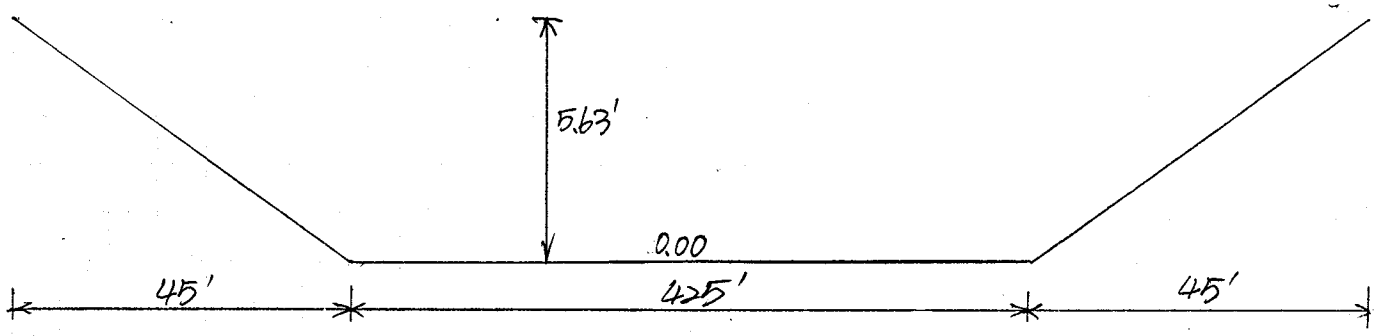
Job SCB RWCD Floodway Reach 6 - E101012
Description Powerline Easement Channel
Alt. No. 3 Dip Section
Calculated by B. Grant Sun Date 11/11/85 Sheet No. 1
Checked by M.S.S. Date _____ of _____

Trial #1

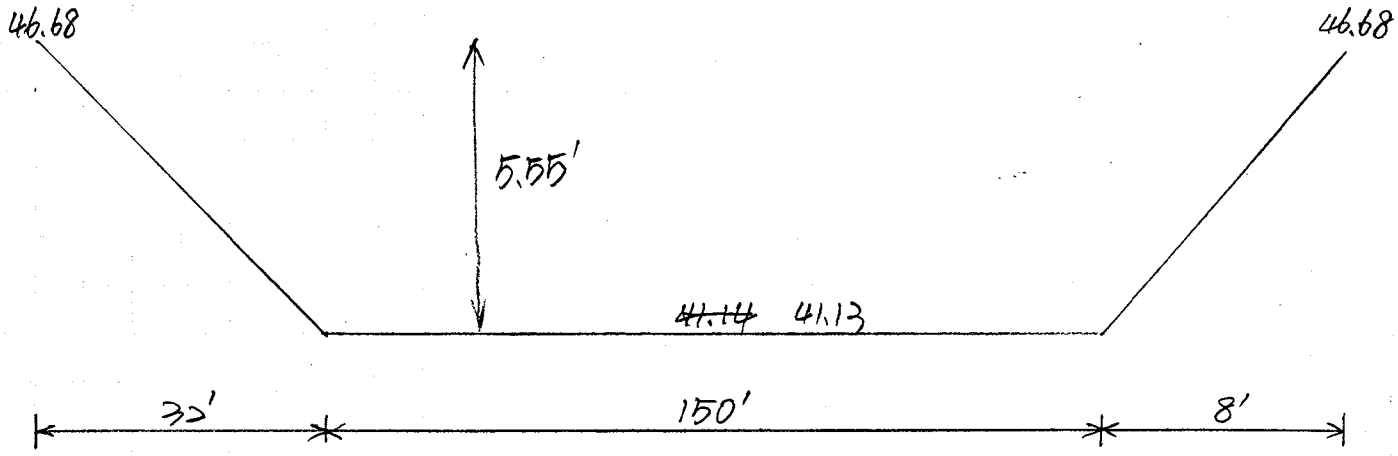
Void 11/19/85



Sec 1. Sta. ~~11+32.70~~ 10+68.50



Sec. 2 Sta. ~~11+73.42 ~ 11+87.42~~ 11+07.86 ~ 11+21.86



Sec. 3 Sta. ~~12+26.81~~ 11+60.00

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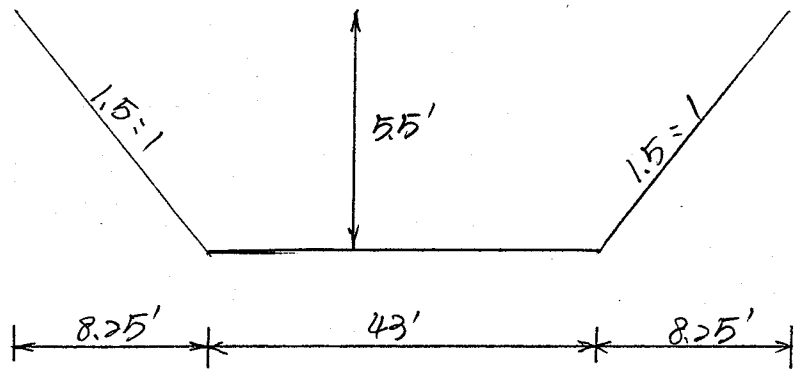
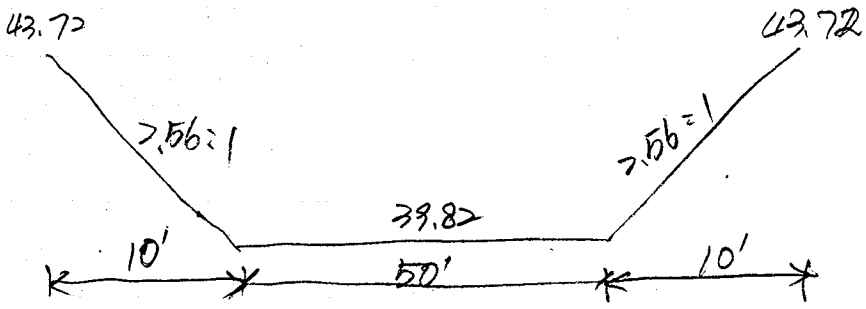
Job SCS RWCD Floodway Reach 6 - E101012
Description Powerline Easement Channel
Alt. No. 3 Dip Section
Calculated by B. Gary Bun Date 11/11/85 Sheet No. 2
Checked by M.S.S. Date _____ of _____

Void 11/19/85



Sec. 4 Sta. ~~12+44~~ 11+77.19, 13+00 & 14+00

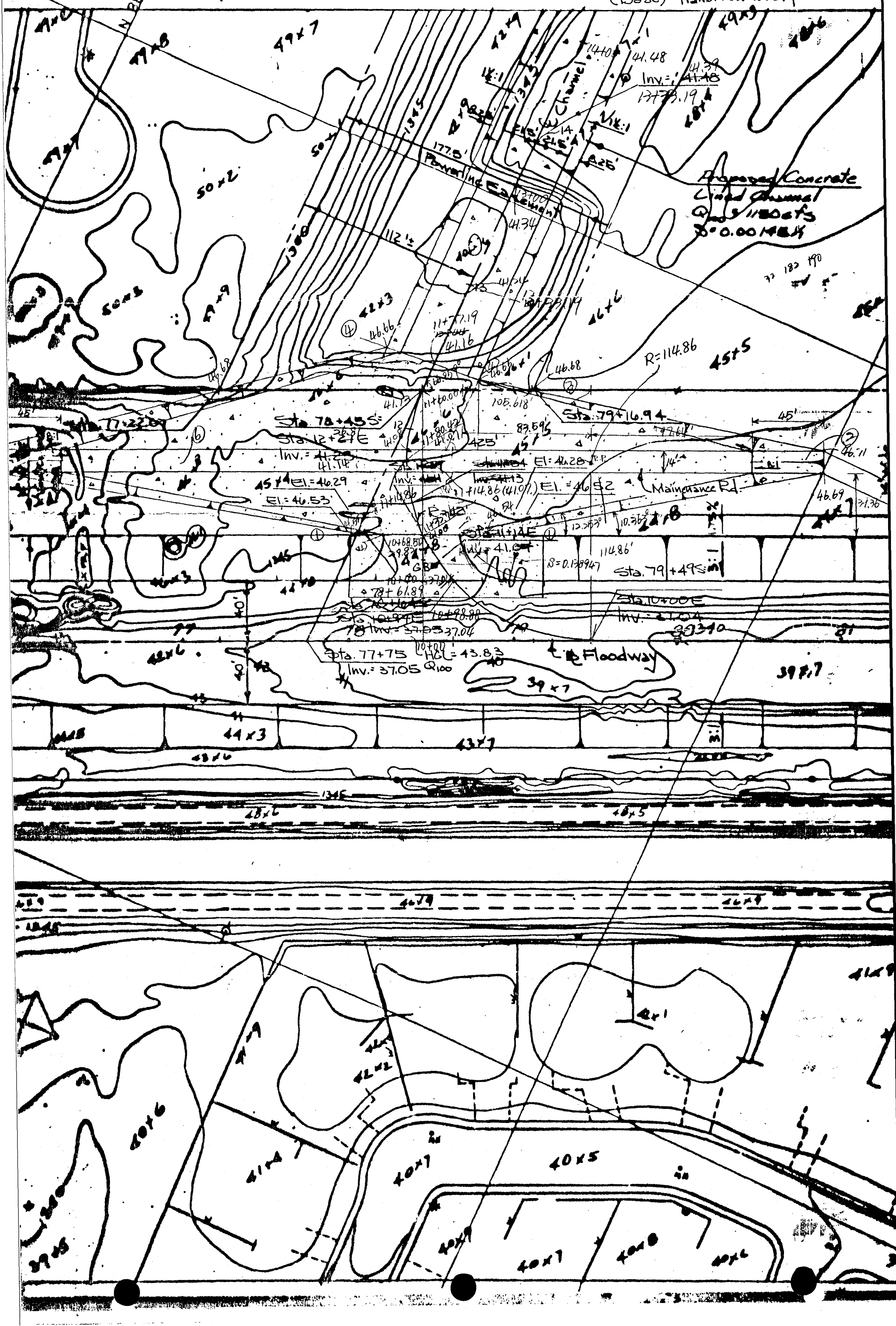


Sec. 5 Sta. 10+60

Scale 1" = 50'

Trial #1

ALT. NO. 3
(Base) Transition for dip section



Three alternates were modeled using WSPG and were shown to work.

(1) Alt. No. 1 Bridge

With Floodway running full (PLEC1.DAT & QPLEC11.DAT)

(i) A superelevation of 1.94 ft. with Q = 1150 cfs & R = 114.86 ft.

A superelevation should not greater than one foot.

(ii) Max. velocity = 13.03 fps (iii) Min. freeboard = 2.1 ft.

With Floodway empty (PLEC11.DAT & QPLEC11.DAT)

(i) Max. velocity = 19.32 fps.

(ii) Superelevation = 1.86 ft.

(2) Alt. No. 2 Box Culvert

With Floodway running full (PLEC2.DAT & QPLEC2.DAT)

(i) Superelevation = 1.94 ft.

(ii) Max. velocity = 13.14 fps

(iii) Min. freeboard = 1.20 ft.

With Floodway empty (PLEC21.DAT & QPLEC21.DAT)

(i) Superelevation = 1.94 ft.

(ii) Max. velocity = 19.38 fps

(3) Alt. No. 3 Dip Section

With Floodway running full

(i) Works.

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Job SCS RWCD Floodway Reach 6 - E101012

Description Powerline Easement Channel

Calculated by B. Gary Sun Date 11/18/85 Sheet No. ____

Checked by M.S.S. Date ____ of ____

Memorandum for a meeting (11/12/85) at Greiner Engineering

From Don Paulus

1. A superelevation greater than 1 foot was not acceptable.
2. A peak flow of 1600 cfs was to be used.
3. The criteria of 12.5° for transitions would still apply.
4. During the flood, it is no need to access to maintenance road.

Greiner Engineering

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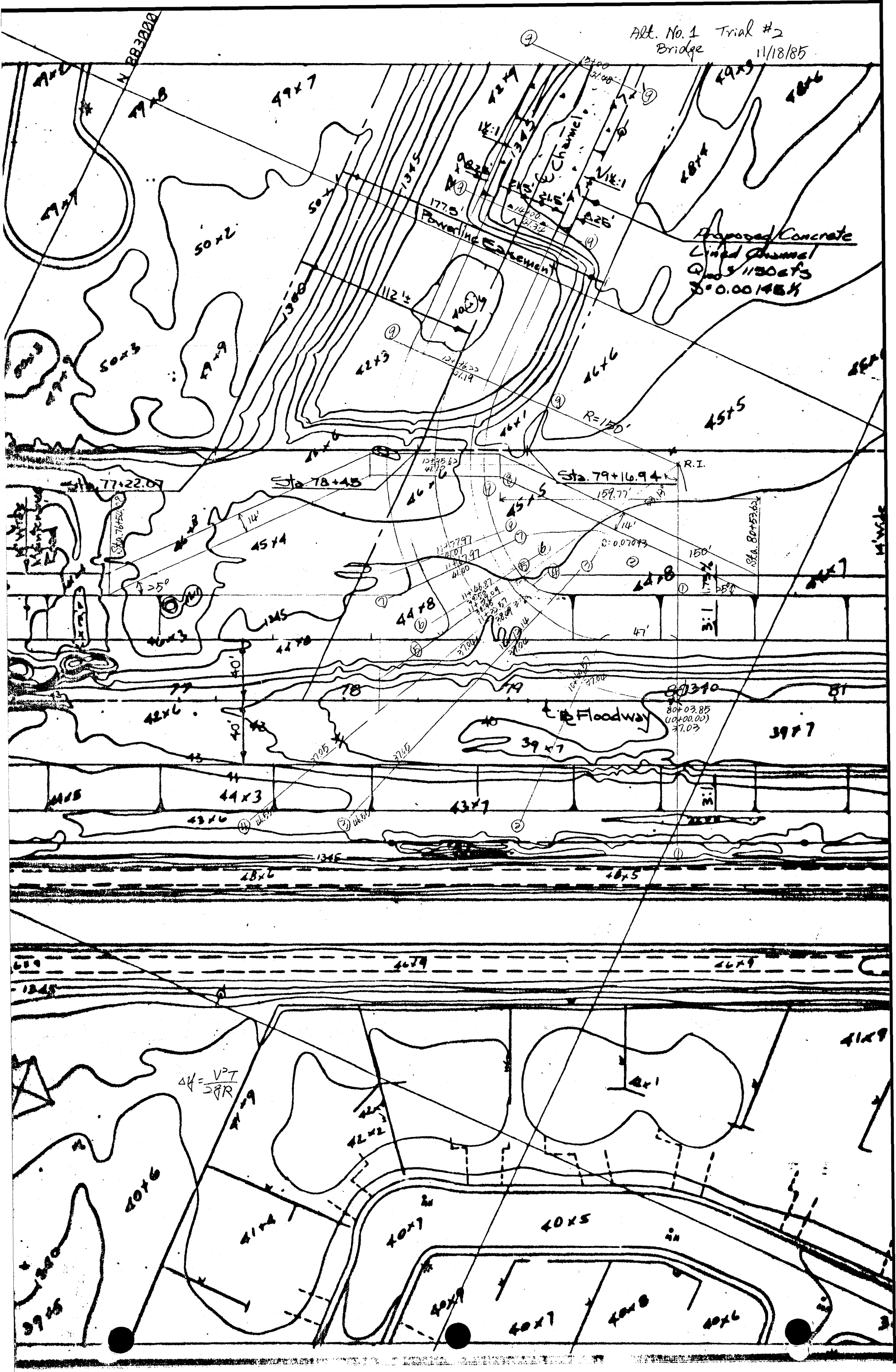
Job SCS RWCD Floodway Reach 6 - E101012
Description Powerline Easement Channel
Alt. No. 1 Trial #2 Bridge
Calculated by B. Gary Sun Date 11/19/85 Sheet No. ____
Checked by M.S.S. Date ____ of ____

Problem Set Up

1. Downstream Control Water Surface Elevation = 43.95.
2. Curve reaches between Sta. 11+12.14 ~ Sta. 12+96.22 with R = 150 ft.
3. At Sta. 11+77.97 set Inv. Elev. at 41.00 and applf S = 0.00145 ft/ft to upstream stations per Anderson-Nichols recommended.
4. Use Q = 1600 cfs.
5. Use 14' long 80' wide bridge.
6. n = 0.013 for concrete lined channel.

Results

1. Superelevations at Sta. 11+46.87 ~ Sta. 12+8.62 were greater than 1 ft. under supercritical flow.
2. WSPG program is not use the right formula to compute superelevations under supercritical flow condition.


Alt. No. 1 Trial #2
Bridge
11/18/85
Proposed Concrete
Lined Channel
Q = 1130 cfs
S = 0.00148
Powerline Easement
177.5'
112 ±
R=150'
R.I.
Sta. 77+22.07
Sta. 78+45
Sta. 79+16.94
Sta. 80+03.85
(10+00.00)
Sta. 76+52.08
Sta. 80+53.62
159.77'
150'
47'
14'
S = 0.07073
Floodway
$\Delta y = \frac{V^2 T}{2gR}$

Greiner Engineering

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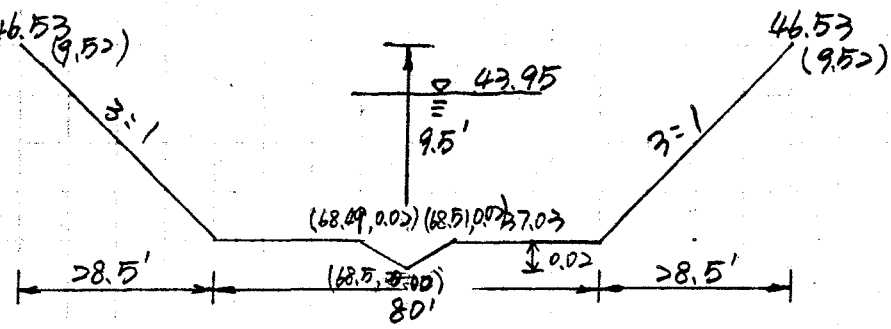
Phoenix 602 275-5400

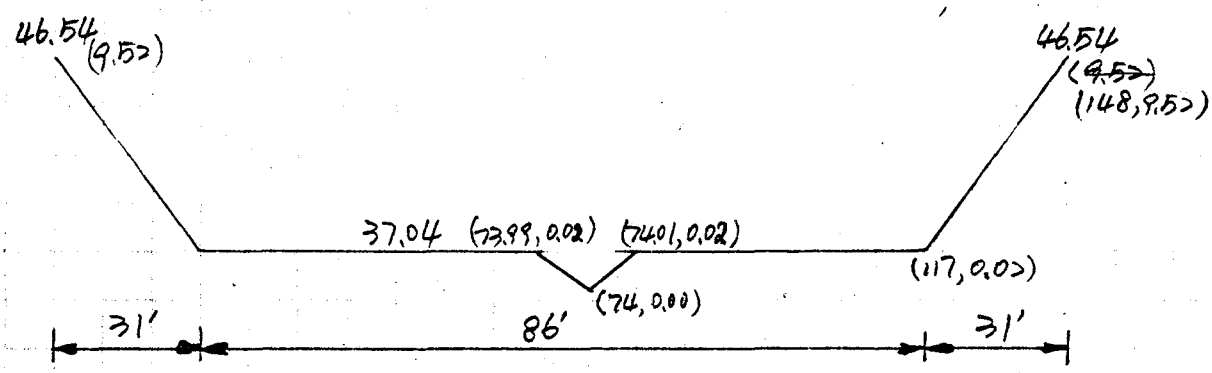
Job SCS RWCD Floodway Reach 6 - E101012
Description Powerline Easement Channel
Alt. No. 1 Trial #2 14' long 80' wide Bridge
Calculated by B. Gary Sun Date 11/18/85 Sheet No. 1
Checked by M.S.S. Date _____ of _____

PLEC12.DAT

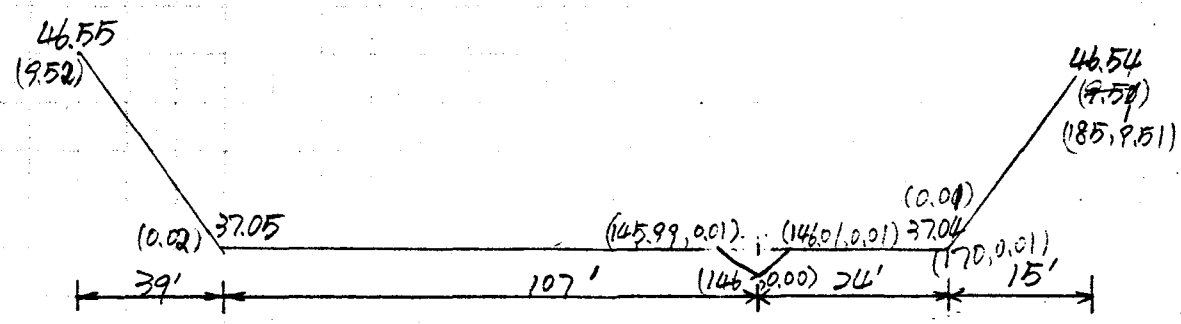
88+94.51 3692
W.E. 43.766



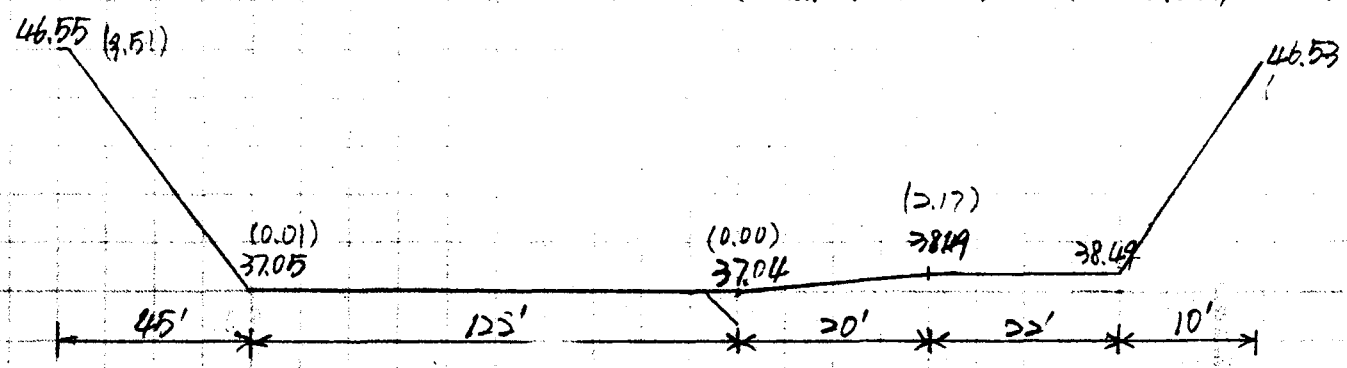
Sec. 1 Sta. 10+00.00 (Sta. 80+03.85) n=0.025 37.01



Sec. 2 Sta. 10+60.57 (Sta. 79+44.91) n=0.025 37.02



Sec. 3 Sta. 11+12.14 (Sta. 79+01.87) n=0.019 37.03



✓ Sec. 4 Sta. 11+32.57 n=0.019 37.04

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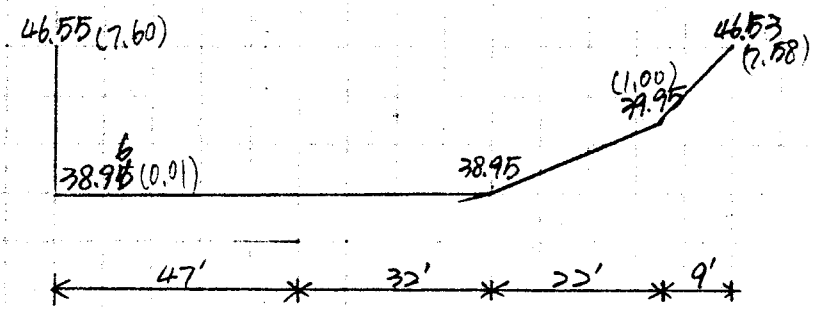
Phoenix 602 275-5400

Job SCR RWCD Floodway Reach 6 - E101012

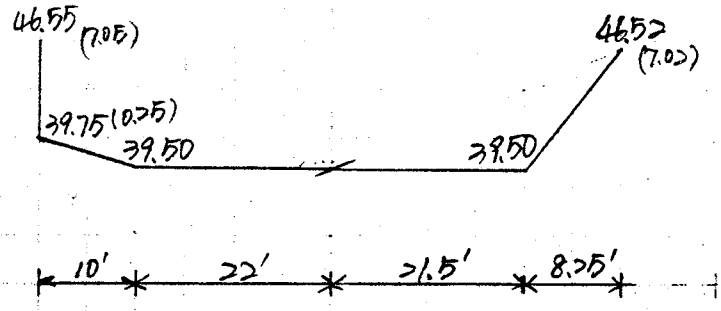
Description Powerline Easement Channel
Alt. No. 1 Trial #2 14' long 80' Wide Bridge

Calculated by B. Gary Sun Date 11/18/85 Sheet No. 2

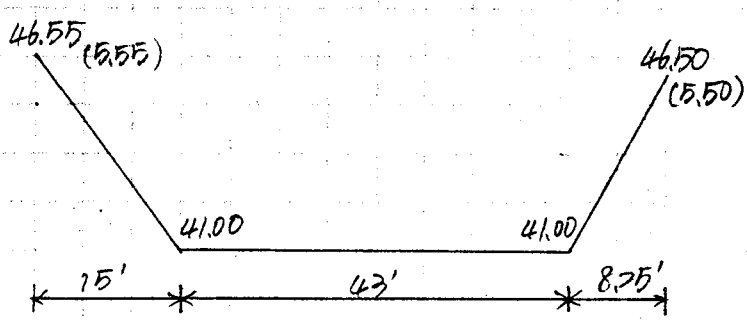
Checked by M.S.S. Date _____ of _____



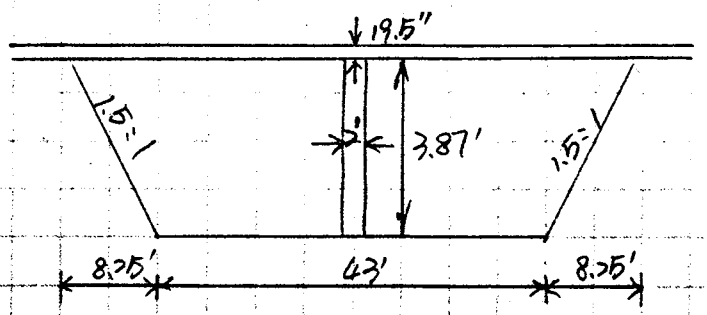
Sec. 5 Sta. 11+39.09



Sec. 6 Sta. 11+46.87



Sec. 7 Sta. 11+67.97



Sec. 8 Sta. 12+28.62 (41.09), 12+42.62 (41.11)

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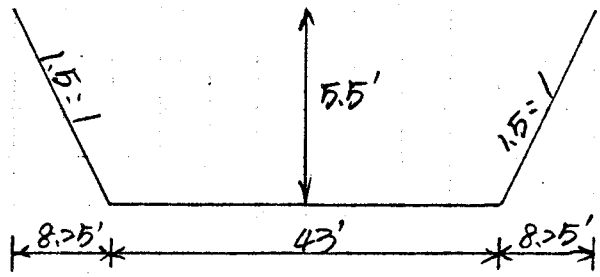
Phoenix 602 275-5400

Job SCS RWCD Floodway Reach 6 - E101012

Description Powerline Easement Channel
Alt. No. 1 Trial #2 14' long 80' wide Bridge

Calculated by B. Gary Burr Date 11/18/85 Sheet No. 3

Checked by M.S.S. Date _____ of _____



Sec. 9 Sta. 12+96.22 (41.19), 14+00 (41.34) & 15+00 (41.48)

Greiner Engineering

Greiner Engineering Sciences, Inc.

Tucson 602 327-3413
Phoenix 602 275-5400

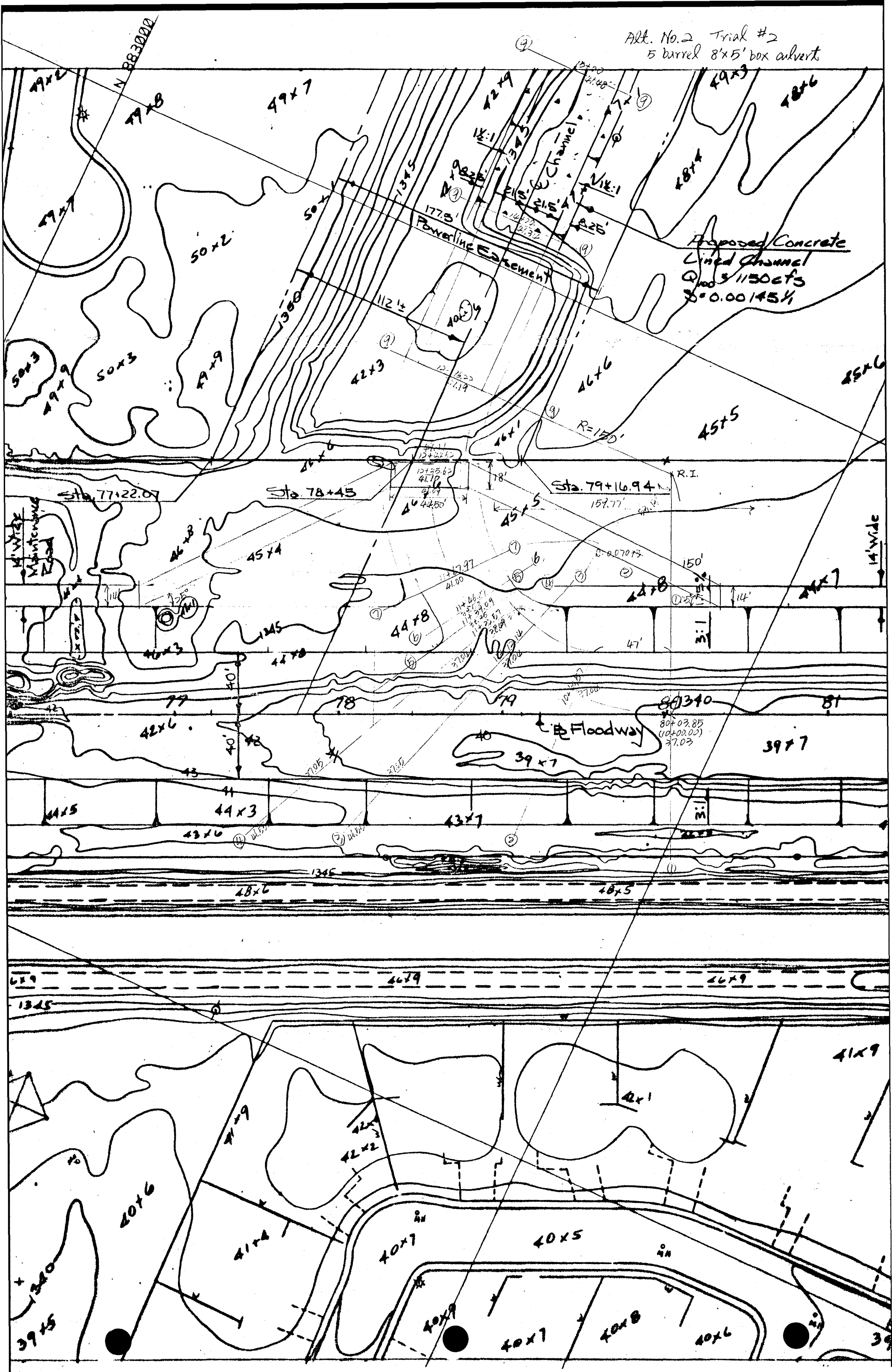
Job SCS RWCD Floodway Reach 6 - E101012
Description Powerline Easement Channel Alt. No. 2 Trial #2 Box Culvert
Calculated by B. Gary Sun Date 11/19/85 Sheet No. ____
Checked by M.S.S. Date ____ of ____

Problem Set Up

1. Downstream control water surface elevation = 43.95.
2. Curve reaches between Sta. 11+12.14 ~ Sta. 12+96.22 with R=150 ft.
3. At Sta. 11+77.97 set Inv. Elev. at 41.00 and apply S=0.00145 ft/ft to upstream stations per Anderson-Nichols recommended.
4. Use Q= 1600 cfs.
5. Use 5 barrel 8'x5' box culvert w/ headwalls

Results

1. Superelvations at Sta. 11+46.87 ~ Sta. 12+26.62 were greater than 1 ft. under supercritical flow.
2. Overbank flow occurs at Sta. 12+44.62 ~ 12+96.22
3. Use 5 barrel 8'x6' box culvert w/ headwalls.


Alt. No. 2 Trial #2
5 barrel 8'x5' box culvert
N 88°30'00"
Proposed Concrete
Lined Channel
Q100 = 1150 cfs
S = 0.00145 ft/ft
Powerline Easement
177.8'
112'±
R=150'
Sta. 77+22.07
Sta. 78+45
Sta. 79+16.94
R.I.
159.77'
150'
14' Wide
Maintenance Road
Floodway
3:1
1345
46+9
48+6
48+5
41+9
40+6
40+5
40+7
40+8
39+5
39+7

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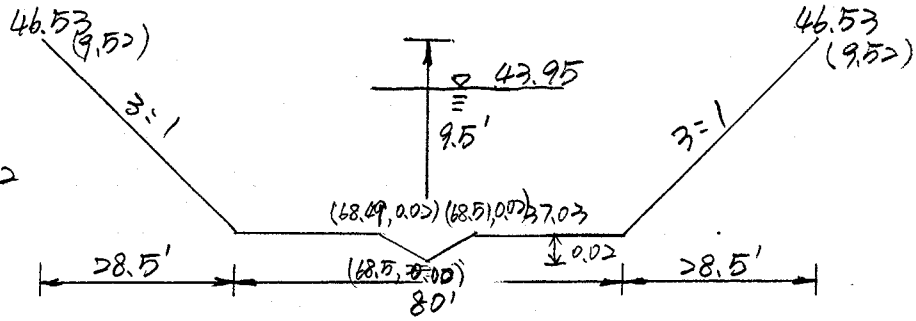
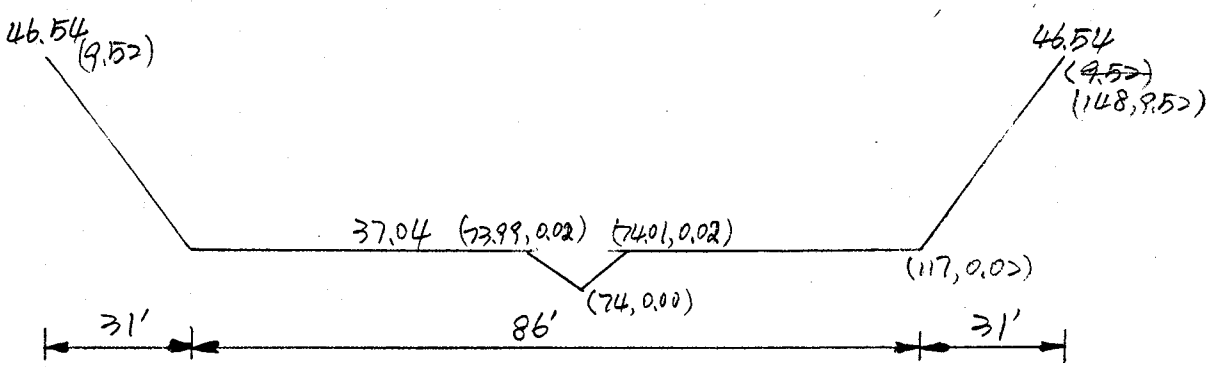
Job SCS RWCD Floodway Reach 6 - E101012
Description Powerline Easement Channel
Alt. No. 2 Trial #2 Box Culvert
Calculated by B. Gary Sun Date 11/18/85 Sheet No. 1
Checked by M.S.S Date _____ of _____

PLEC22.DAT

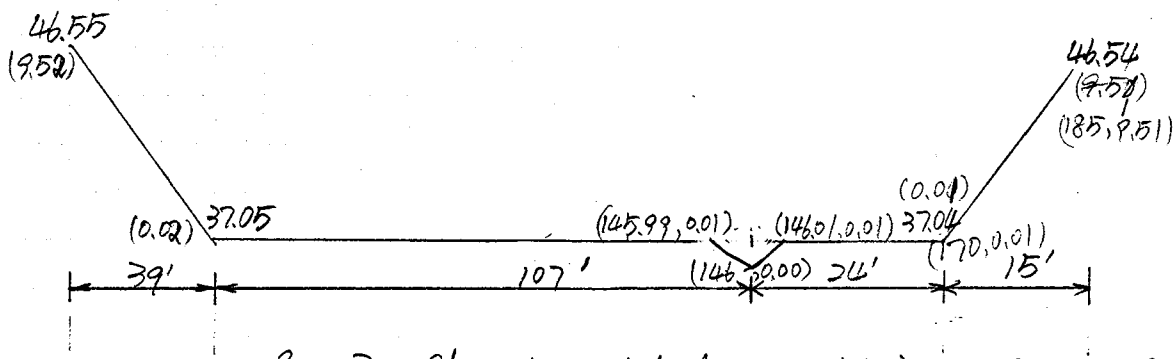
88+94.51 3692
W.E. 43.766



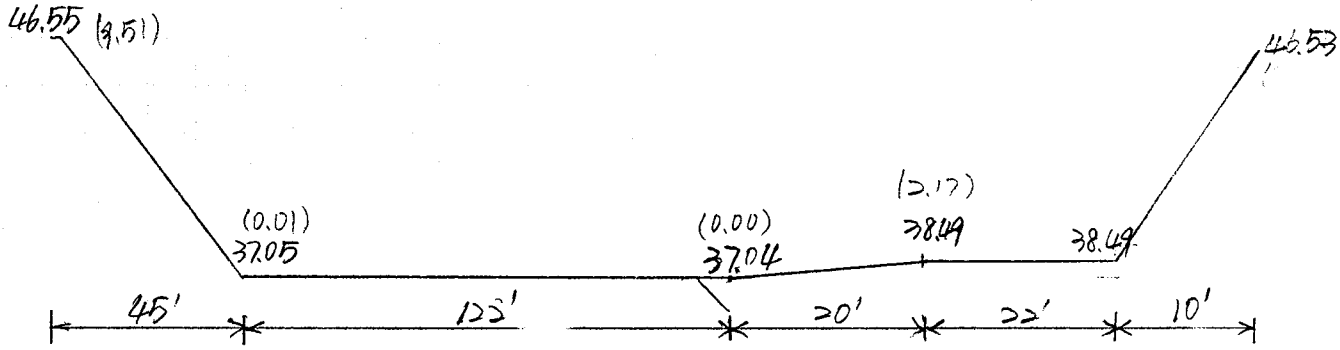
Sec. 1 Sta. 10+00.00 (Sta. 80+03.85) n=0.025 37.01



Sec. 2 Sta. 10+60.57 (Sta. 79+44.91) n=0.025 37.02



Sec. 3 Sta. 11+12.14 (Sta. 79+01.87) n=0.019 37.03



Sec. 4 Sta. 11+32.57 n=0.019 37.04

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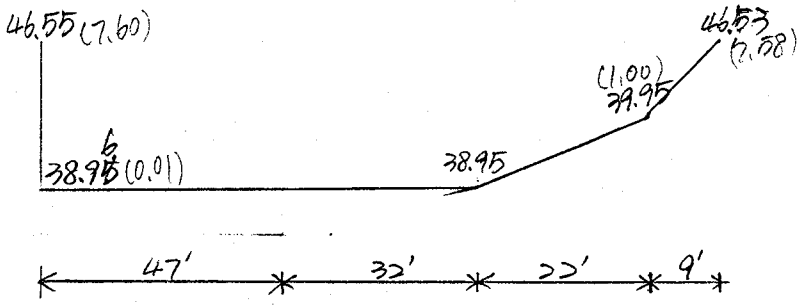
Job SCB RWCD Floodway Reach 6 - E101012

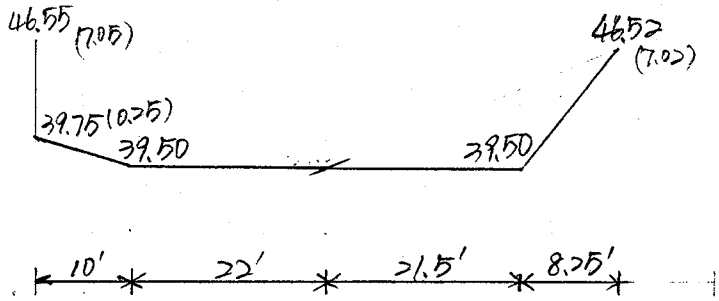
Description Powerline Easement Channel
Alt. No. 2 Trial #2 Box Culvert

Calculated by B. Gard Bun Date 11/18/85 Sheet No. 2

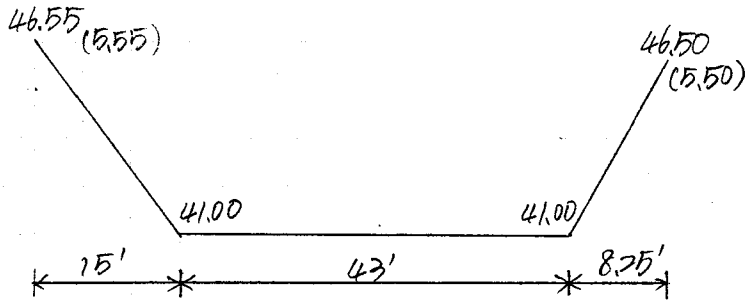
Checked by M.S.S. Date _____ of _____



Sec. 5 Sta. 11+39.09



Sec. 6 Sta. 11+46.87



Sec. 7 Sta. 11+67.97

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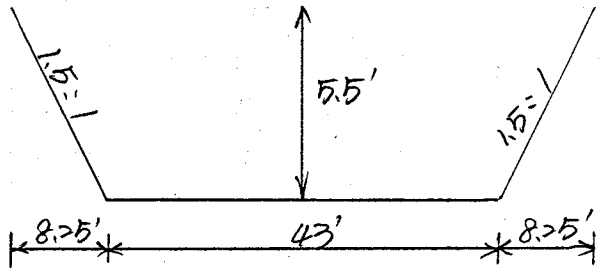
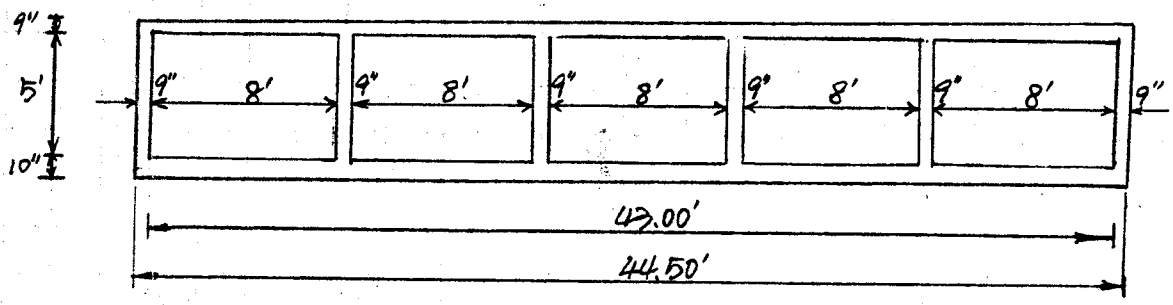
Job SCS RWCD Floodway Reach 6 - E101012
Description Powerline Easement Channel
Alt. No Trial #2 Box Culvert
Calculated by D. Gary Bar Date 11/18/85 Sheet No. 3
Checked by M.S.S. Date _____ of _____



Sec. 9 Sta. 12+96.22 (41.19), 14+00 (41.34) & 15+00 (41.48)



Sec. 8 Sta. 12+26.62 ~ Sta. 12+44.62

5 barrel 8'x5' box culvert w/headwalls (L=18')

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Job SCS RWCD Floodway Reach 6 - E101012
Description Powerline Easement Channel Alt. No. 3 Trial #2 Dip Section
Calculated by B. Gary Sun Date 11/19/85 Sheet No.
Checked by M.S.S. Date of

Problem Set Up for Trial #2-1

1. Downstream control water surface elevation

   ① For Q_{100} W.E. = 43.95

   ② Floodway empty

2. Use Q = 1600 cfs

3. 14' long 59.5' wide dip section with 8 to 1 side slopes.

Results

1. For Floodway empty, Sta. 11+32.57 ~ 11+45.46 have V > 20 fps.

2. Try starating at Sta. 1+09.36 (Inv. Elev. = 36.92) with Floodway empty.

Problem Set Up for Trial #2-2

1. No downstream control water surface elevation & start at Sta. 1+09.36

Results

1. No good. because push too much to downstream.

2. Try regrading the inverts by setting Sta. 12+45.63 at 41.14 & Sta. 11+12.14 at 37.04.

Results for Trial #2-3

1. Doesn't seem to work. V = 19.08 at Sta. 11+32.57

2. No further runs have been made. It was recommended that the drop section should start at further upstream to reduce high velocities at inlet sections.

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Job SCS RWCD Floodway Reach 6 - E101012

Description Powerline Easement Channel Alt. No. 3 Trial #2-3 Dip Section

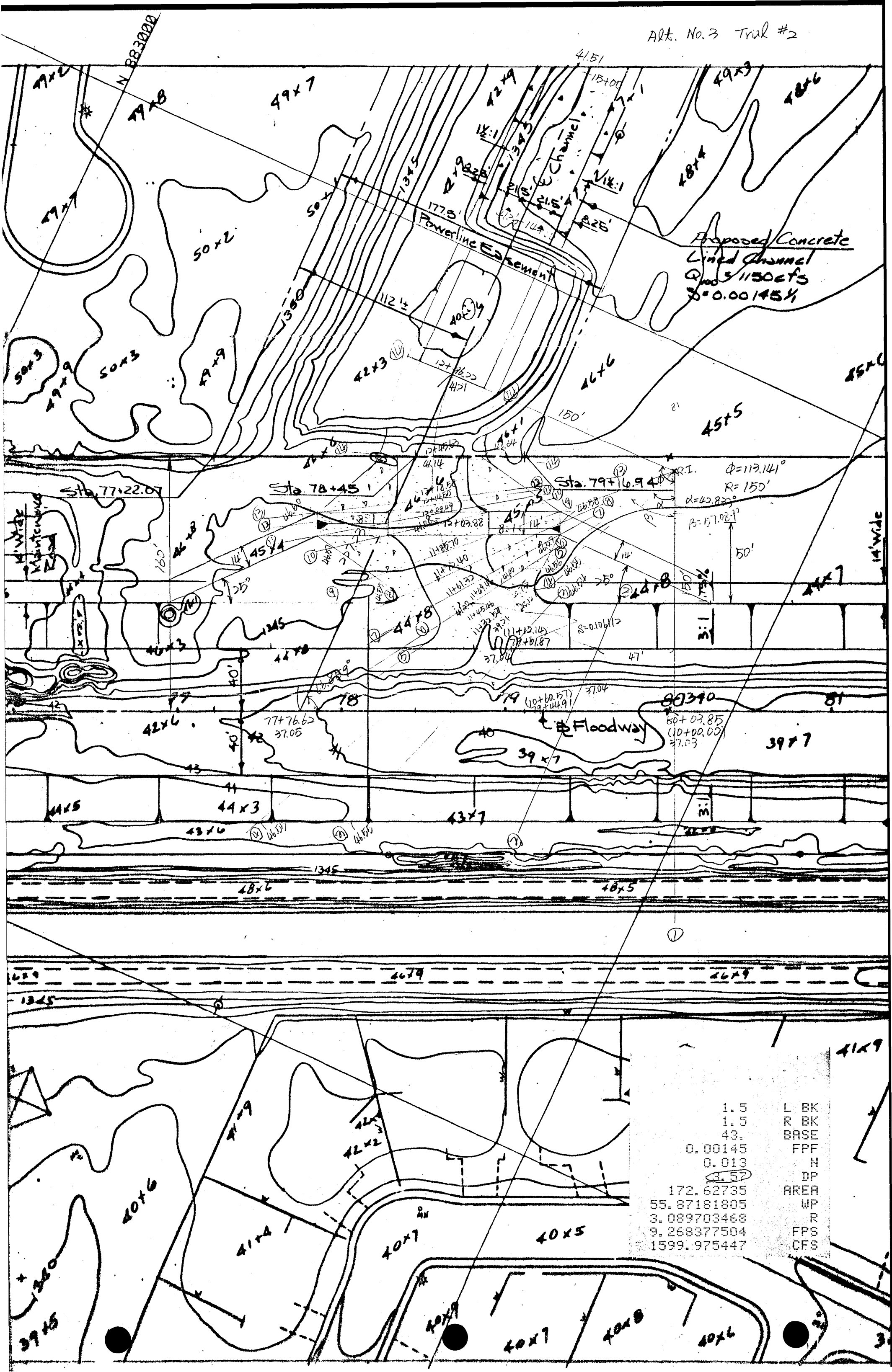
Calculated by B. Gary Sun Date 11/16/85 Sheet No. ____

Checked by M.S.S. Date ____ of ____

Trial #2-3

11+12.14	37.04	PLEC32.DAT QPLEC32.DAT
11+32.57	37.67	
11+45.46	38.06	
11+49.46	38.19	
11+61.32	38.55	
11+72.40	38.89	S= 0.0307139
11+85.70	39.30	
12+03.88	39.86	
12+09.49	40.03	
12+14.55	40.19	
12+18.58	40.31	
12+45.63	41.14	

Alt. No. 3 Trial #2



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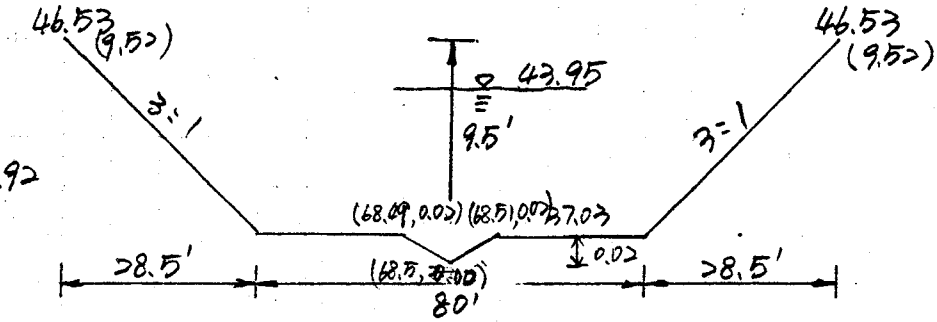
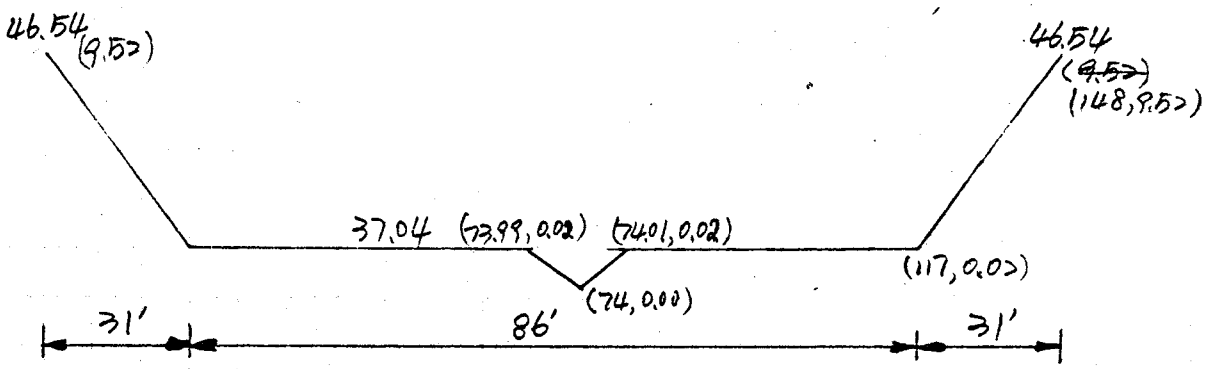
Job: SCS RWCD Floodway Reach 6 - E101012
Description: Powerline Easement Channel
Alt. No. 3 Trial #2 Dip Section R=150
Calculated by: B. Garth Sun Date: 11/15/85 Sheet No. 1
Checked by: M.S.S. Date: _____ of _____

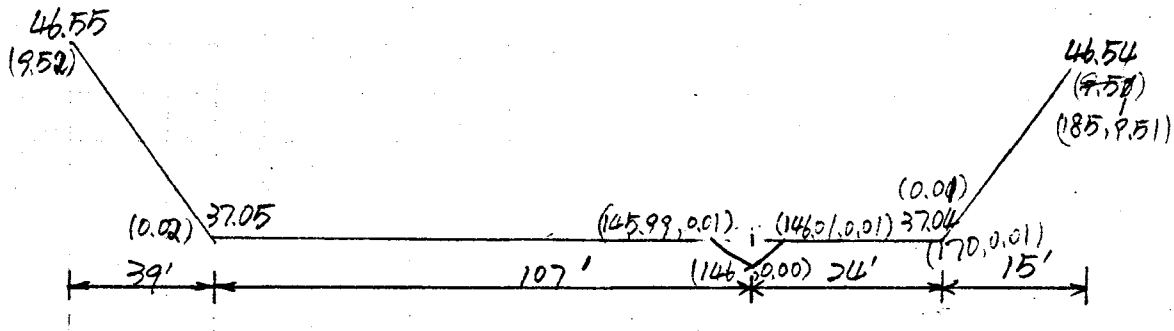
88+94.51 3692
W.E. 43.766



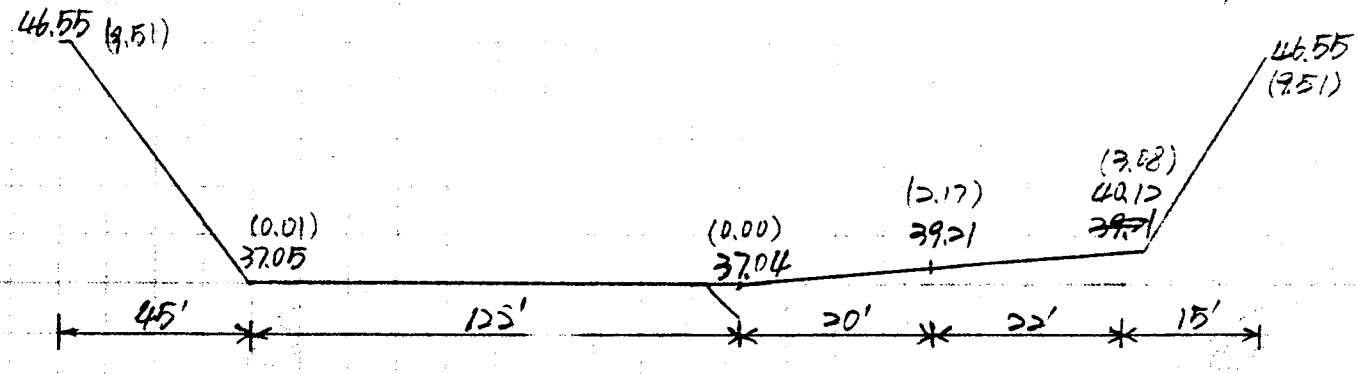
Sec. 1 Sta. 10+00.00 (Sta. 80+03.85) n=0.025 37.01



Sec. 2 Sta. 10+60.57 (Sta. 79+44.91) n=0.025 37.02



Sec. 3 Sta. 11+12.14 (Sta. 79+01.87) n=0.019 37.03



Sec. 4 Sta. 11+32.57 n=0.019 37.04

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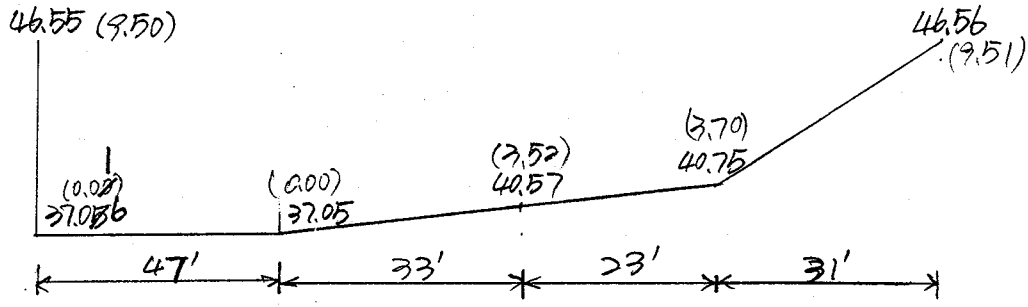
Job SCS RWCD Floodway Reach 6 - E10/012

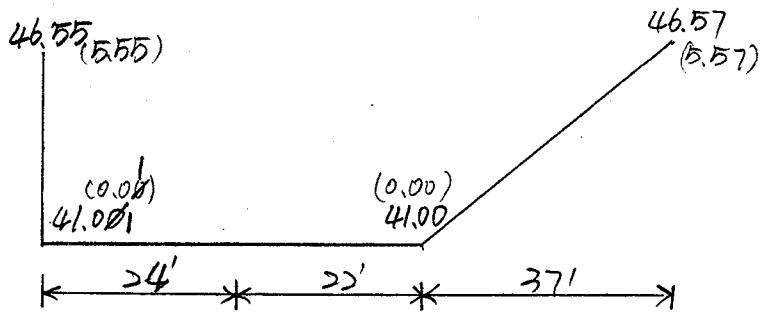
Description Powerline Easement Channel Alt. No. 3 Trial #2 Dip Section

Calculated by B. Gary Sun Date 11/15/85 Sheet No. 2

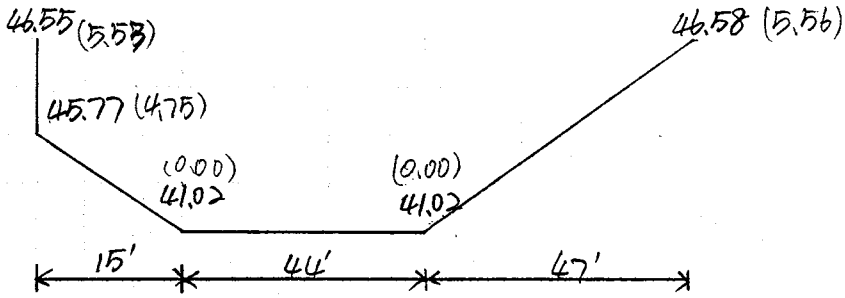
Checked by H.S.S. Date _____ of _____



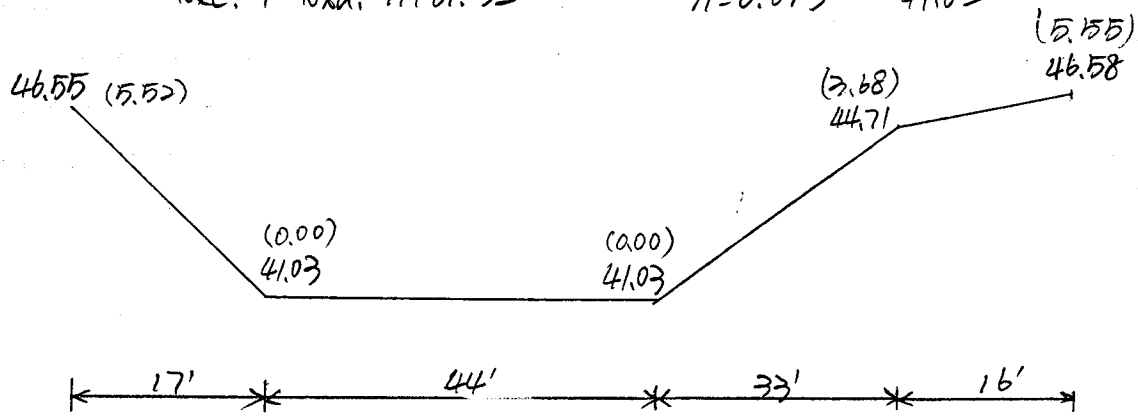
Sec. 5 Sta. 11+45.46 n=0.013 37.05



Sec. 6 Sta. 11+49.46 n=0.013 41.00



Sec. 7 Sta. 11+61.32 n=0.013 41.02



Sec. 8 Sta. 11+72.40 41.03

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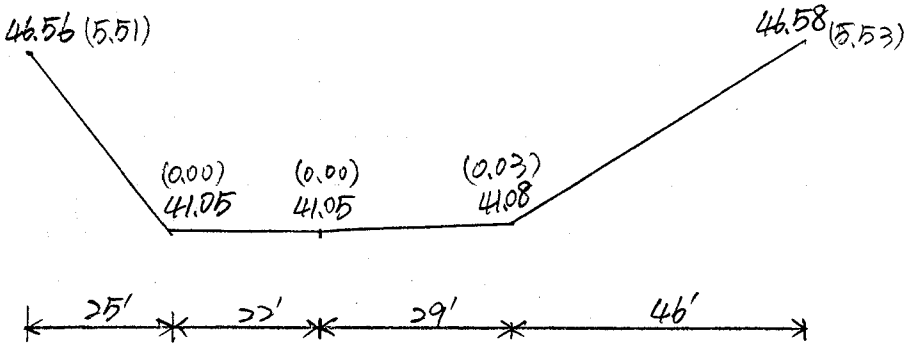
Job SCS RWCD Floodway Reach 6 - E/01012

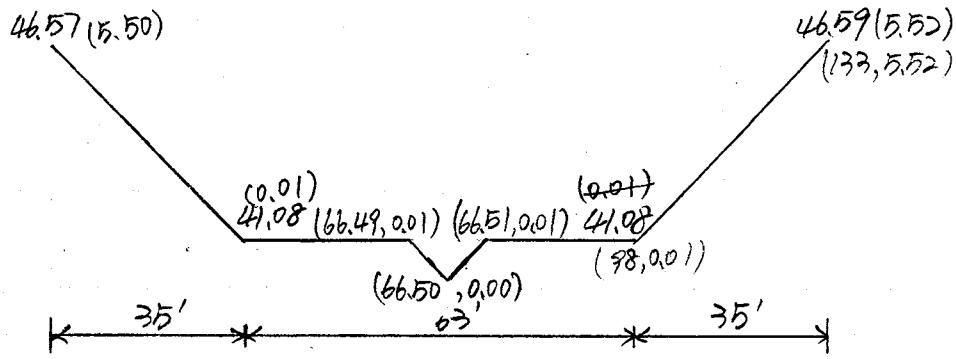
Description Powerline Easement Channel Alt. No 3 Trial #2 Dip Section

Calculated by B. Gary Sun Date 11/15/85 Sheet No. 3

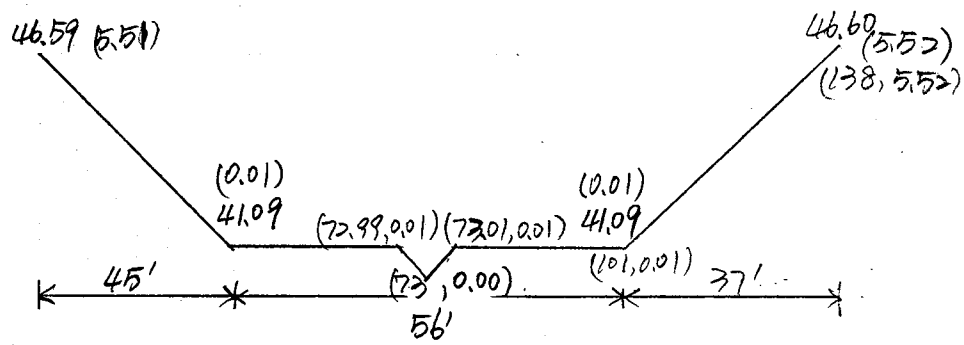
Checked by W.S.S. Date _____ of _____



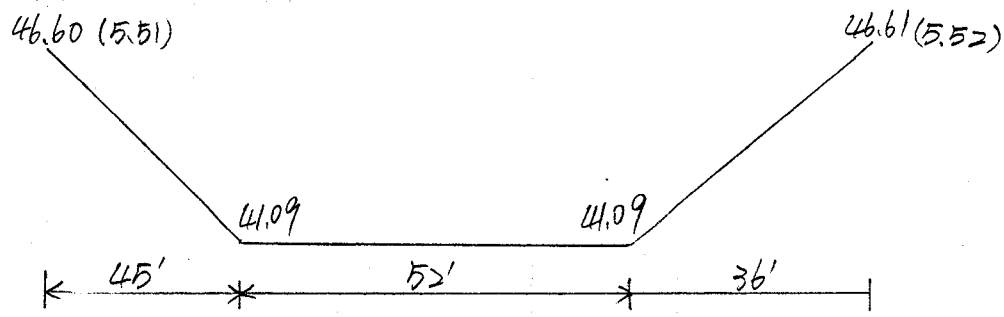
Sec. 9 Sta. 11+85.70 n=0.013 41.05



Sec. 10 Sta. 12+03.88 n=0.013 41.07



Sec. 11 Sta. 12+09.49 n=0.013 41.08



Sec. 12 Sta. 12+14.55 n=0.013 41.09

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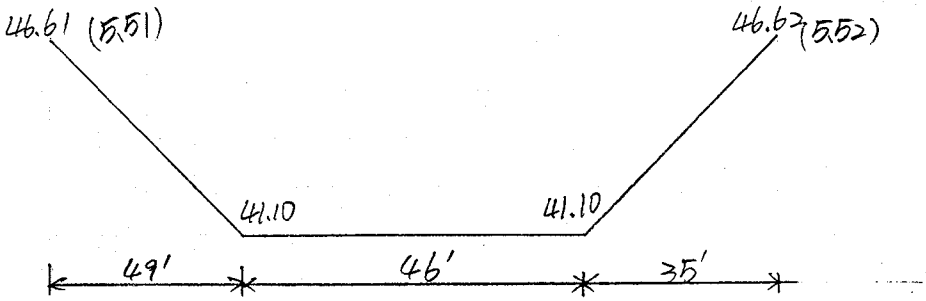
Job SCS RWCD Floodway Reach 6 - E101012

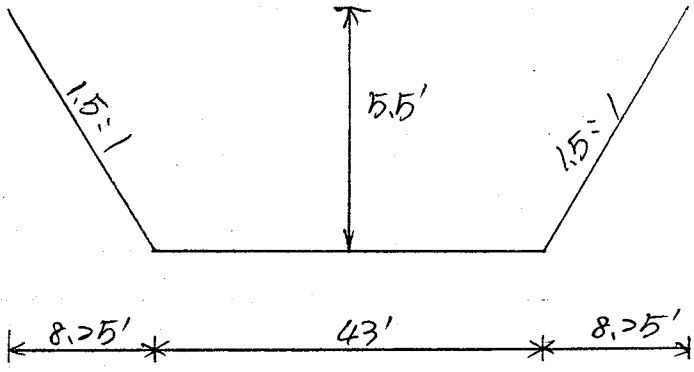
Description Powerline Easement Channel Alt. No. 3 Trial #2 Dip Section

Calculated by B. Gary Sun Date 11/15/86 Sheet No. 4

Checked by M.S.S. Date _____ of _____



Sec. 13 Sta. 12+18.58 n=0.013 41.10



Sec. 14 Sta. 12+45.63, 12+96.22, 14+00 & 15+00

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Job RWCD Reach 6 E10102
Description Estimating effective storage from TR-55 V P7-6
Calculated by M. Shapiro Date 11/7/85 Sheet No. 1
Checked by B. G. B. Date 11/8/85 of

Figure 7-1 is usually accurate within 5% for release rates under 100 csm (cubic feet per second per square mile) and within 10% for release rates over 100 csm.

Figure 7-1 - relates the volume of inflow to volume of required storage for a range of peak release rates.

Figure 7-2 - relates the peak outflow-inflow ratio to the storage-runoff volume ration where a single stage pipe spillway or weir is used.

$Q_i = 1600$ cfs

from chart 5 bureau of public roads Jan. 1963
Q_o for a 48" CMP with HW = 5.0' ⇒ 96 cfs $Q_o = 96$ cfs

$Q_o = 96$ cfs

$= \frac{96 \text{ cfs}}{1.56 \text{ sq. mi.}} = 61.54$ csm

Determine V_r from SCS TR-20 Addhyd 121 Acre-ft = 87.85

$87.85 \text{ ac-ft} = 998.4 \text{ ac.} \times \frac{V_r}{12 \text{ in/ft}}$

$V_r = 1.06$ inches

since Q_o is < 300 csm, use figure 7-1

$V_r = 1.06$ inches ∴ from figure 7-1 $V_s = 0.4$ inches

$V_s = 0.4$ inches

$= \frac{0.4 \text{ in } (640 \text{ acres/mi}^2)(1.56 \text{ sq. mi})}{12 \text{ in/ft}} = 33.28$ acre-ft

With a basin of 5' depth 6.66 acre of storage area is required.

Ave Width = 157 ft ∴ length = 1,847 ft ∴ N.G.

try - 2 - 48" cmps

$Q_o = 192$ cfs

$= \frac{192}{1.56} = 123.07$ csm

since Q_o is < 300 csm, use figure 7-1 ∴

$V_s = 0.33$ in

$= \frac{0.33 in (640)(1.56)}{12} = 27.46$ acre-ft

With basin of 5' deph 5.49 acre is required

Ave width = 157 ft ∴ length = 1,524 ft ∴ N.G.

try - 6 - 48" CMP's.

$Q_o = 576$ cfs

$= \frac{576}{1.56} = 369.23$ csm

since Q_o is > 300 csm, use figure 7-2 ∴

$\frac{Q_o}{Q_i} = \frac{576 cfs}{1600 cfs} = 0.36$

From figure 7-2 $\frac{V_s}{V_r} = 0.368$

since $V_r = 1.06$ inch

$V_s = 0.368(1.06) = 0.39$ in $1.56 sq.mi \times \frac{640 ac}{1 sq. mi} = 998.4$ acres

$$V_s = \frac{0.39\,(998.4\text{ acres})}{12\text{ in/ft}} = 32.45\text{ acre-ft}$$

With a basin of 5' depth 6.49 acre of storage area is required

Ave Width = 157 ft ∴ length = 1,800 ft

Assume the maximum length = 685 ft ∴ we need 2.47 acres at 5' depth ∴ we need 12.34 acre-ft. ∴

$$12.34 = \frac{998.4\,V_s}{12}$$

$$V_s = 0.15 \quad \therefore \quad 0.15 = \frac{V_s}{V_r}(1.06) \quad \therefore \frac{V_s}{V_r} = 0.14$$

$$\left(\frac{Q_o}{Q_1}\right) = 1 \quad \therefore \text{ N.G.}$$

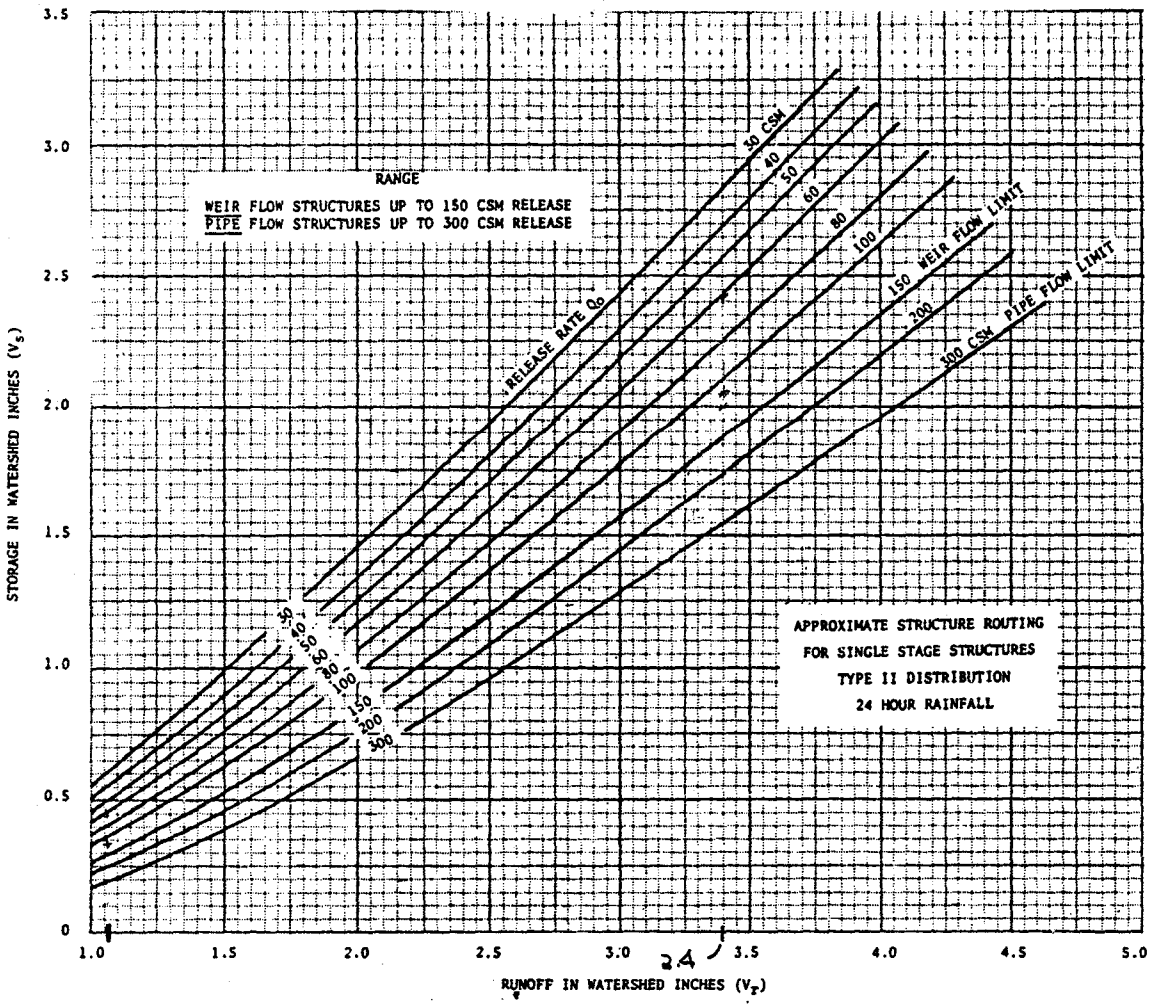


Figure 7-1.--Approximate single-stage structure routing for weir flow structures up to 150 csm release rate and pipe flow structures up to 300 csm release rate.

Figure 7-1 applies to pipe drop inlets of 0 to 300 csm release rate and weir flow structures of 0 to 150 csm release rate. Figure 7-2 applies to pipe drop inlets of over 300 csm release rate and weir flow structures of over 150 csm release rate.

Extrapolation for points falling outside the limits of the curves could introduce a significant error. The steps necessary to use the procedure described in this chapter are:

1. Determine the basic watershed parameters (DA, CN, T_c, etc.).

2. Determine the volume of runoff and peak rate of flow from the watershed.

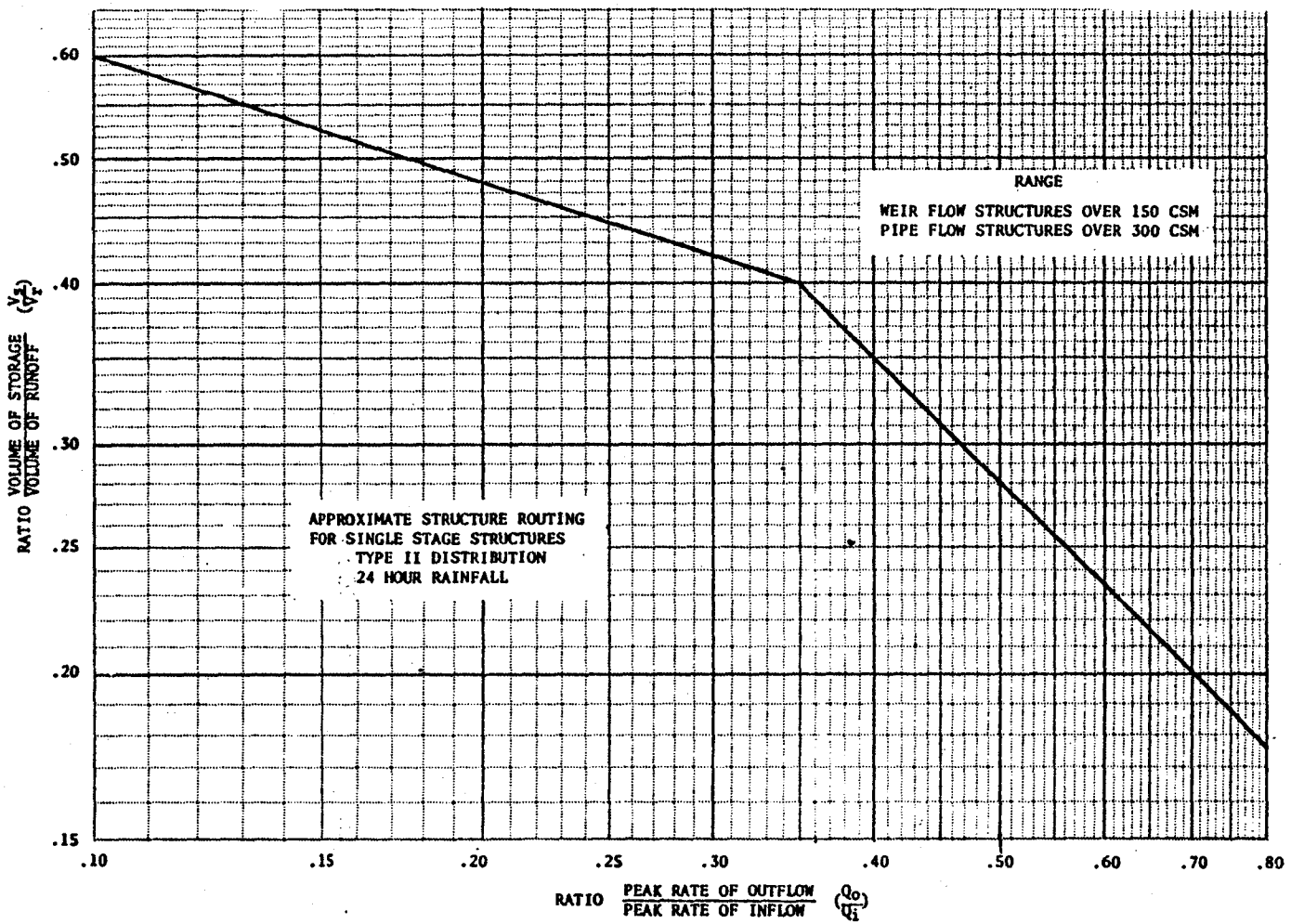
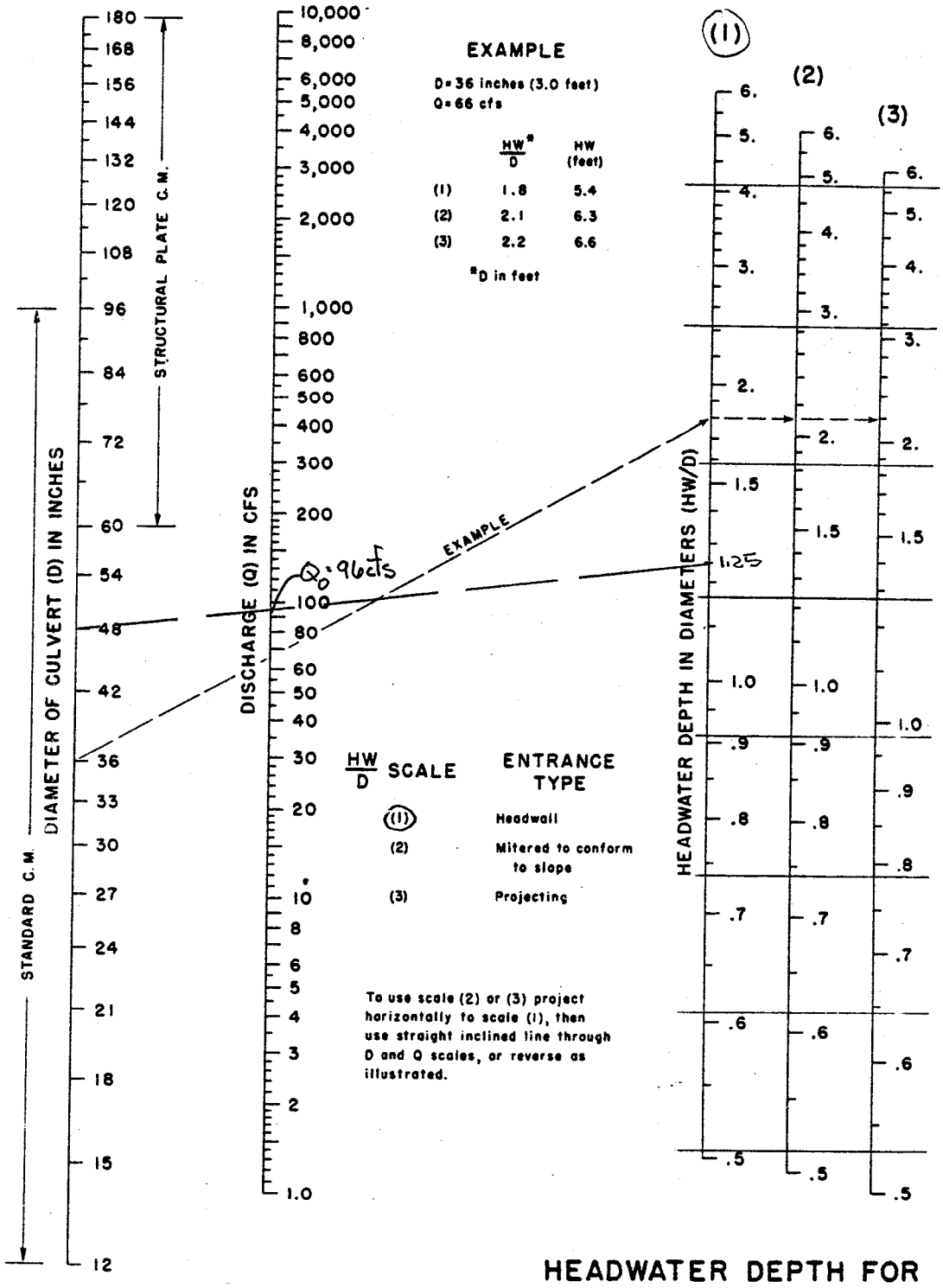


Figure 7-2.--Approximate single-stage structure routing for weir flow structures over 150 csm release rate and pipe flow structures over 300 csm release rate.

use a 48" CMP

$\frac{HW}{D} = \frac{5.0}{4} = 1.25$

CHART 5

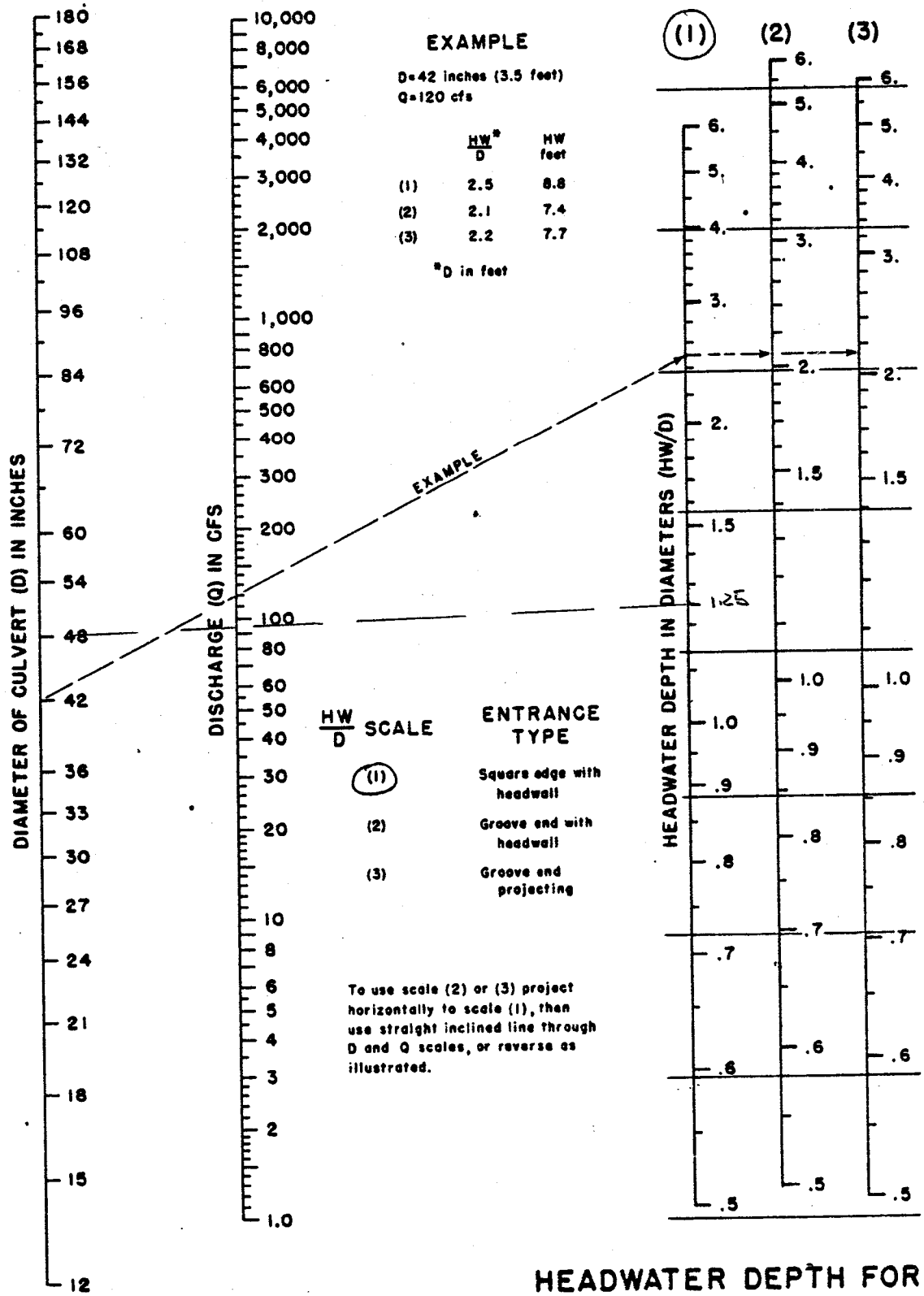


HEADWATER DEPTH FOR C. M. PIPE CULVERTS WITH INLET CONTROL

BUREAU OF PUBLIC ROADS JAN. 1963

use a 48" CMP w/ steel lining
$\frac{HW}{D} = 1.25$

CHART 2



HEADWATER SCALES 2&3
REVISED MAY 1964

HEADWATER DEPTH FOR CONCRETE PIPE CULVERTS WITH INLET CONTROL

BUREAU OF PUBLIC ROADS JAN. 1963

Existing retention basins along the powerline easement between Higley Road built for the subdivision "Stoney brook" provide 6.52 acre-ft of storage. The basins are approximately 1,770 ft long by 150 ft wide. The seven most upsteam basin are one foot deep with one foot of freeboard and provide 2.44 acre-ft. of storage. The downstream basin is approximately 740 ft long and 2.5 foot deep with one foot of freeboard and provide 4.08 acre-ft of storage. (Calc's. based on Hydrology and Hydraulics Report For Stoney Brook Two, Revised June 22, 1984, by Clouse Engineering Inc. and Grading and Drainage Plan for Stoney Brook, Revised June 25, 1984, by Clouse Engineering Inc.)

Ave area of the seven upstream basins = 2.44 acres
Ave area of the downstream basin = 1.92 acres

If basin were deepened to 4.5 ft deep w/ 1.0 ft of freeboard.

2.44 + 1.92 = 4.36 acres × 4.5 ft = 19.62 ac-ft could be provided.

If the seven basins upstream where reshaped and deepened and made into 3 basins and additional land upstream approx. 370 ft long by 240 ft wide by 4.5 ft deep will provide more than 33 acre-ft of storage. Plus notched broad crested weir dividing each basin for outlet control and 6 - 48" CMP's with 2 concrete headwalls and wingwall under the maintenance ramps a discharge Q_o of 576 cfs.

Cost Evaluation

Earthwork - 32.45 ac-ft need
- 6.52 ac-ft provided
25.93 ac-ft of additional excavation

$$25.93 \text{ ac-ft} \times \frac{43{,}560 \text{ sq ft}}{1 \text{ ac}} \times \frac{1 \text{ c.y.}}{27 \text{ ft}^3} = 41{,}834 \text{ c.y}$$

use 41,800 c.y. of export

using \$2.00/c.y. for disposal

41,800 c.y. x \$2.00/c.y. = \$83,600

clearing and grubbing for 6 acres @ \$490/ac. = \$2,940

108 L.F. of 48" CMP @ \$40 /L.F = \$4,320

Inlet headwall w/wingwalls:

conc. 42 C.Y. @ \$165/c.y. = \$6930
steel 2,555 lbs @ \$.38/lb. = 971
\$7901

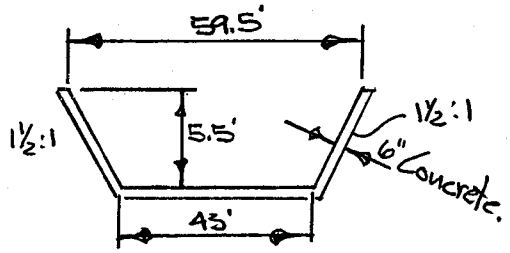
Outlet headwall w/wingwalls

conc. 31 C.Y. @ \$165/c.y. = \$5,115
steel 1,840 lbs @ .38/lb = 699
\$5814

6 outlet control structures (grouted rip-rap)
approx. 2,000 c.y. @ \$36/c.y. = \$72,000

Total costs = \$176,575

If the flood control district were to be a channel along this easement instead of a series of detention basins:



Approx: 2,100 L.F. of channel

Perimeter = 62.83 L.F. ∴

$62.83\,ft \times 0.5\,ft \times 1.0\,ft \times \frac{1\,C.Y.}{27\,ft^3} = 1.164\,C.Y./L.F.$

∴ 1.164 C.Y./L.F. × 2,100 L.F. = 2,443 C.Y. of concrete.

2,443 C.Y. × \$165/C.Y. = \$ 403,095 for the concrete alone.

Extras would be the appurtenances to tying in the existing retention basin facilities into the proposed concrete channel and grading, clearing and grubbing and steel.

The cost for revising the retention facility is \$176,575

The channel would cost approx: 2.3 times the amount of the detention facilities.

If gunite was used instead of concrete for this channel
∴ 62.83 ft × 2,100 L.F. = 131,943 S.F. @ \$2.40/S.F. = \$316,663. The channel would cost approx: 1.8 times the amount for the detention facility

* Another point to be made is that ultimate flows in the RWCD would be cut drastically if with the design of these detention facilities. Without

doing any revision to the TR-20 program we have estimated that flows in the floodway would be reduced as follows:

	Discharges based on detention facilities	Discharge recommended for design
1/4 mi. south of Univ. Dr.	~~1000~~ cfs 1,290 cfs	~~1550 cfs~~ 1840 cfs
Apache Trail	1,350 cfs	1900 cfs
Just S.E. of Higley Rd.	1,850 cfs	2400 cfs
Broadway Rd.	1,850 cfs	2400 cfs

It is possible that these reduced flows would give the box culvert @ Apache Trail and Higley Road the 2 foot of freeboard.

This alternate was presented to the FCD on 11/25/85.

EXHIBIT "A"

Proposed Modification # 3

E. Phase IV - Comparative Design Studies

3. Studies

Additional project features and alternatives to be studied are:

f. Apache/Higley Culvert - Study inlet and outlet conditions and do all hydraulic analysis needed to size and layout the culvert structure. Coordination shall be maintained with the Maricopa County Flood Control District, the City of Mesa, and the Arizona Department of Transportation to establish needed requirements.

g. Study a lined channel and an outlet structure - as needed from end of project to the Apache/Higley culvert such that the water surface elevation through the Apache/Higley culvert maintain one foot of freeboard without having to modify Apache road.

h. Adobe Road Culvert - Study inlet and outlet conditions and do all hydraulic analysis needed to size and layout the culvert structure including: establishing horizontal and vertical roadway alignment, maintenance ramps and roadways and modifications to the channel upstream based on the hydraulics of this structure.

Note:

For (g) above, no design costs should be considered for preliminary or final designs. Upon acceptance of the project feature, we will negotiate and modify for design.

Greiner Engineering

Greiner Engineering Sciences, Inc.

Tucson 602 327-3413
Phoenix 602 275-5400

Job SCB RWCD Floodway Reach 6 - E101012
Description Summary for Modification No. 3

Calculated by B. Gary Sun Date 2/12/86 Sheet No. 1
Checked by M.S.S. Date _____ of 1

The following sub-sections are included:

1. Summary of Conclusions
2. Design Procedure
3. Summary of Sewer Calculations at Broadway Road
4. Adobe Road Culvert
5. Description for Trials 10 ~ 21
6. Cost Estimate for Apache/Higley five barrel 10'x7' box culvert
7. Additional Cost Estimate for a four barrel 10'x8' box culvert at East Adobe Road

Summary of Conclusions for Modification No. 3

Based on the hydraulic calculations and analysis, the following conclusions are made:

A. Apache/Higley Culvert

Based on water surface profile calculations, freeboard maintains at least 1.35 feet inside the 7 foot high box culvert. Hence, an ADOT Std. CB-5 five barrel 10'x7' concrete box culvert with approximate 370 lineal feet in length is recommended. The estimated cost is $619,000. This includes level wingwalls, aprons and slope paving for transitions. Based on the tractive power calculations, Greiner recommended to eliminate slope paving from Sta. 119+02.72 to Sta. 121+13.05 and from Sta. 127+25 to Sta. 128+59.37. Also channel bottom protections should be extended from Sta. 126+71.27 to Sta. 127+25 at downstream of the structure.

B. Channel Geometry and Channel Lining

The proposed constant invert slope (S=0.0011629 ft/ft) between the south end of transition of Apache/Higley structure and the southern terminus of the floodway creates encroachment problems. One is at the Broadway Road Bridge. Side slopes have been changed from 2:1 to 1:1 with a concrete lining. The reason for this was to avoid encroaching into the existing bridge abutments due to the invert being lowered approximately 2 feet. Also revision of the channel geometry

Summary of Conclusions for Modification No. 3 (Cont'd)

B. (Cont'd) has been made between Sta. 140+00 to Sta. 153+50. The above reach provided unadequate room for the west collector system without encroachments. Greiner proposed to transition from a 90 foot bottom width at Sta. 140+00 to a 81 foot bottom width at Sta. 153+50. No additional channel lining or design of an outlet structure is necessary to assure minimum 1 foot freeboard inside Apache/Higley culvert. Actually, It also eliminated channel lining between Sta. 158+90.67 and Sta. 161+30. (See Computer File QA3T30.OUT)

C. East Adobe Road Culvert

A horizontal shift in the construction centerline of East Adobe Road was informed by the City of Mesa. Greiner proposed a vertical profile at this centerline to make sure providing adequate room for construction of structures across the floodway and canal. A series of vertical curves were designed along the centerline of East Adobe Road. These vertical curves have a length of 180 feet, 360 feet and 395 feet from east to west. This alignment took place between the east right-of-way of the flood and the terminus of the existing pavement approximate 666 feet west of the centerline of the floodway. The reason for this alignment is to eliminate the

Summary of Conclusions for Modification No. 3 (Cont'd)

cost of removing and replacing pavement. Also a dip section is placed between the east right-of-way and the east maintenance road of the floodway in order to drain floodwater into the proposed inlet structures along East Adobe Road. Due to tailwater control, an 8 foot high box culvert is used to maintain at least 1 foot of freeboard through the box culvert. Greiner exercised design of two structures, which are 5 barrel 8'x8' and 6 barrel 8'x8' concrete box culvert, incorporating in the water surface profile calculations. Based on the hydraulic analysis, both structures have no backwater effect to the upstream water surface profile. A five barrel 8'x8' concrete box culvert, which provided at least 1.52 feet of freeboard inside the box, is the most cost benefit option, then it is recommended.

The approximate cost of box culvert including wingwalls and aprons is $ 108,000. This structure is a 100 lineal foot ADOT Std. CB-5 box culvert with Std. CW6-6 tapered wingwalls and Std. CWA-1 aprons.

As requested, a four barrel 10'x8' concrete box culvert is also examined. This was estimated to be $ 114,000.

Therefore, It is no need for the calculations of the water surface profile. Greiner's recommendation is to use a five barrel 8'x8' box culvert at East Adobe Road.

Summary of Conclusions for Modification No. 3 (Cont'd)

Greiner was informed by SCS to eliminate the design of collection system at the Apache/Higley intersection. This includes the collection system and spillways upstream and downstream of the structure and connections from the storm drain facilities. These will be handled in the priliminary design phase. (See memo. dated 2/3/86

For computer printouts of "WSPG" runs, refer to the separate file provided.

Low velocities for As-Built condition (50% of design flow) were noted within the main channel. (Trial #21 A2T21.OUT & QA2T21.OUT)

Sta. 30+70 - Sta. 32+24.53	Velocities 0.55 ~ 1.95 fps
Sta. 36+79.83 - Sta. 61+37.97	Velocities 1.14 ~ 1.97 fps
Sta. 65+06.02 - Sta. 78+43.91	Velocities 1.58 ~ 1.59 fps
Sta. 158+90.67 - Sta. 161+30.00	Velocities 1.70 ~ 1.62 fps

This area will need the special procedures for maintenance. This will be looked more details in the preliminary and final Design Phases.

Design Procedure for Modification No. 3

The following steps and criteria were followed in the study of the Modification No. 3:

1. Check if the proposed channel grade has sufficient cover below the invert of the floodway floor to the as-built 10 inch sanitary sewerline at Broadway Road Bridge. This is done by running the "COGO" program with the field survey data.

2. Use the proposed constant slope of 0.001169 ft/ft between the south terminus of project and the downstream end of transition at Apache/Higley box culvert. Make water surface profile computations for Q_{100} and 50% of Q_{100}. Channel geometry or channel protection is adjusted if necessary to satisfy the freeboard requirements through the floodway. Freeboard for an unlined channel is 2 feet while freeboard for a lined channel or concrete structure is 1 foot.

3. If freeboard criteria have been met, the Apache/Higley box culvert is sized either 7-foot or 8-foot high box which is depending on the water surface elevation through the box.

Design Procedure for Modification No. 3 (Cont'd)

4. Determine the cost of the proposed Apache/Higley box culvert.

5. Establish horizontal and vertical roadway alignment for East Adobe Road. This includes cross section taken along the centerline of East Adobe Road, and vertical curves design. Miminum length of vertical curves is 165 feet. Vertical curves start at the east right-of-way of the floodway and end the proposed end of roadway project approximately 666 feet west of centerline of the floodway. This is recommended to eliminate the cost of replacing pavement.

7. Determine the size of East Adobe Road box culvert. Preliminary Hydraulic calculations have been made to size the box culvert. Pick the most cost benefit of these box culvert to run water surface profile computations. The size of box culvert is adjusted if necessary to satisfy miminum 1 foot of freeboard inside the box.

8. Layout the culvert structure in plan and profile and modify the channel geometry wherever it is necessary.

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Job SCS RWCD Floodway Reach 6 - E10/0/2
Description Comparative Design Modification No. 3 Sewer Calculations for Broadway Road
Calculated by B. Gard Bun Date 1/27/86 Sheet No. 1
Checked by M.S.S. Date _____ of 1

Summary of Sewer Calculations

The proposed constant invert slope ($S_o = 0.001169$ ft/ft) for Modification No. 3 between the south end of the transition structure of Apache/Higley culvert and the south terminus of the floodway (i.e. from Sta. 128+79.37 to Sta. 161+30.00) has an approximate 2.1 feet drop in elevation at Broadway Bridge. The existing ten-inch sanitary sewerline at Broadway Road Bridge should have a minimum cover of 3 feet from the finished grade to pipe spring line. Due to the field survey data and "COGO" run, the sewer is flowing from east to west with a slope of 0.005759 ft/ft. The minimum cover for the sewer is found to be 3.34 feet. Hence, the proposed grade has sufficient cover below the invert of the floodway channel at Broadway Road Bridge.

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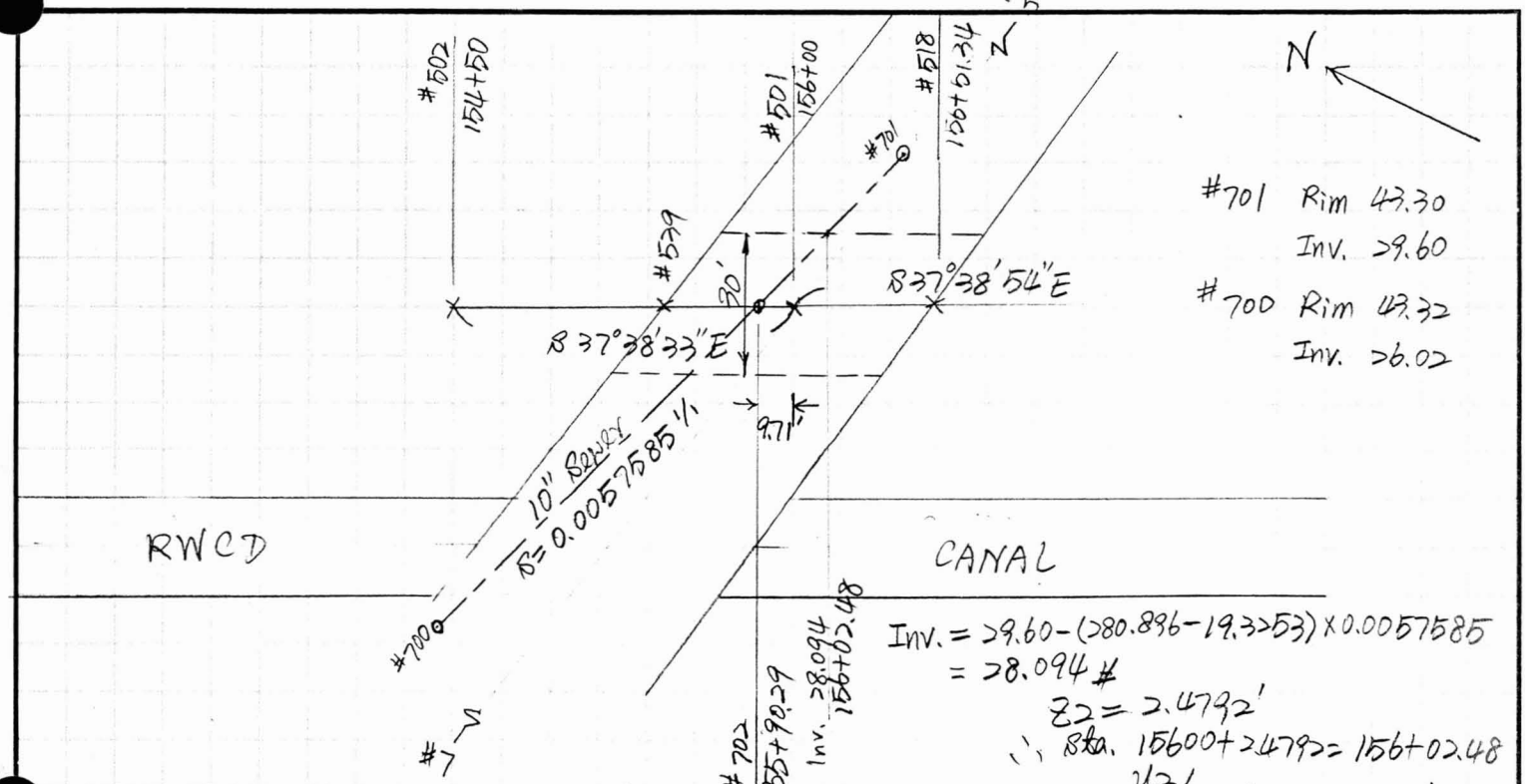
Job: SCB RWCD Floodway Reach 6-E101012
Description: Comparative Design Studies (Mod.) Sewer Calculations for Broadway Road
Calculated by: Gary Sun Date: 12/28/85 Sheet No. 1
Checked by: M.S.S. Date: _____ of _____



#701 Rim 43.30
Inv. 29.60

#700 Rim 43.32
Inv. 26.02

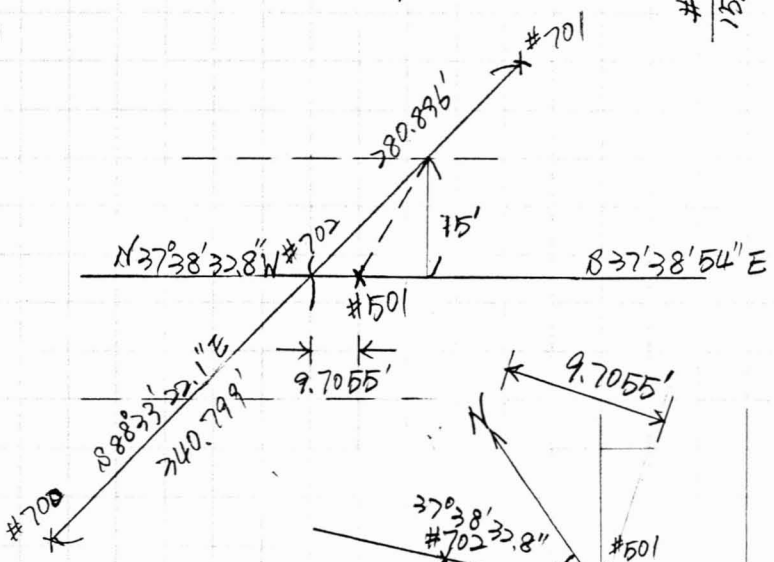
Inv. = 29.60 − (280.896 − 19.3253) × 0.0057585
= 28.094 #

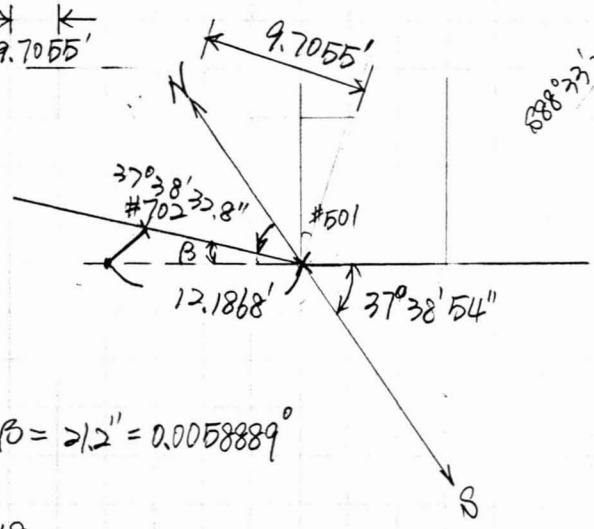
$z_2 = 2.4792'$

∴ Sta. 156+00 + 2.4792 = 156+02.48

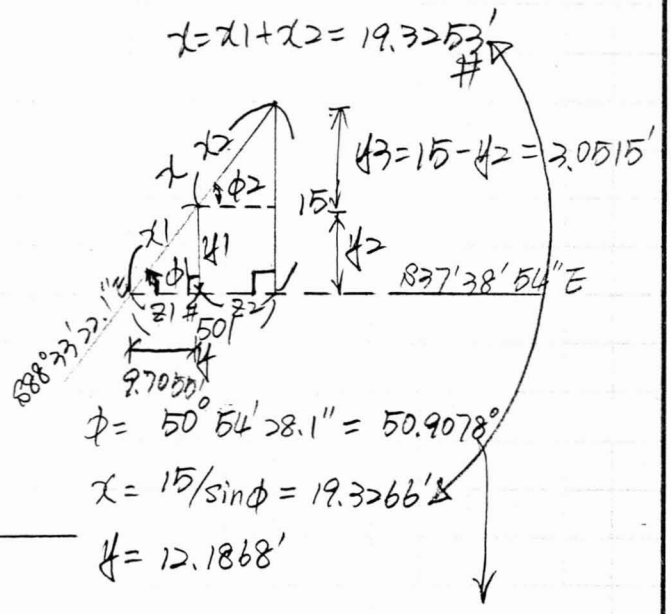
$x_2 = y_3/\sin\phi_2 = 3.9317'$

$x = x_1 + x_2 = 19.3253'$





$\beta = 21.2'' = 0.0058889°$



$y_3 = 15 - y_2 = 2.0515'$

$\phi = 50°54'28.1'' = 50.9078°$

$x = 15/\sin\phi = 19.3266'$

$y = 12.1868'$

$\phi_1 = 50°54'49.3''$, $\phi_2 = 50.9078°$

$x_1 = 9.7055/\cos(50.91394°)$
$= 15.3936'$

$y_1 = 11.9485'$

$y_2 = y_1 \cos\beta = 11.9485'$

At Sta. 156+02.48
Floodway Inv. Trial #8 33.987
Trial #10 31.855

10" Sewer line

At Sta. 156+02.48 Inv. = 1328.094

Floodway Inv. Trial #8 33.987

Trial #10 31.855

Arizona Department of Health Services

Engineering bulletin ~~No~~ no. 11

"Minimum Requirements for Design, Submission of Plans and Specifications of Sewage Works"

Chapter 4 Section D - Design Details 6. Depth of Sewers

Requirements: the sewer pipe should be installed at a minimum depth of 3 feet (finished grade to pipe spring line).

Spring line Ele. = 28.094 + $(\frac{42}{12})/2$ = 28.511

Clearance = 33.987 - 28.511 = 5.476 ft (Trial #8 work plan)

= 31.855 - 28.511 = 3.344 ft # (Trial #10 concrete lined channel from Apache to Broadway)

Arizona Dept. of Health Services

at minimum flows with the inlet structure arranged in such a manner as to bring additional pipes progressively into operation as the flow increases to its ultimate design flow.

Manholes shall be installed at each end of the depressed sewer to provide for cleaning and rodding.

Where circumstances warrant, a bar screen may have to be installed in a structure prior to the depressed sewer inlet. This could be especially true where 6-inch pipes are used. The design Engineer should give careful analysis and attention to potential clogging problems.

6. Depth of Sewers - Sewers shall be installed at a depth sufficient to insure adequate drainage of wastes from each service and to prevent frost damage.

   All sewers shall be designed to absorb superimposed loads and back-fill overburden, without damage to the pipe material, and without adversely affecting the hydraulic characteristics of the pipe.

   It is recommended that the sewer pipe be installed at a minimum depth of 3 feet (finished grade to pipe spring line). Where pipes are required to bridge ravines, washes, and caverns, the pipe shall be of high strength material and shall be supported properly to prevent settlement or washout during storm flows.

7. Easements and Rights-of-Way - No public sewer shall be installed unless the owner has in his possession evidence of his obtaining the necessary easements and rights-of-way.

   Failure to produce these agreements upon request is ground for withdrawal of the Department's "Approval to Construct."

8. Special Conditions for Condominiums, Mobile Home, Travel Trailer, and Recreation Vehicle Parks - Condominiums, mobile home, travel trailer, and recreational parks shall be designed using the requirements of the uniform plumbing code, excluding the water-sewer main separation. The requirements of this Bulletin regarding water and sewer separation shall also apply to condominiums, mobile home, travel trailer, and recreational vehicle parks.

E. PLAN - DETAIL REQUIREMENTS.

In general, the engineering drawings submitted to the Department for approval shall meet the following requirements:

1. Standard Drawing Size - The engineering drawings shall be reproduced on paper not greater 24" x 36".

2. Plan View and Profile - Plans and profiles for sanitary sewers shall be submitted and shall be prepared using the following scales:

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Greiner Engineering Sciences, Inc.

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Phoenix 602 275-5400

Job RWCD Reaches E101012
Description Gravity for 10" Sanitary Sewer at Broadway Road
Calculated by M. Shapiro Date 12/28/85 Sheet No. 1
Checked by B.G.S. Date _____ of 1

GSZ
* Sewer Calculations For Broadway Road
2111
12 501 700 (A 501 7 +319 49) 347.00
1 501 701 (A 501 700 +177 11 08) 274.88
21 702 501 A501 502 700 A700 701
17 700 702 701
501 702

COMPUTER PROGRAM G 0001

Greiner Engineering Sciences, Inc.
CONSULTING ENGINEERS

COGO
INPUT DATA SHEET

CONTRACT _____ DIV. _____ CODE _____

* Comment Card

DATA DISK NO. _____

DES. G.S. DATE 12/27/85 CHK. _____ DATE _____

COMMAND	DATA
*SEWER CALCULATIONS FOR BROADWAY ROAD	
2 1 1 1	
12 501 700	(A501 7 +3 19 49) 347.00
501 701	(A501 700 +177 11 08) 274.88
21 702 501	A501 502 700 A700 701
17 700 702	701
501 702	

PLEASE; 0 Digit Zero, Ø Letter "OH"; 1 Digit One, I Letter "EYE"; 6 Digit Six, G Letter "GEE"; 2 Digit Two, Z Letter "ZEE"; 5 Digit Five, S Letter "ESS"

P 15
RWCD Sewer topo

(15)

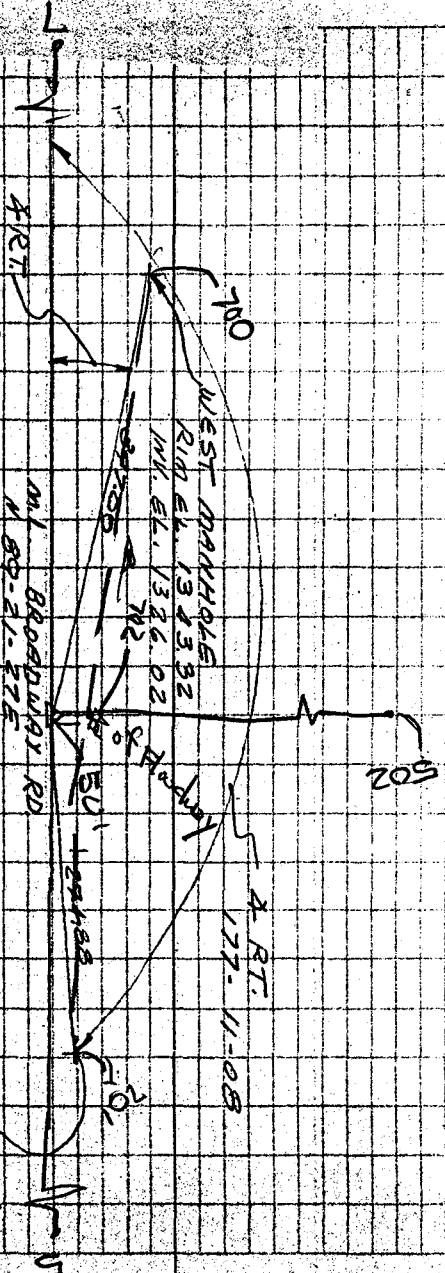
BROADWAY RD SEWER
M.H. TIES AT RWCD
REACH 6 12/26/85
B. RUIZ
C. THOMPSON

B.M. 1346.41

Total Length 700 - 701
= 340.799 + 280.8960 = 621.695

S = 0.0057585 ft/ft
Invert at #702 = 27.982

~~13' Rt. at #702 invert = 28.057~~



M. Shapiro

From Alt. No. 1 Trial #14: TW = 6.60'

L = 98.76 ≈ 99' use 100 ft.

PROJECT: E101012 Mod. No. 3 **DESIGNER:** B. Gary Sun

East Adobe Road proposed box culvert **DATE:** 1/3/86

HYDROLOGIC AND CHANNEL INFORMATION

$d_c = .315 \sqrt[3]{(Q/B)^2}$

$h_o = \frac{d_c + D}{2}$ or TW, whichever is the greater

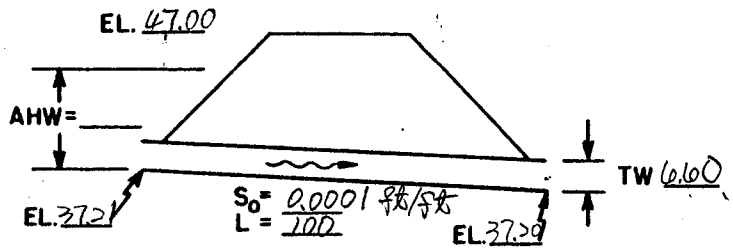
Q_1 = 1200 cfs TW_1 = _____

Q_2 = _____ TW_2 = _____

(Q_1 = DESIGN DISCHARGE, SAY Q_{25}
Q_2 = CHECK DISCHARGE, SAY Q_{50} OR Q_{100})

SKETCH

STATION: 62+77.72



MEAN STREAM VELOCITY = _____

MAX. STREAM VELOCITY = _____

CULVERT DESCRIPTION (ENTRANCE TYPE)	Q	SIZE	HEADWATER COMPUTATION: INLET CONT. HW/D	INLET CONT. HW	OUTLET CONTROL HW=H+h_o−LS_o: K_e	H	d_c	$\frac{d_c+D}{2}$	TW	h_o	LS_o	HW	CONTROLLING HW	OUTLET VELOCITY	COST	COMMENTS
5 barrel box culvert w/wingwalls	240	10'x8'	0.500	4.00	.4	0.13	2.62	5.31	6.60	6.60	0.01	6.72	6.72	3.57	$138,300	1.28' freeboard O.K.
5 barrel box culvert w/wingwalls	240	8'x8'	0.580	4.64	.4	0.34	3.04	5.52	6.60	6.60	0.01	6.93	6.93	4.29	$107,800	1.01' freeboard O.K.
6 barrel box culv. w/wingwalls	200	8'x8'	0.520	4.16	.4	0.14	2.69	5.35	6.60	6.60	0.01	6.73	6.73	3.71	$126,300	1.27' freeboard O.K.

SUMMARY & RECOMMENDATIONS:

Use 6 barrel 8'x8' 30° skew 6:1 slope box culvert with wingwalls

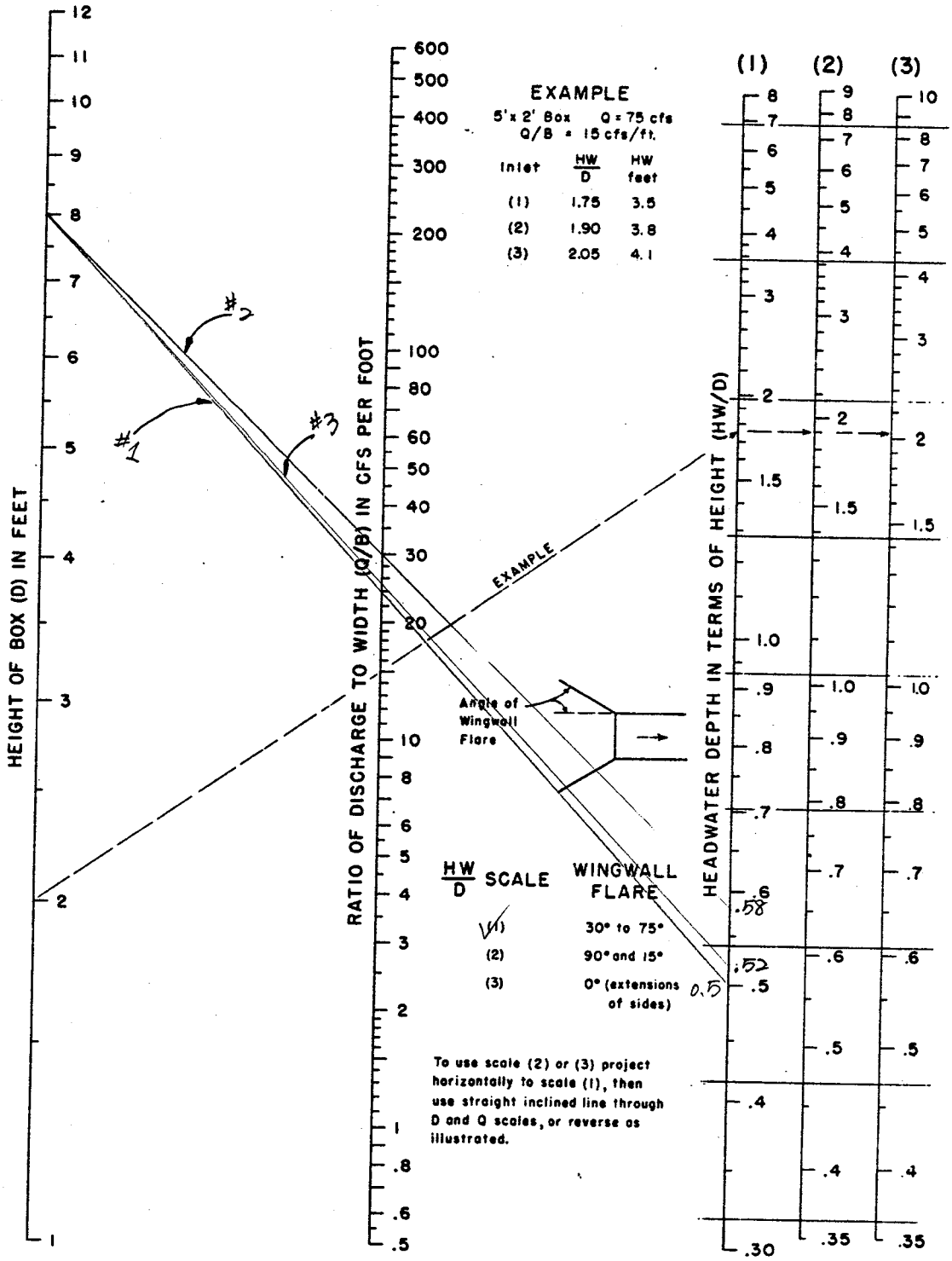
Figure 7

Trial #1 5 barrel 10'x8' box culvert $\frac{Q}{B} = 24 \Rightarrow \frac{HW}{D} = 0.5$

5 barrel 8'x8' box culvert $\frac{Q}{B} = 30 \Rightarrow \frac{HW}{D} = 0.58$

6 barrel 8'x8' box culvert $\frac{Q}{B} = 25 \Rightarrow \frac{HW}{D} = 0.52$

CHART I



HEADWATER DEPTH FOR BOX CULVERTS WITH INLET CONTROL

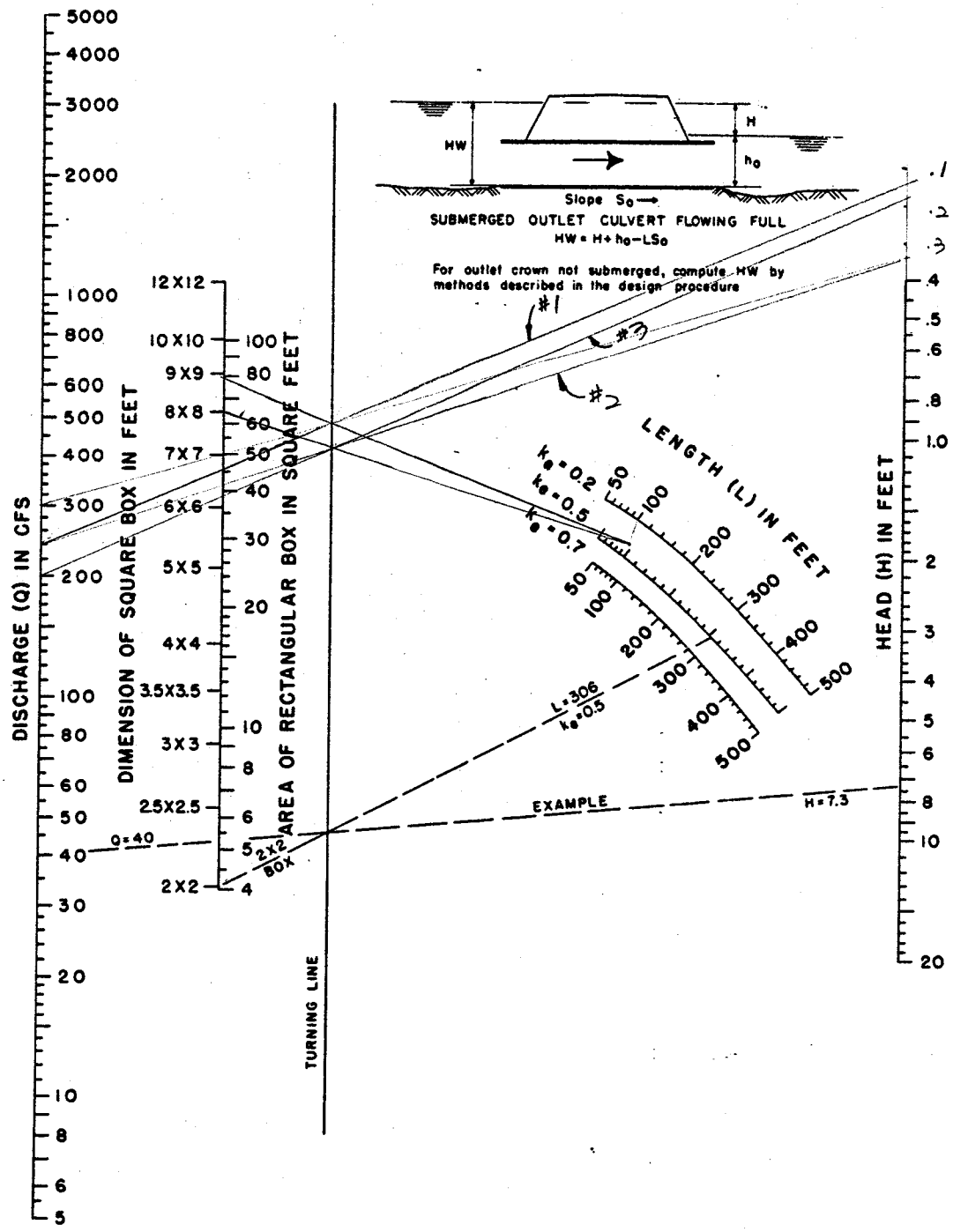
BUREAU OF PUBLIC ROADS JAN. 1963

Trial #1
5 barrel 10'x 8'
$\frac{Q}{5} = 240$

Trial #2
5 barrel 8'x8'
$\frac{Q}{5} = 240$

Trial #3
6 barrel 8'x8'
$\frac{Q}{6} = 200$

CHART 8



HEAD FOR
CONCRETE BOX CULVERTS
FLOWING FULL
n = 0.012

BUREAU OF PUBLIC ROADS JAN. 1963

Greiner Engineering

Greiner Engineering Sciences, Inc.

Tucson 602 327-3413
Phoenix 602 275-5400

Job SCS RWCD Floodway Reach 6 - E101012

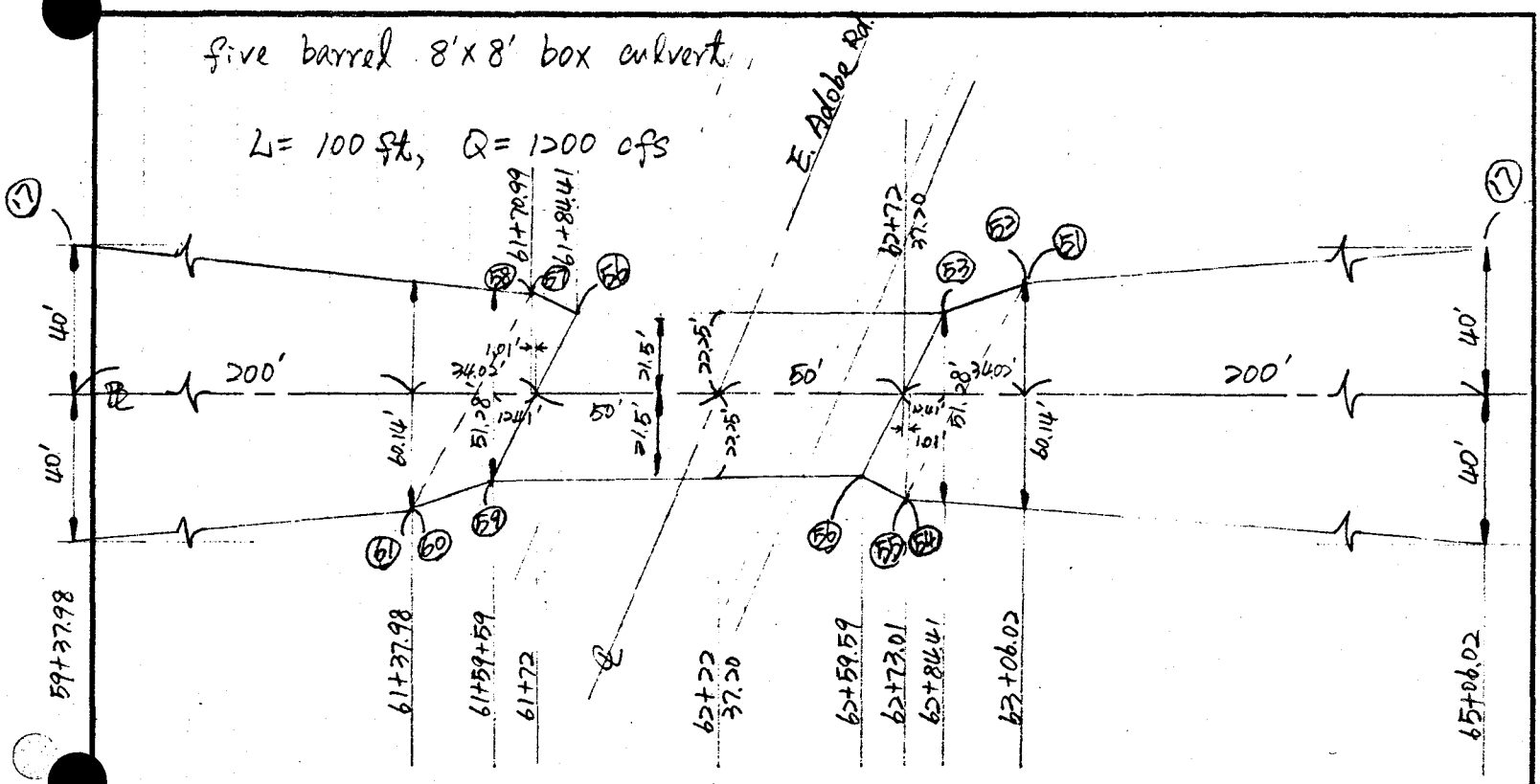
Description Comparative Design (Mod. No. 3)
Proposed box culvert at E. Adobe Road

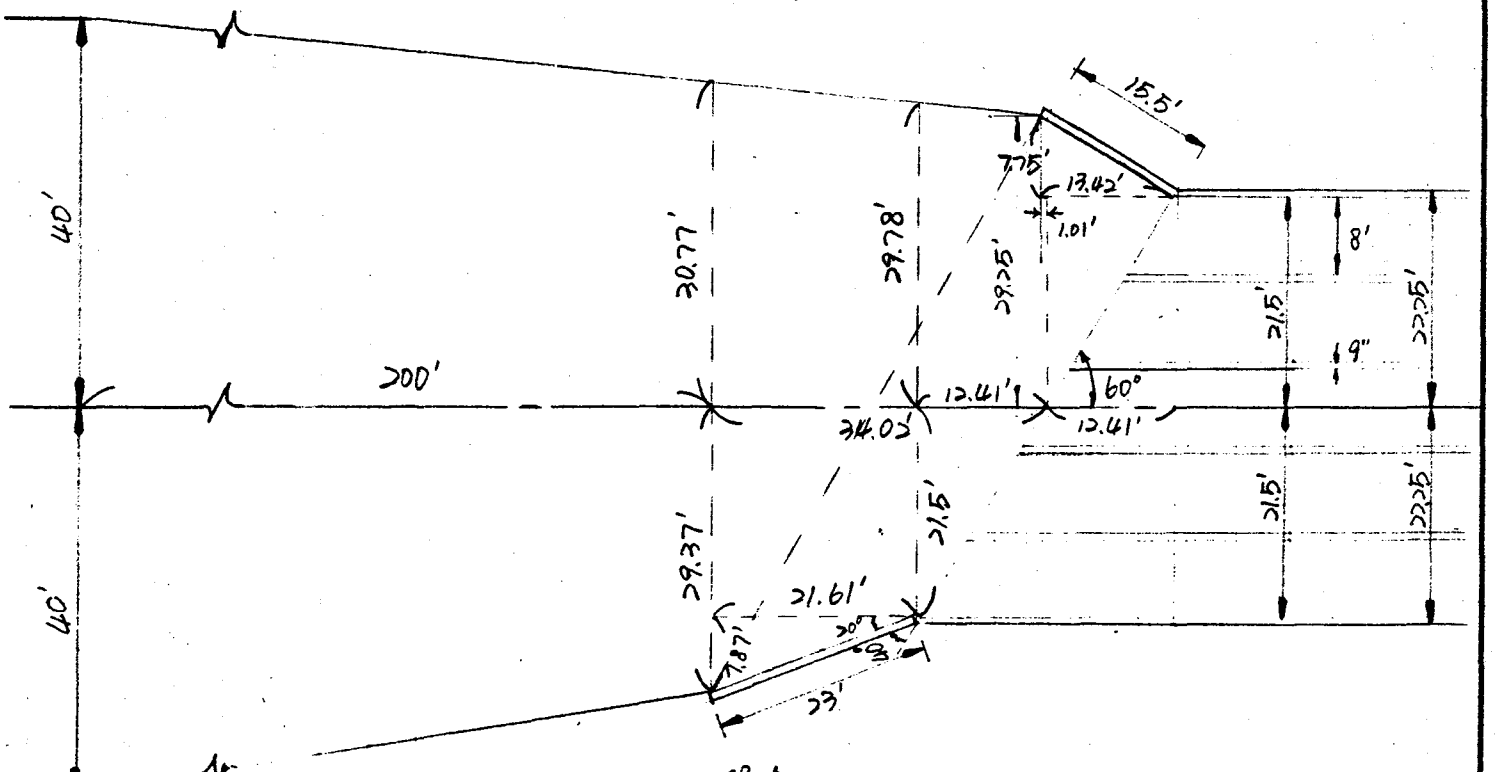
Calculated by B. Gary Sun Date 1/8/86 Sheet No. 1

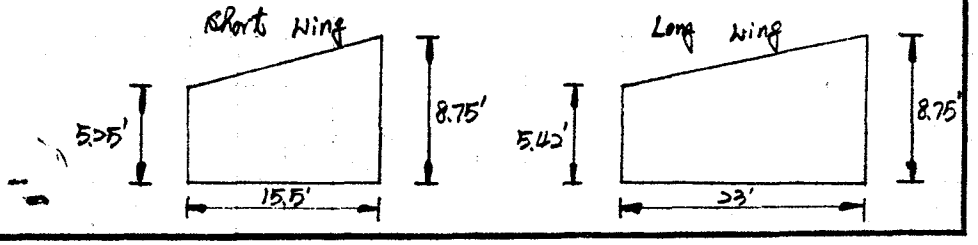
Checked by M.S.S. Date _____ of 19

five barrel 8'x8' box culvert,

L= 100 ft, Q= 1200 cfs

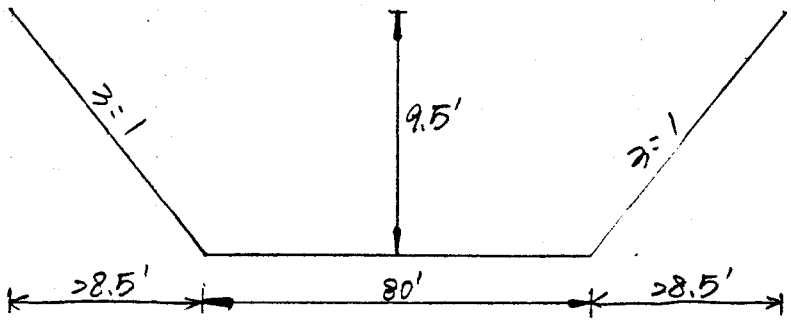




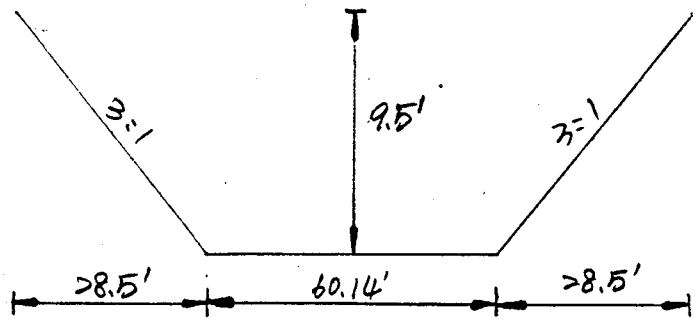


Cross Sections for using five barrel 8'x8'

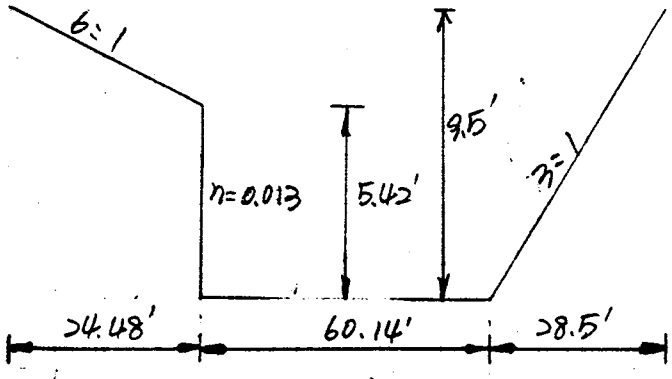
box culvert at East Adobe Road



Sec. 17 Sta. 65+06.02 and Sta. 59+37.98

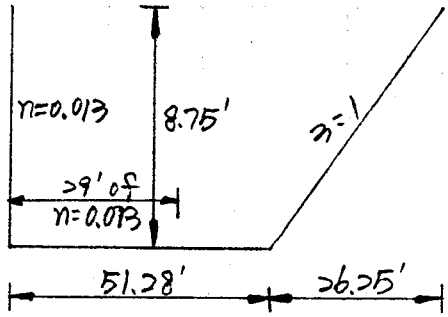


Sec. 51 Sta. 63+06.03

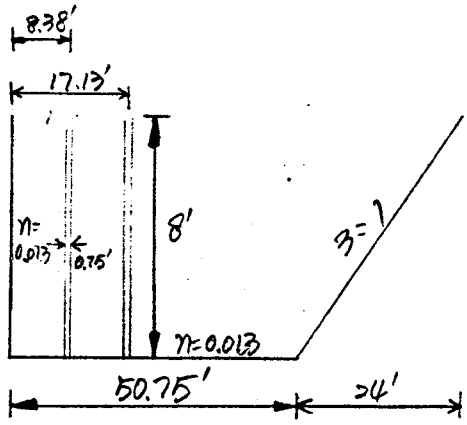


Sec. 52 Sta. 63+06.02 (calc. n=0.024)

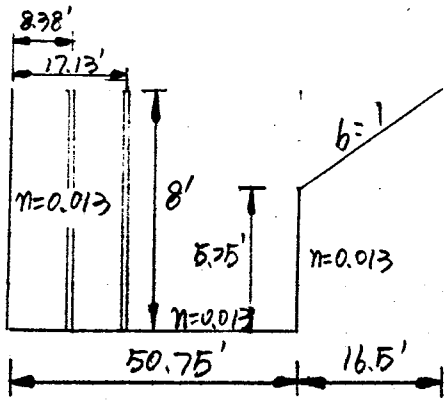
Cross Sections for using five barrel 8'x8' box culvert at E. Adobe



Sec. 53 Sta. 62+84.41 (calc. n = 0.020)

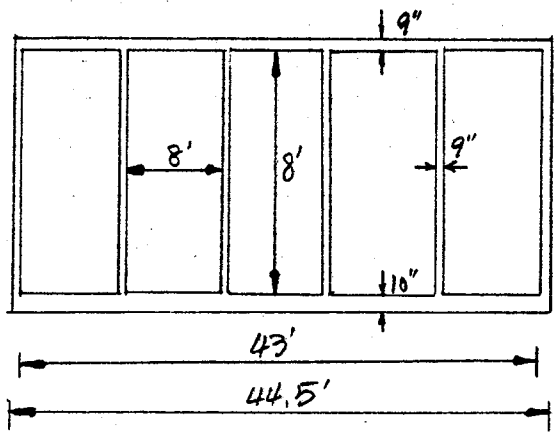


Sec. 54 Sta. 62+73.02 (calc. n = 0.017)

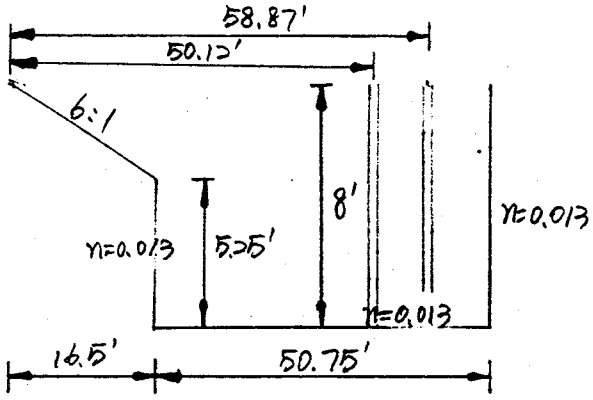


Sec. 55 Sta. 62+73.01 (calc. n = 0.015)

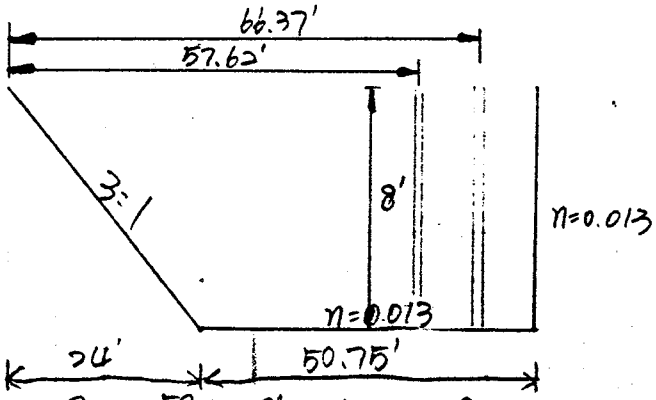
Cross Sections for using five barrel 8'x 8' box culvert at E. Adobe



Sec. 56 Sta. 62+59.59 and Sta. 61+84.41 (n=0.013)

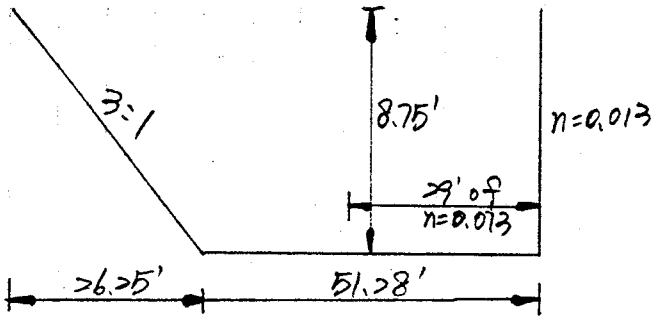


Sec. 57 Sta. 61+70.99 (calc. n= 0.015)

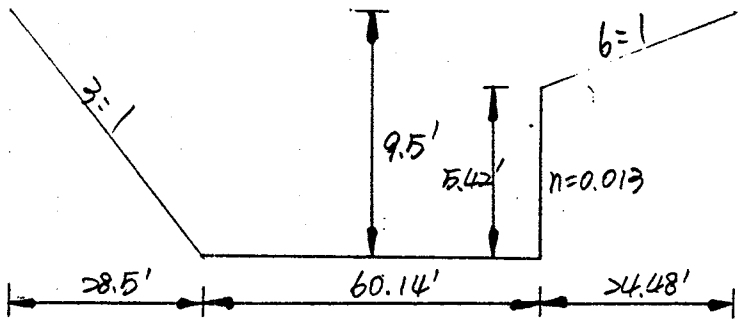


Sec. 58 Sta. 61+70.98 (calc. n= 0.017)

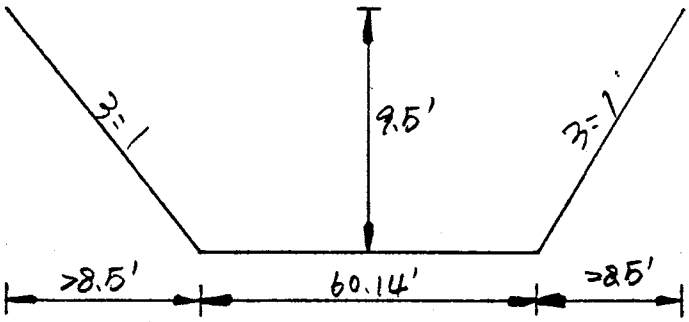
Cross Sections for using five barrel 8'x8' box culvert at E. Adobe Rd.



Sec. 59 Sta. 61+59.59 (calc. n= 0.020)



Sec. 60 Sta. 61+37.98 (calc. n= 0.024)



Sec. 61 Sta. 61+37.97

Composite Manning's n values for five barrel 8'x8' box culvert

1. At Sta. 63+06.02 and Sta. 61+37.98

Assume $d = 6.7$ ft

$$n = \left[\frac{P_1 n_1^{3/2} + P_2 n_2^{3/2} + \cdots + P_n n_n^{3/2}}{P_1 + P_2 + \cdots + P_n}\right]^{2/3}$$

$$= \left[\frac{7.79(0.025)^{3/2} + 5.42(0.013)^{3/2} + 60.14(0.025)^{3/2} + 21.19(0.025)^{3/2}}{(7.79 + 5.42 + 60.14 + 94.58)}\right]^{2/3}$$

$$= \left(\frac{0.3603}{94.58}\right)^{2/3} = 0.02439$$

2. At Sta. 62+84.41 and Sta. 61+59.59

Assume $d = 6.7$ ft

$$n = \left[\frac{6.7(0.013)^{3/2} + 29(0.013)^{3/2} + 22.28(0.025)^{3/2} + 21.19(0.025)^{3/2}}{(6.7 + 29 + 22.28 + 21.19)}\right]^{2/3}$$

$$= \left(\frac{0.2247}{79.17}\right)^{2/3} = 0.02005$$

3. At Sta. 62+73.02 and Sta. 61+70.98

Assume $d = 6.7$ ft.

$$n = \left[\frac{6.7(0.013)^{3/2} + 50.75(0.013)^{3/2} + 21.19(0.025)^{3/2}}{6.7 + 50.75 + 21.19}\right]^{2/3} = \left(\frac{0.1689}{78.64}\right)^{2/3} = 0.01665$$

4. At Sta. 62+73.01 and 61+70.99

Assume $d = 6.7$ ft

$$n = \left[\frac{6.7(0.013)^{3/2} + 50.75(0.013)^{3/2} + 5.25(0.013)^{3/2} + 8.82(0.025)^{3/2}}{6.7 + 50.75 + 5.25 + 8.82}\right]^{2/3} = \left(\frac{0.1278}{71.52}\right)^{2/3} = 0.01473$$

Cost Estimates for box culvert at E. Adobe

1. Use five barrel box culvert with wingwalls (30° skew, 6:1 slope)

Size: 10' x 8'

Box:

Concrete — 5.286 C.Y/L.F. x 100 L.F. = 528.6 C.Y.

Steel — 835.7 LBS/L.F. x 100 L.F. = 83,570 LBS.

Wingwalls:

Inlet:

Concrete — 21.84 C.Y + 1.62 C.Y. x 4 = 28.32 C.Y.

Steel — 1287 LBS. + 149.3 LBS. x 4 = 1,884.2 LBS.

Outlet:

Concrete — 21.85 C.Y. + 1.62 C.Y. x 4 = 28.33 C.Y.

Steel — 1287 LBS. + 149.3 LBS. x 4 = 1,884.2 LBS.

Inlet and Outlet Aprons:

Concrete — 2[6.67 + 3.78 x 4] = 42.58 C.Y.

Steel — 2[565 + 285 x 4] = 3,410 LBS.

Total

Concrete	628.83 C.Y @ $165/C.Y.	=	$ 103,756.95
Steel	90,748.4 LBS. @ $0.38/LBS.	=	$ 34,484.39
			$ 138,241.34

2. Use five barrel 8'x8' box culvert

Box:

Concrete — 4.010 C.Y./L.F. x 100 L.F. = 401 C.Y.

Steel — 641.4 LBS./L.F. x 100 L.F. = 64,140 LBS.

Wingwalls:

Inlet:

Concrete — 21.48 C.Y. + 1.31 C.Y. x 4 = 26.72 C.Y.

Steel — 1253 LBS. + 118.4 LBS. x 4 = 1,726.6 LBS.

Outlet:

Concrete — 21.49 C.Y. + 1.31 C.Y. x 4 = 26.73 C.Y.

Steel — 1253 LBS. + 118.4 LBS. x 4 = 1,726.6 LBS.

Inlet and Outlet Aprons:

Concrete — 2[5.92 C.Y. + 3.04 C.Y. x 4] = 36.16 C.Y.

Steel — 2[504 LBS. + 236 LBS. x 4] = 2,896 LBS.

Total:

Concrete — 490.61 C.Y. @ $165/C.Y. = $80,950.65

Steel — 70,489.2 LBS. @ $0.38/LBS. = $26,785.90

$107,736.55

3. Use six barrel 8'x8' box culvert

Box:

Concrete — 4.754 C.Y./L.F. x 100 L.F. = 475.4 C.Y.

Steel — 761.4 LBS./L.F. x 100 L.F. = 76,140 LBS.

Wingwalls:

Inlet:

Concrete — 21.48 C.Y. + 1.31 C.Y. x 5 = 28.03 C.Y.

Steel — 1253 LBS. + 118.4 LBS. x 5 = 1,845 LBS.

Outlet:

Concrete — 21.49 C.Y. + 1.31 C.Y. x 5 = 28.04 C.Y.

Steel — 1253 LBS. + 118.4 LBS. x 5 = 1,845 LBS.

Inlet and Outlet Aprons:

Concrete — 2[5.92 C.Y. + 3.04 C.Y. x 5] = 42.24 C.Y.

Steel — 2[504 LBS. + 236 LBS. x 5] = 3,368 LBS.

Total:

Concrete: 573.71 C.Y. @ $ 165/C.Y. = $ 94,662.15

Steel: 83,198 LBS. @ $ 0.38/LBS. = $ 31,615.24

$ 126,277.39

Dimensions:

1. five barrel 10'x8': $B = 10'$, $W = 10''$, $T = 10.5''$, $H = 8'$

$$\text{Width} = 5 \times 10' + 6 \times \frac{10}{12} = 55'$$

H_1 (Invert to Top of Deck) $= 8' + \frac{10.5}{12} = 8.875'$ or wingwall high at outlet

H_2 (Bottom to Top) $= H_1 + \frac{(10.5+1)}{12} = 9.833'$

2. five barrel 8'x8': $B = 8'$, $H = 8'$, $W = 9''$, $T = 9''$

$$\text{Width} = 5 \times 8' + 6 \times \frac{9}{12} = 44.5'$$

$$H_1 = 8' + \frac{9}{12} = 8.75'$$

$$H_2 = 8.75 + \frac{10}{12} = 9.583'$$

3. Six barrel 8'x8': $B = 8'$, $H = 8'$, $W = 9''$, $T = 9''$

$$\text{Width} = 6 \times 8' + 7 \times \frac{9}{12} = 53.25'$$

$H_1 = 8.75'$ & $H_2 = 9.583'$

Greiner Engineering

Greiner Engineering Sciences, Inc.

Tucson 602 327-3413
Phoenix 602 275-5400

Job: BCR RWCD Floodway Reach 6 - E101012

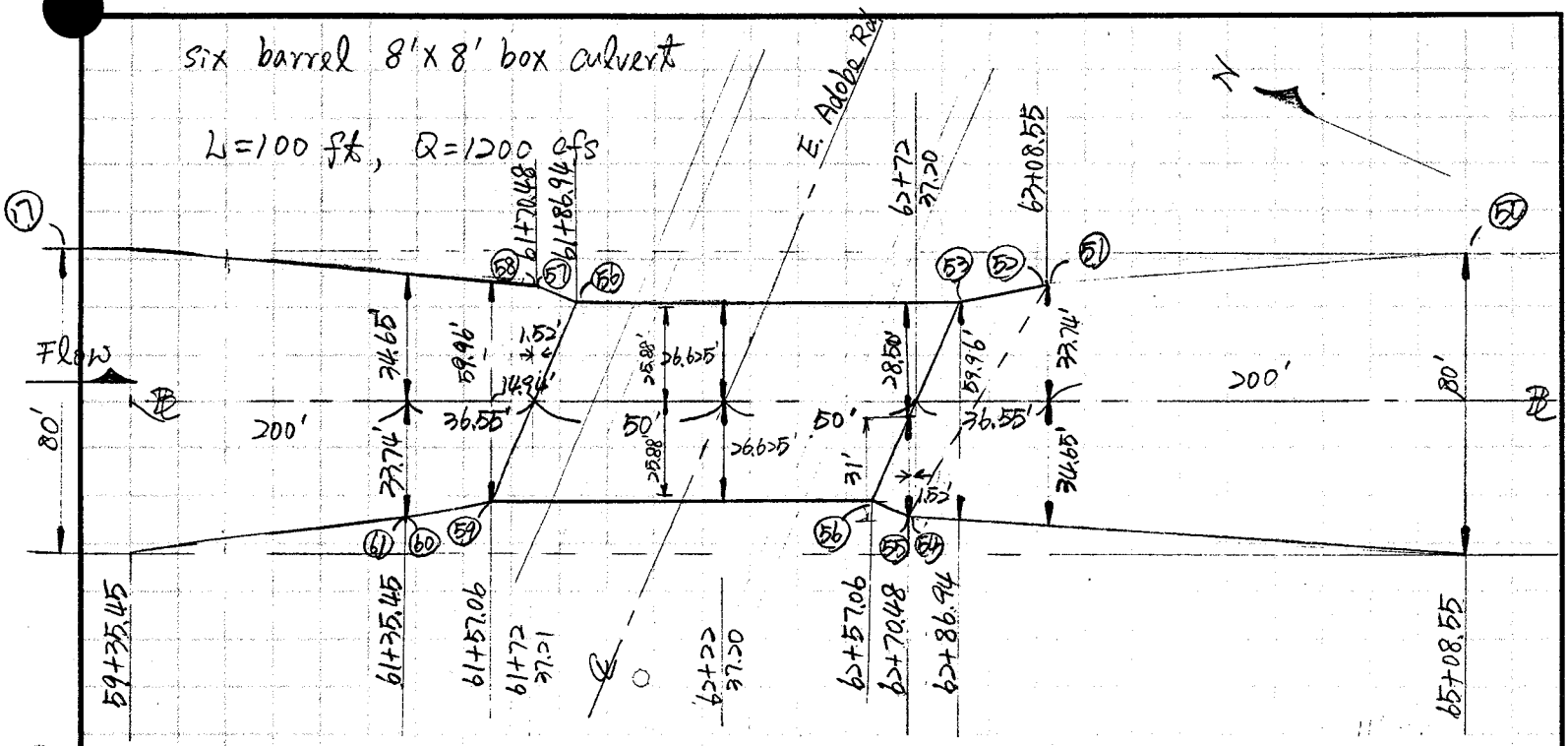
Description: Comparative Design (Mod. No. 3)
Proposed box culvert at E. Adobe Road

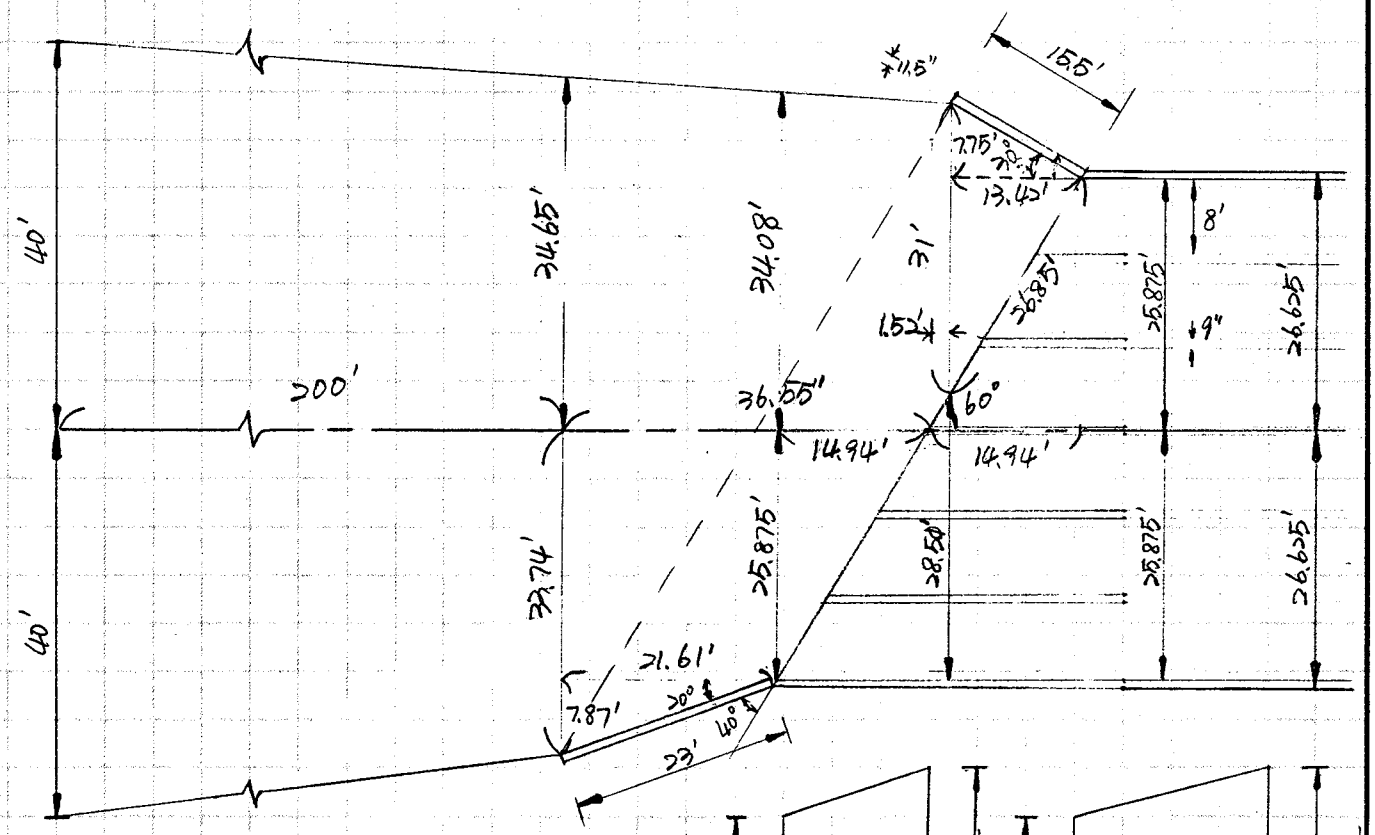
Calculated by: B. Gary Sun Date: 1/8/86 Sheet No. 11

Checked by: M.S.S. Date: _____ of 19

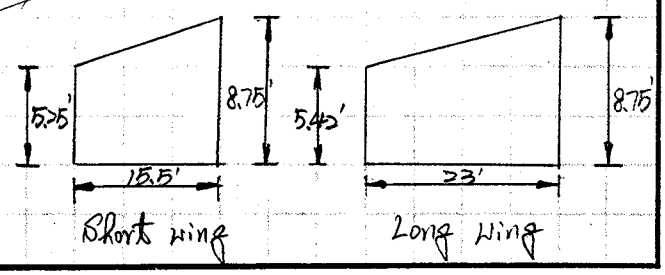
six barrel 8'x8' box culvert

L=100 ft, Q=1200 cfs

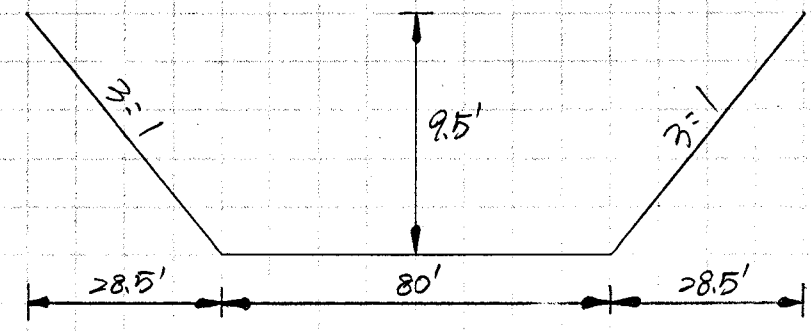




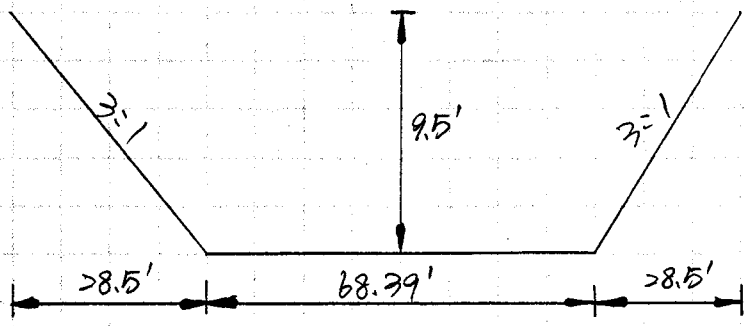
Scale = 1" = 20'



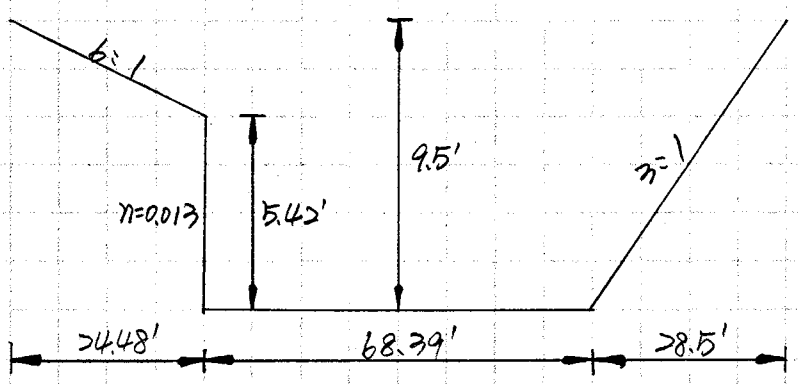
Cross Sections for using six barrel 8'x8' box culvert at E. Adobe



Sec. 17 Sta. 65+08.55 and Sta. 59+35.45
(or 50)

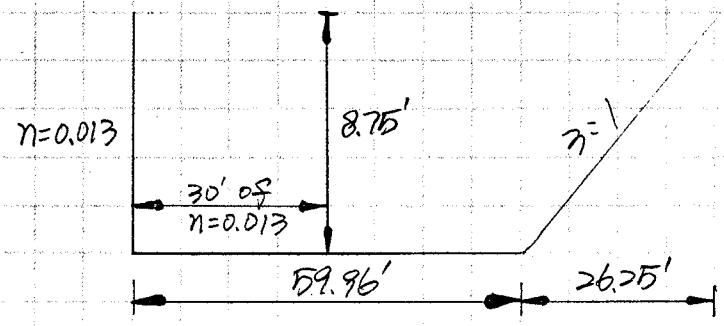


Sec. 51 Sta. 63+08.56

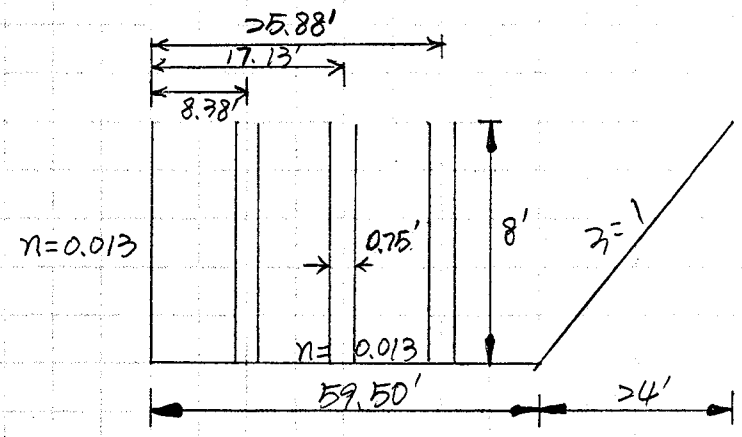


Sec. 52 Sta. 63+08.55

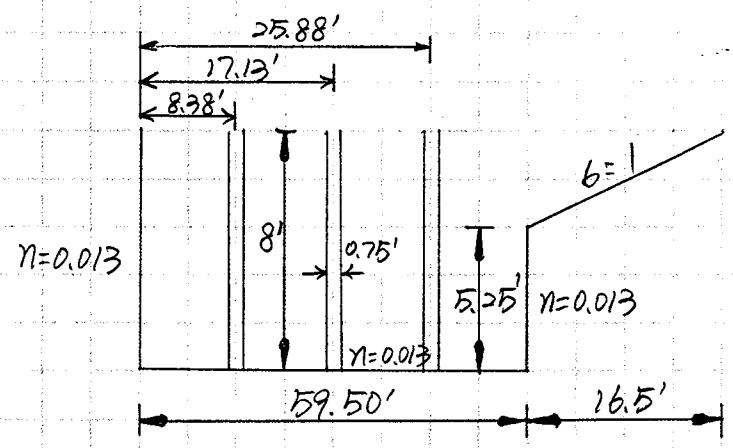
Cross Sections for using six barrel 8'x8' box culvert at E. Adobe Rd.



Sec. 53 Sta. 62+86.94

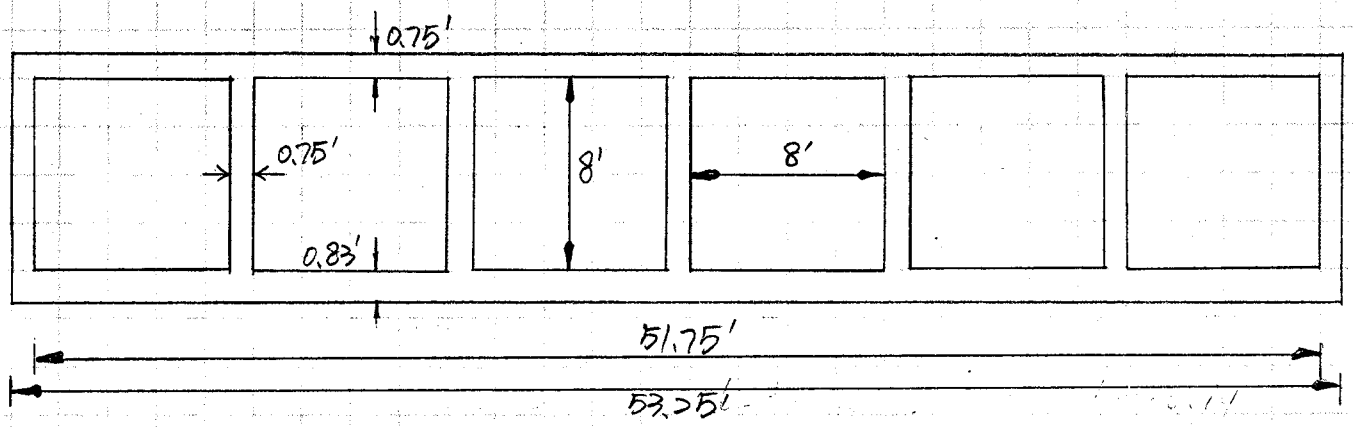


Sec. 54 Sta. 62+70.48

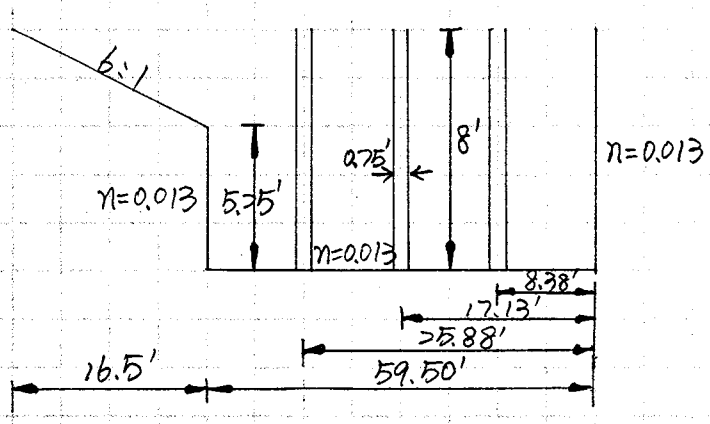


Sec. 55 Sta. 62+70.47

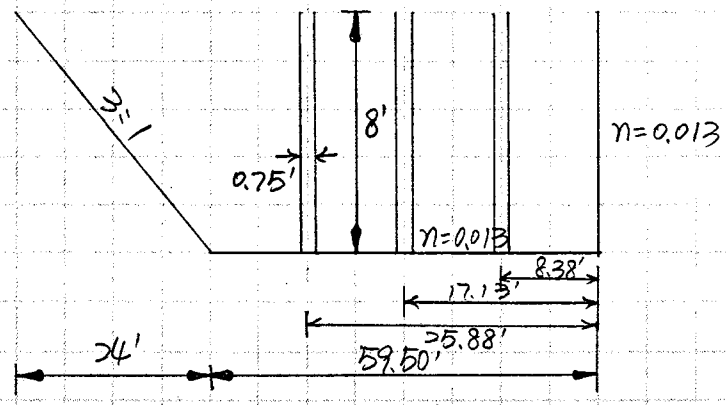
Cross Sections for using six barrel 8'×8' box culvert at E. Adobe Rd.



Sec. 56 Sta. 62+57.66 and Sta. 61+86.94

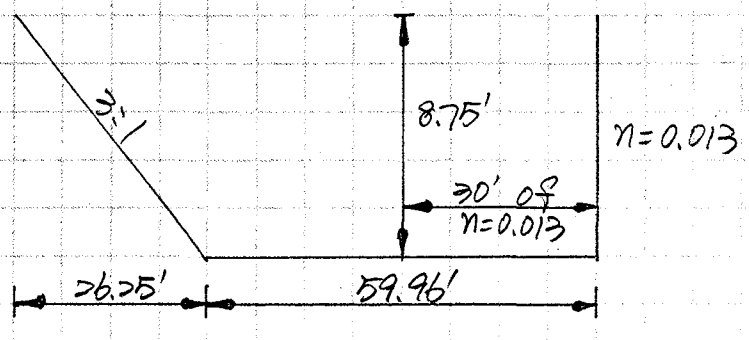


Sec. 57 Sta. 61+70.48

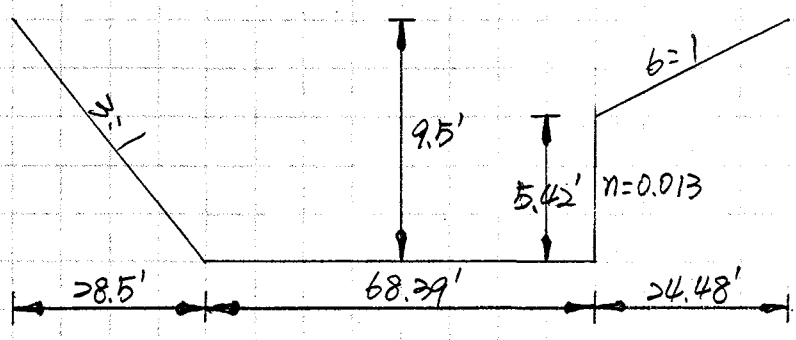


Sec. 58 Sta. 61+70.47

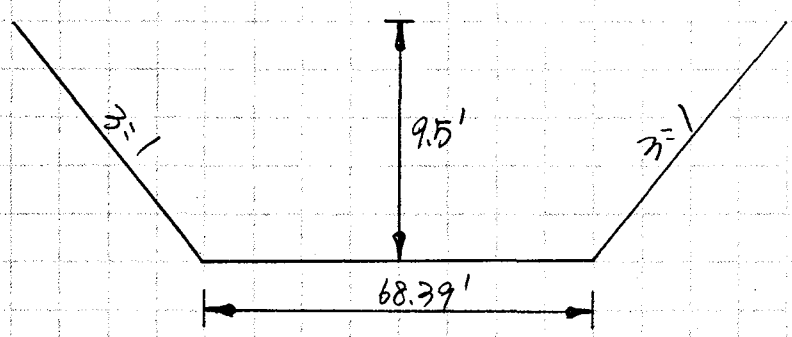
Cross Sections for using six barrel 8'x 8' box culvert at E. Adobe



Sec. 59 Sta. 61+57.06



Sec. 60 Sta. 61+35.45



Sec. 61 Sta. 61+35.44

ADOT "Roadway Guides for use in Office and Field"

1. Find Sight Distance, Stopping:

$$SD_S = 1.467\, V_A(2.5) + \frac{V_A^2}{30(f \pm G)}$$

$V_A = 55$ mph Assumed speed for wet conditions

$f = 0.296$ wet coefficient of friction between tires and roadway

$$SD_S = 1.467(55)(2.5) + \frac{(55)^2}{30(0.296 \pm G)}$$ G: Effective Grade (ft/ft)

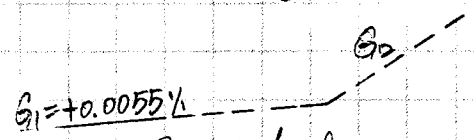
$G_1 = 0.0055$ ft/ft $\quad SD_S = 548.82$ ft

$G_4 = 0.0082$ ft/ft $\quad SD_S = 552.07$ ft

2. Minimum length of Vertical Curves: $3 \times 55 = 165$ ft

3. Find A (algebraic difference in grade in percent)

①



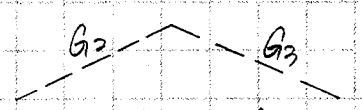
Sag vertical curve

$SD_S = 548.82' > L_S = 165'$

$$L_S = 2(SD_S) - \frac{400 + 3.5(SD_S)}{A} \Rightarrow A = 2.4885\%$$

$\Rightarrow G_2 = +3.0385\% = +0.030385$ ft/ft #

②



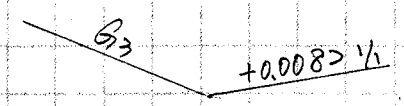
crest vertical curve

$$SD_S = 1.467(55)(2.5) + \frac{55^2}{30(0.296 - G_3)} = 581.33 \text{ ft}$$

$$SD_S > L_C \Rightarrow L_C = 2(SD_S) - \frac{1398}{A} \Rightarrow A = 1.4013\%$$

$\Rightarrow G_3 = -1.6372\% = -0.016372$ ft/ft

③



Sag vertical curve

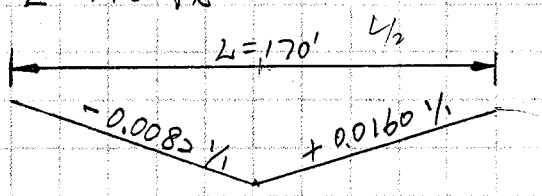
$$SD_S = 1.467(55)(2.5) + \frac{55^2}{30(0.296 - G_3)} = 562.31 \text{ ft}$$

$$SD_S > L_S \Rightarrow L_S = 2(SD_S) - \frac{400 + 3.5(SD_S)}{A} \Rightarrow A = 2.4677\%$$

$G_3 + 0.0082 = 0.02457$ ft/ft $< 0.024677\%$

Sag Vertical Curve:

$L = 170$ ft



$A = 0.0242$ $V = 55$ mph $\Rightarrow K = 130$

min. $L = KA = 130 \times 2.42\% = 314.6$ ft

$SD_S < L_S$ (for Highway)

$L_S = \frac{A(SD_S)^2}{400 + 3.5\,SD_S} = 322.8$ ft

$SD_S > L_S$

min. $L_S = 2(SD_S) - \frac{400 + 3.5(SD_S)}{A} = 145.80$ ft

$SD_S = 1.467(55)(2.5) + \frac{55^2}{30(0.296 - 0.016)} = 561.83$

$L = \frac{AV^2}{46.5} = 157.43$ ft. Use $L = 170$ ft for roadway

Greiner Engineering

Greiner Engineering Sciences, Inc.

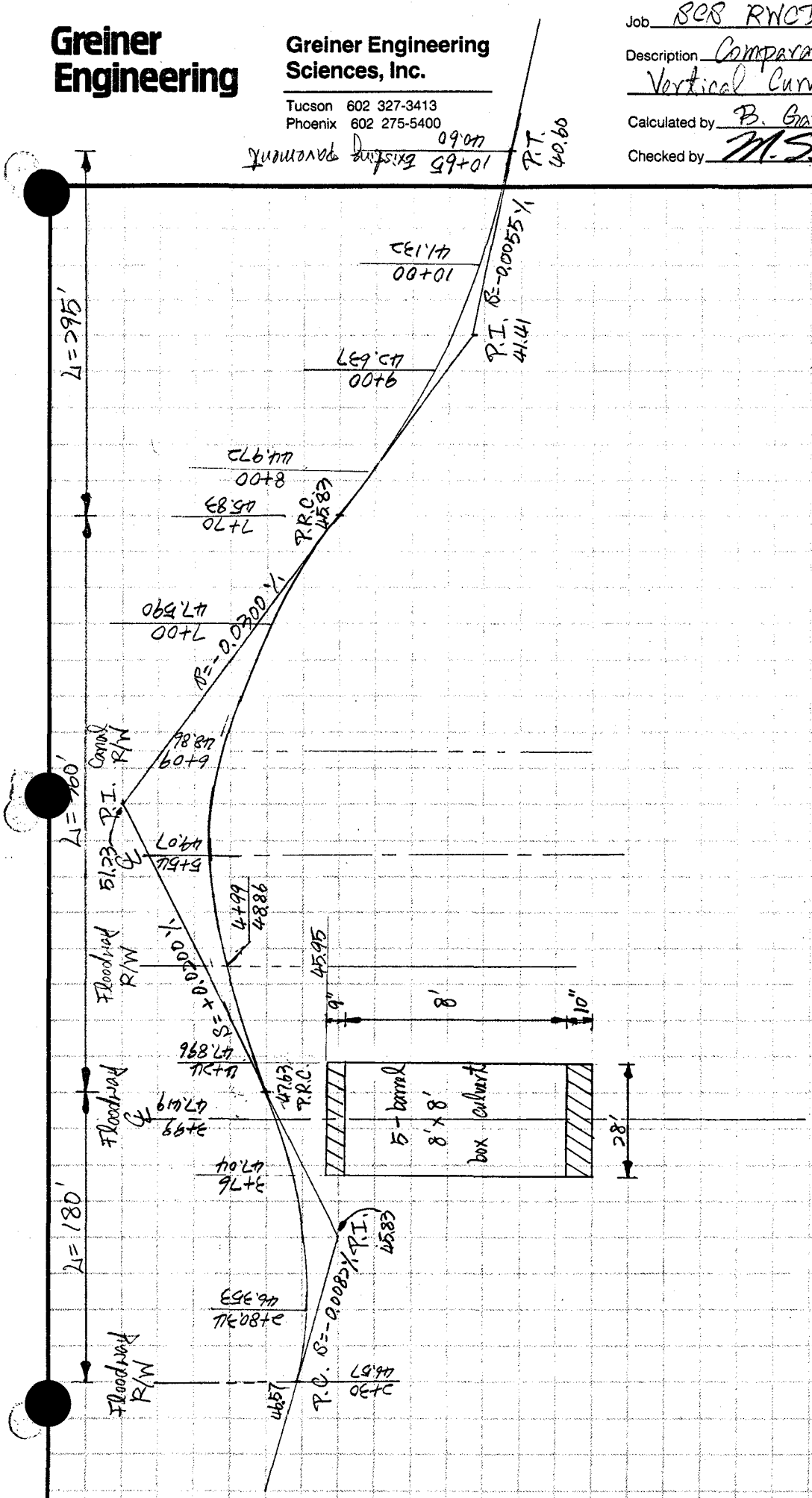
Tucson 602 327-3413
Phoenix 602 275-5400

Job: SCS RWCD Floodway Reach 6 - E101012

Description: Comparative Design (Mod. No. 3)
Vertical Curves at E. Adobe Road

Calculated by: B. Gary Sun Date: 1/13/86 Sheet No. 18

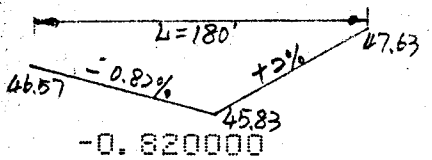
Checked by: M.S.S. Date: _____ of 19



Greiner Engineering

Greiner Engineering Sciences, Inc.
Tucson 602 327-3413
Phoenix 602 275-5400

Job BCS RWCD Floodway Reach 6 - E101012
Description Comparative Design (Mod. No. 3)
Vertical Curves at E. Adobe Road
Calculated by B. G. Sun Date 1/13/86 Sheet No. 19
Checked by M.S.S. Date _____ of 19



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320.000000
1345.830000

230.000000
1346.568000
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282.340426
1346.353404
250.000000
1346.435333
300.000000
1346.377833
320.000000
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1346.712000
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399.000000
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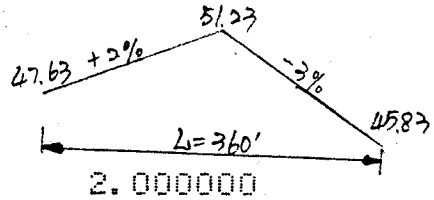
410.000000
1347.630000



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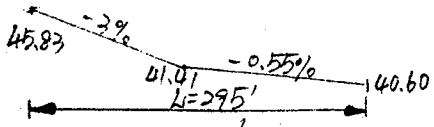

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~~295.000000~~
~~1.203390~~
~~917.500000~~
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~~770.000000~~
~~1345.835000~~
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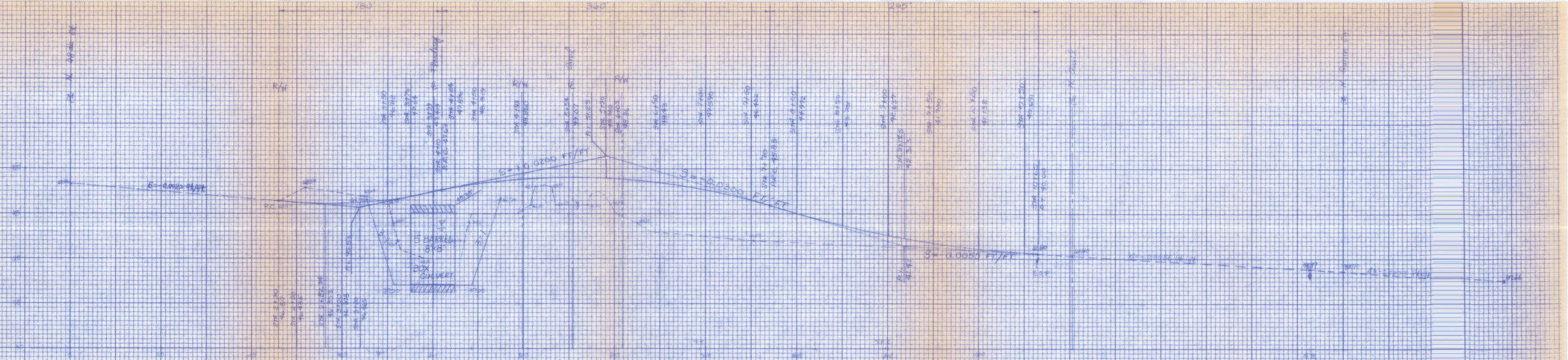

Cross Section at Centerline of East Allouez Road (Facing South-East on Downstream of Floodway)

Horiz. 1" = 60'
Vert. 1" = 15'

EOE RWCD Floodway Reach 6 (E101012) Wsh. No. 3

Alternate No. 2 Trial #10 (Mod. No. 3)

1. Problem Set Up:

① Same as Trial #9 except:

(i) A constant invert slope of 0.001163 ft/ft is used between Sta. 128+79.37 (the downstream end of transitions at Apache/Higley) and Sta. 161+30 (the south terminus of the floodway)

(ii) Use n=0.013 for concrete lined channel between Sta. 128+79.37 and Sta. 161+30.

2. Results:

① Min. 3.177 feet of freeboard was shown at Apache/Higley 8 foot box culvert.

② High velocities between Sta. 157+00 and Sta. 155+00 ranges from 5.56 fps to 7.71 fps.

③ Encroach into the abutment of Broadway Road Bridge due to lowing invert.

Alternate No. 2 Trial #11 (Modification)

1. Problem Set Up:

① Same as Trial #10 except:

(i) Use side slopes of 1:1 under Broadway Bridge

(ii) Change Sta. 152+74.98 to Sta. 153+50.00

2. Results:

① High velocities from Sta. 157+00.00 to 155+00.00 and from Sta. 128+89.37 to 121+13.04

② Make Trial #12 run and change n = 0.025 from Sta. 161+30.00 to 128+79.37. (i.e. Make earth channel reaches between Sta. 161+30.00 and 128+79.37)

③ Check on cross sections because of deeper inverts.

Alternate No. 2 Trial #12 (Modification)

1. Problem Set Up:

① Same as Trial #11 except:

(i) Make earth channel reaches between Sta. 161+30.00 and 128+79.37.

2. Results:

① Check on X-sections because of deeper inverts.

② At Sta. 125+76.45 (downstream side of Apache Higley box culvert) water surface elevation exceeds freeboard requirement by 0.04 ft. for a proposed five barrel 10'x7' box culvert.

③ Make run of Trial #13 with:

(i) Let concrete lined channel reaches between Sta. 157+00.00 and Sta. 155+00.00.

(ii) Use composite n values for reaches at Sta. 128+79.37 ~ Sta. 126+71.23 and Sta. 121+13.05 ~ Sta. 118+75.72.

(1) Reach at Sta. 128+79.37 ~ Sta. 126+71.23

Sec. 4 b=90.00 ZL=3.00 and ZR=3.00

2. Results: (Cont'd)

Assume $y \approx 6.5'$

For Concrete Lined Side Banks $P_2 = P_3 = \sqrt{9.5^2 + 6.5^2} = 20.55'$

For Earthen Channel base $P_1 = 90'$ and $n_1 = 0.025$, $n_2 = 0.013$

Composite $n = \left[\dfrac{P_1 n_1^{3/2} + P_2 n_2^{3/2} + P_3 n_2^{3/2}}{P_1 + P_2 + P_3}\right]^{2/3} = \left[\dfrac{90(0.025)^{3/2} + 2 \times 20.55(0.013)^{3/2}}{90 + 2 \times 20.55}\right]^{2/3}$

$= 0.0216$

Sec. 7 $b = 64.39$, $ZL = ZR = 1.0$ Sta. 121+13.05 ~ Sta. 118+75.72

Concrete lined Side Banks $P_2 = P_3 = 9.19'$

Earth channel Base $P_1 = 64.39$

Composite $n = \left[\dfrac{64.39(0.025)^{3/2} + 2 \times 9.19(0.013)^{3/2}}{64.39 + 2 \times 9.19}\right]^{2/3}$

$= 0.0226$

Average $n = \dfrac{0.0216 + 0.0226}{2} = 0.0221$ Use 0.022 #

Alternate No. 2 Trial #13 (Modification #3)

1. Problem Set Up:

① Same as Trial #12 except:

(i) Make concrete lined channel reaches between Sta. 157+00.00 and Sta. 155+00.00.

(ii) Use $n = 0.022$ for reaches at Sta. 128+79.37 ~ 126+71.23 and Sta. 121+13.05 ~ 118+75.72 as composite n values. (Concrete lined with earth channel base.)

2. Results:

① Eliminated 191 ft of protection by changing grade, inverts & side slopes for Broadway Road Bridge.

② Check cross sections from Sta. 161+30 to Sta. 128+79.37.

(i) No problems between Sta. 140+00 and Sta. 128+79.37.

(ii) No problems between Sta. 161+30 and Sta. 153+50.

(iii) From Sta. 153+50 to Sta. 144+00 There are no room for west side collector channel.

③ Make Trial #14 run with transition base width from 90 ft to 81 ft from Sta. 140+00 to 153+50.

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Job BCS RWCD Floodway Reach 6 - E101012
Description Comparative Design Studies
Alt. No. 2 Trial #13
Calculated by B. Gail Sun Date 12/31/85 Sheet No. 6 of 8
Checked by M.S.S. Date

Channel Depth	Station	Invert	W.S. Elev.	Bank Width			Distance from edge of O&M Road to R.O.W. on West Side
10.66	✓ 152+00	32.32	40.98	31.98	Check this		4.02 38.[illegible]
3:1 sideslopes							
	✓ 153+50.00				Check this		
10.27'	✓ 148+00	32.79	41.06	30.81	41.057	Check this	5.19 39.1[illegible]
9.98'	✓ 144+00	33.26	41.14	29.94		Check this	6.06 40.[illegible]
9.5'	✓ 140+00	33.72	41.22	28.50	← original		7.50 41.5
9.11'	✓ 136+00	34.19	41.30	27.33	No problems		
8.72'	✓ 132+00	34.66	41.38	26.16			
8.56'	128+79.37	35.03	41.59	25.68			

Trial 1 Trans.
base width from 90 ft to 81 ft from sta. 140+00 - 153+50.00

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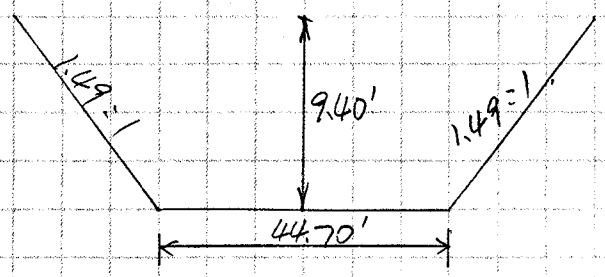
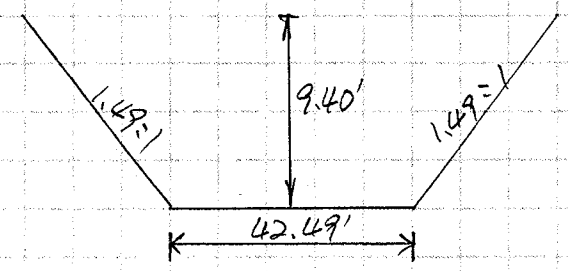


Sec. 31 (Trial #11~#13)



Sec. 31 (for Trial #14 only)

Trial #15 : 50% Q_{100} for Trial #14

Trial #16 : Proposed a five-barrel 8'x8' box culvert at E. Adobe Rd. (See details of channel geometry & cross sections in the preceding sub-section) use Q_{100}

Trial #17 : Proposed a six-barrel 8'x8' box culvert at E. Adobe. (See details in the preceding sub-section) use Q_{100}

Results of Trials #16 & #17:

Based on the results of water surface profile calculations, both structures have no backwater effect to the upstream water surface profile. A five barrel 8'x8' box culvert with 100 feet in length was chosen.

Trials #18 and #19:

Finalizing Trial #16 run with Q_{100} and 50% of Q_{100}.

Trials #20 and #21:

Add four elements for Tractive Power Calculations. Results are identical to Trials #18 and #19 with the corresponding design Q. See "Summary of Conclusions" for the results.

Summary of Cost Estimate for Apache/Higley five barrel 10'x7' Box

The total cost associated with the box culvert including wingwalls, aprons, and slope paving for the banks of transitions is approximately $619,000. This does not include guard rails, fencing, and earthwork associated with the structure.

Cost Estimate of 5-barrel 10' x 7' box culvert on Apache/Higley

Five Barrel 10'x7' Reinforced Concrete Box Culvert

ADOT Standard No. CB-5 L = 371.23 L.F. (Sta. 122+05.22 ~ 125+76.45)

Quantities:

1. Box: Plan No. B-02.50

Concrete — 5.101 C.Y./L.F. x 371.23 L.F. = 1,893.64 C.Y. ✓

Steel — 856.2 LBS./L.F. x 371.23 L.F. = 317,847.13 LBS.

2. Wingwalls: ADOT Std. CWL-2, Plan B-08.20, Type B,

Span = 10', H = 7'. (includes curb and cut-off wall quantities)

Type B: Level wingwall height = 6" + H + T = 6" + 7' + 9" = 8.25'

① Inlet East Wingwall: L = 105 L.F.

Concrete: For first 9 L.F. (single barrel) 11.09 C.Y.

add. 96 L.F. .529 C.Y./L.F. x 96 L.F. = 50.78 C.Y.

(Curb & cut-off) add. 4 barrels 1.370 C.Y./barrel x 4 barrels = 5.48 C.Y.

67.35 C.Y. ✓

Steel: For first 9 L.F. (single barrel) 946 LBS.

add. 96 L.F. 43 LBS/L.F. x 96 L.F. = 4,128 LBS.

add. barrels 130 LBS/barrel x 4 barrels = 520 LBS.

5,594 LBS.

2. Wingwalls: (Cont'd)

② Inlet West Wingwall: L = 80 L.F.

Concrete: For first 9' L.F. (single barrel) 11.09 C.Y.

add. 71 L.F. .529 C.Y./L.F. × 71 L.F. = 37.56 C.Y.

add. barrels 1.37 C.Y./barrel × 4 barrels = 5.48 C.Y.

54.13 C.Y. ✓

Steel: For first 9' L.F. (single barrel) 946 LBS.

add. 71 L.F. 43 LBS./L.F. × 71 L.F. = 3,053 LBS.

add. barrels 130 LBS./barrel × 4 barrels = 520 LBS.

4,519 LBS.

③ Inlet Apron & Cutoff Wall

$A = \frac{1}{2}(38.17)(105) + \frac{1}{2}(37.60)(80 \times \cos 10°) + \frac{1}{2}(68.74)(92.17 \times \sin 38.086°)$

$= 5439.18\ ft^2$

Concrete: t = 6" $0.5' \times 5439.18 = 2719.59\ ft^3 = \underline{100.73\ C.Y.}$ ✓ (Apron)

t = 9" $4' \times \frac{9}{12}' \times 75.77' = 227.31\ ft^3 = \underline{8.42\ C.Y.}$ ✓ (Cutoff)

Steel: #4 94 × 70 L.F. + 71 × 93 L.F = 13,181 L.F. (Apron)

#4 77 × 6 L.F. + 4 × 76 L.F. = 766 L.F. (Cutoff)

(13,181 + 766) L.F. × .668 LBS./L.F. = <u>9,317 LBS.</u>

④ Inlet E. Slope Paving $L = 200$ L.F.

typical 2:1 slope 9' high

Unit foot: Concrete: $3 \times 1 + 1.5 \times 0.5 + 20.12 \times \frac{4}{12} + 1.5 \times 4$

$= 16.458\ ft^3 \approx 0.6096$ C.Y./L.F.

Steel: $[4 \times 1 + 0.5 \times 3.5 + 3 \times 1 + 0.5 \times \frac{32}{12} + 1(20.12 + 2)$

$+ 30 \times 1] \times .668 = 41.552$ LBS./L.F.

Concrete: $0.6096 \times 200 = 121.86$ C.Y.

$[(12 + 24) \times 4 \times \frac{9}{12}] = 4$ C.Y. $\Big\}$ 125.86 C.Y. ✓ cutoff walls

Steel: $41.552 \times 200 + [4 \times 22 + 3.5 \times 4] \times 2 \times .668 =$ 8,446.67 LBS.

⑤ Inlet W. Slope Paving $L = 202$ L.F.

Concrete: $0.6096 \times 202 + 4 =$ 127.08 C.Y. ✓

Steel: $41.552 \times 202 + 136.27 =$ 8,529.77 LBS.

⑥ Guard Rails $L = 295 + 245 + 265 + 260 = 1,065$ L.F.

⑦ ADOT Fence Type 1 - 6' High $L = 114 + 88 + 99 + ?\ 109 =$

⑧ Outlet East Wingwall: L = 90 L.F.

Concrete: For first 9 L.F. (single barrel) 11.09 C.Y.

add. 81 L.F. .529 C.Y./L.F. × 81 L.F. = 42.85 C.Y.

add. barrels 1.37 C.Y./barrel × 4 barrels = 5.48 C.Y.

59.42 C.Y. ✓

Steel: For first 9 L.F. (single barrel) 946 LBS.

add. 81 L.F. 43 LBS./L.F. × 81 L.F. = 3,483 LBS.

add. barrels 130 LBS./barrel × 4 barrels = 520 LBS.

4,949 LBS.

⑨ Outlet West Wingwall: L = 100 L.F.

Concrete: For first 9 L.F. (single barrel) 11.09 C.Y.

add. 91 L.F. .529 C.Y./L.F. × 91 L.F. = 48.14 C.Y.

add barrels 1.37 C.Y./barrel × 4 barrels = 5.48 C.Y.

64.71 C.Y. ✓

Steel: For first 9 L.F. (single barrel) 946 LBS.

add. 91 L.F. 43 LBS./L.F. × 91 L.F. = 3,913 LBS.

add. barrels 130 LBS./barrel × 4 barrels = 520 LBS.

5,379 LBS.

⑩ Outlet Apron & Cutoff Wall

$A = \frac{1}{2}(55)(94.78 \cos 9°) + \frac{1}{2}(31.06)(90) + \frac{1}{2}(33.33)(100 \cos 7°)$

$= 5{,}626.14 \text{ ft}^2$

Concrete : $0.5' \times A = 2{,}813.06 \text{ ft}^3 \approx 104.19$ C.Y. (Apron)

$t = 9''$ $4' \times \frac{9}{12}' \times 64.39' = 193.17 \text{ ft}^3 \approx 7.15$ C.Y. (Cutoff)

111.34 C.Y. ✓

Steel : #4 96×60 L.F. $+ 61 \times 95$ L.F. $= 11{,}555$ L.F. (Apron)

#4 65×6 L.F. $+ 4 \times 65$ L.F. $= 650$ L.F. (Cutoff)

$(11{,}555 + 650)$ L.F. $\times .668$ LBS./L.F. $=$ 8,152.94 LBS.

⑪ Outlet E. Slope Paving $L = 200$ L.F.

Concrete : 125.86 C.Y.

Steel : 8,446.67 LBS.

⑫ Outlet W. Slope Paving $L = 185$ L.F.

Concrete : $0.6096 \times 185 + 4 =$ 116.78 C.Y.

Steel : $41.552 \times 185 + 136.27 =$ 7,823.39 LBS.

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Total:

Concrete = 2,855.32 C.Y. @ $165/C.Y. = $ 471,127.80

Steel = 389,004.57 LBS. @ $.38/LBS. = $147,821.74

$618,949.54

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Job SCS RWCD Floodway Reach 6 - E101012
Description Comparative Design Studies (Mod. #3)
Cost Estimate of Culvert at E. Adobe Rd.
Calculated by B. Gard Run Date 2/3/86 Sheet No. 1
Checked by M.S.S. Date _____ of 2

Summary of Cost Estimate of a four barrel 10'x8'
Box Culvert at East Adobe Road

As requested, cost estimate is performed for a four barrel 10'x8' Concrete box culvert at East Adobe Road. The cost including wingwalls and aprons is approximately $114,000. This is higher than the cost of a five barrel 8'x8' concrete box culvert, which is approximately $108,000. A five barrel 8'x8' box culvert is recommended.

Cost Estimate for the proposed four barrel 10'x8' box culvert at East Adobe Road

Box: ADOT Std. CB-4 Table No. I

Concrete - 4.294 C.Y./L.F. x 100 L.F. = 429.4 C.Y.

Steel - 676.2 LBS./L.F. x 100 L.F. = 67,620 LBS.

Wingwalls: ADOT Std. CW6-6 30° Skew, 6:1 Slope, Height 8' to 12'
Std. CWQ-1 for Quantities CW6 Wings

Inlet:

Concrete - 21.84 C.Y. + 1.62 C.Y./barrel x 3 barrels = 26.70 C.Y.

Steel - 1,287 LBS. + 149.3 LBS./barrel x 3 barrels = 1,734.90 LBS.

Outlet:

Concrete - 21.85 C.Y. + 1.62 C.Y./barrel x 3 barrels = 26.71 C.Y.

Steel - 1,287 LBS. + 149.3 LBS./barrel x 3 barrels = 1,734.90 LBS.

Inlet and Outlet Aprons: ADOT Std. CWA-1 for 30° Skew, CW6 Wings

Concrete - 2(6.67 + 3.78 x 3) = 36.02 C.Y.

Steel - 2(565 + 285 x 3) = 2,840 LBS.

Total:

Concrete: 518.83 C.Y. @ $165/C.Y. = $ 85,606.95

Steel: 73,929.80 LBS. @ $0.38/LBS. = $ 28,093.32

Total = $ 113,700.27

From Alt. No. 1 Trial #14: TW = 6.60'

L = 98.76 ≈ 99' use 100 ft.

PROJECT: E101012 Mod. No. 3 DESIGNER: B. Gary Sun

East Adobe Road proposed box culvert DATE: 1/3/86

HYDROLOGIC AND CHANNEL INFORMATION

$d_c = .315 \sqrt[3]{(Q/B)^2}$

$h_o = \frac{d_c + D}{2}$ or TW, whichever is the greater

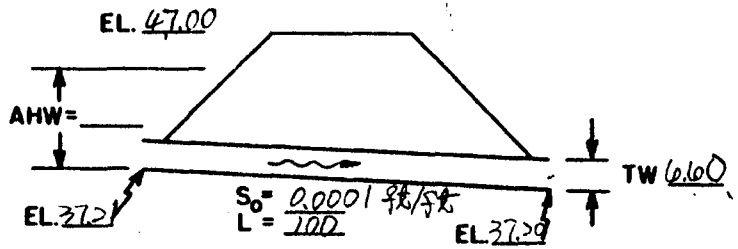
Q_1 = 1200 cfs TW_1 = _____

Q_2 = _____ TW_2 = _____

(Q_1 = DESIGN DISCHARGE, SAY Q_{25}
Q_2 = CHECK DISCHARGE, SAY Q_{50} OR Q_{100})

SKETCH

STATION: 62+77.72



MEAN STREAM VELOCITY = _____

MAX. STREAM VELOCITY = _____

CULVERT DESCRIPTION (ENTRANCE TYPE)	Q	SIZE	HEADWATER COMPUTATION: INLET CONT. HW/D	INLET CONT. HW	OUTLET CONTROL HW=H+h_o−LS_o: K_e	H	d_c	$\frac{d_c+D}{2}$	TW	h_o	LS_o	HW	CONTROLLING HW	OUTLET VELOCITY	COST	COMMENTS
5 barrel box culvert w/wingwalls	240	10'x8'	0.500	4.00	.4	0.13	2.62	5.31	6.60	6.60	0.01	6.72	6.72	3.57	$138,300	1.28' freeboard O.K.
5 barrel box culvert w/wingwalls	240	8'x8'	0.580	4.64	.4	0.34	3.04	5.52	6.60	6.60	0.01	6.93	6.93	4.29	$107,800	1.01' freeboard O.K.
6 barrel box culv. w/wingwalls	200	8'x8'	0.520	4.16	.4	0.14	2.69	5.35	6.60	6.60	0.01	6.73	6.73	3.71	$126,300	1.27' freeboard O.K.
4 barrel box culv. w/wingwalls	300	10'x8'	0.580	4.64	.4	0.34	3.04	5.52	6.60	6.60	0.01	6.93	6.93	3.75	$113,700	

SUMMARY & RECOMMENDATIONS:

Use 6 barrel 8'x8' 30° skew 6:1 slope box culvert with wingwalls

1/28/86

Figure 7

Mirafi Subsurface Drainage Fabric

This drainage fabric is generally used for lining the trench in a french drain and for use as a filter fabric under riprap or gabions to prevent erosion of the underlying soils. The supplier is Western Tech Sales and the manufacturer has provided design guidelines to aid the designer. The fabric provides the same particle retention as aggregate filters while maintaining high permeability. Laboratory tests and analysis of the soil-fabric system are required to ensure proper drainage system performance. Installation procedures are provided by the supplier. The cost of this drainage fabric based on 10,000 sq. yds. or more is $0.55/sq. yd.

Corrugated Channel Lining

Armco Construction Products manufactures a corrugated channel lining in various sizes. The installation consists of a half pipe section with a flange on each edge to tie the structure down. This channel lining provides enough flexibility to conform to shifting soils. Tie down stakes are provided for every ten feet and are included with the lining. Mastic sealer is not required at the tie down stakes according to the manufacturer. Corrugated channel lining with a 36 inch top width and an 18 inch depth costs 14.00/ft. installed. This price is for 13000 lineal feet.

Slip-Form Concrete Lined Channel

A concrete channel with parabolic cross section was examined for its application as a collector channel. The grading operation for a parabolic channel is considered to be difficult. The shaping of the ditch to the required cross section would require a great deal of time. A parabolic shaped slip form would have to be built which would increase the cost substantially. The cost for a 4 inch thick slip-formed channel is $2.00/ft^2 plus the cost of the slip-form.

Gunite and Shotcrete Channel Lining

A gunite channel with a 2 inch thickness will cost $2.00/ft^2 and a Shotcrete channel with a 4 inch thickness will cost $2.00/ft^2.

Soil Cement

Soil-cement is a mixture of pulverized soil material and measured amounts of portland cement and water, compacted to high density. As the cement hydrates, the mixture becomes a hard, durable material. Soil cement can bridge over local weak subgrade areas. It is little affected by water or freezing and thawing.

Soil cement and water can be mixed-in place using traveling mixing machines or mixed in a central mixing plant. Whatever type of mixing equipment is used, the principles and objectives are the same.

In soil cement construction the objective is to thoroughly mix a pulverized soil material in correct proportions with sufficient moisture to permit maximum compaction. Proper compaction is one of the fundamental requirements of soil-cement

construction. If the subgrade is soft and cannot properly support the compaction equipment then adequate density will not be obtained. Therefore, soft areas should be corrected before processing.

Sometime after construction, transverse shrinkage cracks occur in the soil-cement. Such shrinkage cracking is a natural characteristic of soil-cement and does not affect the performance of the material.

On most projects the soil-cement is constructed in stair-step fashion by placing and compacting the soil-cement in horizontal layers stairstepped up the embankment. For many smaller slope protection projects a 6 inch to 12 inch thick layer of soil-cement can be placed parallel to the face of the embankment rather than in horizontal layers. Embankment slopes from 2.5:1 to 4:1 and horizontal layer widths of from 7 to 9 feet provide minimum protective thicknesses of about 1.5 ft. to 2.5 ft. measured normal to the slope.

For maximum economy and efficient construction, it is recommended that the soil material contain no material retained on a 2-in. sieve, and at least 55% of the material pass the No. 4 sieve, and between 5% and 35% pass the No. 200 sieve.

Standard laboratory tests are available to determine the required proportions of cement and moisture to produce durable soil-cement. The following table shows the method of estimating the cost of soil cement.

Table 3. Estimating Cost of Soil-Cement Slope Protection
(Based on 1982 Construction Costs)

TOTAL COST =	COST OF PROCESSING +	COST OF CEMENT (Cwt (kg) cement per cubic yard (m³) x cost per cwt (kg)
	Cost of processing depends upon quantity of soil-cement to be placed.	Cement required depends on results of durability testing using soil aggregate proposed for the job.
	Cost of processing includes cost of material, hauling, central plant mixing, water for mixing and curing, transporting mixed soil-cement to the embankment, spreading, compacting, and curing. This depends to some extent on the quantity of soil-cement to be processed. If the soil to be mixed with cement must be hauled from off the site, an additional cost must be added to the processing costs suggested.	Cost of cement per cwt (kg) depends on mill base price and cost of delivery plus contractor's cost for handling, overhead, and profit.
	Less than 5000 cu yd (3800 m³)—$13.75/cu yd ($18.00/m³) 5000-10,000 (3800-7600)—$12.00 ($15.70) 10,000-40,000 (7600-30,600)—$10.50 ($13.75) 40,000-100,000 (30,600-76,500)—$9.00 ($11.75) More than 100,000 (76,500)—$8.25 ($10.80)	If no soil-cement tests have been conducted and no cement prices are available, assume 300# cement/cu yd (180 kg/m³) and obtain cement cost information from latest Engineering News-Record or other sources.

Note: The above estimated costs apply best to soil-cement protection for earth dams. Processing costs for soil-cement slope protection on highway embankments should run slightly less than the figures shown and for long, low, cooling water reservoir embankments slightly more. For construction in years after 1982, the estimated costs should be increased to include anticipated increases in costs of labor and materials.

If standard highway construction equipment is to be used to place and compact the soil-cement for each horizontal layer, a 7- to 9-ft. working width is required. For a horizontal working width of 8 ft., a slope of 3:1, and 6-inch thick layers, the resulting minimum thickness of facing would be about 2 feet, measured normal to the slope. This is the maximum thickness recommended as necessary for durability and performance.

For a given embankment material, steeper embankment slopes can be used with soil-cement than with other slope protection methods, because of its excellent shear strength properties.

An important consideration in the design of the soil-cement facing is to ensure that all extremities of the facing are tied into non-erodible sections or abutments. Where miscellaneous structures extend through the facing, the small areas adjacent

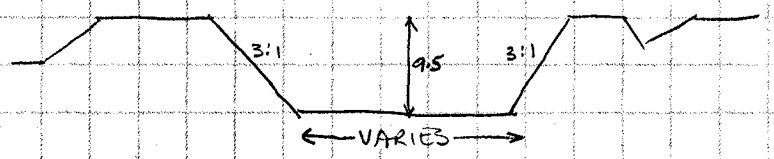
can be constructed by placing and compacting the soil-cement by hand or with small power tools.

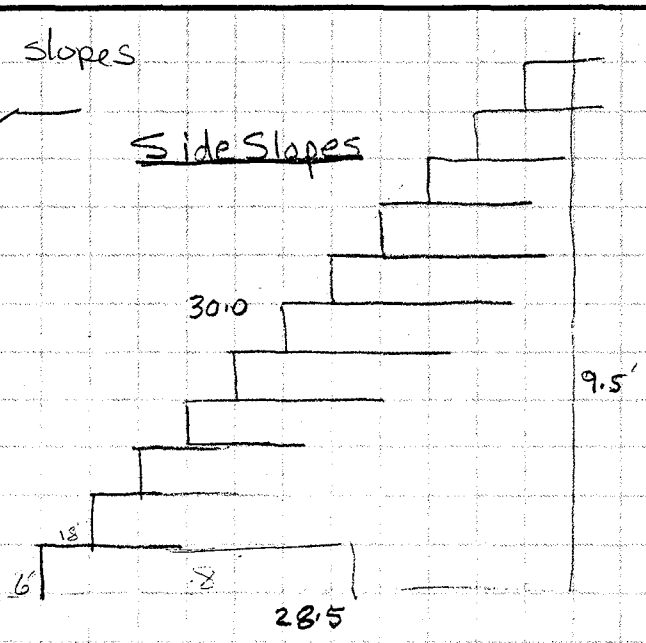
Standard laboratory tests (ASTM D558, D559, and D560) should be performed to determine the proper cement content, optimum moisture content, and maximum density of the soil-cement mixture.

The portland cement should comply with one of the following specifications for Portland Cement: ASTM C150, CSA A5, or AASHTO M85 for portland cement of the type specified.

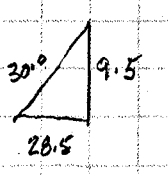
The probable method of construction (central plant or mixed in place) should be given consideration when the cross section of the facing has been determined. A compacted layer thickness of 6 in. is most widely used, with the recommended maximum being 9 in. for uniform compaction.

Volume Calculations for soil-cement slopes





side slopes = 23.7'



6" lifts = 2 x 9.5 = 19

lift dimensions = 0.5' x 8' = 4 ft²
per unit linear foot: 0.5' x 8' x 1' = 4 ft³

19 lifts x $4\frac{ft^3}{ft_{channel}} = \frac{76 ft^3}{ft\ channel}$ ⇒ 2.8 yd³/ft. channel.
(for 9.5' depth).

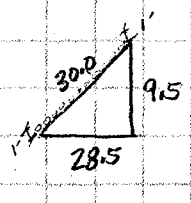
Channel Bottoms
26'
80'
110'
33'
90'
30'

Channel Bottom; Line with 12" (2-6" lifts) soil cement.

for 90' bottom width
90' x 1' x 1' = $\frac{90 ft^3}{ft_{channel}}$.

Channel bottom	Volume of soil cement (2-6" lifts) per foot of channel
26'	26 ft³/ft
80'	80 ft³/ft
110'	110 ft³/ft
33'	33 ft³/ft
90'	90 ft³/ft
30'	30 ft³/ft

Volume calcs for rip-rap slopes.



$30 ft^3/ft_{channel} = 1.1\ yd^3/ft_{channel}$

Rip Rap Prices.

Grouted: $4.00/ft^2$

Dumped: \$15-20.00/ton
\$17/yd²

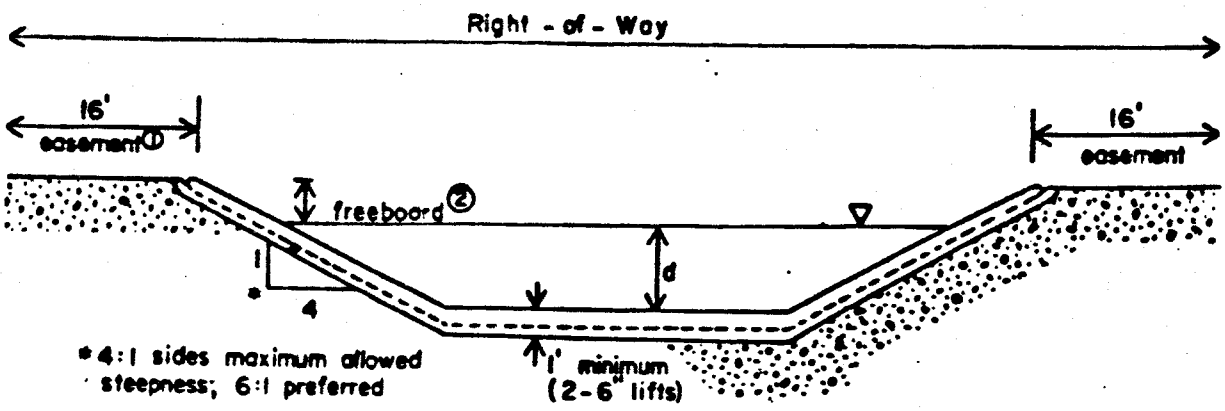
Plating Method

On most projects the soil-cement is constructed in stairstep fashion by placing and compacting the soil-cement in horizontal layers stairstepped up the embankment. For many smaller slope protection projects (less than 10 feet in height) a 6 inch to 9 inch thick layer of soil-cement can be placed parallel to the face of the embankment rather than in horizontal layers. This is known as the plating method of placement. A compacted layer of 6 in. is most widely used with the recommended maximum being 9 in. for efficient and uniform compaction. The steepest slope using the plating method should be 3:1.

The mixed in place method may be used for single-layer bottom lining or plating of slopes 4:1 or flatter. The central plant method is used for multiple layer applications and for steeper slope construction because mixing equipment is difficult to operate on steeper slopes. Examples of the plating method are shown on the following drawing.

LOCAL DRAINAGE
EXAMPLES OF SOIL CEMENT

CHANNEL CROSS-SECTIONS



Soil Cement Lined Channel
(Excluding Control Structures)

① Where bottom width > 20' only one 16' easement is required.

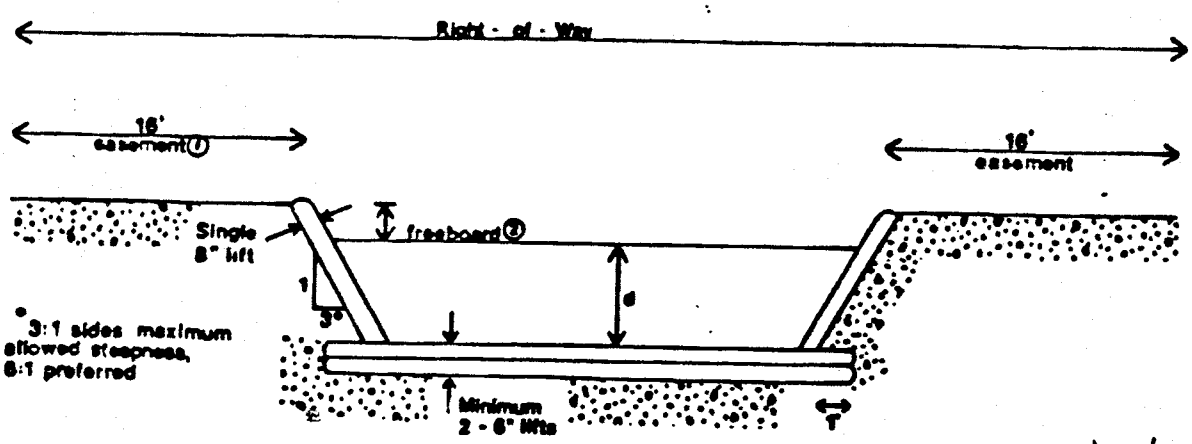
② $F < 0.86$ Freeboard = 1' minimum*

$F \geq 0.86$ Freeboard = $\frac{1}{6}\left[d + \frac{F^2}{2g}\right]$; 1' minimum

*For tranquil flow, Freeboard = 0.25d, when d ≤ 4 feet.

LOCAL DRAINAGE
EXAMPLES OF SOIL CEMENT

CHANNEL CROSS-SECTIONS



Soil Cement Lined Channel
For $v_{100} \leq 15$ fps,
Frequency Of Flow Less Than
5 to 6 Times A Year

* Recommended Techique

GREINER ENGINEERING SCIENCES, INC.
RECORD OF TELEPHONE CONVERSATION

DATE: 12-4-85 TIME: 1 : 20 E101012
JOB NUMBER

PERSON CALLED: Tom Nunn ADDRESS: 1313 S. Mission, Tucson

REPRESENTING: Pima County HWY PHONE NUMBER: 882-2620

NAME OF CALLER: Mustafa PHONE NUMBER:

ADDRESS: REPRESENTING: Greiner

DETAILS OF CONVERSATION: Tom is a design engineer with Pima County HWY Dpt and F.C.D. I asked him what "N" coefficient they use for Soil cement design.

REPLIES: n = 0.015 for trimmed soil cement, banks and bottom.

n = 0.018 banks only, and bottom

M.C.
(Name and Title)

Distribution

Gabions

Gabions are compartmented rectangular containers made of galvanized steel hexagon wire mesh and filled with stone. Compartments of equal capacity are formed by factory-inserted wire netting diaphragms or partitions.

Gabions are available in different sizes to suit conditions of terrain and application. The following table lists the typical sizes.

Size Length	Width	Depth	Partitions	Capacity (cu.yd)
6	3	3	1	2
9	3	3	2	3
12	3	3	3	4
6	3	1½	1	1
9	3	1½	2	1.5
12	3	1½	3	2
6	3	1	1	0.666
9	3	1	2	1
12	3	1	3	1.33

Average bid price quoted from supplier (11-20-85)

larger gabions 75.00 - 80.00/yd² } rock filled and placed
smaller gabions 65.00 - 75.00/yd² }

the gabion is filled with hand-sized rock, dumped into it mechanically.

One advantage of the gabion is its flexibility. It will tolerate differential settlement without fracture. Another advantage is that hydrostatic pressure will not develop behind a gabion wall.

Gabions require little maintenance and construction is simple.

Gabions can be used as outlet aprons and will settle without fracture. Little excavation is required.

To avoid lifting and overturning of an apron, a minimum of 12 in is required.

Gabions can be used as channel lining and the walls must be keyed solidly to the bank at both upstream and downstream ends.

Dumped RipRap

This type of protection consists of rock courses placed on gravel filters on bank slopes and channel beds. Rip rap can also be used for outlet protection and plunge basins. Dumped rip rap has the advantage of simple maintenance procedures. Damage can be repaired by the addition of more rock to the existing installation. Dumped rip rap has a natural appearance and will blend in well with other features of the floodway project. The cost of dumped rip rap is $20/ yd^3.

Grouted RipRap - This type of protection consists of rock rip rap having voids filled with portland cement concrete grout to form a monolithic armor. Grouted rock rip rap has application in areas where rock of sufficient size for ordinary rock rip rap is not economically available. Grouting protects the stones from the full force of the water and

integrates a greater mass to resist movement. This type of protection is rigid without high strength and support by the subgrade must be maintained. The cost of grouted rip rap is $40/ yd^3.

Revetment Mattress

The revetment mattress consists of heavy-duty nylon mats that are placed on a slope surface and filled with fine aggregate concrete mortar. When the mortar hardens, the mat can act as a concrete armor against the erosive action of water.

Revetment mattress comes in 60 inch panels and are sewn together to match the dimensions of a slope and for a continuous system without joints or overlaps. The fabric forms are unrolled on the graded slope and positioned by hand. Top and side edges are toed into trenches for protection against undercutting and scour. Fine-aggregate mortar is pumped into the mat section. Two designs are available: Filter point and uniform cross section. Filter point fabric is designed with open-weave filter units that relieve hydrostatic uplift pressure. Uniform cross section

fabric forms a slab-like, impermeable surface. Filter points can be added to relieve uplift pressures. As per the supplier of the revetment mattress (SoilTech, Inc.) this material is not recommended for flow conditions that produce a velocity in excess of 10 fps. The cost of the revetment is $3.00/ft^2. The literature was reviewed for a design procedure and none was given. The supplier suggests analyzing the structure as a slab. Suggested 'n' values for the revetment system range from .015 for the uniform mat and .025 for the filter point. These are suggested 'n' values and were not determined experimentally.

Cement

Contacted Az Portland Cement located in Rillito Az.

Delivered price of cement is $90.00/ton (2-7-86).

Phoenix Cement → 82.00/ton

Riprap (river run)

Union Rock $12/c.y. unsorted

Johnson-Stewart $7.80/c.y. 6"-20" unsorted

CALMAT $2.80/c.y. No-delivery - unsorted.
need ~2 month advance notice to clean and pile.

Ariz. Granite $12.00/ton - sorted

1½ ton per yd³ for river run.

United States
Department of
Agriculture

Soil
Conservation
Service

201 E. Indianola Ave.
Suite 200
Phoenix, AZ 85012

August 21, 1987

FLOOD CONTROL DISTRICT
RECEIVED
AUG 26 '87

	CH ENG		P & PM
	DEF		HYDRO
	ADMIN		LMGT
	FINANCE		FILE
	C & O		
	ENGR		

REMARKS

Dan Sagramoso, P.E.
Manager and Chief Engineer
Flood Control District of Maricopa County
3335 W. Durango Street
Phoenix, AZ 85009

RE: Leisure World Fence

Dear Dan:

We have reviewed the plans submitted by United Fence Co. Incorporation and offer the following comments:

1. The fence as shown at Southern Avenue will not affect the hydraulic design of the floodway. It is important to note, however, that the fence must tie into the lake as shown leaving approximately 100 feet of unrestricted floodway bottom width.

2. The fence along the 56 street low flow crossing is not acceptable. Please refer to design review of the crossing submitted June 2, 1986 and August 4, 1986. From these design reviews it can be seen that a restriction above the road surface will have a major effect to the upstream floodway reach and structures.

   One suggestion to alleviate this problem is to install the fence upstream of the road crossing such that the height of the fence does not exceed the height of the road crossing within the 100 year flow depth.

Sincerely,

Don R. Phillips Acting For

Verne M. Bathurst
State Conservationist

cc: Scott Clement, FCDMC