NEAL RANCH

MASTER DRAINAGE PLAN UPDATE

BROADMOOR OAKS

FILINGS 3, 4, 7, 8, 9, AND 10

May 5,1988

Revised
June 24, 1988

Revised
July 21, 1988

Prepared For:

DAVID R. SELLON AND ASSOCIATES

Oliver E. Watts
Consulting Engineer
Colorado Springs

OLIVER E. WATTS, PE-LS
CONSULTING ENGINEER, INC.
614 ELKTON DRIVE
COLORADO SPRINGS, COLORADO 80907
719-593-0173

July 21, 1988

City Engineering
30 South Nevada Ave #403
Colorado Springs, CO 80903

ATTN: Mr. Chris Smith

SUBJECT: Neal Ranch Master Drainage Plan Update
Broadmoor Oaks Filings 3,4,7,8,9 & 10.

Gentlemen

Transmitted herewith is the subject reoprt, which has been revised in accordance with your review comments of July 11, 1988.

All hydrographs were computed at Broadmoor Bluffs Drive so as to route through proposed culverts, then they were routed to the hydrograph points at the boundary, where combined hydrographs were computed. This was done for both the developed and historic runoffs, each done for both the 10 and 100-year runoffs. Only one of the proposed culverts needed modification, being hydrograph point no. 12- where a 54" insert into a 96" riser is placed on the inlet to the 78" CMP, which is inserted into the ultimate 90" CMP.

All culvert locations are routed, based on the final design configuration, including those in filings 4 and 3 which were previously accepted. Detailed sheets are included which show the proposed high water marks, so that easements may be written above the 100-year water level.

One again, it is clearly shown that the historic runoffs for both the 10 and 100-year storms will not be exceeded by the facilities as proposed.

17 additional pages of computations are enclosed, with revised sheets for all culvert installations (sheets 8A, 8B, 8C, and 9A). A summary of all runoff conditions is revised on page 7 of the report.

Please contact me if I may provide further information or answer any questions you may have.

Sincerely

Oliver E. Watts
Consulting Engineer

Encl

OLIVER E. WATTS, PE-LS
CONSULTING ENGINEER, INC.
614 ELKTON DRIVE
COLORADO SPRINGS, COLORADO 80907
719-593-0173

June 24, 1988

City Engineering
30 South Nevada Ave #403
Colorado Springs, CO 80903

ATTN: Mr. Chris Smith

SUBJECT: Neal Ranch Master Drainage Plan Update
Broadmoor Oaks Filings 3,4,7,8,9 & 10.

Gentlemen

Transmitted herewith is the subject report, which has been revised in accordance with our meeting of June 23, 1988.

A detailed hydrograph routing procedure has been performed for hydrograph point No. 10. The original report showed a very slight increase in runoff over the historic, while this detailed analysis shows that the developed outflow from the culvert installation will be virtually the same as the historic runoff. Two pages of additional computations are enclosed.

A summary of the runoffs from the existing development has been added to the report on page 7. It is clearly shown that the existing proposed filings will not increase the runoff over that of the historic conditions.

Please contact me if I may provide further information or answer any questions you may have.

Sincerely

Oliver E. Watts
Consulting Engineer

Encl

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614 ELKTON DRIVE
COLORADO SPRINGS, COLORADO 80907
719-593-0173

RECEIVED
PUBLIC WORKS/ENGINEERING
COLO. SPRINGS COLO.
MAY 18 1988
AM 7,8,9,10,11,12,1,2,3,4,5,6 PM

May 5, 1988

City Engineering
30 South Nevada Ave #403
Colorado Springs, CO 80903

ATTN: Mr. Chris Smith

SUBJECT: Neal Ranch Master Drainage Plan Update
Broadmoor Oaks Filings 3,4,7,8,9 & 10.

Gentlemen

Transmitted herewith for your review and approval is the master drainage plan update for Neal Ranch, concerning Broadmoor Oaks Filings 3, 4, 7, 8, 9, and 10.

Please contact me if I may provide any further information or answer any questions you may have.

Sincerely

Oliver E. Watts
Consulting Engineer

Encl:
- Drainage Report
- Computations, 15 pages
- HP Details, 5 sheets
- Area Drainage Map
- Area Soils Map
- Soils Interpretation Sheets- 4
- Reference Sheets- 18
- dwg 88-1713-02, Highway 115 Culvert Details
- dwg 88-1713-01, Master Drainage Plan

Engineer's Statement:

The attached drainage plan and report were prepared under my direction and supervision and are correct to the best of my knowledge and belief. Said drainage report has been prepared according to the criteria established by the City for drainage reports and said report is in conformity with the master plan of the drainage basin. I accept responsibility for any liability caused by any negligent acts, errors or omissions on my part in preparing this report.

Oliver E. Watts   Colo PE-LS No. 9853

Developer's Statement:

The developer has read and will comply with all of the requirements specified in this drainage report.

DAVID R. SELLON CO.

By: ____________________

Title: Pres.

225 East Cheyenne Mountain Boulevard
Colorado Springs, CO 80906

City of Colorado Springs:

Filed in accordance with Section 15-3-906 of the Code of the City of Colorado Springs, 1980, as amended.

City Engineer   date 8/1/88

Conditions:

"SEE ATTACHED CONDITIONS OF APPROVAL"

CITY OF COLORADO SPRINGS

The "America the Beautiful" City

DEPARTMENT OF PUBLIC WORKS CITY ENGINEERING DIVISION (719) 578-6606

30 S. NEVADA SUITE 403 P.O. BOX 1575
COLORADO SPRINGS, COLORADO 80901

August 1, 1988

RE: CONDITIONS OF APPROVAL FOR THE PARTIAL UPDATE OF THE NEAL RANCH MASTER DRAINAGE PLAN INCLUDING THE BROADMOOR OAKS FILING NO. 3, 4, 7, 8, 9 AND 10.

1. The Drainage Report and Facility Design for Broadmoor Oaks No. 7,8, 9 and 10 by Donnel Jeffries as referenced in this report is considered preliminary as of this date and is subject to final review by the City.

2. The review of historic runoff rates and temporary on site detention will consider Broadmoor Oaks Filings 3, 4, 7, 8, 9 and 10 only in this report.

   Prior to the approval of the final drainage report and construction drawings, a detailed pond analysis is to be submitted for the proposed temporary on-site detention facilities to establish volumes, elevations, and construction requirements for the 10-year and 100-year design storms.

3. Where the temporary detention facility analysis indicates water levels causing potential building site flooding on the Broadmoor Oaks plattings, building permits for the effected lots will not be issued until the detention control devices are removed.

   Adequate drainage easements will be required to accommodate the floodplans caused by the 100-year design storm within the Broadmoor Oaks boundaries.

4. Drainage facility construction providing temporary detention will not be accepted by the City for maintenance until the temporary detention devices are removed.

5. No flows over historic rates and form will allowed to discharge downstream of the Neal Ranch Development for the 10-year or 100-year storm unless drainage easements are procured from downstream ownerships extending to State Highway 115. No flows over historic rates will be allowed to discharge into the Fort Carson property.

6. The sizing and location of any proposed ultimate detention facility downstream of the Neal Ranch Development in this report is considered conceptional and will be designed on the basis of total tributary, fully developed conditions. Allowable discharge at Highway 115 will be subject to the Colorado Department of Highways.

   Where runoff over historic rates is discharged downstream, the Broadmoor Oaks Development is subject to any additional requirements of El Paso County.

7. Floodwater Management Structure will be subject to the State Engineers interpretation for jurisdictional dams. Outlet works and spillways will be subject to any additional City/County requirements.

8. A final Drainage Report and Construction Cost Estimates are required prior to the platting of Broadmoor Oaks Filing No. 7, 8, 9 and 10.

City Engineer   8/1/88 Date

1. Location and Description: The Neal Ranch is located in Sections 12 and 13, T15S, R67W of the 6th PM in the City of Colorado Springs, as shown on the enclosed drainage plan.

The site is bordered on the West by Norad properties and some undeveloped land, on the North by previous Broadmoor Oaks filings, on the South by undeveloped Broadmoor Oaks properties and the Norad Road, and on the east by the J L Ranch, now totally undeveloped.

The site lies in an unstudied drainage basin shown on the enclosed area drainage map. Panel 290 B of the FEMA mapping indicates that none of the site falls within a designated flood plain or flood hazard area.

2. Purpose and Scope: This study will update the master drainage plan of Neal Ranch, prepared by G.J. Weiss, dated June 24, 1987, and the effects of existing platted Broadmoor Oaks filings on the historic runoff within the basin, and recommended steps to mitigate any increased in runoff.

Drainage reports have been previously submitted and filed by the City for the following subdivisions:

Broadmoor Oaks 3 and 4	ELB and ASsociates	October 19, 1987
Broadmoor Oaks 7, 8, 9 & 10	Donnel Jeffries	January 25, 1988

This report will offer minor changes to the above to mitigate increases in runoff and examine their effect, and provide further analysis of the capacities of existing outfall structures and master plan facitiies in that area. No changes to the above approved reports are intended, except where specifically called out and mentioned, and are only minor and temporary in nature.

3. Criteria: All drainage computations have been prepared in accordance with the criteria prescribed and adopted by the City of Colorado Springs and are enclosed for reference and review. 10 year and 100 year runoffs were computed using the 24-hour storms of 3.3 inches and 4.6 inches of rainfall, respectively, as described in detail in a later section.

Soils mapping of the area has been prepared by the local USDA/ SCS office and is enclosed for reference. Major hydrologic groups are shown on the enclosed drainage plan.

4. Hydrologic Computations: The drainage basins originates on the top of Cheyenne Mountain and outfalls through existing culverts on Colorado Highway 115. The terrain is very rugged and generally steep, and the basins are relatively long and slender, which rules out many typical hydrologic techniques.

The methodology used is the same as prepared by me for G.J. Weiss in the approved master drainage plan. Individual basins are computed by the SCS synthetic hydrograph procedure. Detailed hydrographs are computed at significant points to analyze the historic and developed (through the existing filings) runoffs and the amount of detention required to stage any increase to peak historic values. Channel routing techniques were employed for results that will be realistic with the terrain characteristics. It may be seen that the upper basin runoffs are very high and the hydrographs steep and short, and that they flatten out as the terrain levels out in the lower reaches of the basin. In basins of this nature it is not unusual for runoffs to decrease from upstream to downstream when this occurs.

All applicable portions of the criteria manual and other information used is enclosed for reference and review.

5. Detailed Computations:

a. Hydrograph Point No. 8: This is the Southernmost outfall point of the existing development and occurs on the Southeast corner of filing 8, as shown on the enclosed drainage plan. A small portion of filing 9 is drained also.

As described in the master plan, the total Neal Ranch development will increase the runoff from a historic value of 664 cfs to 705 cfs, requiring 82,622 Cubid Feet of detention storage. Donell Jeffries has specified a 120" CMP culvert on Broadmoor Bluffs Drive, which has not yet had a final design. It may be represented schematically as shown on Page 8A of the HP details, and will require improvements in the approach channel to develope sufficient inlet headwater to accomodate the design runoff of 705 cfs.

The drainage basin limits have been modified slightly as designed by Donnel Jeffries and the runoff recomputed to determine the effect of existing platted ground. The historic runoff of 639 cfs will be increased only slightly to 646 cfs, requiring only 15,121 CF detention at this time.

When sufficient inlet headwater is developed to accomodate the design rufoff of 705 cfs, the existing 100-year runoff of 646 cfs will create enough headwater and detention to lower the peak to the historic value of 639 cfs. The ultimate requirement of 82,622 CF detention will not be available, however, so additional development will require further examination. For the present filings, however, 28,120 CF storage is available, significantly more than the 15,121 CF required.

b. Hydrograph Point No. 10: This is the outfall of parts of

FOR FINAL VALUES, SEE PLAN AND CALCS -

Filings 7 through 10, and Donell Jeffries has proposed a 90" CMP on Broadmoor Bluffs Drive, having a detailed design shown on Page 8B of the HP details. The Master plan shows that 232,045 CF detention storage will be necessary to lower the final peak runoff of 488 cfs to the historic runoff of 394 cfs. This total storage is not available before the road overtops, however the existing runoff will increase from 413 cfs to 448 cfs, requiring only 70,649 CF runoff.

Under Jeffries ultimate design the 448 cfs will create a headwater elevation of 35.44, with 14,464 CF detention. This creates the peculiar situation of the ultimate design requirements being to great to do any good for the present situation. It is recommended that one joint of 78" CMP be inserted into the 90" with a cutout plate to restrict the opening so that the existing 100-year developed runoff would be accomodated without overtopping the road to elevation 39.0, creating 67,601 CF detention storage. The sums of the storage available from HP #10 and HP #8 are within 4% of the total requirement, so that the combined peak outflow will be virtually the same as the historic under these conditions.

As shown on the detail HP sheet 8C, however, this additional headwater depth will create special problems with lots 74 and 75 (master plan numbering) by possibly inundating the building sites. These lots should be held back from sale for this interim period until downstream detention, discussed in a later section, can be arranged. This period is not expected to be longer than one year.

<u>c. Hydrograph Point No. 13:</u> This is the outfall for most of filings 3 and 4, where a 60"CMP and a 78" CMP have been constructed on Broadmoor Bluffs Drive to accomodate the ultimate design runoff of 690 cfs. The increase from the historic 536 cfs would require 370,905 CF detention storage according to the master plan. The ultimate design situation would create a headwater elevation of 61.14, with a detention of 111,700 CF.

The existing developed runoff would increase to 593 cfs, creating a requirement of 64,821 CF detention. This runoff will create a headwater elevation of 58.58, with a detention of 64,254 CF, so that the outflow is virtually the same as the historic and no further improvements will be required until development progresses further.

<u>d. Existing Development Summary:</u> With the above described minor modification to the inlet of the 90" CMP above HP #10, the culverts as now designed will create 144,711 CF of detention storage, where 150,591 CF would be required, being within 4% of the requirement. This is well within the range of tolerance of the computations. so that it may be said that the outflow from the existing development is virtually the same as the historic value. No

FOR FINAL VALUES, SEE PLAN AND CALC'S - [initials] additional mitigation will be necessary for the existing development conditions.

e. Outfall Point Analysis: As shown on drawing 88-1713-02, 2 84" CMP culverts across Colorado Highway 115 represent the outfall structures of the drainage basin. The culverts across the Norad off-ramp are 52.7 feet long, with headwalls and wingwalls, while the culverts across the main highway and the North-bound on-ramp are 216.4 feet long, with beveled entries matching the paved end slopes. A hydrograph at this point (#16) was computed to have a peak runoff of 1781 cfs, under historic conditions.

The main culverts have a capacity of 700 cfs under inlet control conditions before runoff will overtop the highway at a point a couple of hundred yards to the South. The total historic runoff of 1781 cfs will create an overtopping of the travelled lanes to a depth of 0.40' for a duration of 71 minutes.

The Norad off-ramp culverts have a capacity of 960 cfs, with inlet control conditions again governing. The remaining historic runoff will overtop the off-ramp to a depth of 0.67' for 21 minutes.

As discussed previously, the existing development is totally mitigated for increased runoff by culverts as designed and only modified slightly, so that the developed runoff at the outfall point has the same peak as the historic value, and no mitigation at this point is required. Even though the culverts will not handle historic runoff, this is a concern only to the Highway Department and not the problem of the developer. As illustrated above, the inconvenience to driving is much less that can be anticipated from snowstorms that occur several times annually.

f. Master Planned Detention Pond: As described in the master plan, a total of 685,572 CF of detention storage would be required to lower the various peak outflows to the historic values. This figure represents the value at the outfall of the Neal Ranch development, and will logically be lowered significantly when routed to highway 115, but for the time being and approximate sizing may be made for the structure, at least from a feasibility standpoint.

Under ultimate development conditions, headwater on the above described culverts will provide 171,195 CF detention, so that a balance of 514,377 CF or less will be required. The existing culverts on highway 115 do not have enough headwater storage to approach this figure, so a tentative structure has been designed and is shown on Sheet 14A of the HP details, drawing 88-1713-02, and the master drainage plan. This should be a roadway culvert that would provide detention advantages without falling under the dam requirements of the State Engineer's office. This detention pond would require re-examination for each major phase of development within the basin, and a detailed hydrologic investigation would be warranated then and at the time of final design.

Preliminarily the culverts would be designed for the passage of the historic runoff of 1781 cfs onto the highway right of way, while provided sufficient detention for the anticipated increase in runoff so that the detention would not overtop the roadway. In this case, the water surface would be elevation 64.93, with the roadway at 66.00 minimum, with two 108" CMP's appearing to be the most economical culverts, governed by inlet control conditions.

6. Cost Estimate:

Temporary modifications to the 90" CMP on Broadmoor Bluffs Drive would not be credited against the basin fees, so they would not change the approved cost/fee relationship for previously approved drainage plans. The estimate of this cost would be as follows:

78" inlet to 90" CMP	$2000.00
10% engineering	200.00
Total Estimated Cost	$2200.00

The master planned detention facility would be a permanent facility to be constructed when needed and perhaps modified periodically to meet specific needs of progressing development conditions. The total ultimate facility is estimated to cost as follows:

Roadway Embankment	6510	CY	@$ 2.00	$ 13,020.00
108" CMP	216	LF	220.00	47,520.00
Headwalls	2	EA	3500.00	7,000.00
Subtotal				$ 67,540.00
10% Engineering				6,754.00
Total Estimated Cost				$ 74,294.00

7. Summary of Runoff:

As requested, the following is a summary of the 100-year and the 10-year design runoffs:

Hydrograph Point and Location:	Developed Runoff -cfs- Inflow	Developed Runoff -cfs- Outflow	Historic Runoff -cfs-	Ultimate Design Runoff
100-year Runoffs:				
8 @ BM Bluffs Rd:	682	634	681	
@ East Bndry:	599	599	639	705
10 @ BM Bluffs Rd:	452	420	428	
@ East Bndry:	410	410	413	488
13 @ 78"CMP BM B Rd:	377	361	374	
@ 60"CMP BM B Rd:	160	160	152	
@ East Bndry:	554	554	564	690
10-Year Runoffs:				
8 @ BM Bluffs Rd:	432	418		
@ East Bndry:	388	388	402	N/A
10 @ BM Bluffs Rd:	236	215		
	209	209	212	N/A
13 @ 78"CMP BM B Rd:	206	206	205	
@ 60"CMP BM B Rd:	67	67	62	
@ East Bndry:	285	285	290	N/A

1" = 400'   See Also 4-25-88 Calcs

	MAJOR BASIN	SUB BASIN	AREA Planim. Read.	AREA MILE	BASIN LENGTH	BASIN HEIGHT	Tc	K	SOIL GROUP	DEV. TYPE	CURVE NO.	FLOW Q	FLOW qp	Return Period
(11)	D	1	158.40Ac	0.2475	7200	2680	0.178	850	D & B	GJW 6-10	76	1.22 / 2.21	257 / 465	10 / 100
(12)		2	94.58Ac	0.1478	5200	1470	0.154	880	D & B	GJW 6-10	62	0.52 / 1.20	68 / 156	10 / 100
	D	3A	1.73						B	Oak 37%	55			
			0.66						B	SF	69.9			
			2.39	0.0137	1940	170	0.113	960	B	Mix	59.1	0.44 / 1.016	5.5 / 13.4	10 / 100
		3B	10.28						B	37% Oak	55			
			2.18						B	SF	69.9			
			12.46	0.0715	2100	192	0.118	940	B	Mix	57.6	~~0.364~~ / 0.936	24.5 ~~59.5~~ / 62.9	10 / 100
		3C	2.17	0.0125	680	58	0.0509	990	B	SF	69.9	0.895 / 1.742	10.9 / 21.5	10 / 100
		4	6.21						B	Oak 37%	55			
			11.42Ac 3.11						B	SF 24 Lots	70.2			
			34.23Ac 9.32	0.0535	2800	275	0.144	900	B	Mix	60.1	0.454 / 1.077	21.9 / 51.8	10 / 100
(13)	D	1-4	349.73Ac	0.5465	10,000	2915	0.252	760	B	Developed Mix	67.7	0.775 / 1.579	322 / 656	10 / 100
				0.548				760		Historic	66.4	0.710 / 1.488	295 / 618	10 / 100

HYDROLOGIC COMPUTATION – BASIC DATA

PROJ: Broadmoor Oaks Master   By: OEW   Date: 7-14-88

24 hr
I_{10} = 3.3"
I_{100} = 4.6"

Oliver E. Watts
CONSULTING ENGINEER

Page 1 of 4 Pages

$$T_c = \left(\frac{11.9 L^3}{H}\right)^{0.385}$$

Project BROAD OAKS
Calc. by OEW date 7-14
Checked by ______ date ______

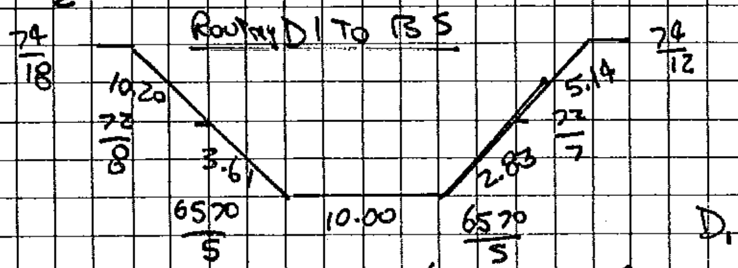
Oliver E. Watts
CONSULTING ENGINEER

100 yr

Pt # 13 South Hydrograph

Basin	Tc-hr	A-SM	Developed CN	Q	qp	Historic CN	Q	qp
D1	0.178	0.2475	76	2.21	0.5470K (20)	76	2.21	0.5470K (20)
D3A	0.113	0.037	59.1	1.016	0.0139 K (21)	55	0.79	0.0108K (22)
Σ								

Routing D1 To B5



qp = 465 n = 0.060 S = 4.09%

d	A	WP	R	Q	V
74	70.00	31.78	2.2026	885	
72	25.00	16.44	1.5207	247	
72.68	40.38			465	11.52

$D_1\ T_T = \frac{1940}{3600 \times 11.52} = 0.0468$ (10)

Use Tc = 0.225

TIME HRS	K D1	K D3A	qp Developed D1	D3A	Σ	qp Historic D1	D3A	Σ	Δ qp	ST-OF Inc	Σ
0	0	0	0	0	0	0	0	0	0		0
5.0	14.26	14.78	7.80	0.21	8.01	7.80	0.16	7.96	0.05	431	431
5.5	35.01	38	19.15	0.53	19.68	19.15	0.41	19.56	0.12	149	579
5.7	182.26	216.50	99.69	3.01	102.71	99.69	1.08	100.77	1.94	741	1,320
5.8	499.12	599.26	273.01	8.34	281.34	273.01	6.49	279.50	1.85	682	2,003
5.9	669.02	782.34	365.94	10.89	376.83	365.94	8.47	374.41	2.42	768	2,771
6.0	500.00	513.64	273.52	7.15	280.67	273.52	5.56	279.08	1.59	722	3,493
6.2	228.05	140.88	124.74	1.96	126.70	124.74	1.52	126.26	0.43	729	4,222
6.5	60.97	43.10	33.35	0.60	33.95	33.35	0.47	33.82	0.13	304	4,526
7.0	~~27.21~~ 26.37	~~14.88~~ 27.61	14.42	0.38	14.81	14.42	0.30	14.72	0.09	196	4,722
8.0	19.15	19.13	10.48	0.27	10.74	10.48	0.21	10.69	0.06	261	4,983
10.0	10.52	10	5.75	0.14	5.89	5.75	0.11	5.86	0.03	335	5,318
12.0	9.63	10	5.27	0.14	5.40	5.27	0.11	5.38	0.03	202	5,520
15.75	0	0	0	0	0	0	0	0	0	203	5,722

Project BROAD OAK

Oliver E. Watts
CONSULTING ENGINEER

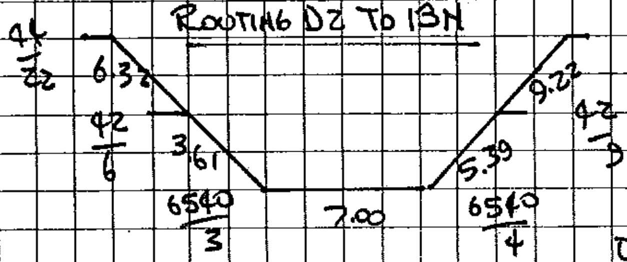
Calc. by OEW date 2.14

Checked by ________ date ________

100yr

Pt # 13 North Hydrograph			Developed			Historic		
BASIN	Tc hr	A-SM	CN	Q	qp	CN	Q	qp
D2	0.154	0.1478	62	1.20	0.1774 K (20)	62	1.20	0.1774 K (20)
D3B	0.118	0.0715	57.6	0.936	0.0669 K (21)	55	0.79	0.0565 K (22)

ROUTING D2 TO 13N



44/18 d	A	WP	R	Q	V
44	67.00	31.54	2.1243	785	
42	22.00	16.00	1.3750	193	
43.62	17.78			156	8.77

D_2 $T_T = \frac{2100}{8.77 \times 3600} = 0.0665$ (10)

Use Tc = 0.220

TIME	K		qp Developed			qp HISTORIC			Δ	ST - CF	
HRS	D2	D3B	D2	D3B	Σ	D2	D3B	Σ	qp	Inc	Σ
0	0	0	0	0	0	0	0	0	0		0
										1,326	
5.0	13.87	14.18	2.46	0.95	3.41	2.46	0.80	3.26	0.15		1,326
										496	
5.5	33.74	38	5.98	2.54	8.53	5.98	2.15	8.13	0.40		1822
										1,126	
5.7	181.48	261.50	32.19	17.50	49.69	32.19	14.77	46.96	2.73		2,948
										2,105	
5.8	534.61	~~94.82~~ 859.06	94.82	57.49	152.31	94.82	48.52	143.34	8.97		5,053
										3,025	
5.9	616.83	750.54	109.40	50.23	159.63	109.40	42.39	151.79	7.84		8,079 ← 13N
										2,436	
6.0	516.79	545.50	91.57	36.51	128.08	91.57	30.81	122.38	5.69		10,515
										2,475	
6.2	251.42	113.28	44.59	7.58	52.17	44.59	6.40	50.99	1.18		12,989
										894	
6.5	67.54	45.67	11.98	3.06	15.04	11.98	2.58	14.56	0.48		13,884
										122	
7.0	27.32	27.46	4.85	1.84	6.68	4.85	1.56	6.40	0.28		14,006
										867	
8.0	18.84	19.18	3.34	1.28	4.62	3.34	1.08	4.42	0.20		14,873
										1,107	
10.0	10.67	10	1.89	0.67	2.56	1.89	0.56	2.45	0.11		15,980
										769	
12.0	9.47	10	1.68	0.67	2.35	1.68	0.56	2.24	0.10		16,749
										676	
15.75	0	0	0	0	0	0	0	0	0		17,424

Oliver E. Watts
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Project: BROAD' OAKS
Calc. by: OEW date: 7.15
Checked by: date:

100 yr

#13 SOUTH STORAGE INFO 78" CMP w MES Very Steep Inlet Control Cond(1) Final Design

Elev	PR	A	V-CF		78" CMP	
	IN²	SF	Inc	Σ	HW/D	Q
48.28	0	0		0	0	0
1.72			175.4			21
6450	0.51	204		175.4	0.265	21
			996			79
52	1.98	792		1171	0.572	100
			2428			100
54	4.09	1636		3599	0.88	200
			4728			100
56	7.73	3092		8327	1.19	300
			7868			90
58	11.94	4776		16195	1.50	390
			11616			60
6460	17.10	6840		27811	1.80	450
			17120			55
62	25.70	10280		44931	2.11	505

Staging

Time	Qp	78" CMP		ST-CF		WSEl
Hrs	IN	Qp OUT	Qp ST	Inc	Σ	
0	0	0	0		0	48.28
				66.8		
5.0	8.01	8.00	0.01		66.8	48.94
				99.0		
5.5	19.68	19.58	0.10		165.8	49.91
				1008.0		
5.7	102.71	100.01	2.70		1173.8	52.00
				5067.0		
5.8	281.34	255.89	25.45		6240.8	55.12
				7423.2		
5.9	376.83	361.04	15.79		13664.0	57.36
				-3799.8		
6.0	280.67	317.57	-36.90		9864.2	56.39
				-8044.9 @0.12		
6.2	126.70	126.70	-0-		1819.3	52.53
6.5	33.95	33.95				
7.0	14.81	14.81				
8.0	10.74	10.74				
10.0	5.89	5.89				
12.0	5.40	5.40				
15.75	0	0				

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Project Broad Oaks
Calc. by OEW date 2-19
Checked by ______ date ______

100yr

PT #13 North Storage Info 1"=20' Final Design 60" CMP w MFES cond (1) Inlet Control

1"=20' (2)

WSL Elev	PR -in²-	A -SF-	V-CF- Inc	V-CF- Σ	60" CMP OK HW/D	60" CMP OK Cap	42" CMP No Go HW/D	42" CMP No Go Cap
49.71	0	0		0	0	0	0	0
2.29			92			35		26
52	0.20	80		92	0.46	35	0.65	26
	2.16		944			65		37
54	[illegible]	864		1036	0.86	100	1.23	63
			2960			69		31
56	5.24	2096		3996	1.26	169	1.80	94
			6268			51		25
58	10.43	4172		10264	1.66	220	2.37	119
			10212			42		19
6460	15.10	6040		20476	2.06	262	2.94	138
			14264			38		13
62	20.56	8224		34740	2.46	300	3.51	151

Stag Tbl — 60" CMP Use This — 42" CMP No Need to Use This

Time HRS	Qp In	Q0 Out	Q1 ST	ST-CF- Inc	ST-CF- Σ	WS Elev	42" Q0 Out	Qp ST	ST-CF- Inc	ST-CF- Σ	WS Elev
0	0	0	0		0	49.71	0	0		0	
				9.00					12.1		
5.0	3.41	3.41	0.00		9.00	49.93	3.41	0		12.1	50.01
				13.40					18.0		
5.5	8.53	8.52	0.01		22.40	50.16	8.51	0.02		30.1	50.46
				266.4					630.0		
5.7	49.69	48.96	0.73		288.8	52.42	47.96	1.73		660.1	53.20
				2505.6					7686.0		
5.8	152.31	139.12	13.19		2794.4	55.13	111.34	40.97		8346.1	57.39
				876.64 @ 5.85					11484.0		
5.9	159.63	159.63	-0-		3594.0	55.72	136.80	22.83		19830.1	59.87
									2086.2		
6.0	128.08	128.08					139.32	-11.24		21916.3	60.10
									-18169.2		
6.2	52.17	52.17					91.40	-39.23		3747.1	55.83
									-3693.9		@ 6.25 I=0
6.5	15.04	15.04					15.04	-0-		53.2	51.03
7.0	6.68	6.68					6.68				
8.0	4.62	4.62					4.62				
10.0	2.56	2.56					2.56				
12.0	2.35	2.35					2.35				
15.75	0	0					0				

This Provides No Benefit @ 13 North But will Work @ Pond #17

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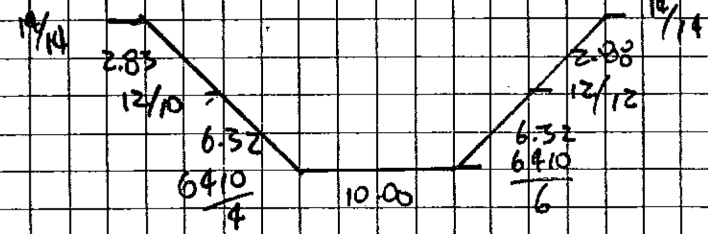
Project Broad'r Oaks
Calc. by OEW date 7-15
Checked by ____ date ____

100 yr Routing to Boundary PT# 13



q_p = ~~290.5~~ 497.8 CFS

n = 0.060

S = 7.69%

WS ELEV	A	R	R	Q	V
12	32.00	22.64	1.4134	276.8	
14	82.00	28.30	2.8975	1144.6	
12.51	44.71			497.8	11.13

$T_T = \frac{680}{11.13 \times 3600} = 0.0170$ hrs (1.0)

Basin D3C T_c = 0.0509 Use 0.10
A = 0.0025 SF
CN = 69.9
Q_{100} = 1.742
q_R = 0.0218 K (30)

Hydrographs @ PT # 13 — For 13N & 13S Use T_c = 0.240 hrs (= $T_c + T_T$)
For D4 & Historic See Page 7 of 4-26-88 Calc's

TIME	K	q_p Developed 48" CMP @ 13N					q_p	q_p Developed 60" CMP @ 13N		
HRS	D3C	13S+N	T_T=0.017	D_3C	D_4	Σ	HISTORIC	13S+N	T_T=0.017	Σ
0	0	0	0	0	0	0	0	0	0	0
5.0	14	11.41	11.27	0.30	0.83	12.40	10.76	11.41	11.27	12.40
5.5	38	28.09	27.26	0.83	2.19	30.28	29.61	28.10	27.27	30.29
5.7	275	147.92	139.72	5.99	13.94	159.65	160.15	148.97	140.66	160.59
5.8	937	367.22	345.39	20.40	43.01	408.80	455.38	395.01	371.52	439.93
5.9	741	497.84	470.76	16.14	44.04	530.94	563.75	520.67	493.35	553.53
6.0	562	456.89	447.09	12.24	30.91	490.13	427.48	445.65	436.09	479.14
6.2	105	218.10	215.54	2.29	7.27	225.05	186.59	369.74	365.40	374.91
6.5	47	48.99	50.05	1.02	2.58	53.65	51.10	48.99	50.05	53.65
7.0	28	21.49	22.74	0.61	1.54	24.89	22.46	21.49	22.74	24.89
8.0	19	15.36	15.23	0.41	1.12	16.76	16.12	15.36	15.23	16.76
10.0	10	8.45	8.73	0.22	0.58	9.53	8.85	8.45	8.73	9.53
12.0	10	7.75	7.85	0.22	0.58	8.65	8.13	7.75	7.85	8.65
15.75	0	0	0	0	0	0	0	0	0	0

(13) ← 100 yr

48" CMP @ 13N Not Needed

Use 60" CMP @ 13N OK

Project BM Oaks

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Calc. by OEW date 7.15
Checked by ______ date ______

10 year Storm Basic Data			Developed				Historic			
Basin	Tc-hr-	A-SM-	CN	Q	qp		CN	Q	qp	
D1	0.178	0.2475	76	1.22	0.3020 K	(20)	76	1.22	0.3020 K	(29)
D2	0.154	0.1478	62	0.52	0.0769 K	(22)	62	0.52	0.0769 K	(22)
D3A	0.113	0.0137	59.1	0.414	0.0057 K	(21)	55	0.28	0.0039 K	(26)
D3B	0.118	0.0715	57.6	0.364	0.0260 K	(23)	55	0.28	0.0200 K	(27)
D3C	0.0509	0.0125	69.9	0.885	0.0111 K	(24)	55	0.28	0.0035 K	(28)
D4	0.144	0.0535	60.1	0.454	0.0243 K	(25)	55	0.28	0.0150 K	(29)
HYDROGRAPHS	0.0977	0.152					D3 56	0.28	0.0426 K	(30)

	POINT # 13 S								POINT # 13 N							
TIME	K (See p2)		Developed qp			Historic qp			K (p3)		qp Dev			qp Hist		
HRS	D1	D3A	D1	D3A	Σ	D3A	Σ		D2	D3B	D2	D3B	Σ	D3B	Σ	
0	0	0	0	0	0	0	0		0	0	0	0	0	0	0	
5.0	14.26	14.78	4.31	0.08	4.39	0.06	4.36		13.87	14.8	1.07	0.37	1.44	0.28	1.35	
5.5	35.01	38	10.57	0.22	10.79	0.15	10.72		33.74	38	2.59	0.99	3.58	0.76	3.35	
5.7	182.26	216.50	55.03	1.23	56.26	0.83	55.86		181.48	261.50	13.95	6.81	20.75	5.24	19.8	
5.8	499.12	599.26	150.71	3.40	154.11	2.30	153.01		534.61	859.06	41.09	22.36	63.45	17.20	58.29	
5.9	669.02	782.39	202.01	4.44	206.45	3.00	205.01		616.83	750.54	47.41	19.53	66.94	15.63	62.45	13N
6.0	500.06	513.64	150.99	2.91	153.91	1.97	152.96		516.29	545.50	39.68	14.20	53.88	10.92	50.60	13S
6.2	228.05	140.88	68.86	0.80	69.66	0.54	69.40		251.42	113.38	19.32	2.95	22.27	2.27	21.59	10 yr
6.5	60.97	43.10	18.41	0.24	18.65	0.17	18.58		67.54	45.67	5.19	1.19	6.38	0.91	6.11	
7.0	26.37	27.61	7.96	0.16	8.12	0.11	8.07		27.32	27.46	2.10	0.71	2.81	0.55	2.65	
8.0	19.15	19.13	5.78	0.11	5.89	0.07	5.86		18.84	19.8	1.45	0.50	1.95	0.38	1.83	
10.0	10.52	10	3.18	0.06	3.23	0.04	3.21		10.67	10	0.82	0.26	1.08	0.20	1.02	
12.0	9.63	10	2.91	0.06	2.96	0.04	2.95		9.47	10	0.73	0.26	0.99	0.20	0.93	
15.75	0	0	0	0	0	0	0		0	0	0	0	0	0	0	

13 S Routing See p 4 for Raw Data

TIME	qp	78" CMP outlet				
HRS	In	qp out	qp ST	Δ ST	ST-CF	WS Elev
0	0	0	0		0	48.28
				36.7		
5.0	4.39	4.39	0		36.7	48.64
				54.0		
5.5	10.79	10.73	0.06		90.7	49.17
				511.2		
5.7	56.26	54.90	1.36		601.9	50.86
				1688.4		
5.8	154.11	146.09	8.02		2290.3	52.92
				1578.6		
5.9	206.45	205.70	0.75		3868.9	54.11
				-1207.8		
6.0	153.91	161.37	-7.46		2661.1	53.23
				-1872.2 @ 0.13		
6.2	69.66	69.66			788.9	51.23
6.5	18.65	18.65 same				
7.0	8.12	8.12				

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Project: BM Oaks
Calc. by: OEW date: 7.15
Checked by: date:

13N Routing See p5 for Storage Data

TIME HRS	Qp IN	60" CMP Qp OUT	Qp ST	ST - CF	WS Elev
0	0	0	0	0	49.71
				3.8	
5.0	1.44	1.44	~0	3.8	49.80
				5.6	49.94
5.5	3.58	3.58	~0	9.4	49.5
				43.2	
5.7	20.75	20.63	0.12	52.6	51.02
				421.2	
5.8	63.45	61.23	2.22	473.8	52.81
				82.1 @ 0.02	
5.9	66.94	66.94	0	555.9	52.98
6.0	53.88	53.88			
6.2	27.27	27.27			
6.5	6.38	6.38			
7.0	2.81	2.81			
8.0	1.95	1.95			
10.0	1.08	1.08			
12.0	0.99	0.99			
15.75	0	0			

Qp Dev'p = 13S + 13N outfalls routed by T_T = 0.0170 hrs + D3c + D4 dev'p

Routing To Pt #13 For D4 Info See p7 84-26-88 Dwg

TIME HRS	K's 20 D1	22 D2	30 D3	29 D4	28 D3C	Qp HISTORIC D1	D2	D3	D4	Σ	Qp Dev'p 13S+N	T_T	24 D3C	25 D4	Σ
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5.0	14.08	7.48	14.52	14.44	14	4.25	0.57	0.62	0.22	5.66	5.83	5.76	0.15	0.35	6.26
5.5	38.99	36.55	38	38	38	10.26	2.81	1.62	0.57	15.26	14.31	13.89	0.42	0.92	15.23
5.7	170.60	216.46	236.00	242.00	295	51.51	16.64	10.04	3.63	81.82	75.53	71.32	3.04	5.88	80.24
5.8	465.01	645.80	711.84	746.48	937	140.41	49.63	30.30	11.18	231.52	207.37	194.99	10.37	18.13	223.49
5.9	630.92	717.77	768.56	764.32	791	190.35	55.16	32.71	11.45	289.68	272.64	257.81	8.20	18.56	284.57
6.0	495.43	524.36	529.76	534.72	562	149.60	40.30	22.55	8.01	220.45	215.25	210.63	6.72	12.99	229.84
6.2	257.74	171.72	128.92	125.24	105	77.82	13.16	5.49	1.88	98.35	96.99	95.79	1.16	3.04	100.00
6.5	67.06	51.30	44.40	44.80	47	20.24	3.94	1.89	0.67	26.75	25.03	25.57	0.52	1.09	27.18
7.0	26.61	26.70	26.44	26.68	28	8.03	2.05	1.13	0.40	11.61	10.93	11.57	0.31	0.65	12.52
8.0	18.94	19.30	19.52	19.41	19	5.72	1.48	0.83	0.29	8.32	7.84	7.77	0.21	0.47	8.46
10.0	10.70	10.23	10	10	10	3.23	0.79	0.43	0.15	4.59	4.31	4.45	0.11	0.24	4.81
12.0	9.50	9.82	10	10	10	2.87	0.77	0.43	0.15	4.20	3.95	4.00	0.11	0.24	4.35
15.75	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

← (13) 10 yr

1" = 400'

MAJOR BASIN	SUB BASIN	AREA Planim. Read.	AREA MILE	BASIN LENGTH	BASIN HEIGHT	Tc	K	SOIL GROUP	DEV. TYPE	CURVE NO.	FLOW Q	FLOW qp	Return Period
C	1	184.11 Ac	0.2877	6000	2400	0.150	900	D B	GJW 6-10-87	74	1.11 / 2.05	287 / 531	10 / 100
	2A	10.16						HIST B	Oak 37%	55			
		5.95						Dev'p B	SF See 4-25	71.1			
		16.11	0.0925	2020	160	0.121	950	B	Mix	60.9	0.486 / 1.133	42.7 / 99.5	10 / 100
	2B	2.46	0.0124	1320	83	0.098	990	B	See 4-25	71.1	0.945 / 1.827	13.2 / 25.5	10 / 100
B	4	206.61 Ac	0.3228	6600	2660	0.161	860	D B	See GJW 6-10	89	2.19 / 5.39	605 / 941	10 / 100
	5A	6.19						HIST B	Oak 37% See 4-25	55 ~~70.3~~			
		0.25						B	SF See 4-25	70.3			
		6.44	0.0370	2740	228	0.150	900	B	Mix	55.6	0.298 / 0.820	9.9 / 27.3	10 / 100
	5B	1.79						B	SF	70.3			
		0.73						B	Oak	55			
		2.52	0.0145	1020	46	0.089	990	B	Mix	65.9	0.686 / 1.453	9.8 / 20.8	10 / 100

HYDROLOGIC COMPUTATION – BASIC DATA

PROJ: Broadmoor Oakes

By: OEW
Date: 7-15

24 hr
$I_{10} = 3.3"$
$I_{100} = 4.6"$

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$$T_c = \left(\frac{11.9 L^3}{H}\right)^{0.385}$$

Project BM Oaks

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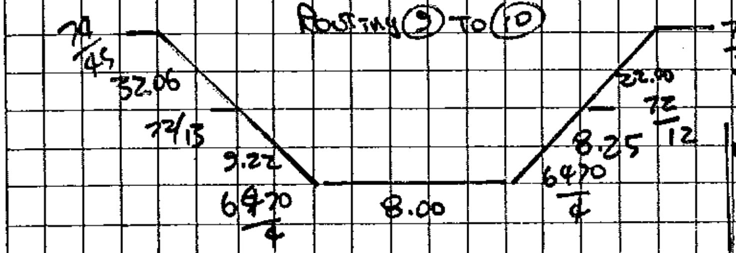
Calc. by OEW date 7.15

Checked by ______ date ______

PT#10 Hydrograph Info 100yr

Basin	T_c-hr	A-SM	Developed CN	Developed Q	Developed q_p	Historic CN	Historic Q	Historic q_p
C1	0.150	0.2877	74	2.05	0.5898K (20)	74	2.05	0.5898K (20)
C2A	0.121	0.0925	60.9	1.133	0.1048K (21)	55	0.79	0.0731K (23)
C2B	0.096	0.0124	71.1	1.827	0.0227K (22)	55	0.79	0.0098K (24)

Routing (9) to (10)



Q = 531 CFS
n = 0.060
S = 8.20%

WSEl	A	WP	R	Q	V
74	137.00	79.62	1.7207	1395	
72	33.00	25.47	1.2956	278.1	
72.45	56.55			531	9.39

Inflow/Outflow: Basin C_1 $T_T = \frac{2020}{9.39 \times 3600} = 0.0598$ (10)

See 6-23-88 run data

78" Inlet in 90" CMP P/2

TIME HRS	K C_1	K C2A	q_p Developed C1	q_p Developed C2A	q_{p} in Total	q_p Historic C2A	q_p Historic Total	q_o out	q_p Stored	ST-CFS	ST-CFS (cum.)	WS Elev
0	0	0	0	0	0	0	0	0	0		0	25.47
										69.0		
5.0	13.90	14.21	8.20	1.49	9.69	1.04	9.24	9.69	0		69.0	25.78
										117.0		
5.5	34.18	~~20.16~~ 38	~~38~~ 20.16	3.98	24.14	2.78	22.94	24.01	0.13		186.0	26.32
										806.4		
5.7	189.22	259.25	111.60	27.17	138.77	18.94	130.54	136.66	2.11		992.4	29.98
										11536.2		
5.8	565.14	~~333.31~~ 846.07	333.31	88.67	421.98	61.83	395.14	360.00	61.98		12528.6	35.08
										16835.4		
5.9	631.97	752.13	372.73	78.83	451.55	54.96	427.69	420.00	31.55		29364.0	37.21 ← @Road (10) 100yr
										-2950.2		
6.0	521.08	~~302~~ 548.98	307.33	57.53	364.86	40.12	347.45	412.80	-47.94		26413.8	36.91
										-24933.6		
6.2	236.87	114.66	139.70	12.02	151.72	8.38	148.08	173.04	-21.32		1480.2	30.65
										-1183.7 @0.03		
6.5	62.43	45.95	36.82	4.82	41.63	3.36	40.18	41.63	0		296.5	
7.0	27.34	27.37	16.12	2.87	18.99	2.00	18.12	18.99				
8.0	18.90	19.79	11.15	2.07	13.22	1.45	12.59	13.22				
10.0	10.60	10	6.25	1.05	7.30	0.73	6.98	7.30				
12.0	9.52	10	5.62	1.05	6.66	0.73	6.35	6.66				
15.75	0	0	0	0	0	0	0	0				

Project BM Oaks

Oliver E. Watts
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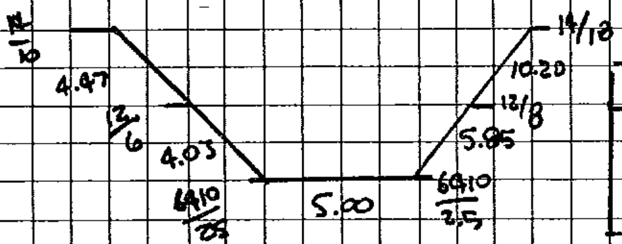
Calc. by OEW date 7-15

Checked by ______ date ______

Route To PT#10 100year

q_p = 420 cfs
n = 0.060
S = 11.1%



WS EL	A	WP	R	Q	V
12	19.00	14.88	1.2769	184.5	
14	61.00	29.55	2.0643	816.0	
12.75	34.66			420.0	12.12

T_T Road To HP#10: $\frac{1320}{12.12 \times 3600}$ = 0.0303 (10)

Use T_c for D = 0.240

Hydrograph @ PT#10 - 100yr

TIME HRS	Developed q_{pOUT}	T_T=0.0303 (11)	K C_2B (22)	$q_p C_2B$	Σq_p	HISTORIC See p 6 & 4-26
0	0	0	0	0	0	0
5.0	9.69	9.14	14	0.32	9.79	8.75
5.5	24.01	22.75	38	0.86	23.62	19.11
5.7	136.66	123.09	275	6.23	129.32	123.32
5.8	360.00	321.89	937	21.23	343.12	368.15
5.9	420.00	379.34	741	16.79	396.13	413.02
6.0	412.80	397.04	562	12.73	409.77	350.54
6.2	173.04	206.64	105	2.38	209.02	169.67
6.5	41.63	~~[illegible]~~ 46.41	47	1.06	47.48	45.80
7.0	18.99	20.96	28	0.63	21.60	18.52
8.0	12.22	~~13.29~~ 13.03	19	0.43	13.46	12.68
10.0	7.30	7.74	10	0.23	7.97	7.20
12.0	6.66	6.82	10	0.23	7.05	
15.75	0	0	0	0	0	0

HP#(10) 100year

Project BM Oaks

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Calc. by OEW date 7.21

Checked by ______ date ______

At #10 Hydrograph Info – 10 yr

Basin	Tc-hr	A-SM	Developed CN	Developed Q	Developed qp	Historic CN	Historic Q	Historic qp
C1	0.150	0.2877	74	1.11	0.3193 K (20)	74	1.11	0.3193 K (20)
C2A	0.121	0.0925	60.9	0.486	0.0450 K (21)	55	0.28	0.0259 K (23)
C2B	0.096	0.0124	71.1	0.945	0.0117 K (22)	55	0.28	0.0035 K (24)
C2	0.145	0.1066				55	0.28	0.0298 K (25)

Inflow/Outflow & Routing To HP#10 — For Raw Storage Data See 6.23.88 p 1/2

10 year

TIME HRS	K C1	K C2A	qp Developed C1	qp Developed C2A	qp In	qp out	qp ST	ST-CF Inc	ST-CF Σ	qp out @ 0.0303	qp C2B	qp @ HP#10
0	0	0	0	0	0	0	0		0	0	0	0
								36.2				
5.0	13.90	14.21	4.44	0.64	5.08	5.08	0		36.2	4.79	0.36	5.15
								54.0				
5.5	34.18	[illegible]	10.92	1.71	12.62	12.56	0.06		90.2	11.90	0.45	12.35
								414.0				
5.7	189.22	259.25	60.43	11.65	72.08	70.99	1.09		504.2	63.94	3.22	67.16
								1535.4				
5.8	565.4	846.07	180.48	38.04	218.51	211.07	7.44		2039.6	188.73	10.98	199.71
						No storage		360.0 @ 0.03 hr				
5.9	631.97	752.13	201.82	33.81	235.63	235.63	0		2399.6	212.82	8.68	221.50 ← @ 10 yr Dev
								-604.8				
6.0	521.08	[illegible]	166.41	24.68	191.08	194.44	-3.36		1794.8	183.78	6.59	190.37
								-1220.4				
6.2	236.87	114.66	75.64	5.15	80.80	80.83	-0.03		574.4	96.53	1.23	97.76
								-410.4				
6.5	62.43	65.95	19.94	2.07	22.00	22.73	-0.73		164.0	25.34	0.55	25.89
								-93.1 @ 0.07 hrs				
7.0	27.34	27.37	8.73	1.23	9.96	9.96	0		70.9	10.99	0.33	11.32
8.0	18.90	19.79	6.04	0.89	6.93	6.93				6.83	0.22	7.05
10.0	10.60	10	3.39	0.45	3.83	3.83				4.06	0.12	4.18
12.0	9.52	10	3.04	0.45	3.49	3.49				3.57	0.12	3.69
15.75	0	0	0	0	0	0				0	0	0

Maximum WS Elev @ 235.63 cfs: 6431.88

Project BM Oaks
Calc. by OEW date 7-21
Checked by ____ date ____

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HISTORIC Hydrograph PT 10 10yr See p's 5 & 6 4-26-88 Comp's

TIME HRS	Basin C1 K	(20) q_p	Basin C2 K	(25) q_p	Σ q_p
0	0	0	0	0	0
5.0	12.78	4.08	14.45	0.43	4.51
5.5	26.97	8.61	38	1.13	9.75
5.7	174.64	55.77	241.25	7.20	62.97
5.8	518.24	165.50	742.15	22.15	187.65
5.9	591.07	188.76	764.85	22.83	211.59
6.0	518.09	165.45	534.10	15.94	181.39
6.1	375.55	119.93	259.50	7.75	127.68
6.2	269.74	86.14	125.70	3.75	89.89
6.3	182.72	58.35	80.05	2.39	60.74
6.4	113.92	36.38	59.30	1.77	38.15
6.5	71.26	22.76	44.75	1.34	24.09
6.7	39.06	12.47	30.55	0.91	13.39
7.0	27.59	8.81	26.65	0.80	9.61
7.5	21.69	6.93	22	0.66	7.59
8.0	18.72	5.98	19.45	0.58	6.56
9.0	10.93	3.49	10	0.30	3.79
10.0	10.78	3.44	10	0.30	3.74
15.753	0	0	0	0	0

← (10) 10 yr HISTORIC (211.59)

Using Smaller Inlet Pipes to Lower 10yr q_{out} See p 1 of 6-23-88
Headwall Condition (1)

WS Elev	Storage Curve PR -m²-	A SF	V - CF Inc	Σ	Outlet Capacity 60" CMP HW/D	Cap. CFS	54" CMP HW/D	Cap
6425.47	0	0		0	0	0	0	0
4.53			997			109		97
6430	1.10	440		997	0.91	109	1.01	97
2			1496			64		53
32	2.64	1056		2493	1.31	173	1.45	150
2			4212			49		38
34	7.89	3156		6705	1.71	222	1.90	188
2			10776			44		32
36	19.05	7620		17481	2.11	266	2.34	220
2			19592			34		22
38	29.93	11972		37073	2.51	300	2.78	242
2			30528			40		32
6440	46.39	18556		67601	2.91	340	3.23	274

Project BMoles
Calc. by OEW date 7.21
Checked by ______ date ______

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Inflow/Outflow & Routing to HP@10 - 10 yr Event

TIME HRS	Q_p In (See p12)	Q_p out (60" CMP outlet)	Q_p ST	ST-CF In	Σ	Q_p out @0.303	Q_p C2B	ΣQ_p @(10)	Q_p out (54" CMP)	Q_p ST	ST-CF	Q_p @0.753	Q_p @10
0	0		0		0		0		0	0	0	0	0
				19.0							52.2		
5.0	5.08	5.08	0		19.0	4.79	0.36	5.15	5.08	0	52.2	4.79	5.15
				99.0							81.0		
5.5	12.62	12.51	0.11		118.0	11.85	0.49	12.36	12.53	0.09	133.2	11.87	12.32
				529.2							590.4		
5.7	72.08	70.72	1.36		647.2	62.73	3.22	65.95	70.53	1.55	723.6	63.53	66.75
				3976.2							5902.2		
5.8	218.51	197.78	20.73		4623.4	170.80	10.98	181.78	187.27	31.24	6625.8	167.45	178.43
				4447.8							9279.0		
5.9	235.63	231.65	3.98		9071.2	209.23	8.68	217.91	215.37	20.31	15904.8	194.48	203.16
				-3168.0							-460.8		
6.0	191.08	212.66	-21.58		5903.2	204.53	6.59	211.13	213.95	-22.87	15444.0	202.22	208.81 ← (10) 10yr
				-5164.1 @0.13 hr						-14448.0	-3048.4		
6.2	80.80	80.80	0		739.1	96.53	1.23	97.76	97.98	-17.18	1026.0	117.01	118.24
											-799.9 @0.03		
6.5	22.00	22.00				25.34	0.55	25.89	22.00	0	226.1	24.53	25.08
7.0	9.96	9.96				10.99	0.33	11.32	9.96			10.99	11.32
8.0	6.93	6.93				6.83	0.22	7.05	6.93			6.83	7.05
10.0	3.83	3.83				4.06	0.12	4.18	3.83			4.06	4.18
12.0	3.49	3.49				3.57	0.12	3.69	3.49			3.57	3.69
15.75	0	0					0	0				0	0

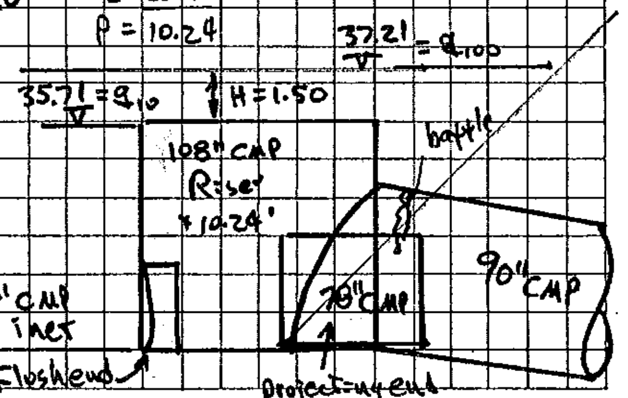
Max WS Elev above = 35.71'

$Q = C_0 L H^{3/2}$ L = πD C_0 from Fig 283
Max 100yr WS = 37.21 p10
Max 10yr WS = 35.71
H = 1.50

Max 100yr Q = 420.00 cfs See p10
Max 10yr Q = 233.31 p13 @ 100yr WS 37.21
weir Q = 186.69 cfs
Max 10yr WS = 35.71
Inv = 25.47
P = 10.24

Try D"	R_s	H/R_s	P/R_s	C_0	L	Q
78"	3.25	0.46	3.16	3.43	18.85	118.8
96"	4.00	0.38	2.56	3.6	25.13	166.2
108"	4.50	0.33	2.28	3.7	28.27	192.2

Use 108" riser



Project BM Oaks
Calc. by OEW date 7-21
Checked by ____ date ____

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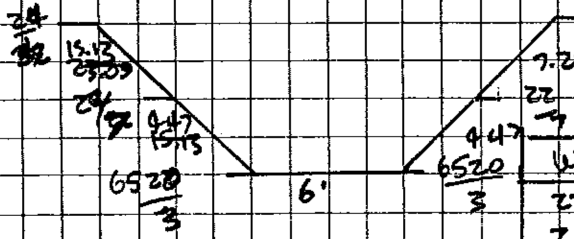
HP # 8 Hydrograph Info 100-Yr

			Developed			Historic		
Basin	Tc-Hr	A-SM	CN	Q	qp	CN	Q	qp
B4	0.161	0.3228	89	3.39	1.0943K (20)	89	3.39	1.0943K (20)
B5A	0.150	0.0370	55.6	0.820	0.0303K (21)	55	0.79	0.0292 K (23)
B5B	0.089	0.0145	65.9	1.453	0.0211 K (22)	55	0.79	0.0115 K (24)

B5

Routing (9) to (8)



qp = 941 CFS
n = 0.060
S = 8.93%

WS	A	WP	R	Q	V
22	20.00	14.94	1.338	1798	
24	70.00	37.35	1.874	7875	
24.51	82.63			941	11.39

Tr (9) - Street:

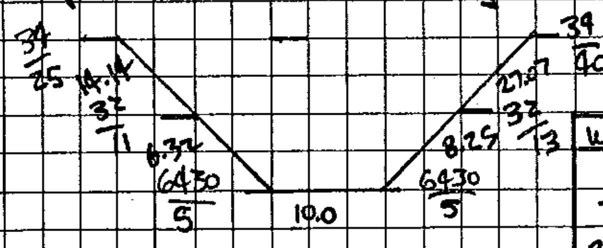
$T_T = \frac{2740}{11.39 \times 3600} = 0.0668 \text{ hrs}$ (19)

Use Tc of B4 = 0.161 + 0.067 = 0.228

Street Hydrograph:

TIME	Basin B4		Developed			Historic		
HRS	K	qp (20)	Basin B5A K	qp (21)	Total CFS	Basin B5A K	qp (23)	Total CFS
0	0	0	0	0	0	0	0	0
5.0	14.76	16.15	14.50	0.44	16.59	14.50	0.42	16.57
5.5	35.38	38.72	38	1.15	39.87	38	1.11	39.83
5.7	147.52	161.43	237.5	7.21	168.63	237.5	6.94	168.37
5.8	359.23	393.10	720.5	21.86	414.96	720.5	21.06	414.16
5.9	601.71	658.44	767.5	23.29	681.73	767.5	22.43	680.88
6.0	488.86	534.95	531	16.11	551.06	531	15.52	550.48
6.2	328.74	359.74	128	3.88	363.63	128	3.74	363.48
6.5	119.49	130.76	44.5	1.35	132.11	44.5	1.30	132.06
7.0	35.88	39.26	26.5	0.80	40.07	26.5	0.77	40.03
8.0	21.67	23.72	19.5	0.59	24.31	19.5	0.57	24.28
10.0	11.17	12.23	10	0.30	12.53	10	0.29	12.52
12.0	10.22	11.18	10	0.30	11.49	10	0.29	11.47
15.75	0	0	0	0	0	0	0	0

Routing To HP # 8 See Next Pg



qp = 634.05 CFS (see next Pg)
S = 10%
n = 0.060

WS	A	WP	R	Q	V
32	34.00	24.57	1.3838	330.7	
34	123.00	65.79	1.8696	1462.0	
32.54	57.94			635.05	10.96

T_T: Road To HP # 8: $T_T = \frac{1020}{10.96 \times 3600} = 0.0259 \text{ hrs}$ (10)

Use Tc for qpout = 0.228 + 0.026 = 0.254 hrs

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Project BM Oaks
Calc. by OEW date 7-21
Checked by ______ date ______

Storage Data - See p 8 of 5-3-88 — MCES Cond(1) 120" CMP

Elev	PR	A-SF	V-CF	Hw/D	Cap
6464	0	0	0	0	0
			800		58
66	0.02	800	800	0.20	58
			2600		95
68	0.18	1800	3400	0.40	153
			4300		167
6470	0.25	2500	7700	0.60	320
			7100		200
72	0.46	4600	14800	0.80	520
			14800		190
74	1.02	10200	29600	1.00	710
			4700		80
74.5			34300	1.05	790

Inflow/Outflow & Routing to HP 8 — See p 4 & 5 4-26-88

Time Hrs	Qp In	120" CMP Qp out	Qp ST	ST-CF-	Basin B5B K	Qp (24)	Qp out @ 8	Qp @ 8	Historic Qp
0	0	0	0	0 (270.0, ~~328.8~~)	0	0	0	0	0
5.0	16.59	16.58	0.03 (~~16.56~~)	270.0 (~~3288~~)	14	0.30	16.24	16.54	15.51
				270.0					
5.5	39.37	39.59	0.28	549.0	38	0.80	37.81	38.62	36.55
				3042.0					
5.7	168.63	160.46	8.17	3591.0	275	5.79	146.98	152.77	180.16
				6490.8					
5.8	414.96	387.07	27.89	10,081.8	937	19.74	352.20	371.94	547.33
				13602.6					
5.9	681.73	634.05	47.68	23684.4	741	15.61	581.64	597.25	638.63
				-1920.6					
6.0	551.06	609.41	-58.35	21763.8	562	11.84	587.12	598.96	572.73
				-12514.9 0.12					
6.2	363.63	363.63	0	9248.9	105	2.21	412.99	415.20	339.83 (~~546.46~~)
6.5	132.11	132.11	0		47	0.99	142.86	143.85	86.73
7.0	40.07	40.07	0		28	0.59	44.34	44.93	31.18
8.0	24.81	24.31	0		19	0.40	24.07	24.47	21.26
10.0	12.53	12.53	0		10	0.21	13.27	13.48	12.37
12.0	11.49	11.49	0		10	0.21	11.89	12.10	10.53
15.75	0	0	0	0	0	0	0	0	0

← PT 8 100 year (638.63)

Project BM Acres

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Calc. by OEW date 7-21

Checked by ______ date ______

HP#8 Hydrograph Info - 10yr

Basin	Tc-hr	A-SM	Developed CN	Developed Q	Developed qp	Historic CN	Historic Q	Historic qp
B4	0.161	0.3228	89	2.18	0.7037K (20)	89	2.18	0.7037K (20)
B5A	0.150	0.0370	55.6	0.298	0.0110K (21)	55	0.28	0.0104K (23)
B5B	0.083	0.0145	65.9	0.686	0.0099K (22)	55	0.28	0.0041K (24)
B5	0.165	0.0514				55	0.28	0.0406K (25)

K's are all the same as in the 100year Analysis — 0.0144K @ 25.38 See pg 4&5 Stock

Inflow/Outflow - Routing To HP#8 / 120" RCP — Developed / Historic @8

Time Hrs	B4 qp	B5A qp	Σ= qp in	qp out	q ST	Storage -CF-	qp out @8	B5B qp	Σ= qp (8)	B5 qp	B4 @8	Σ= qp Hist
0	(20)	(21)	0	0	0	0	0	(22)	0	(25)	(20)	
						145.2						
5.0	10.39	0.16	10.55	10.53	0.02	145.2	10.53	0.14	10.47	0.21	9.59	9.80
						198.0						
5.5	24.90	0.42	25.32	25.12	0.20	343.2	24.99	0.38	24.38	0.55	22.51	23.06
						1659.6						
5.7	103.81	2.62	106.43	102.02	4.41	2002.8	93.45 (97.15)	2.74	96.19 (99.87)	3.26	109.95	113.21
						3749.4						
5.8	252.79	7.94	260.74	244.32	16.42	5752.2	234.77	9.32	244.09	9.43	334.85	344.28
						5432.4						
5.9	423.43	8.46	431.89	418.13	13.76	11184.6	380.46	7.37	387.83	11.16	390.44	401.60
						-1616.4						
6.0	344.01	5.85	349.87	372.61	-22.74	9568.2	341.81	5.59	347.40	7.51	354.68	362.19
						-4114.8 @ 0.10 hrs						
6.2	231.34	1.41	232.75	232.75	-0-	5453.4	264.34	1.04	265.38	1.94	215.01	216.95
6.5	84.09	0.49	84.58	84.58	0		91.46	0.47	91.93	0.63	54.63	55.26
7.0	25.25	0.29	25.54	25.54	0		28.26	0.28	28.54	0.37	19.37	19.75
8.0	15.25	0.22	15.46	15.46	0		15.31	0.19	15.50	0.28 (0.32)	13.16 (15.16)	13.44 (15.47)
10.0	7.86	0.11	7.97	7.97	0		8.44	0.10	8.54	0.14 (0.28)	7.69 (13.16)	7.84 (13.44)
12.0	7.19	0.11	7.30	7.30	0		7.55	0.10	7.65	0.14	6.51	6.65
15.75	0	0	0	0	0	0	0	0	0	0	0	0

Project Broadmoor Oaks
Calc. by OEWatts date 6.23.88
Checked by ______ date ______

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HP#10 Flood Routing

90" CMP w/78" Inlet per DLJ 4.10.88 Design

See p 8/15 5.3.88 Comps For Storage

For Outlet Capacity Use Projecting end Inlet Control

WS Elev	Storage Curve PR -in²-	A -SF-	V-CF Inc	V-CF Σ	Outlet Capacity HW/D	Cap -CFS-	
6425.47	0	0		0	0		0
4.53			997			140	
6430	1.10	440		997	0.755		140
2			1496			102	
32	2.64	1056		2493	1.088		242
2			4212			83	
34	7.89	3156		6705	1.422		325
2			10776			65	
36	19.05	7620		17481	1.755		390
2			19592			50	
38	29.93	11972		37073	2.088		440
2			30528			45	
6440	46.39	18556		67601	2.422		485

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Project: Broad Oaks
Calc. by: OEW date: 6-23
Checked by: date:

HP 10-CONT $ST_{CF} = 1800 \times \Sigma CFS_{ST} \times \Delta T_{hr}$ See p 6/15 4-26-88

TIME -HRS-	ΔT -hrs-	q_I in	q_O out	q ST	Storage - CF - Inc	Storage - CF - Σ	WS Elev
0		0				0	25.47
	5.0				63.0		
5.0		9.41	9.403	0.007	~~63.0~~	63.0	25.76
	0.5				84.6		
5.5		20.84	20.753	0.087		147.6	26.14
	0.2				794.5		
5.7		134.32	132.20	2.12		942.1	29.75
	0.1				9828.0		
5.8		402.01	349.53	52.48		10770.1	34.75
					15730.2		
5.9		447.91	413.00	34.91		26500.3	36.92 (Peak)
					-392.4		
6.0		374.91	412.00	-37.09		26107.9	36.88
					-19326.6		
6.1		255.19	325.47	-70.28		6781.3	34.01
6.2		175.41					
6.3		118.16					
6.4		74.87					
	0.1						
6.5		47.84					
	0.2						
6.7		27.00					
	0.3						
7.0		19.73					
	0.5						
7.5		15.65					
	0.5						
8.0		13.57					
	1.0						
9.0		7.74					
	1.0						
10.0		7.66					
	5.73						
15.73		0					

	MAJOR BASIN	SUB BASIN	1"=400' AREA Planim. Read.	AREA MILE	BASIN LENGTH	BASIN HEIGHT	Tc	K	SOIL GROUP	DEV. TYPE	CURVE NO.	FLOW Q	FLOW qp	RETURN PERIOD	INCREASED RUNOFF
(7)	B	4	206.61Ac	0.3228	6600	2660	0.161	860	D B	See GJW 6-10-87	89	2.18 / 3.39	605 / 941	10 / 100	
		5	7.03						HISTORIC B	Oak 37%	55				
			7.09Ac 1.93						Dev'p Part B	SF 19 Lots	70.3				
			8.96	0.0514	3600	405	0.165	870	B	Mix	58.3	0.389 / 0.975	17.4 / 43.6	10 / 100	
(8)		4+5		0.3742	+3600	+405	+0.165 0.326	690	B/D HISTORIC	Oak 37%	84.3	1.794 / 2.937	463 / 758	10 / 100	
				0.3742				690	Developed		86.4	1.952 / 3.134	504 / 809	10 / 100	41 / 51
(9)	C	1	184.11Ac	0.2877	6000	2400	0.150	900	D B	See GJW 6-10-87	74	1.11 / 2.05	287 / 531	10 / 100	
		2	10.16						HIST B	Oak 37%	55				
			30.89Ac 8.41						Dev'p B	SF 78 Lots	71.1				
			18.57	0.1066	2700	240	0.145	910	B	Mix	62.3	0.535 / 1.218	51.9 / 118	10 / 100	
(10)		1+2		0.3943	8700	2640	0.222	800	HISTORIC		68.9	0.705 / 1.481	222 / 467	10 / 100	
				0.3943				800	DEVELOPED		70.8	0.930 / 1.806	293 / 570	10 / 100	71 / 103
(11)	D	1	158.40Ac	0.2475	7200	2680	0.178	850	D B	GJW 6-10	76	1.22 / 2.21	252 / 465	10 / 100	
(12)		2	94.58A	0.1478	5200	1470	0.154	830	D B	GJW 6-10	62	0.52 / 1.20	68 / 156	10 / 100	

HYDROLOGIC COMPUTATION – BASIC DATA

PROJ: BROADMOOR OAKS MASTER

By: OEW

Date: 4-25-88 5-3

24 HR

$I_{10} = 3.3"$

$I_{100} = 4.6"$

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$$T_c = \left(\frac{11.9 L^3}{H}\right)^{0.385}$$

	MAJOR BASIN	SUB BASIN	AREA Planim. Read.	AREA MILE	BASIN LENGTH	BASIN HEIGHT	Tc	K	SOIL GROUP	DEV. TYPE	CURVE NO.	FLOW Q	FLOW qp	RETURN PERIOD	INCREASE RUNOFF
	D	3	12.07						B	Oak 37%	55				
			18.18Ac 4.95						B	SF 35 Lots	69.9				
			62.52Ac 17.02	0.0977	2800	235	0.152	900	B	Mix	59.3	0.422 / 1.028	37.1 / 90.4	10 / 100	
		4	6.21						B	Oak 37%	55				
			11.42Ac 3.11						B	SF 24 Lots	70.2				
			34.23Ac 9.32	0.0535	2800	275	0.144	900	B	Mix	60.1	0.454 / 1.077	21.9 / 51.8	10 / 100	
(13)	D	1-4	349.73Ac	0.5465	10,000	2915	0.252	760	D B	Developed Mix	67.7	0.775 / 1.579	322 / 656	10 / 100	27 / 38
				0.5465				760		Historic	66.4	0.710 / 1.488	295 / 618	10 / 100	
	C	3	10.32Ac 2.81	0.0161 ~~0.0044~~	1640	137	0.101	990	B	Oak 37%	55	0.28 / 0.79	4.5 / 12.6	10 / 100	
	B	6	6.32Ac 1.72	0.0099	1240	117	0.078	990	B	Oak 37%	55	0.28 / 0.79	2.7 / 7.7	10 / 100	
(14)	B C	4-6 1-3	500.97Ac	0.7828	+1120 ~~1040~~	+103	+0.093 0.399	640	B D	Historic	76.8	1.268 / 2.266	635 / 1135	10 / 100	
				0.7828				640	B D	Developed	78.1	1.356 / 2.388	679 / 1196	10 / 100	44 / 61
	C	4	22.79						B	Oak 37%	55				
			7.29						C	Oak 37%	64				
			19.39						C	R/L Fair	79				
			181.71Ac 49.47	0.2839	6320	491	0.294	720	B/C	Mix	65.7	0.678 / 1.439	139 / 294	10 / 100	

HYDROLOGIC COMPUTATION – BASIC DATA

PROJ: Broad. Oaks. M.

By: OEW

Date: 4-25-53

24 hr
I_{10} = 3.3"
I_{100} = 4.6"

Oliver E. Watts
CONSULTING ENGINEER

	MAJOR BASIN	SUB BASIN	AREA Planim. Read.	AREA MILE	BASIN LENGTH	BASIN HEIGHT	Tc	K	SOIL GROUP	DEV. TYPE	CURVE NO.	FLOW Q	FLOW qp	RETURN PERIOD	INCREASE RUNOFF
	D	5	12.37						B	Oak 37%	55				
			9.31						C	Oak 37%	64				
			2.33 8.56Ac 7.61						B C	SF 26 Lots R/L Fair	72 79				
			116.14 Ac 31.62	0.1815	5400	521	0.240	770	B C	Mix	64.7 D 63.4 H	0.586 / 1.288	81.9 / 180	10 / 100	
	D	6	0.69						B	R/L Fair	69				
			13.12						C	R/L Fair	79				
			2.56						C	Oak 37%	64				
			60.12 Ac 16.37	0.0940	3040	397	0.137	920	B C	Mix	76.2	1.232 / 2.226	106 / 192	10 / 100	
(15) South	B C	4-6 1-4	682.68 Ac	1.0667	+4930	+334	+0.248 0.647	505	B C D	HISTORIC	73.8	1.098 / 2.034	591 / 1096	10 / 100	
				1.0667				505	B C D	Developed	74.8	1.150 / 2.114	619 / 1139	10 / 100	28 / 43
(15) North	D	1-5	465.87 Ac	0.7279	+5810	+431	+0.280 0.532	560	B C D	HISTORIC	65.7	0.678 / 1.439	276 / 587	10 / 100	
				0.7279				560	B C D	Developed	66.6	0.720 / 1.502	293 / 612	10 / 100	17 / 25
(15) E	B C D	4-6 1-4 1-5	1148.55 Ac	1.7946			0.647	505	B C D	Hist	70.5	0.915 / 1.785	829 / 1618	10 / 100	
				1.7946				505	B C D	Dev	71.5	0.965 / 1.855	875 / 1681	10 / 100	46 / 63
(16)	B C D	4-6 1-4 1-6	1208.67 Ac	1.8885	+1240	+26	+0.139 0.786	450	B C D	Hist	70.8	0.930 / 1.806	790 / 1535	10 / 100	
				1.8885				450	B C D	Dev	71.7	0.975 / 1.869	829 / 1588	10 / 100	39 / 53

HYDROLOGIC COMPUTATION — BASIC DATA

PROJ: Broad. Oaks M.

By: OEW

Date: 4-25

24 hr

$I_{10} = 3.3''$

$I_{100} = 4.6''$

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Project BROADMOOR OAKS

Oliver E. Watts
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Calc. by OEW date 4-25-88/5-3

Checked by ______ date ______

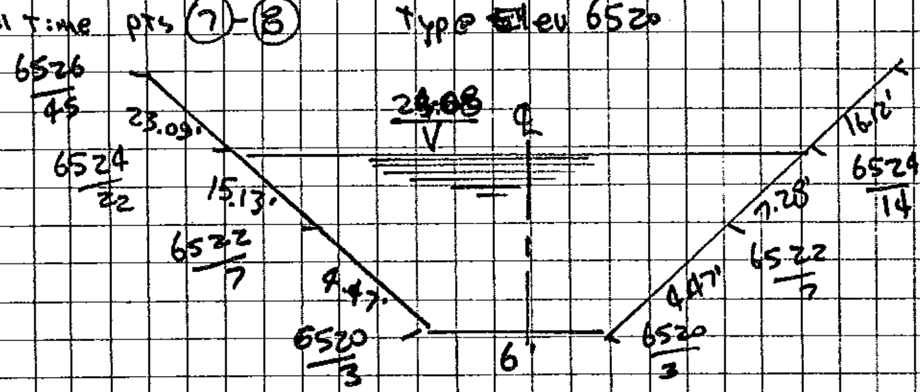
DETAILED HYDROGRAPHS 100 yr, 24 hr, I=4.6"

BROADMOOR OAKS OUTFALLS $q_p = KAQ$ $T_b = 2.67 T_p$

PT #(8)

Basin	Tc-hr	A-SM	Developed CN	Q	q_p	Historic CN	Q	q_p
B4	0.161	0.3228	89	3.39	1.0943K (11)	89	3.39	1.0943K (11)
B5	0.165	0.0514	58.3	0.975	0.0501 K (12)	55	0.79	0.0406K (13)
Σ	0.326	0.3742	84.4	3.134	809± See below	84.3	2.932	758± See below

Travel time pts (7)-(8) Type Elev 6520



S = 8.93%
n=0.060
Choked, Brushy

For d:

WSEl	A	WP	R	Q	V-fps
6522	20.00	14.94	1.338	179.8	
24	70.00	37.35	1.874	787.5	
6524.08	71.77			809	11.27

B4 T_T : $\frac{3780}{11.27 \times 3600}$ = 0.0932

TIME HRS.	Basin B4 K	Basin B4 q_p	Developed Basin B5 K	Developed Basin B5 q_p	Developed Total -cfs-	Historic Basin B5 K	Historic Basin B5 q_p	Historic Total -cfs-	Δ q_p cfs	Increase Runoff -cf- Inc	Increase Runoff -cf- Σ
0	0	0	0	0	0	0	0	0	0		0
										1245	
5.0	13.63	14.9162	14.65	0.73	15.65	14.65	0.595	15.58	0.1383		1245
										450	
5.5	31.99	35.0068	38	1.90	36.91	38	1.54	36.59	0.3613		1694
										905	
5.7	156.24	170.9701	226.25	11.34	182.31	226.25	9.19	180.16	2.1535		2600
										1510	
5.8	475.84	520.7083	655.55	32.85	553.56	655.55	26.62	547.33	6.2342		4110
										2449	
5.9 (q_p →)	554.83	607.1460	775.45	38.86	646.01	775.45	31.49	638.63	7.3738		6,558
										2220	
6.0	504.02	551.5451	521.70	26.14	577.69	521.70	21.18	572.73	4.9608		8,779
										1368	
6.1	488.16	534.1896	277.50	13.91	548.10	277.50	11.27	545.46	2.6387		10,147
										706	
6.2	305.54	334.3540	134.90	6.76	341.11	134.90	5.48	339.83	1.2827		10,853

Project BROAD OAKS
Calc. by OEW date 4-26/63
Checked by ______ date ______

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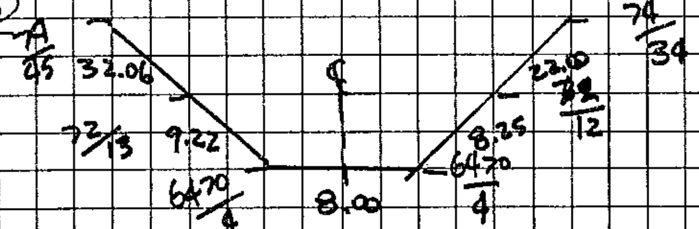
PT#8 -cont-	TIME -Hrs-	Basin B1 t	qp	Developed Basin B5 K	qp	Total -CFS-	Historic Basin B5 K	qp	Total -CFS-	Δ qp -CFS-	Increase Runoff Inc	Σ
	6.3	200.47	212.3739	81.85	4.10	223.47	81.85	3.32	222.70	0.7783	371	11,224
	6.4	126.09	137.9793	58.40	2.93	140.91	58.40	2.37	140.35	0.5553	240	11,464
	6.5	77.63	84.9482	43.75	2.19	87.14	43.75	~~2.19~~ 1.78	~~87.14~~ 86.73	0.4160	175	11,639
	6.6	54.12	59.2231	36.65	1.84	61.06	36.65	1.49	60.72	0.3485	138	11,776
	6.7	40.67	44.5049	30.35	1.52	46.03	30.35	1.23	45.74	0.2886	115	11,891
	6.8	32.76	35.8490	28.05	1.41	37.25	28.05	1.19	36.99	0.2667	100	11,991
	7.0	27.53	30.1259	26.05	1.31	31.43	26.05	1.06	31.18	0.2477	185	12,176
	7.5	21.54	23.5710	22	1.10	24.67	22	0.89	24.46	0.2092	411	12,588
	8.0	18.70	20.4633	19.65	0.98	21.45	19.65	0.80	21.26	0.1868	356	12,944
	9.0	11.04	12.0810	10	0.50	12.58	10	0.41	12.49	0.0951	507	13,451
	10.0	10.93	11.9606	10	0.50	12.46	10	0.41	12.37	0.0951	342	13,794
	12.0	9.25	10.1222	10	0.502	10.62	10	0.41	10.53	0.0950	685	14,478
	15.7530	0	0	0	0	0	0	0	0	0	642	15,121 ← #8

PT#10 :

Basin	T_c-hr	A-SM	Developed CN	Q	qp	Historic CN	Q	qp
C1	0.150	0.2877	74	2.05	0.5898K (15)	74	2.05	0.5898K (15)
C2	0.146	0.1066	52.3	1.218	0.1298K (16)	55	0.79	0.0842K (17)
Σ	0.222	0.3943	70.8	1.806	570 ±	68.9	1.431	467 ±

Travel Time (#9) to (#10)



n = 0.060
S = 8.20%

For d:

Wgt	A	WP	R	Q	V
74	137.00	79.62	1.7207	1395	
72	33.00	25.47	1.2956	278.1	
72.52	60.18			570	9.47

Basin C1 $T_T = \frac{2640}{9.47 \times 3600} = 0.0774$ (10)

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Project Broad Oaks
Calc. by OEW date 4-26/5-3
Checked by ______ date ______

#10 CONT

TIME ~HRS.	Basin C1 K	q_1 ~cfs	Developed Basin C2 K	Developed Basin C2 q_p	Σ q_p	Historic Basin C2 K	Historic Basin C2 q_p	Σ q_p	Δ q_1 ~cfs~	Increase Runoff Inc	Σ
0	0	0	0	0	0	0	0	0	0		0
	(15)		(16)			(17)					
5.0	12.78	7.5375	14.45	1.88	9.41	14.45	1.22	8.75	0.6592	5933	5,933
5.5	26.97	15.9065	38	4.93	20.84	38	3.20	19.11	1.7337	2154	8,087
5.7	174.64	103.0001	241.25	31.72	134.32	241.25	20.32	123.32	11.0069	4587	12,673
5.8	518.24	305.6502	742.15	96.36	402.01	742.15	62.50	368.15	33.8604	8076	20,749
q_1 → 5.9	591.07	348.6042	764.85	99.31	447.91	764.85	64.41	413.02	34.8961	12376	33,126
6.0	518.09	305.5617	534.10	69.35	374.91	534.10	44.98	350.54	24.3682	10668	43,793
6.1	375.55	221.4938	259.50	33.69	255.19	259.50	21.85	243.35	11.8396	6517	50,311
6.2	269.74	159.0886	125.70	16.32	175.41	125.70	10.59	169.67	5.7350	3163	53,474
6.3	182.72	107.7655	80.05	10.39	118.16	80.05	6.74	114.51	3.6523	1690	55,164
6.4	113.92	67.1883	59.20	7.69	74.87	59.20	4.99	72.17	2.7010	1144	56,307
6.5	71.26	42.0281	44.75	5.81	47.84	~~46.68~~ 44.75	77 3.88	45.80	2.0417	854	57,161
6.7	39.06	23.0370	30.55	3.97	27.00	~~26.20~~ 30.55	2.57	25.61	1.3938	1237	58,397
7.0	27.59	16.2722	26.65	3.46	19.73	~~18.68~~ 26.65	2.24	18.57	1.2159	1409	59,807
7.5	21.69	12.7924	22	2.86	15.65	22	1.85	14.65	1.0038	1998	61,804
8.0	18.72	11.0408	19.45	2.53	13.57	19.45	1.64	12.68	0.8874	1702	63,506
9.0	10.93	6.4464	10	1.30	7.74	10	0.84	7.29	0.4562	2418	65,925
10.0	10.78	6.3579	10	1.30	7.66	10	0.84	7.20	0.4562	1642	67,567
15.753	0	0	0	0	0	0	0	0	0	3082	70,649 ← (10)

Pt #(13)

Basin	T_c hr	A. SM	Developed CN	Developed Q	Developed q_p		Historic CN	Historic Q	Historic q_p	
D1	0.178	0.2475	76	2.21	0.5470 k	(20)	76	2.21	0.5470 k	20
D2	0.154	0.1478	62	1.20	0.1774 k	(21)	62	1.20	0.1774 k	21
D3	0.152	0.0977	59.3	1.028	0.1004 k	(23)	55	0.79	0.0772 k	23
D4	0.144	0.0535	60.1	1.077	0.0576 k	(24)	55	0.79	0.0423 k	25
Σ	0.252	0.5466	62.7	1.579	656±	62	66.4	1.488	618±	See below

Project BROAD OAKS
Calc. by OEW date 4-26
Checked by ______ date ______

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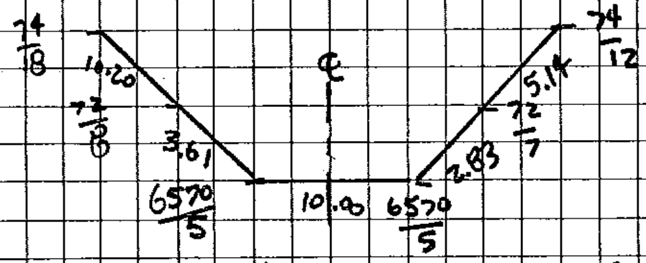
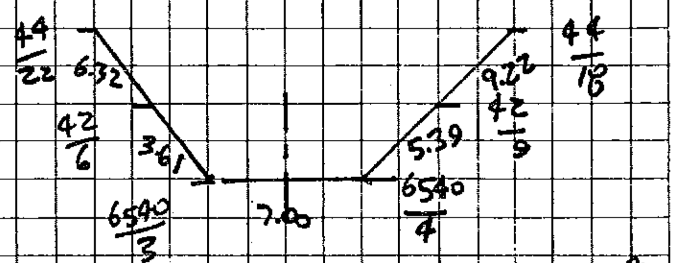
PT #(3) Cont:

ROUTING D1 TO HP #13



ROUTING D2 TO HP #13



Q_p = 465 n = 0.060 S = 9.09% Q_p = 156 n = 0.060 S = 8.20%

For d:

d	A	WP	R	Q	V	d	A	WP	R	Q	V
74	70.00	31.78	2.2026	885		44	67.00	31.54	2.1243	785	
72	25.00	16.44	1.5207	247		42	22.00	16.00	1.3750	193	
72.68	40.38			465	11.52	43.62	17.78			156	8.77

$D_1: T_t = \frac{2600}{11.52 \times 3600} = 0.0627$ (10) $D_2: T_t = \frac{2860}{8.77 \times 3600} = 0.0906$ (11)

TIME	K				Q_p Developed					Q_p Historic			Δ	ST-OF-(18)	
HRS	D1	D2	D3	D4	D1	D2	D3	D4	Σ	D3	D4	Σ	Q_p	INC	Σ
0	0	0	0	0	0	0	0	0	0	0	0	0	0		0
														5055	
5.0	14.08	7.48	14.52	14.44	7.7038	1.3265	1.46	0.83	11.32	1.12	0.61	10.76	0.5617		5055
														1826	
5.5	33.99	36.55	38	38	18.5898	6.4827	3.82	2.19	31.08	2.93	1.61	29.61	1.4670		6981
														3841	
5.7	170.60	216.46	234.00	242.00	93.3165	38.3905	23.70	13.94	169.35	18.22	10.23	160.15	9.2034		10,822
														6699	
5.8	465.01	645.80	711.84	746.48	254.3487	114.5390	71.49	43.01	483.39	54.94	31.55	455.38	28.0140		17,521
														10372	
5.9	630.42	717.77	768.56	764.32	344.8235	127.3040	77.19	44.04	593.36	59.32	32.30	563.75	29.6068		27,893
														9024	
6.0	495.93	524.36	529.76	534.72	270.9889	93.0008	53.21	30.81	448.01	40.89	22.60	427.48	20.5287		36,917
														9162	
6.2	257.74	171.22	128.92	125.24	140.9770	30.3675	12.95	7.22	191.51	9.95	5.29	186.59	4.9207		46,079
														3586	
6.5	67.06	51.30	44.40	44.80	36.6819	9.0983	4.46	2.58	52.82	3.43	1.89	51.10	1.7210		49,665
														2471	
7.0	26.61	26.70	26.44	26.68	14.5526	4.7353	2.66	1.54	23.48	2.04	1.13	22.46	1.0245		52,136
														3199	
8.0	18.945	19.30	19.52	19.44	10.3624	3.4236	1.96	1.12	16.87	1.51	0.82	16.12	0.7525		55,335
														4099	
10.0	10.70	10.23	10	10	5.8503	1.8142	1.00	0.58	9.24	0.77	0.42	8.85	0.3860		59,434
														2780	
12.0	9.50	9.82	10	10	5.1953	1.7415	1.00	0.58	8.52	0.77	0.42	8.13	0.3861		62,213
														2608	
15.75															164,821 (13)

Q_p → (at 5.9)

Project Broad Oaks
Calc. by OEW date 5.3-88
Checked by ______ date ______

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EXISTING STORAGE CAPABILITIES & FUTURE REQ'S

HP#8 120" CMP x 125'± Thalweg elev 6474.5 See DLJ 2.12.88 profile

q_p (design) = 705 CFS (see p 5 of 6.16.87 calc's)

Inlet Control HW/D req'd = 1.05 = 10.5' Inv = 6464.0 @ Inlet
Ditch Inlet to Daylight @ ℄ = 6488 S = 12% in 200'
1" = 100' Master Plan

Elev	PR	A-SF	V-CF	
6464	0	0		0
			800	
66	0.08	800		800
			2600	
68	0.18	1800		3400
			4300	
6470	0.25	2500		7700
			7100	
72	0.46	4600		14800
			14800	
74	1.02	10200		29600
			4700	
74.5			18800	34300
76	0.86	8600		48400

@ 646 CFS HW/D = 0.98
HW = 6473.8
15,121 CF req'd Now (see p 5)
82,622 CF eventual See 6.16.87

El 6473.8 St = 28,120 CF OK
q_p = 646 CFS

by Interp Amt available To TW

HP#10 90" CMP x 130' Thalweg elev = 6439.0 See DLJ 4/19/88 Design
q_p = 448 CFS (see p 6) St req'd = 70,649 CF
Inlet Control HW/D = 1.33 HW elev = 6425.47 + 9.98 = 6435.44
1" = 20'

Elev	PR	A-SF	V-CF-	
6425.47	0	0		0
			996.6	
6430	1.10	440		996.6
			1496	
32	2.64	1056		2493
			4212	
34	7.89	3156		6705
			10776	
36	19.05	7620		17481
			19592	
38	29.93	11972		37073
6439.0			30528	52337
6440	46.39	18556		67601

Eventual St req'd = 232,045 CF See 6.16.87

EL 6435.44 ST = 14,464 CF
q_p = 448 CFS

488 CFS HW/D = 1.509
EL. 6436.79 25,195 CF
232,045 req'd

by Interpolation To Sag
HW = 13.5' @ 448 CFS
HW/D = 2.07 Use 78" Inlet

Project Broad Oaks
Calc. by OEW date 5-3-88
Checked by ______ date ______

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HP#13 Exist 78" CMP & 60" CMP Thalweg elev = 6461.99

Existing Developed: q_p = 593 CFS St req'd = 64,821 CF
See p7

Future Developed: q_p = 690 CFS St Req'd = 370,905 CF
See 6·16·87 & DLT 2·12·88 pipe

Storage: 1" = 100' master plan

ELEV	PR-SI	A-SF	V-CF	
48	0	0		0
			1800	
6450	0.15+0.03	1800		1800
			6200	
52	0.44	4400		8000
			9400	
54	0.50	5000		17400
			14900	
56	0.99	9900		32300
			23300	
58	1.34	13400		55600
			30100	
6460	1.67	16700		85700
			45500	
62	2.88	28800		131,200

← EL 58.58 593 CFS, ST = 64,254 CF
← EL 61.14 690 CFS, ST = 111,700 CF
← Total avail to Say

For Capacity: Headwater Inlet Control

Elev	78" CMP HW/D	78" CMP q	60" CMP HW/D	60" CMP q	Σ q
48	0	0	0	0	0
54	0.92	192	1.20	142	334
56	1.23	282	1.60	187	469
58	1.54	350	2.00	220	570
6460	1.85	405	2.40	245	650
62	2.15	445	2.80	275	720
	72"		54"		
62	2.33	470			

← 593 CFS exist dev'p, HW EL 58.58
← 690 CFS eventual, HW EL 6461.14

Oliver E. Watts CONSULTING ENGINEER	Project: Broad Oaks		
	Calc. by: OEW	date: 5.3.88	
	Checked by:	date:	

Summary

	HP #	Existing Dev'p Cond's: Qp -CFS-	WS EL	Storage -CF- available	Storage -CF- Req'd	Future Full Dev'p: Qp -CFS-	WS EL	ST Avail	ST req'd
As Designed	8	646	6473.8	28,120	15,121	705	6474.5	34,300	82,622
	10	448	6935.44	14,464	70,649	488	6936.79	25,195	232,045
	13	593	6458.52	64,254	64,821	690	6961.14	111,700	370,905
Total				106,838 CF	150,591 CF			171,195	685,572 CF
				43,752 CF Short				514,377 CF Short	
As Modified 78" CMP	8	646	6473.8	28,120	15,121				
	10	448	6439.00	52,337	70,649				
	13	593	6458.52	64,254	64,821				
				144,711	150,591				
				5,880 CF short (3.90%)					

Future Hwy 115 Detention Site - See Sheet 10A

1" = 100'

Elev	PR	A-SF	V-CF (increment)	V-CF (cumulative)
49.4	0	0		0
			640	
5950	0.08	800		640
			6100	
52	0.53	5300		6740
			20300	
54	1.50	15000		27040
			40300	
56	2.53	25,300		67340
			59800	
58	3.45	34500		127140
			80300	
5960	4.58	45800		207440
			102000	
62	5.62	56200		309440
			128100	
64	7.19	71900		437540
			164900	
66	9.30	93000		602440

← EL 64.93, 514,377 CF

Project BROAD OAKS

Calc. by OEW date 4-27

Checked by ______ date ______

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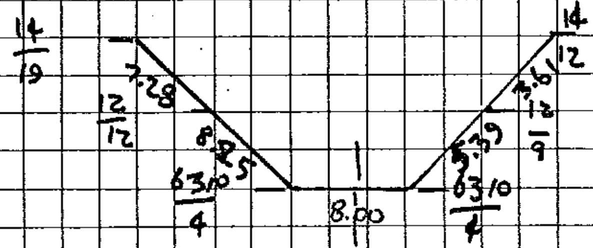
HP #15 & 16 Routings

Routing 8, 10 & 13 to 15:

Routing 8 to 14

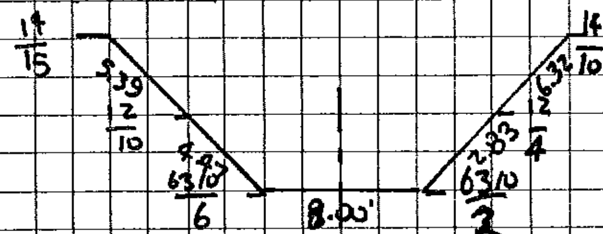


q_p = 656 CFS L = 1120' n = 0.060 S = 9.20%

WSEL	A	WP	R	Q	V
6312	29.00	21.64	1.340	264.8	
14	81.00	32.53	2.490	1117.8	
12.92	52.85			656	12.41

T_T 8-14 : $\frac{1120}{12.41 \times 3600}$ = 0.0251 hrs ← 8-14

Routing 10 to 14

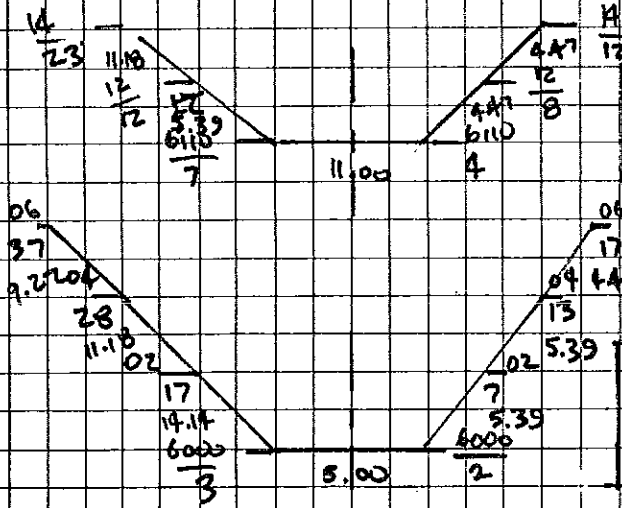


q_p = 396 CFS L = 1050' n = 0.060 S = 8.38%

6312	30.09	15.30	1.967	338.6	
14	61.00	27.01	2.258	752.8	
12.28	34.37			396	11.52

T_T 10-14 : $\frac{1050}{11.52 \times 3600}$ = 0.0253 hrs ← 10-14

Routing 14 to 15



q_p = 1020 CFS ± L = 1890' n = 0.050 S = 9.79%

6112	31.00	20.86	1.486	375.4	
14	86.00	36.51	2.356	1415.8	
13.24	65.08			1020	15.67

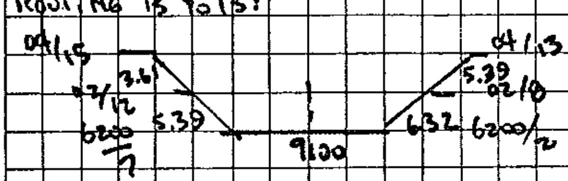
T_T = $\frac{1890}{15.67 \times 3600}$ = 0.0335 hrs

q_p = 1000 CFS ± L = ~~4430~~ 3040' n = 0.045 S = ~~3.36%~~ 4.99%

6002	29.00	24.53	1.182	237.0	
04	94.00	41.10	2.287	1192.8	
06	189.00	54.79	3.450	[illegible]	
3.60	80.89			1000	12.36

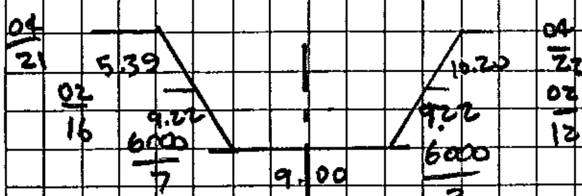
T_T 14-15 = $\frac{3430}{3600 \times 12.36}$ + 0.0335 = 0.1330 hrs ← 14-15

Routing 13 to 15:



q_p = 593 ± L = 2120' n = 0.050 S = 9.06%

6202	29.00	20.71	1.4003	324.7	
04	77.00	29.71	2.5917	1299.7	
02.55	42.21			593	14.05



q_p = 525 ± L = 3690 n = 0.045 S = 6.48%

6002	38.00	27.44	1.385	396.9	
04	109.00	43.03	2.533	1702.6	
2.20	44.97			525	11.67

T_T 13-15 : $\frac{2120}{3600 \times 14.05}$ + $\frac{3690}{11.67 \times 3600}$ = 0.1297 hrs ← 13-15

Project Broad Oaks

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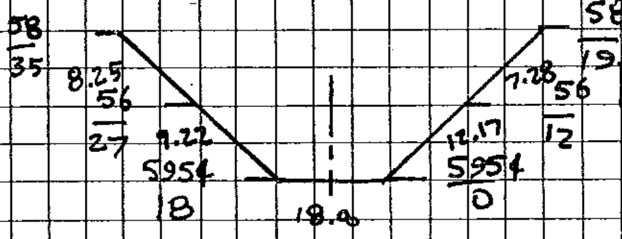
Calc. by OEW date 4·27

Checked by ______ date ______

Routing (15) - (16)

L= 1240'

q_1 = 1400 cfs± n=0.040 S= 1.85%



WS	A	WP	R	Q	V
56	57.00	39.39	1.447	368.5	
58	150.00	54.92	2.732	1481.0	
57.85	143.23			1400	9.77

T_T: (15) — (16) $= \frac{1240}{3600 \times 9.77} =$ 0.0352 hrs

Basin Routings ΣT_T:

Basin	B4	55	B6	C1	C2	C3	C4	D1	D2	D3	D4	D5	D6
T_c	0.161	0.165	0.078	0.150	0.145	0.101	0.294	0.178	0.154	0.152	0.144	0.240	0.137
TT@ HP#													
7	0												
	0.0932												
8	0.0932	0											
9				0									
				0.0774									
10				0.0774	0								
11								0					
12									0				
								0.0627	0.0906				
13								0.0627	0.0906	0	0		
	0.0251	0.0251		0.0253	0.0253								
14	0.1183	0.0251	0	0.1027	0.0253	0							
	0.1330	0.1330	0.1330	0.1330	0.1330	0.1330		0.1297	0.1297	0.1297	0.1297		
15	0.2513	0.1581	0.1330	0.2357	0.1583	0.1330	0	0.1924	0.2203	0.1297	0.1297	0	
	0.0352	0.0352	0.0352	0.0352	0.0352	0.0352	0.0352	0.0352	0.0352	0.0352	0.0352	0.0352	
16	0.2865	0.1933	0.1682	0.2709	0.1935	0.1682	0.0352	0.2276	0.2555	0.1649	0.1649	0.0352	0
A-SM	0.3228	0.0514	0.0099	0.2877	0.1066	0.0161	0.2839	0.2475	0.1478	0.0977	0.0535	0.1815	0.0940
	(11)	(12)	(14)	(15) Developed		(18)	(19)	(20)	(21)	(22)	(24)	(26)	(28)
CN	89	58.3	55	74	62.3	55	65.7	76	62	59.3	60.1	64.7	76.2
Q	3.39	0.975	0.79	2.05	1.218	0.79	1.439	2.21	1.20	1.028	1.077	1.372	2.226
qp	1.0943K	0.0501K	0.0078K	0.5898K	(16) 0.1293K	0.0127K	0.4085K	0.5470K	0.1774K	0.1004K	0.0576K	0.2490K	0.2092K
	(11)	(13)	(14)	(15) Historic		(18)	(19)	(20)	(21)	(23)	(25)	(27)	(28)
CN		55			55					55	55	63.4	
Q	Do	0.79	Do	Do	0.79 (17)	Do	Do	Do	Do	0.79	0.79	1.288	Do
qp	"	0.0406K		0.5898K	0.0842K					0.0772K	0.0423K	0.2338K	

(11) ≡ Computer storage registers

HP# 16 HISTORIC RUNOFF HYDROGRAPH

Basin	B4		B5		B6		C1		C2		C3	
Tc	T_c = 0.161		0.165		0.078		0.150		0.145		0.101	
Tr	T_r = 0.1933		0.1933		0.1682		0.2709		0.1935		0.1682	
K	(11)		(13)		(14)		(15)		(17)		(18)	
Time, hrs	K	qp	K	qp	K	qp	K	qp	K	qp	K	qp
0												
5.0	12.59	13.8	12.59	0.5	12.64	0.1	11.75	6.9	12.55	1.1	12.65	0.2
5.5	34.37	37.6	34.37	1.4	27.24	0.2	21.66	12.8	25.62	2.2	27.24	0.3
5.7	78.8	86.3	77.95	3.2	116.2	0.9	34.29	20.2	82.27	6.9	116.2	1.5
5.8	204^{16}	224.5	226^{52}	9.2	361^{8}	2.8	66.65	39.3	151^{38}	12.7	361^{8}	4.6
5.9	323^{0}	353.7	321^{03}	13.0	405^{9}	3.2	186^{75}	110.1	331^{35}	22.9	405^{9}	5.2
6.0	482^{64}	528.2	476^{74}	19.4	571^{4}	4.5	454^{18}	267.9	506	42.6	571^{4}	7.3
6.1	539^{10}	589.9	538^{34}	21.9	507^{6}	4.0	585^{54}	345.3	542	45.7	507^{6}	6.5
6.2	488^{40}	534.5	491^{39}	20.0	399^{0}	3.1	566.95	334.4	477	40.2	399^{0}	5.1
6.3	326^{60}	357^{4}	295^{1}	12.0	313^{5}	2.5	413.40	243.8	333	28.0	313^{5}	4.0
6.4	197^{67}	216^{3}	198^{46}	8.1	169^{3}	1.3	261^{98}	154.0	195	16.4	169^{3}	2.2
6.5												
6.6												
6.8												
7.0												
7.5												
8.0												
9.0												
10.0												
12.0												

Basin	C4		D1		D2		D3		D4		D5		D6		TOTAL
Tc	0.294		0.178		0.154		0.152		0.144		0.240		0.137		
Tr	0.0352		0.2276		0.2555		0.1649		0.1649		0.0352		-0-		
K	(19)		(20)		(21)		(23)		(25)		(27)		(28)		
Time, hrs	K	qp	K	qp	K	qp	K	qp	K	qp	K	qp	K	qp	Σqp
0															0
5.0	16	6.7	12.72	6.7	11.9	2.1	13.7	1.1	13.6	0.6	15	3.6	14.37	3.0	46
5.5	42^{6}	17.5	23.4	12.8	38	6.7	33	2.5	33	1.4	38.7	9.0	38	8.0	112
5.7	146^{0}	59.7	49.9	27.3	230	40.8	104	8.0	106	4.5	163^{4}	38.2	247	51.7	354
5.8	340^{5}	139.1	112	61.3	689	122.2	289	22.3	302	12.7	398	93.1	777	162.5	906
5.9	620	253.2	231	126.3	757	134.3	373	30.3	396	16.7	668	156.2	761	153.7	1389
6.0	558	227.9	448	244.8	528	93.6	499	38.5	509	21.5	517	120.8	539	112.8	1730
6.1	504	205.8	580	317.0	275	48.8	387	29.9	384	16.2	415	97.0	252	52.8	1781
6.2	413	168.7	565	309.0	140	24.8	430	33.2	424	17.9	301	70.3	122	25.5	1587
6.3	311	127.0	362	198.3	88	15.6	293	22.6	296	12.5	205	47.9	79	16.6	1088
6.4	257	104.9	226	123.9	63	11.1	176	13.6	174	7.4	158	36.8	60	12.5	708
6.5															
6.6															
6.8															
7.0															
7.5															
8.0															
9.0															
10.0															
12.0															

qp (16) ← 1781

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Project: Broad Oaks

Calc. by: [illegible] date: 5-4-88

Checked by ______ date ______

Project Broad Oaks

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Calc. by OEW date 5-4

Checked by ______ date ______

Capacity of Hwy 115 Culverts See Dwg 88-1713.02

Hwy 115 Culverts

Flowing Full: FIG 9.24

South: 84" x 216.4' CMP Ke = 0.5 H = 48.9 - 35.5 - 7 = 6.4' q_p = 360

North: — — — — H = 48.9 - 35.1 - 7 = 6.8' = 375

735 CFS

Inlet Control: FIG 9.33

South: 84" CMP Mitered @ entrance $\frac{Hw}{D} = \frac{48.9 - 40.5}{7} = 1.20$ q_p = 350

North: — — — — $\frac{Hw}{D} = \frac{48.9 - 40.41}{7} = 1.21$ q_p = 350

700 CFS ←

From p13 700 cfs exceeded 5.22 - 6.41 = 71 minutes

Norad Off Ramp Culvert

Flowing full: FIG 9.24

South: 84" x 52.7' CMP Ke = 0.50 H = 54.4 - 48.9 = 5.5' q_p = 480

North: — — — — H = — 5.5 q_p = 480

See p 13: 960 cfs 5.99 hrs — 6.33 hrs exceeded (21 minutes) 960 CFS ←

Inlet Control: Fig 9.22

South: 84" x 52.7 CMP Headwall $\frac{Hw}{D} = \frac{54.4 - 43.06}{7} = 1.62$ q_p = 510

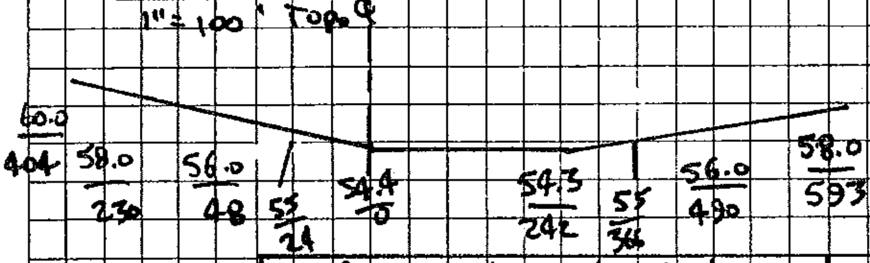
North: — — — $\frac{Hw}{D} = \frac{54.4 - 43.08}{7} = 1.62$ = 510

1020

Norad Off-Ramp Overflow Area
1" = 100' Topo

Use $d = d_c$ $Fr = 1$ $V = \sqrt{gd}$ where $d = \frac{A}{T}$

q_p = 1781 - 960 = 821 CFS ~



WSEL	A	T	d	V	q_p
54.3	0				0
56.0	648.50	538.00	1.21	6.23	4040
55.0	207.90	390.00	0.53	4.14	861
54.97					821 ←

DETENTION POND OUTFALL - FUTURE

Project Broad Oaks

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Calc. by OEW date 5.4
Checked by date

Future Road Culvert For Detention @ Hwy 115. 514,377 CF req'd
See p 10

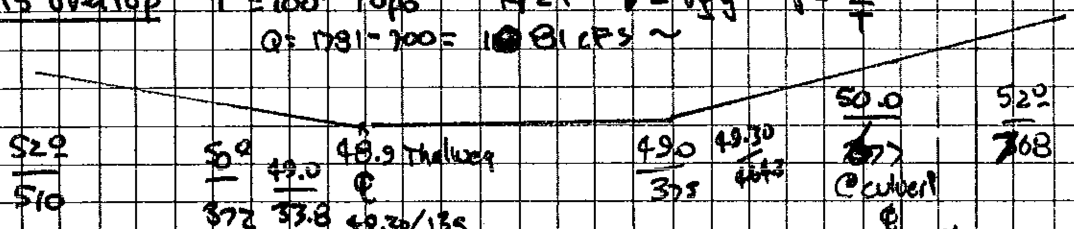
Top@ WS = 64.93 Inlet Culvert = 49.4 Tailwater = 54.97
q_p = 1781 CFS L = 100' ± See 88.1713.02

Flowing Full: H = 64.93 - 54.97 = 9.96'
9.21: 9.5' × 9.5' CBC w/headwall Say 10' × 9' CBC
9.22: RCP will not work @ 1 Use 2@96" w/headwall
9.23: Use 2 - 96" CMP w/headwall
9.24: Use 1 - 144" CMP ℄ w/headwall
or 2 - 102" CMP ℄ w/headwall

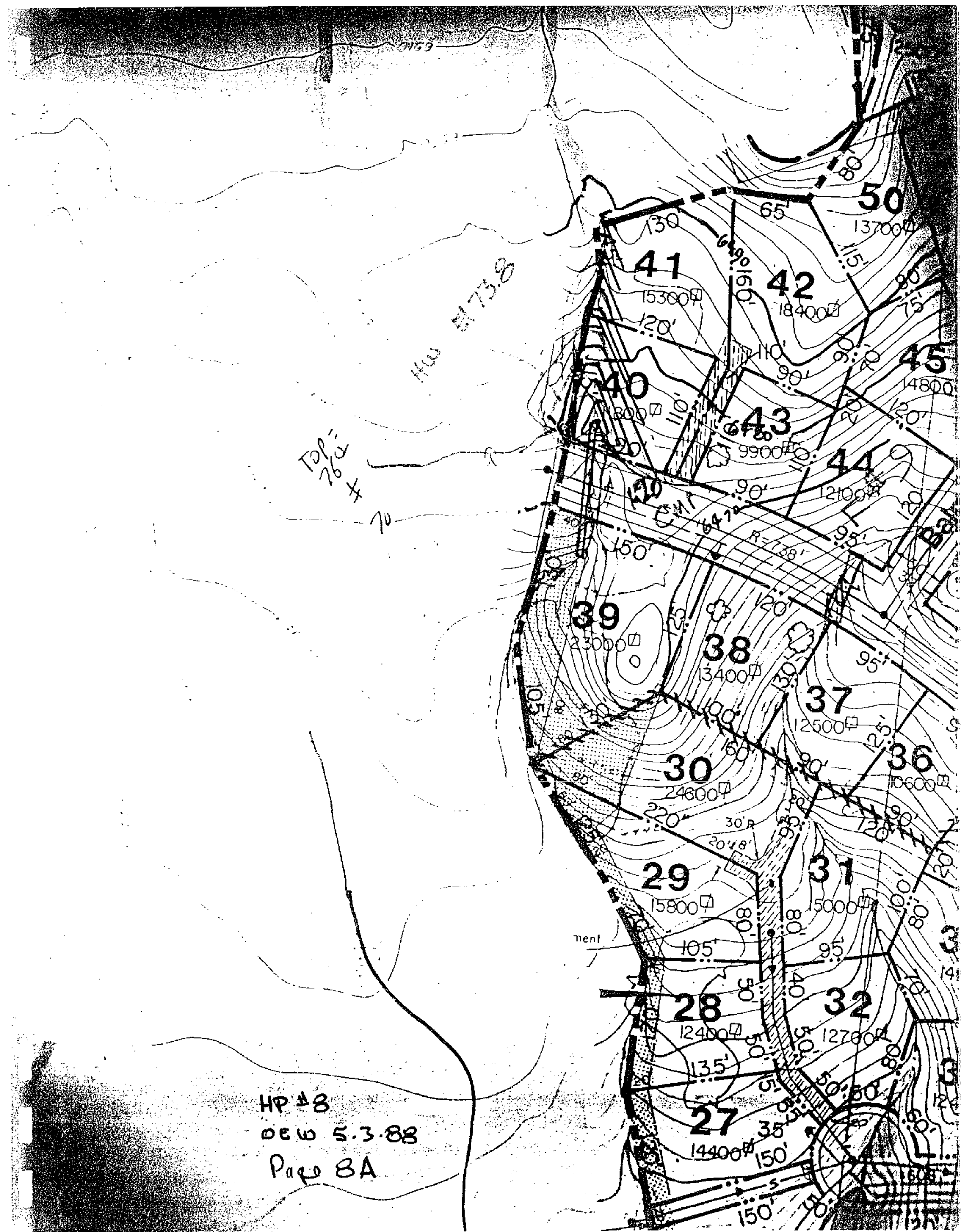
Headwater Inlet Control Check: Hw = 64.93 - 49.4 = 15.53

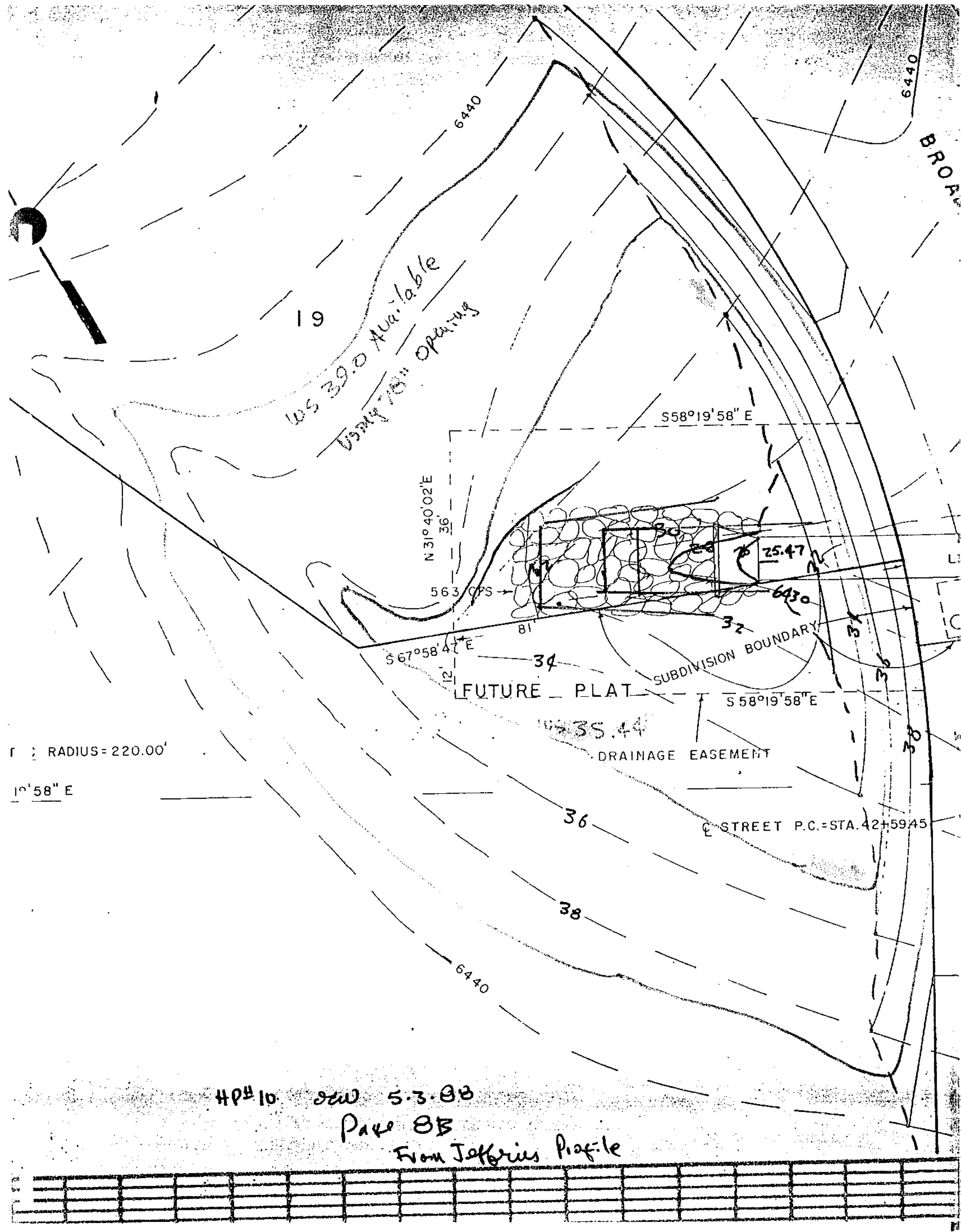
9-26: 10' × 9' CBC Hw/D = 1.73 q = 144 × 10 = 1440 Governs
Use 1781 / 141 = 13' × 9' CBC
9-32: 2@96" Hw/D = 1.94 Cap = 2 × 800 = 1600 CFS Governs
Use 2-108" Hw/D = 1.73 Cap = 2 × 990 = 1980 CFS
9-33: 2@96" Hw/D = 1.94 Cap = 2 × 800 = 1600 CFS Governs
Use 2 - 108" Hw/D = 1.73 Cap = 2000 CFS → 2-108" CMP w headwall
9.31 RCB Inlet Control, Beveled Edge
d = 9' Hw/D = 1.73 Use 1781/148 = 12' × 9' CBC

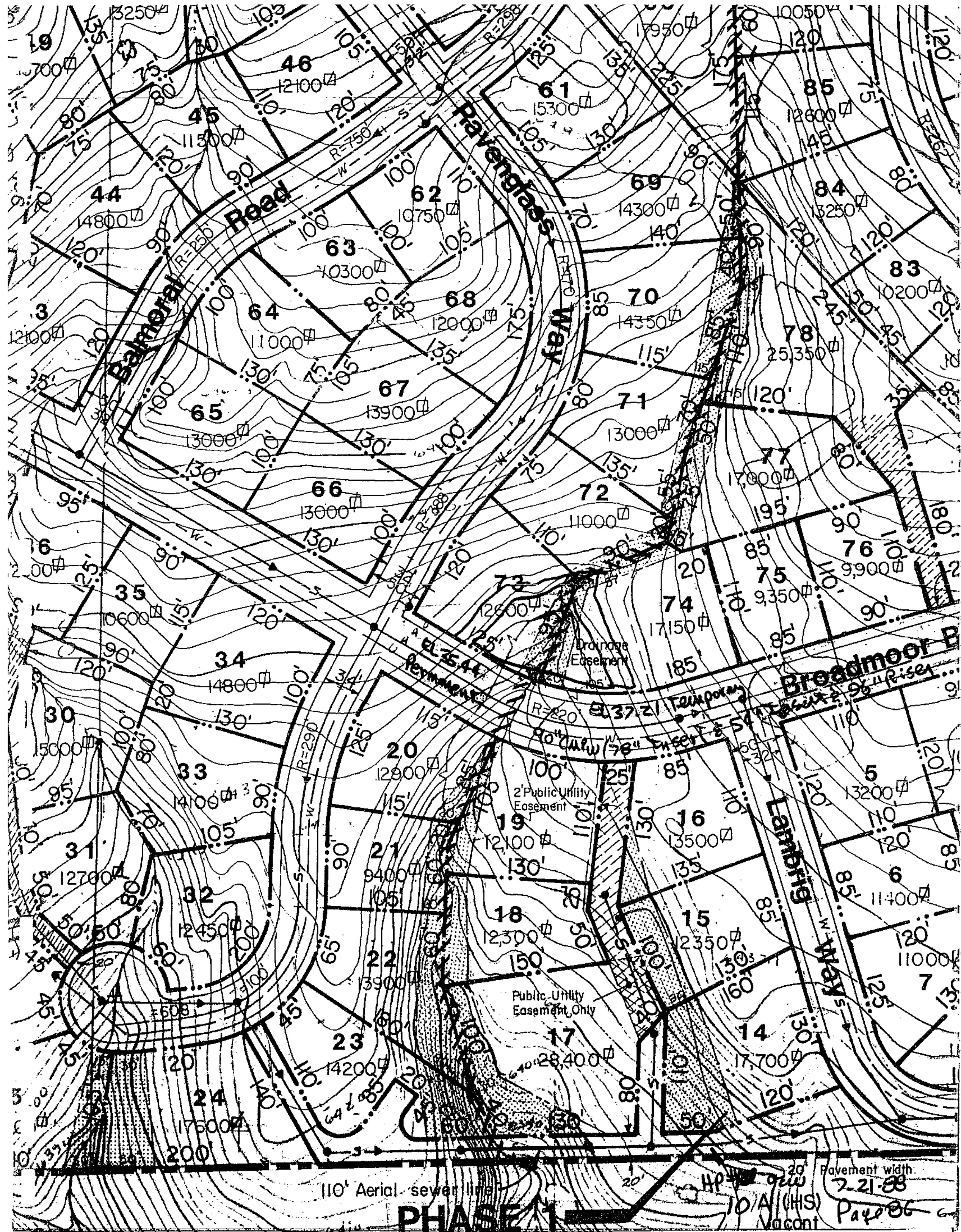
Hwy 115 overtop 1" = 100' Topo Fr = 1 $V = \sqrt{gy}$ $y = \frac{A}{T}$
Q = 1781 - 700 = 1081 CFS ~



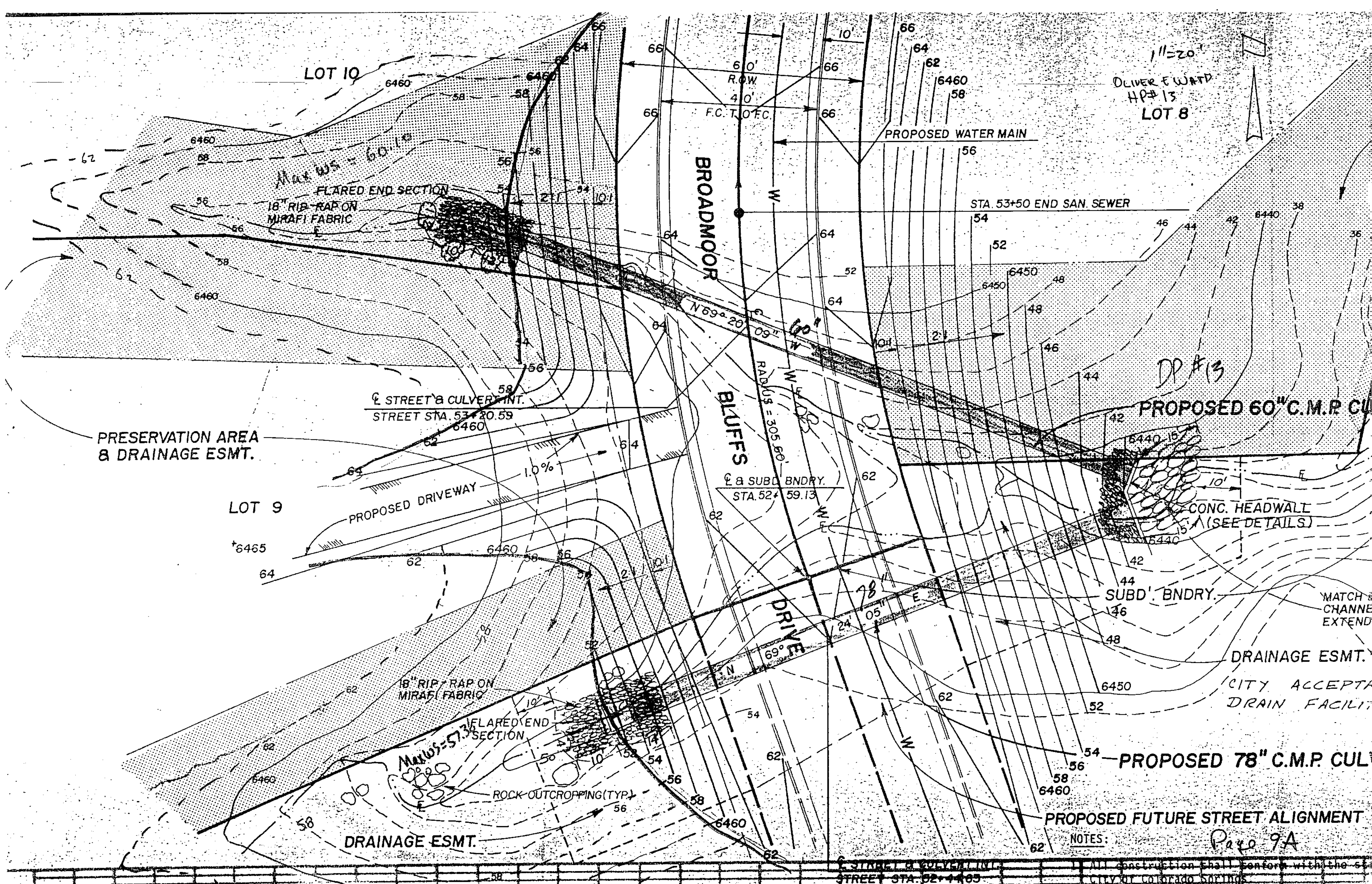
WS El	A	T	y	V	Q	
48.9	0				0	
50.0	749.35	1049	0.80 .71	5.08 4.80	3047	3594
49.0	20.44	408.8	0.05	1.27	26	
49.30					1081	


50
13700
41
15300
42
18400
45
14800
40
11800
43
9900
44
12100
39
23000
38
13400
37
12500
36
10600
30
24600
29
15800
31
15000
28
12400
32
12700
27
14400
R=738'
30'R
HP #8
DEW 5.3.88
Page 8A

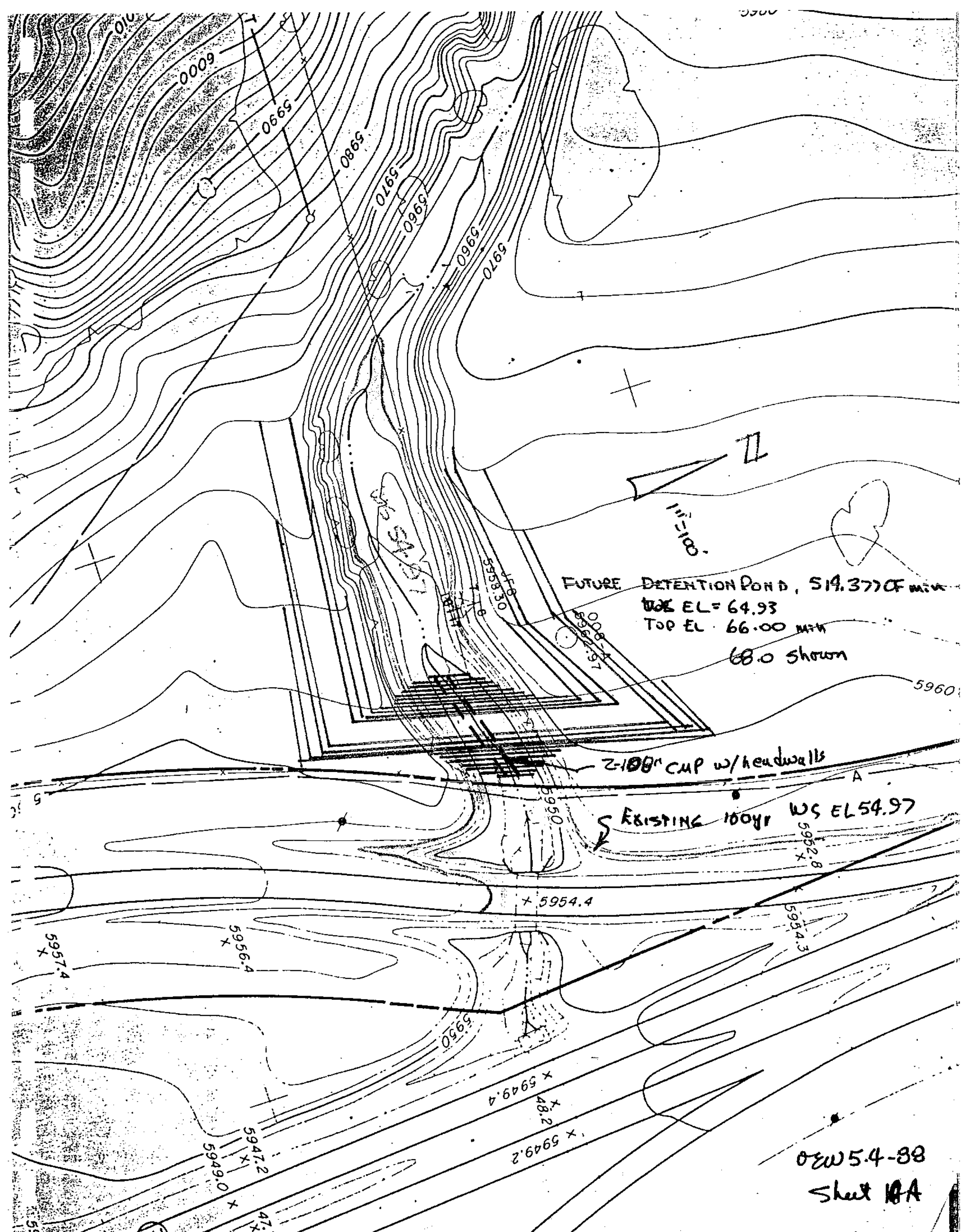

6440
6440
BROA
19
WS 39.0 Available
S58°19'58" E
N 31°40'02"E
36'
563 CPS
25.47
6430
81
S 67°58'47" E
SUBDIVISION BOUNDARY
12'
FUTURE PLAT
S 58°19'58" E
WS 35.44
DRAINAGE EASEMENT
RADIUS = 220.00'
°58" E
36
38
℄ STREET P.C.=STA.42+59.45
6440
HP# 10 5.3.88
Page 8B
From Jeffries Profile



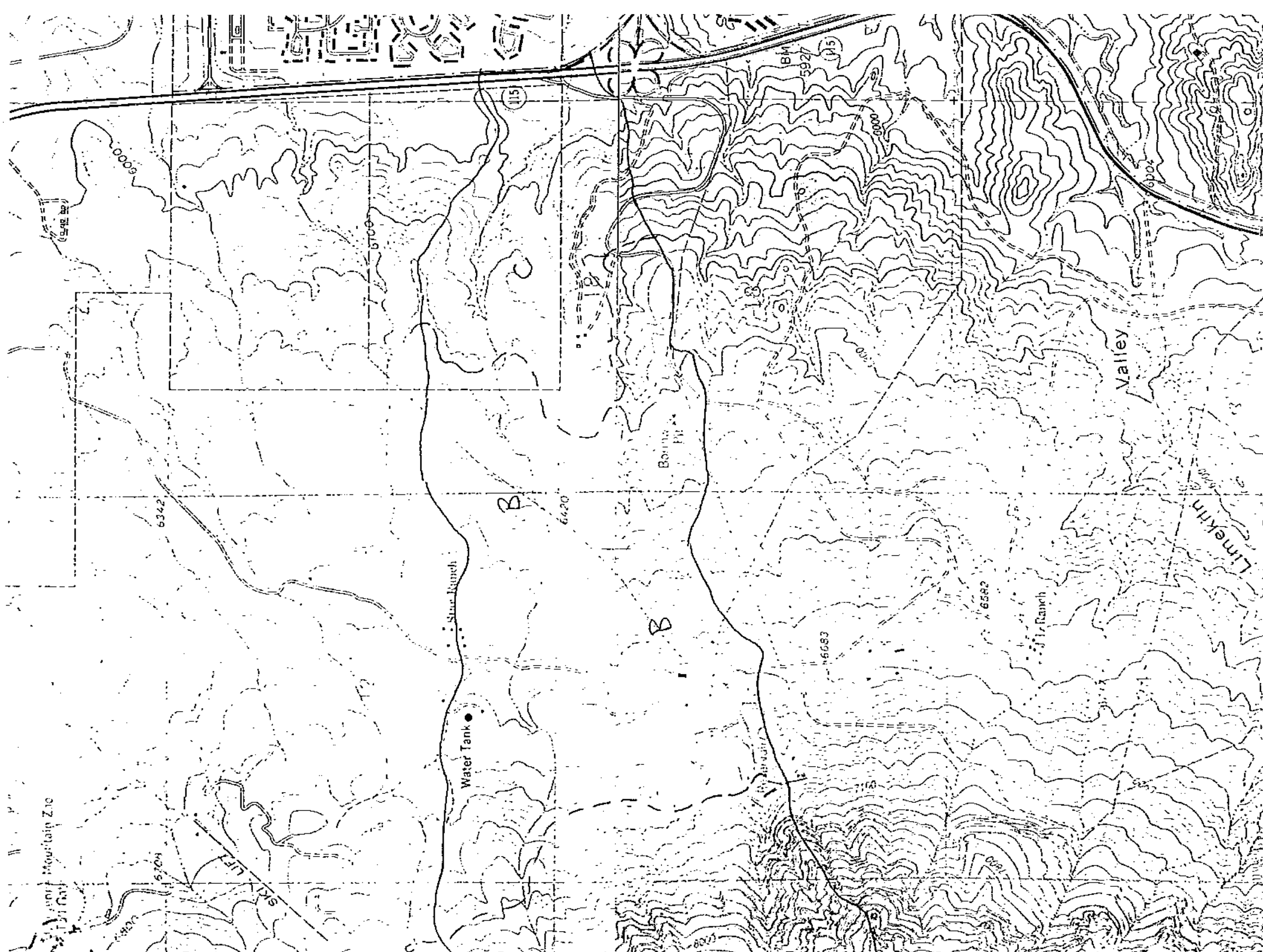
Balmoral Road
Ravenglass Way
Broadmoor B
Lambrig Way
46 12100
45 11500
44 14800
61 15300
62 10750
63 10300
64 11000
65 13000
66 13000
67 13900
68 12000
69 14300
70 14350
71 13000
72 11000
73 12600
74 17150
75 9,350
76 9,900
77 17,000
78 25,350
83 10200
84 13250
85 12600
35 10600
34 14800
33 14100
32 12450
31 12700
30 15000
20 12900
21 9400
22 13900
23 14200
24 17600
19 12,100
18 12,300
17 28,400
16 13500
15 12350
14 17,700
5 13200
6 11400
7
Drainage Easement
2' Public Utility Easement
Public Utility Easement Only
R=750
R=250
R=290
R=220
EL 35.44 Permanent
EL 37.21 Temporary
110' Aerial sewer line
20' Pavement width
PHASE 1



1"=20'
OLIVER E WATD
HP#13
LOT 10
LOT 8
LOT 9
60' R.O.W.
40' F.C. TO F.C.
10'
PROPOSED WATER MAIN
BROADMOOR
BLUFFS
DRIVE
RADIUS = 305.60'
Max WS = 60.10
FLARED END SECTION
18" RIP-RAP ON MIRAFI FABRIC
STA. 53+50 END SAN. SEWER
N 69° 20' 09" W
60"
DP #13
PROPOSED 60" C.M.P. CU
℄ STREET & CULVERT INT.
STREET STA. 53+20.59
PRESERVATION AREA
& DRAINAGE ESMT.
PROPOSED DRIVEWAY
1.0%
℄ & SUBD. BNDRY.
STA. 52+59.13
CONC. HEADWALL
(SEE DETAILS)
SUBD'. BNDRY.
MATCH
CHANNE
EXTEND
78"
N 69° 24' 05" E
DRAINAGE ESMT.
CITY ACCEPTA
DRAIN FACILI
Max WS = 57.3
18" RIP-RAP ON MIRAFI FABRIC
FLARED END SECTION
ROCK OUTCROPPING (TYP.)
PROPOSED 78" C.M.P. CUL
PROPOSED FUTURE STREET ALIGNMENT
DRAINAGE ESMT.
NOTES:
Page 9A
℄ STREET & CULVERT INT.
STREET STA. 52+44.65
1. All construction shall conform with the st
City of Colorado Springs.



6000
5990
5980
5970
5960
1"=100'
FUTURE DETENTION POND
EL = 64.93
TOP EL 66.00 min
68.0 shown
5958.30
5960
2-100" CMP w/ headwalls
EXISTING 100yr WS EL 54.97
5950
5952.8
5954.4
5954.3
5956.4
5957.4
5950
5949.4
5949.2
5947.2
5949.0
OEW 5.4-88



NEAL RANCH MASTER DRAINAGE STUDY
AREA DRAINAGE MAP
FROM USGS
COLORADO SPRINGS AND CHEYENNE MTN

1"=2000'

OLIVER E. WATTS
CONSULTING ENGINEER
COLORA

NEAL RANCH MASTER DRAINAGE STUDY
FROM USDA/SCS
COLORADO SPRINGS AND
CHEYENNE MTN QUADS

AREA SOILS MAP
1"=2000'

OLIVER E. WATTS
CONSULTING ENGR
COLO SPGS

TABLE 16.--SOIL AND WATER FEATURES

[Absence of an entry indicates the feature is not a concern. See "flooding" in Glossary for definition of terms as "rare," "brief," and "very brief." The symbol > means greater than]

Soil name and map symbol	Hydro-logic group	Flooding			Bedrock		Potential frost action
		Frequency	Duration	Months	Depth	Hardness	
					In		
Alamosa:							
1	C	Frequent	Brief	May-Jun	>60	---	High.
Ascalon:							
2, 3	B	None	---	---	>60	---	Moderate.
Badland:							
4	D	---	---	---	---	---	---
Bijou:							
5, 6, 7	B	None	---	---	>60	---	Low.
Blakeland:							
8	A	None	---	---	>60	---	Low.
[1]9:							
Blakeland part	A	None	---	---	>60	---	Low.
Fluvaquentic Haplaquolls part	D	Common	Very brief	Mar-Aug	>60	---	High.
Blendon:							
10	B	None	---	---	>60	---	Moderate.
Bresser:							
11, 12, 13	B	None	---	---	>60	---	Low.
Brussett:							
14, 15	B	None	---	---	>60	---	Moderate.
Chaseville:							
16, 17	A	None	---	---	>60	---	Low.
[1]18:							
Chaseville part	A	None	---	---	>60	---	Low.
Midway part	D	None	---	---	10-20	Rippable	Moderate.
Columbine:							
19	A	None to rare	---	---	>60	---	Low.
Connerton:							
[1]20:							
Connerton part	B	None	---	---	>60	---	High.
Rock outcrop part	D	---	---	---	---	---	---
Cruckton:							
21	B	None	---	---	>60	---	Moderate.
Cushman:							
22, 23	C	None	---	---	20-40	Rippable	Moderate.
[1]24:							
Cushman part	C	None	---	---	20-40	Rippable	Moderate.
Kutch part	C	None	---	---	20-40	Rippable	Moderate.
Elbeth:							
25, 26	B	None	---	---	>60	---	Moderate.
[1]27:							
Elbeth part	B	None	---	---	>60	---	Moderate.

See footnote at end of table.

TABLE 16.--SOIL AND WATER FEATURES--Continued

Soil name and map symbol	Hydrologic group	Flooding			Bedrock		Potential frost action
		Frequency	Duration	Months	Depth	Hardness	
					In		
Elbeth:							
Pring part	B	None	---	---	>60	---	Moderate.
Ellicott:							
28	A	Frequent	Brief	Mar-Jun	>60	---	Low.
Fluvaquentic Haplaquolls:							
29	B/D	Frequent	Brief	Mar-Jul	>60	---	High.
Fort Collins:							
30, 31	B	None to rare	---	---	>60	---	Moderate.
Fortwingate:							
[1]32:							
Fortwingate part	C	None	---	---	20-40	Hard	Low.
Rock outcrop part	D	---	---	---	---	---	---
Heldt:							
33	C	None	---	---	>60	---	Moderate.
Holderness:							
34, 35, 36	C	None	---	---	>60	---	Moderate.
Jarre:							
37	B	None	---	---	>60	---	Moderate.
[1]38:							
Jarre part	B	None	---	---	>60	---	Moderate.
Tecolote part	B	None	---	---	>60	---	Moderate.
Keith:							
39	B	None	---	---	>60	---	High.
Kettle:							
40, 41	B	None	---	---	>60	---	Moderate.
[1]42:							
Kettle part	B	None	---	---	>60	---	Moderate.
Rock outcrop part	D	---	---	---	---	---	---
Kim:							
43	B	None	---	---	>60	---	Moderate.
Kutch:							
44, 45	C	None	---	---	20-40	Rippable	Moderate.
Kutler:							
[1]46:							
Kutler part	C	None	---	---	20-40	Rippable	Low.
Broadmoor part	C	None	---	---	20-40	Rippable	Low.
Rock outcrop part	D	---	---	---	---	---	---
Limon:							
47	C	Occasional	Brief	May-Sep	>60	---	Moderate.
Louviers:							
48	D	None	---	---	10-20	Rippable	Moderate.
49	D	None	---	---	10-20	Rippable	Low.

See footnote at end of table.

TABLE 16.--SOIL AND WATER FEATURES--Continued

Soil name and map symbol	Hydro-logic group	Flooding			Bedrock		Potential frost action
		Frequency	Duration	Months	Depth	Hardness	
					In		
Manvel:							
50	C	None	---	---	>60	---	High.
Manzanola:							
51, 52, 53	C	None to rare	---	---	>60	---	Moderate.
Midway:							
54	D	None	---	---	10-20	Rippable	Moderate.
Nederland:							
55	B	None	---	---	>60	---	Moderate.
Nelson:							
[1]56:							
Nelson part	B	None	---	---	20-40	Rippable	Low.
Tassel part	D	None	---	---	10-20	Rippable	Low.
Neville:							
57	B	None	---	---	>60	---	High.
[1]58:							
Neville part	B	None	---	---	>60	---	High.
Rednun part	C	None	---	---	>60	---	Moderate.
Nunn:							
59	C	None	---	---	>60	---	Moderate.
Olney:							
60, 61	B	None	---	---	>60	---	Moderate.
[1]62:							
Olney part	B	None	---	---	>60	---	Moderate.
Vona part	B	None	---	---	>60	---	Moderate.
Paunsaugunt:							
[1]63:							
Paunsaugunt part	D	None	---	---	10-20	Hard	Moderate.
Rock outcrop part	D	---	---	---	---	---	---
Penrose:							
[1]64:							
Penrose part	D	None	---	---	10-20	Rippable	Low.
Manvel part	C	None	---	---	>60	---	High.
Perrypark:							
65	B	None	---	---	>60	---	Moderate.
Peyton:							
66, 67	B	None	---	---	>60	---	Moderate.
[1]68, [1]69:							
Peyton part	B	None	---	---	>60	---	Moderate.
Pring part	B	None	---	---	>60	---	Moderate.
Pits, gravel:							
70	A	---	---	---	---	---	---
Pring:							
71, 72	B	None	---	---	>60	---	Moderate.
Razor:							
73, 74	C	None	---	---	20-40	Rippable	Moderate.

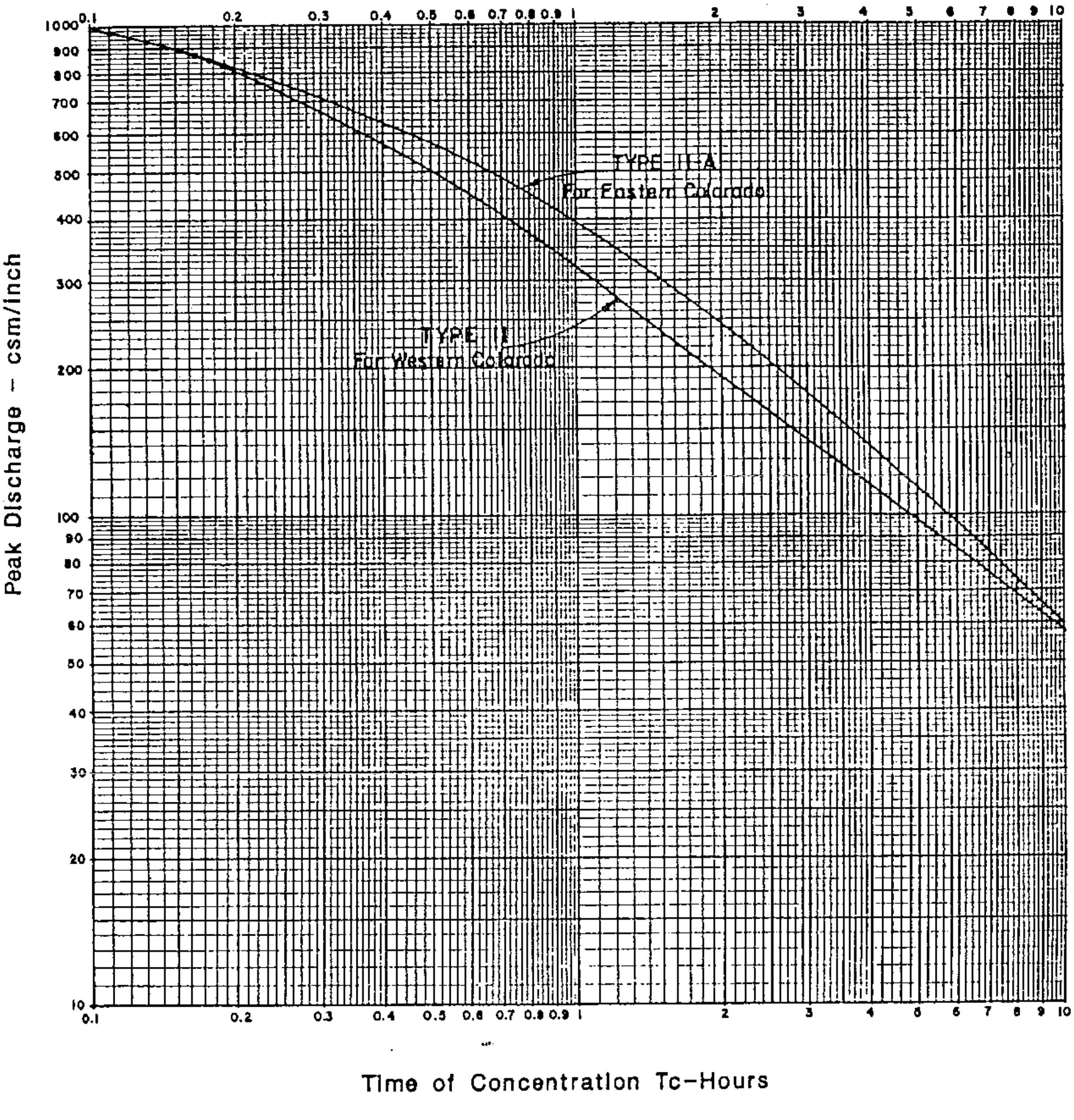
See footnote at end of table.

TABLE 16.--SOIL AND WATER FEATURES--Continued

Soil name and map symbol	Hydro-logic group	Flooding			Bedrock		Potential frost action
		Frequency	Duration	Months	Depth	Hardness	
					In		
Razor:							
[1]75:							
Razor part-----	C	None----------	---	---	20-40	Rippable	Moderate.
Midway part----	D	None----------	---	---	10-20	Rippable	Moderate.
Rizozo:							
[1]76:							
Rizozo part----	D	None----------	---	---	4-20	Hard	Low.
Neville part---	B	None----------	---	---	>60	---	High.
Rock outcrop:							
[1]77:							
Rock outcrop part----------	D	---	---	---	---	---	---
Coldcreek part-	B	None----------	---	---	40-60	Rippable	Moderate.
Tolman part----	D	None----------	---	---	10-20	Hard	Moderate.
Sampson:							
78--------------	B	None----------	---	---	>60	---	Moderate.
Satanta:							
79, 80----------	B	None----------	---	---	>60	---	Moderate.
[1]81:							
Satanta part---	B	None----------	---	---	>60	---	Moderate.
Neville part---	B	None----------	---	---	>60	---	High.
Schamber:							
[1]82:							
Schamber part--	A	None----------	---	---	>60	---	Moderate.
Razor part-----	C	None----------	---	---	20-40	Rippable	Moderate.
Stapleton:							
83, 84----------	B	None----------	---	---	>60	---	Moderate.
[1]85:							
Stapleton part-	B	None----------	---	---	>60	---	Moderate.
Bernal part----	D	None----------	---	---	8-20	Hard	Moderate.
Stoneham:							
86, 87----------	B	None----------	---	---	>60	---	Moderate.
Stroupe:							
[1]88:							
Stroupe part---	C	None----------	---	---	20-40	Hard	Moderate.
Travessilla part----------	D	None----------	---	---	6-20	Hard	Low.
Rock outcrop part----------	D	---	---	---	---	---	---
Tassel:							
89--------------	D	None----------	---	---	10-20	Rippable	Low.
Terry:							
90--------------	B	None----------	---	---	20-40	Rippable	Moderate.
[1]91:							
Terry part-----	B	None----------	---	---	20-40	Rippable	Moderate.
Razor part-----	C	None----------	---	---	20-40	Rippable	Moderate.

See footnote at end of table.

Peak Discharge in
csm Per Inch of Runoff
Versus
Time of Concentration, Tc
Type II Storm Distribution, 24 Hour
Type II-A Storm Distribution, 24 Hour



HDR Infrastructure, Inc.
A Centerra Company

The City of Colorado Springs / El Paso County
Drainage Criteria Manual

Date
OCT. 1987

Figure
5-11d

TABLE 5-5
RUNOFF CURVE NUMBERS
FOR HYDROLOGIC SOIL-COVER COMPLEXES
URBAN AND SUBURBAN CONDITIONS 1/
(For Antecedent Moisture Condition II)
(From: U.S. Department of Agriculture,
Soil Conservation Service, 1977)

NOTE: THIS TABLE TO BE USED FOR 24-HOUR STORM ONLY.

Land Use		Hydrologic Soil Group A	B	C	D
Open spaces, lawns, parks, golf courses, cemeteries, etc.					
Good condition: grass cover on 75% or more of the area		39*	61	74	80
Fair conditon: grass cover on 50% to 75% of the area		49*	69	79	84
Commercial and business areas (85% impervious)		89*	92	94	95
Industrial districts 72% impervious)		81*	88	91	93
Residential:2/					
Acres per Dwelling Unit	Average % impervious3/				
1/8 acre or less	65	77*	85	90	92
1/4 acre	38	61*	75	83	87
1/3 acre	30	57*	72	81	86
1/2 acre	25	54*	70	80	85
1 acre	20	51*	68	79	84
Paved parking lots, roofs, driveways, etc.		98	98	98	98
Streets and roads:					
paved with curbs and storm sewers		98	98	98	98
gravel		76*	85	89	91
dirt		72*	82	87	89

1/ For a more detailed description of agricultural land use curve numbers, refer to in the National Engineering Handbook (U.S. Dept. of Agriculture, Soil Conservation Service, 1972).
2/ Curve numbers are computed assuming the runoff from the house and driveway is directed towards the street with a minimum of roof water directed to lawns where additional infiltration could occur.
3/ The remaining pervious areas (lawn) are considered to be in good pasture condition for these curve numbers.

* Not to be used wherever overlot grading or filling is to occur.

TABLE 5-4
RUNOFF CURVE NUMBERS FOR HYDROLOGIC
SOIL-COVER COMPLEXES--RURAL CONDITIONS
(Antecedent Moisture Condition II, and I_a = 0.2 S)
(From: U.S. Dept. of Agriculture,
Soil Conservation Service, 1977)

NOTE: THIS TABLE TO BE USED FOR 24-HOUR STORM ONLY.

Land Use	Cover Treatment or Practice	Hydrologic Condition	Runoff curve number by Hydrologic soil group A	B	C	D
Fallow	Straight Row	----	77	86	91	94
Row crops	Straight Row	Poor	72	81	88	91
	Straight Row	Good	67	78	85	89
	Contoured	Poor	70	79	84	88
	Contoured	Good	65	75	82	86
	Cont. and terraced	Poor	66	74	80	82
	Cont. and terraced	Good	62	71	78	81
Small grain	Straight Row	Poor	65	76	84	88
		Good	63	75	83	87
	Contoured	Poor	63	74	82	85
		Good	61	73	81	84
	Cont. and terraced	Poor	61	72	79	82
		Good	59	70	78	81
Close-seeded legumes 1/ or rotation meadow	Straight Row	Poor	66	77	85	89
	Straight Row	Good	58	72	81	85
	Contoured	Poor	64	75	83	85
	Contoured	Good	55	69	78	83
	Cont. and terraced	Poor	63	73	80	83
	Cont. and terraced	Good	51	67	76	80
Pasture or range		Poor	68	79	86	89
		Fair	49	69	79	84
		Good	39	61	74	80
	Contoured	Poor	47	67	81	88
	Contoured	Fair	25	59	75	83
	Contoured	Good	6	35	70	79
Meadow		Good	30	58	71	78
Woods		Poor	45	66	77	83
		Fair	36	60	73	79
		Good	25	55	70	77
Farmsteads		----	59	74	82	86
Roads (dirt) 2/		----	72	82	87	89
(hard surface) 2/		----	74	84	90	92

1/ Close-drilled or broadcast
2/ Including right-of-way

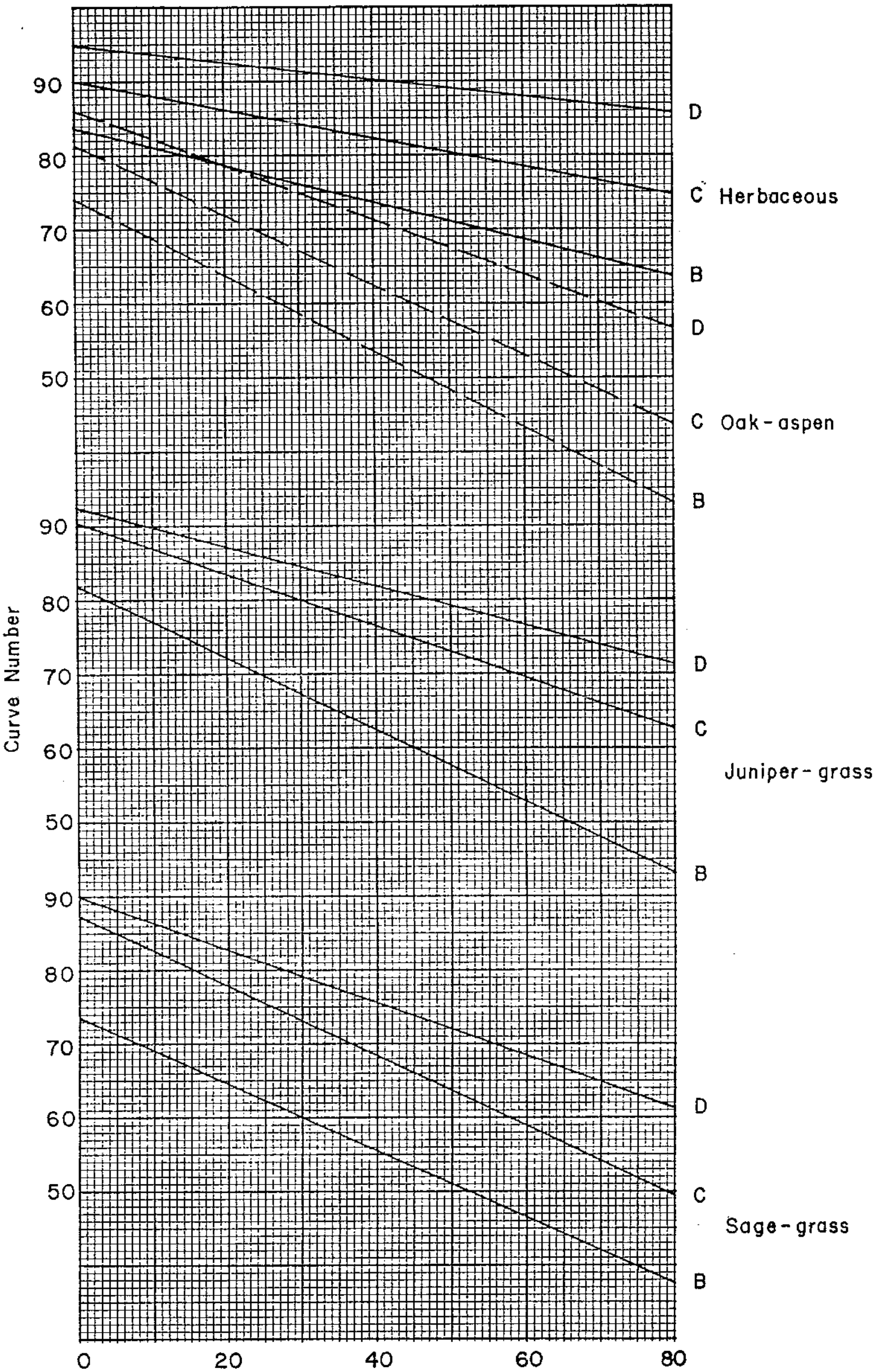


Figure S-3

HYDROLOGIC SOIL COVER COMPLEX & ASSOCIATED CURVE NUMBERS

TABULAR DISCHARGES FOR TYPE IIA STORM (csm/in) Tc = 0.10

	Tt	5.0	5.5	5.7	5.8	5.9	6.0	6.1	6.2	6.3	6.4	6.5	6.6	6.7	6.8	6.9	7.0	7.2	7.5	8.0	8.5	9.0	10.0	12.0
	0.00	14	38	275	937	741	562	219	105	76	61	47	36	31	30	29	28	24	22	19	14	10	10	10
(10)	0.0938	13.25	31.99	186.42	646.10	554.09	567.25	386.99	269.01	208.49	121.43	72.90	52.14	41.51	34.13		29.83			18.62		11.50	10.75	9.25
	0.25	12	22	39	82	243	576	648	542	429	222	116	79	59	41	35	31	28	22	18	16	14	12	8
(10)	0.0778	12.62	26.97	201.56	670.95	586.04	566.36	352.49	240.98	185.84	111.10	68.47		39.71			28.93		22	18.09		11.24	10.62	
	0.50	9	16	21	25	39	78	215	443	548	539	505	291	153	97	68	47	34	26	20	16	14	12	9
(10)	0.0627	13.50	33.99	215.30	722.53	616.08	565.51		214.62			64.31					28.75			18.75			10.50	
	0.75	7	12	15	17	20	24	38	73	143	292	456	487	449	424	257	142	73	64	22	18	15	11	8
(11)	0.0936	13.91		253.63	359.57	695.90	563.27		144.57			51.26					28.27			18.91			10.18	
	1.00	5	9	11	12	14	16	19	24	37	67	122	244	393	444	426	367	230	84	37	24	16	12	8
(10)	0.1933	12.47	34.37	92.52	275.91	355.95	572.82	550.70	442.89	348.94	185.49													
	1.50	4	6	7	8	8	9	10	11	13	15	17	22	33	53	115	217	388	357	156	62	32	19	11
(10)	0.1682	12.65	27.24	116.2	361.8	405.9	571.4	507.67	399.01	313.50	169.32													
	2.00	2	4	4	5	5	6	6	7	8	8	9	10	12	13	16	20	55	224	351	141	80	35	16
(11)	0.2709	11.75	21.66	37.50	77.23	225.95	534.37	611.80	533.72	438.97	248.50													
	2.50	2	4	4	5	5	5	5	6	6	6	7	7	7	8	9	9	12	31	223	324	149	57	24
(10)	0.1935	12.47	25.62	32.34	275.23	355.55	572.84	551.04	443.25	389.72	185.61													
	3.00	2	2	3	3	4	4	5	5	5	5	6	6	6	7	7	7	7	10	37	220	304	74	34
(10)	0.2276	12.18	23.45	60.15	158.4	287.62	574.75	609.56	502.84	397.57	75.45 207.57													
	3.50	1	2	2	2	3	3	3	3	4	204	4	5	5	5	5	6	6	6	13	54	287	158	39
(10)	0.2555	11.93	37.64	269.30	918.19	730.04	562.31	228.44	114.61	83.87	64.54													
	4.00	0	0	0	0	0	0	1	1	1	1	2	2	2	2	3	3	4	5	6	13	62	274	39
(10)	0.1649	13.32	32.54	119.33	373.04	412.51	566.77	365.03	393.24	308.84	167.20													

Oliver E. Watts
Consulting Engineer
Colorado Springs

TABULAR DISCHARGES FOR TYPE IIA STORM (csm/in)   Tc = 0.20 hours

Tt	5.0	5.5	5.7	5.8	5.9	6.0	6.1	6.2	6.3	6.4	6.5	6.6	6.7	6.8	6.9	7.0	7.2	7.5	8.0	8.5	9.0	10.0	12.0
0.00	15	38	200	504	794	500	309	151	85	57	42	37	30	27	26	25	23	22	20	15	10	10	10
0.25	12	22	32	59	158	403	597	625	379	249	145	86	57	40	34	29	25	20	16	15	12	13	8
0.50	9	16	21	24	33	56	146	328	485	544	388	289	182	110	69	46	33	24	18	14	12	11	8
0.75	7	12	15	17	20	23	32	55	130	273	486	490	375	307	210	132	64	31	20	15	13	10	7
1.00	6	9	12	13	14	16	19	23	31	52	93	194	334	422	451	333	217	91	34	20	14	10	7
1.50	3	6	7	8	8	9	10	12	13	15	17	21	28	44	88	169	327	398	124	52	30	16	9
2.00	2	4	5	5	5	6	7	7	8	8	10	10	12	14	16	23	54	190	362	131	55	25	12
2.50	1	2	3	3	3	4	4	5	5	5	6	7	7	8	8	10	15	32	198	336	136	37	16
3.00	0	0	1	1	2	2	3	3	3	3	4	4	5	5	5	6	7	12	38	201	315	64	21
3.50	0	0	0	1	1	1	2	2	2	2	3	3	4	4	4	5	6	7	15	46	299	140	25
4.00	0	0	0	0	0	1	1	1	1	1	2	2	2	3	3	3	4	5	7	15	52	285	32

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Consulting Engineer
Colorado Springs

TABULAR DISCHARGES FOR TYPE IIA STORM (csm/in) Tc = 0.30 hours

Tt	5.0	5.5	5.7	5.8	5.9	6.0	6.1	6.2	6.3	6.4	6.5	6.6	6.7	6.8	6.9	7.0	7.2	7.5	8.0	8.5	9.0	10.0	12.0
0.00	17	45	162	380	692	602	509	387	296	245	218	164	114	78	58	44	39	34	29	17	10	10	10
0.0352	16.58	43.17	144.11	334.10	614.27	562.43	513.51	425.04	322.61	267.81													
0.25	14	25	35	54	140	321	541	660	485	407	330	276	238	211	153	108	69	44	28	24	21	18	18
0.50	11	18	23	28	34	53	100	249	434	562	589	409	345	292	255	224	162	98	57	37	26	16	12
0.75	8	14	17	19	22	26	33	51	92	212	363	484	540	405	370	332	233	140	88	60	41	25	15
1.00	6	11	13	15	16	19	21	25	32	49	83	142	282	411	487	503	314	173	102	60	54	44	26
1.50	4	5	6	8	9	10	11	12	15	17	19	23	29	42	86	152	319	451	176	77	74	40	29
2.00	2	4	5	6	6	6	7	8	9	10	11	12	14	15	17	26	51	177	414	181	81	43	28
2.50	1	2	3	3	4	4	5	5	6	6	6	7	8	9	10	11	18	32	190	387	183	51	28
3.00	0	1	2	2	2	2	2	3	3	4	4	5	5	6	6	7	8	15	38	198	365	86	29
3.50	0	0	1	1	1	1	2	2	2	2	2	2	3	3	4	4	5	7	15	43	202	347	32
4.00	0	0	0	0	0	0	1	1	1	1	1	2	2	2	2	2	3	4	9	17	50	332	38

0.0303 16.69 42.57 146.62 340.54 625.18 567.99 420.04 231.57 51.74 28.88 10.97 10.97

0.0668 16.20 39.69 128.04 292.85 544.43 526.38 459.98 247.94 61.11 28.73 12.14 12.14

Oliver E. Watts
Consultin g Engineer
Colorado Springs

0.0259 16.69 42.93 140.09 346.29 634.92 572.94 415.23 229.58 50.62 28.90 10.83 10.83

TABLE 9-1

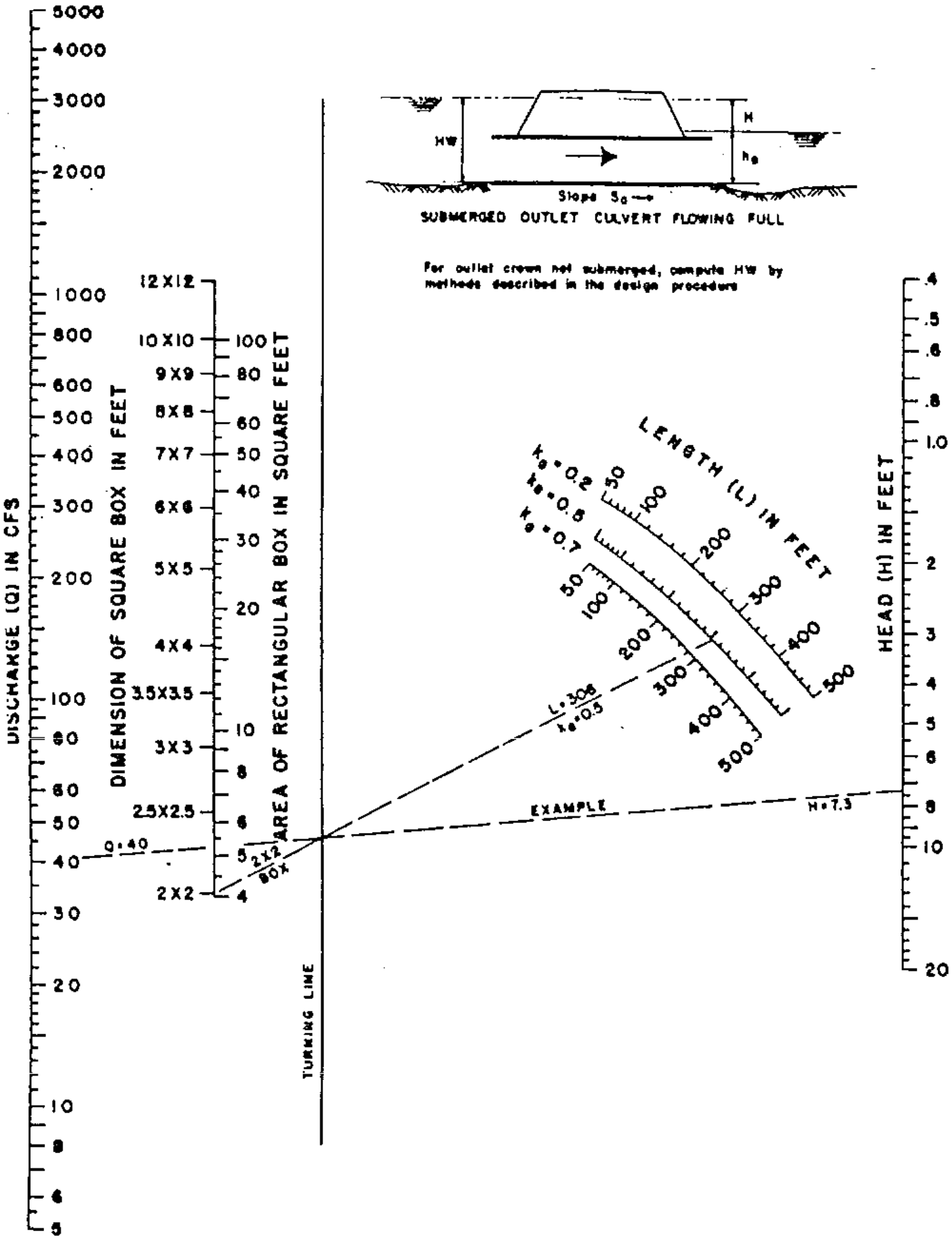
Entrance Loss Coefficients

Outlet Control, Full or Partly Full

Type of Structure and Design of Entrance	Coefficient k_e
Pipe, Concrete	
Projecting from fill, socket end (groove end)	0.2
Projecting from fill, square-cut end	0.5
Headwall or headwall and wingwalls	
Socket end of pipe (groove end)	0.2
Square-edged	0.5
Rounded (radius = 1/12D)	0.2
Mitered to conform to fill slope	0.7
*End section conforming to fill slope	0.5
Beveled edges, 33.7-degree to 45-degree bevels	0.2
Side- or slope-tapered inlet	0.2
Pipe, or Pipe-Arch, Corrugated Metal	
Projecting from fill (no headwall)	0.9
Headwall or headwall and wingwalls square-edge	0.5
Mitered to conform to fill slope, paved or unpaved slope	0.7
*End section conforming to fill slope	0.5
Beveled edges, 33.7-degree to 45-degree bevels	0.2
Side- or slope-tapered inlet	0.2
Box, Reinforced Concrete	
Headwall parallel to embankment (no wingwalls)	
Square-edged on 3 edges	0.5
Rounded on 3 edges to radius of 1/12 barrel dimension, or beveled edges on 3 sides	0.2
Wingwalls at 30 degrees to 75 degrees to barrel	
Square-edged at crown	0.4
Crown edge rounded to radius of 1/12 barrel dimension, or beveled top edge	0.2
Wingwall at 10 degrees to 25 degrees to barrel	
Square-edged at crown	0.5
Wingwalls parallel (extension of sides)	
Square-edged at crown	0.7
Side- or slope-tapered inlet	0.2

*Note: End sections conforming to fill slope are the sections commonly available from manufacturers. From limited hydraulic tests, they are equivalent in operation to a headwall in both inlet and outlet control. Some end sections incorporating a closed taper in their design have a superior hydraulic performance.

Federal Highway Administration, HEC No. 13



HEAD FOR CONCRETE BOX CULVERTS FLOWING FULL

n = 0.012

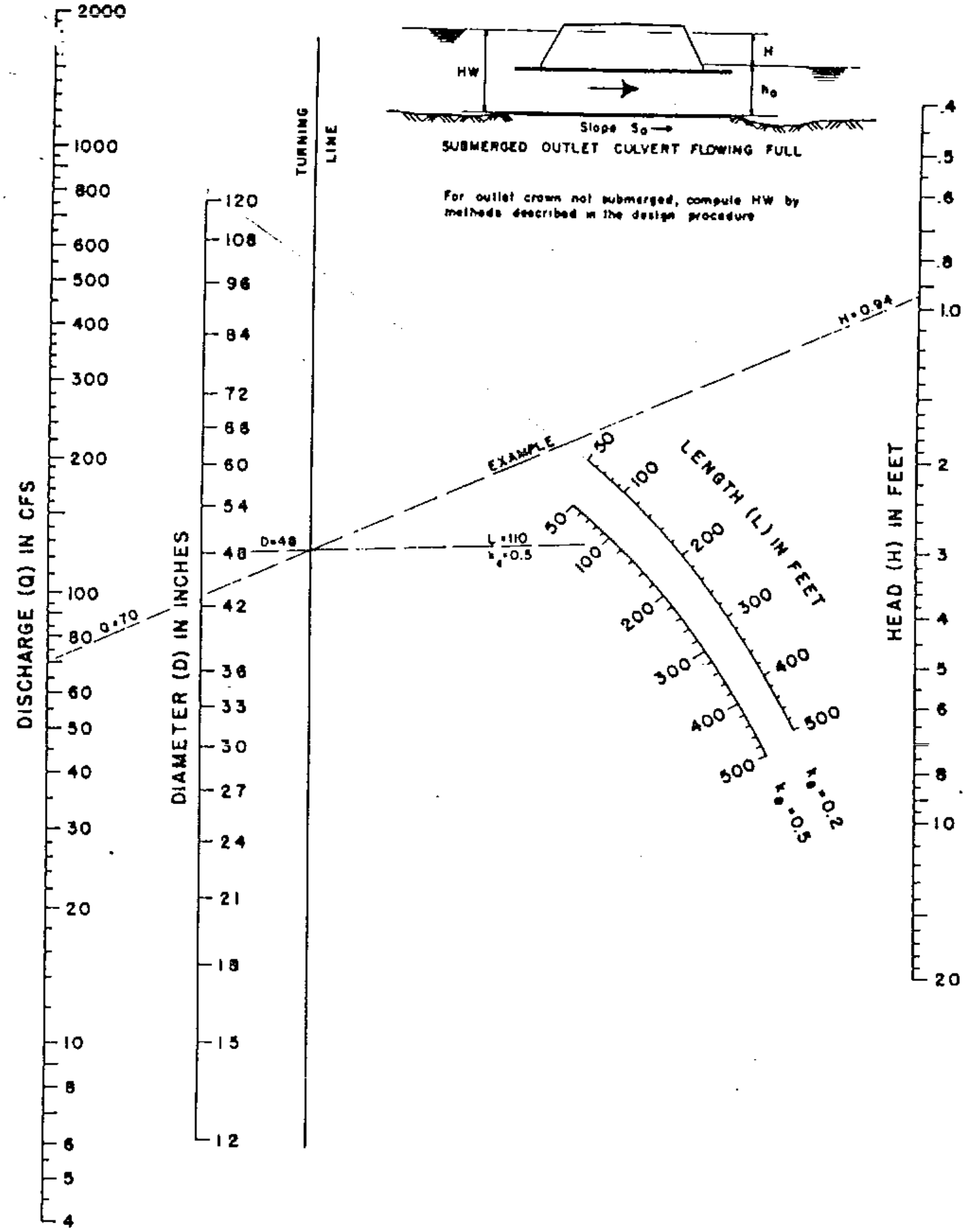
BUREAU OF PUBLIC ROADS JAN 1963

HDR Infrastructure, Inc.
A Centerra Company

The City of Colorado Springs / El Paso County
Drainage Criteria Manual

Date
OCT. 1987

Figure
9 - 21



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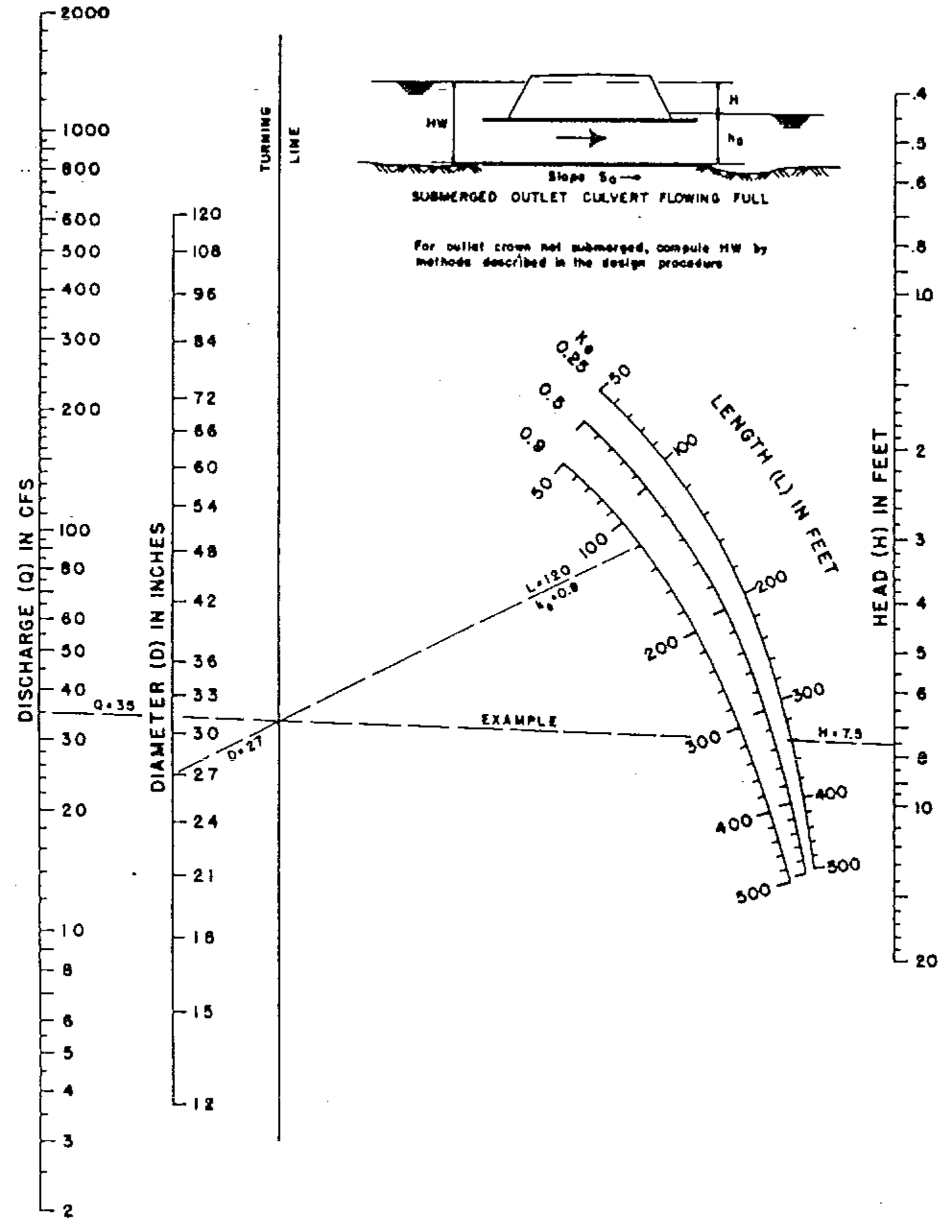
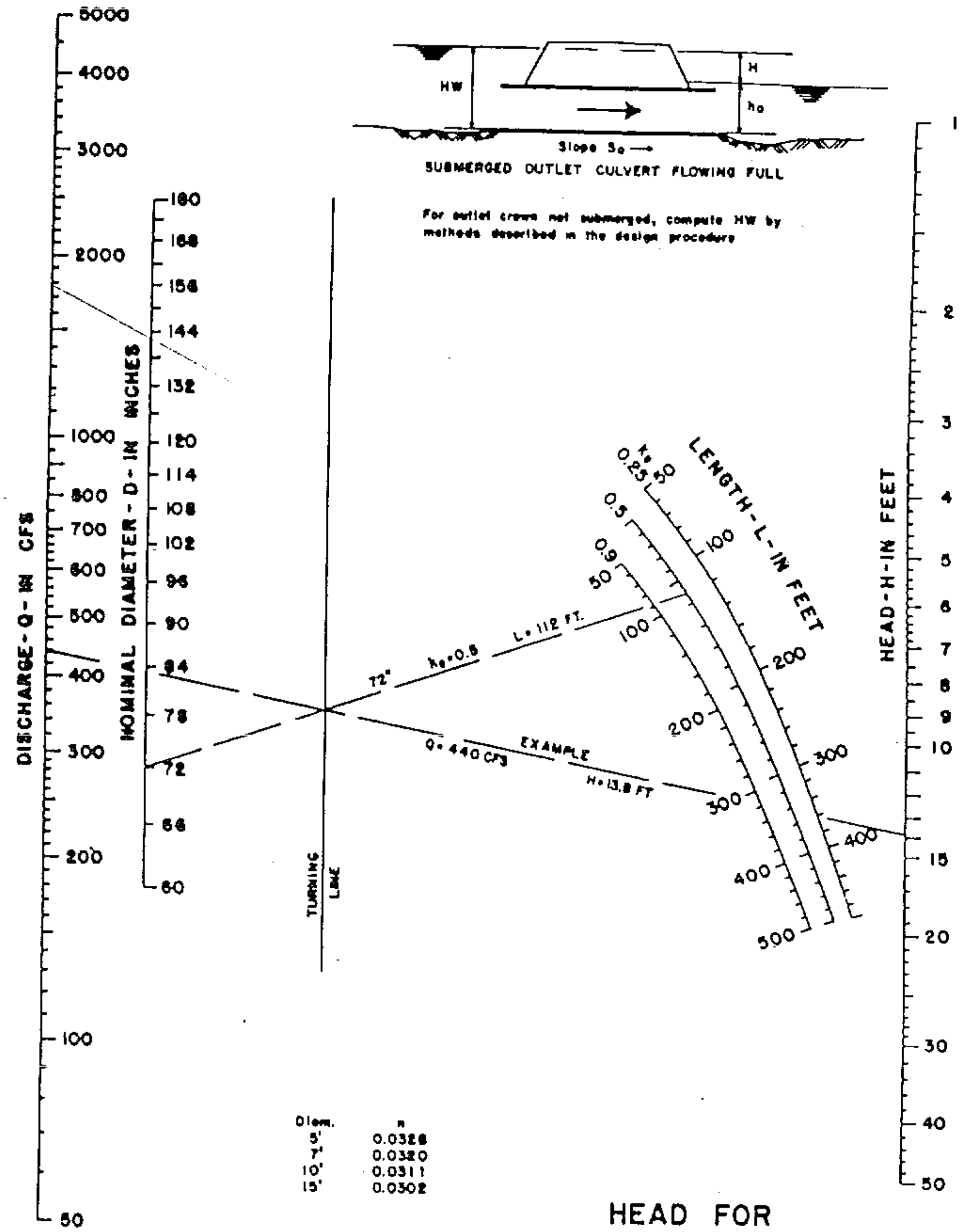
HEAD FOR CONCRETE PIPE CULVERTS FLOWING FULL
$n = 0.012$



HEAD FOR STANDARD C. M. PIPE CULVERTS FLOWING FULL

$n = 0.024$

BUREAU OF PUBLIC ROADS JAN. 1963



Diam.	n
5'	0.0328
7'	0.0320
10'	0.0311
15'	0.0302

HEAD FOR STRUCTURAL PLATE CORR. METAL PIPE CULVERTS FLOWING FULL
n = 0.0328 TO 0.0302

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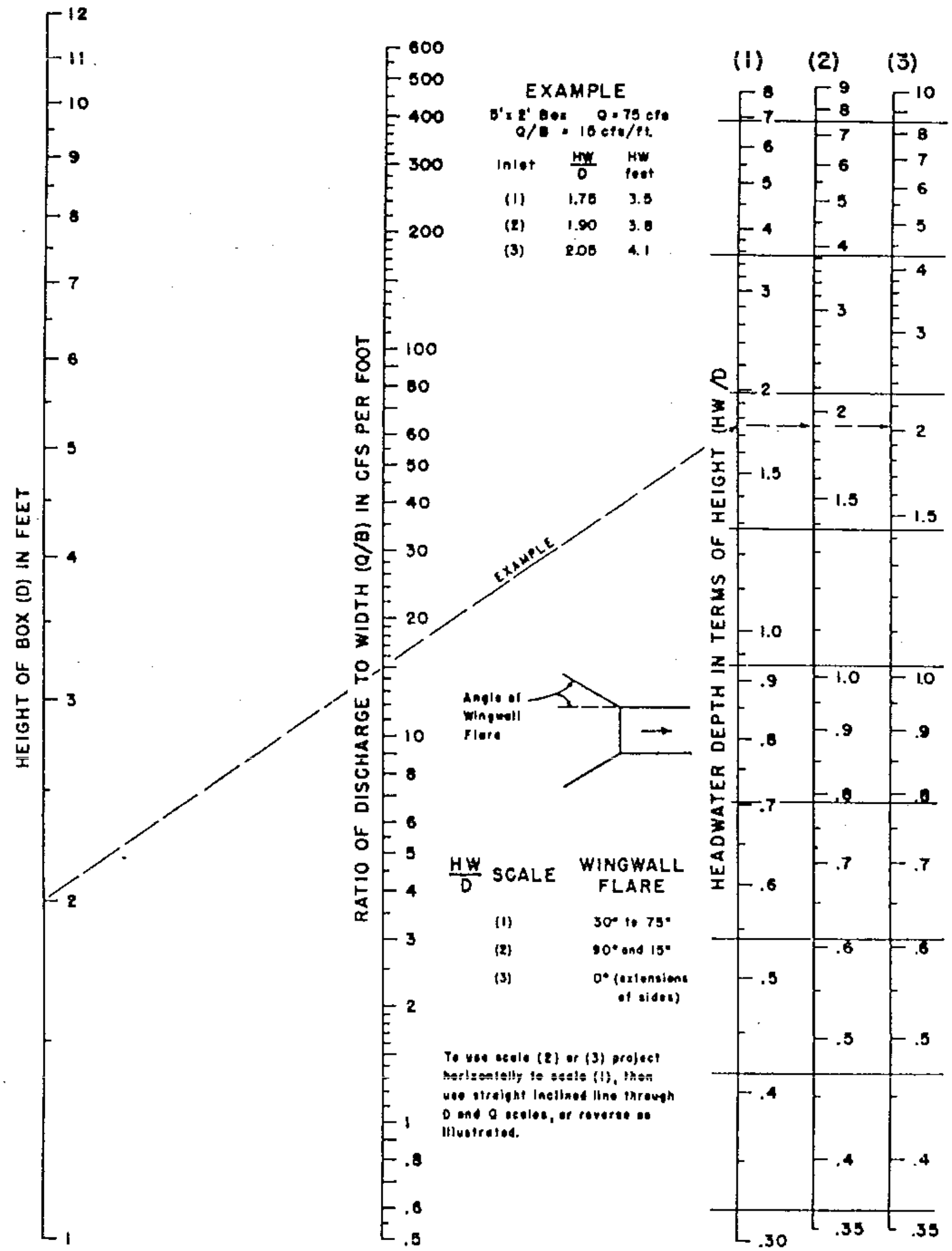

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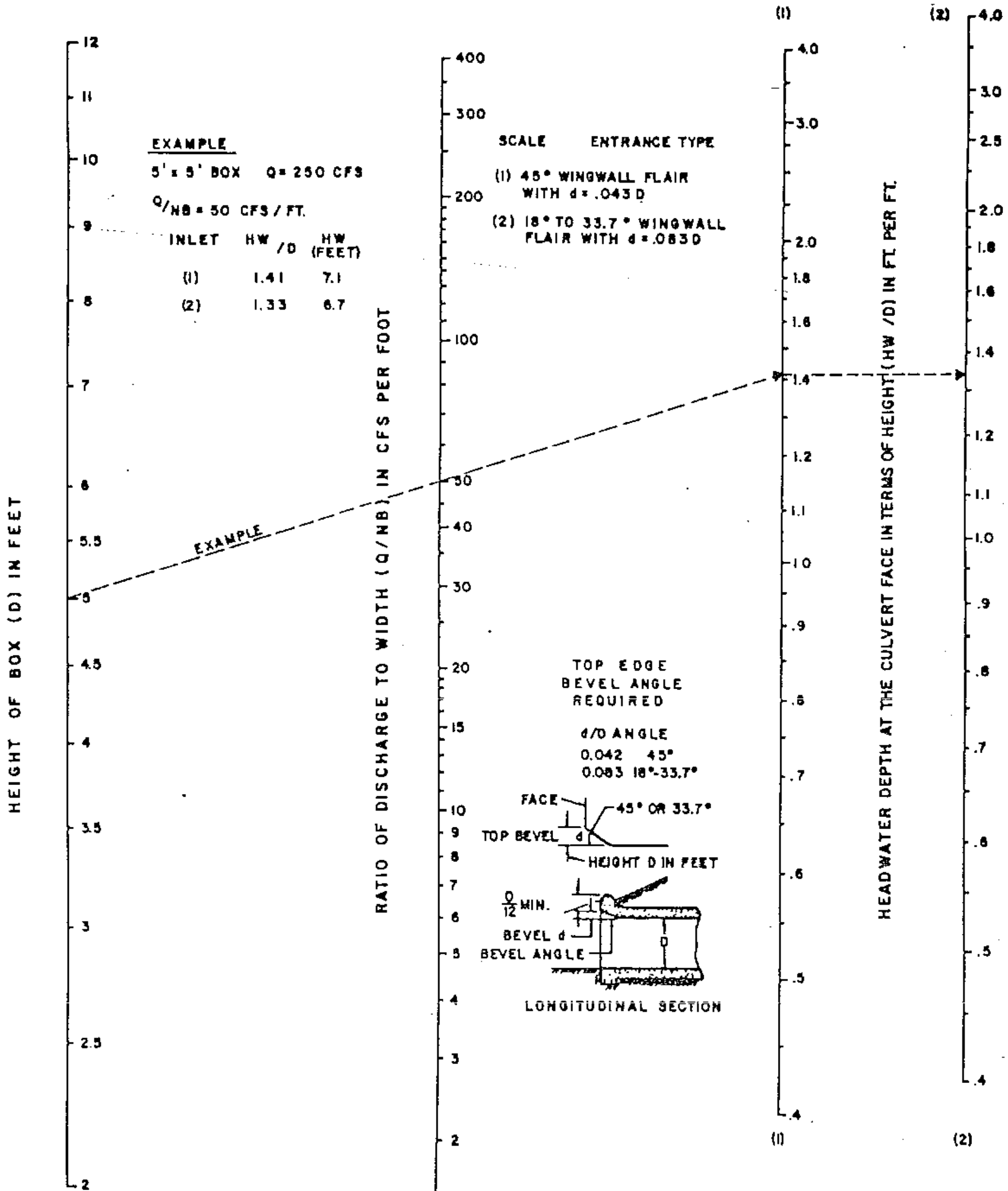
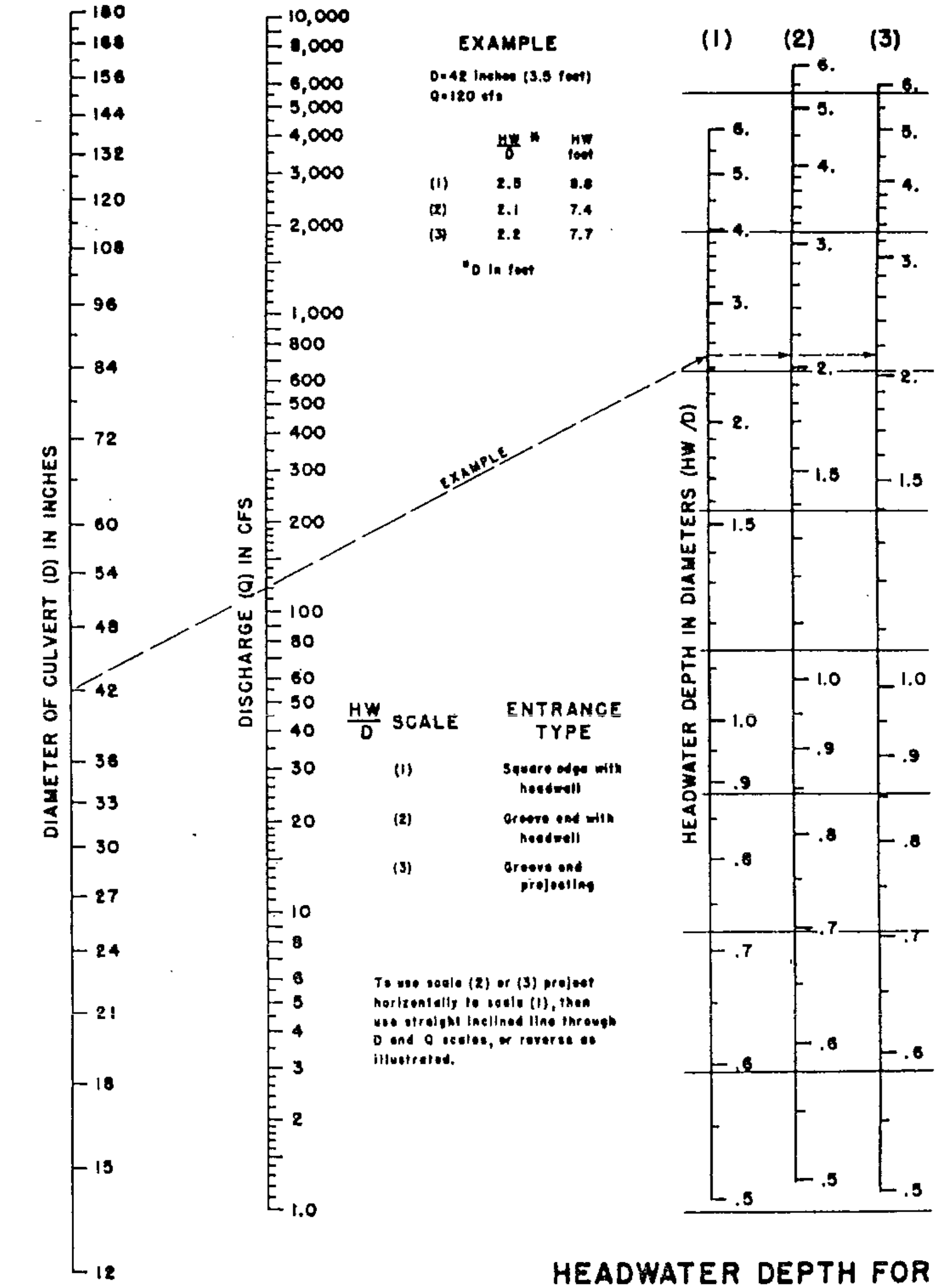
HEADWATER DEPTH FOR BOX CULVERTS WITH INLET CONTROL



HEADWATER DEPTH FOR INLET CONTROL
RECTANGULAR BOX CULVERTS
FLARED WINGWALLS 18° TO 33.7° & 45°
WITH BEVELED EDGE AT TOP OF INLET

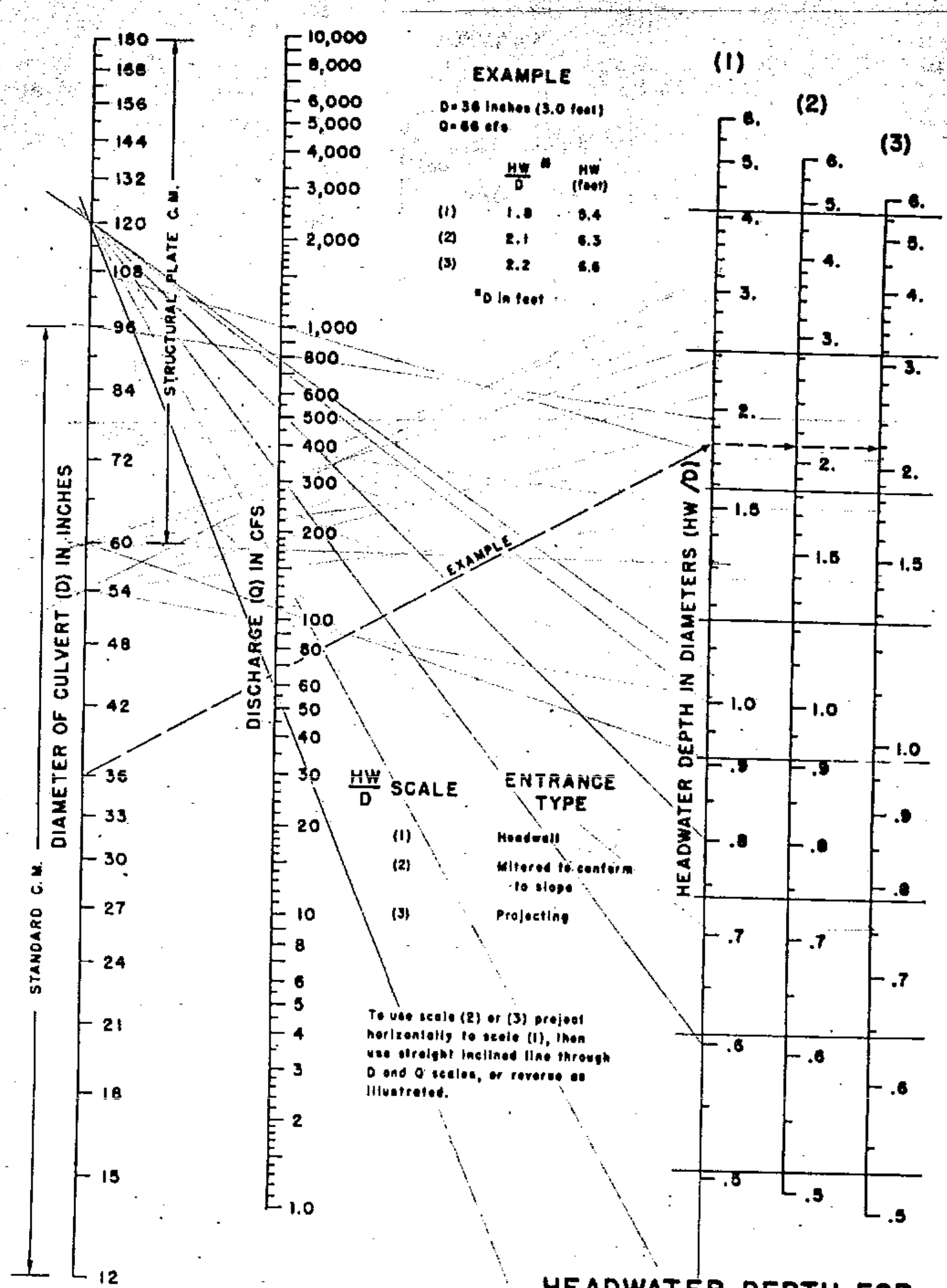
BUREAU OF PUBLIC ROADS JAN 1963



HEADWATER DEPTH FOR CONCRETE PIPE CULVERTS WITH INLET CONTROL

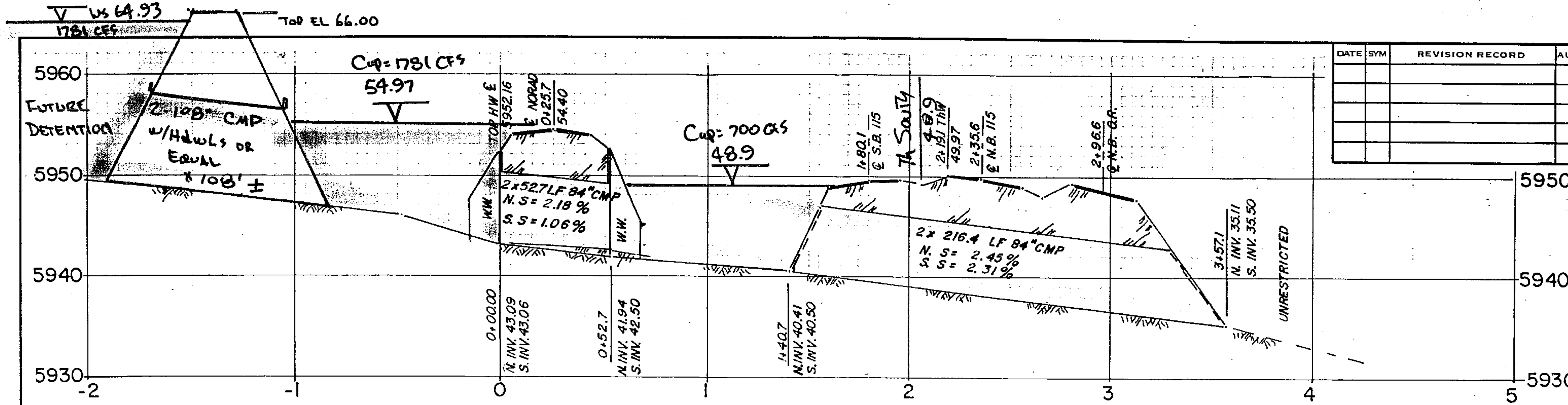
HEADWATER SCALES 2&3
REVISED MAY 1964

BUREAU OF PUBLIC ROADS JAN. 1963

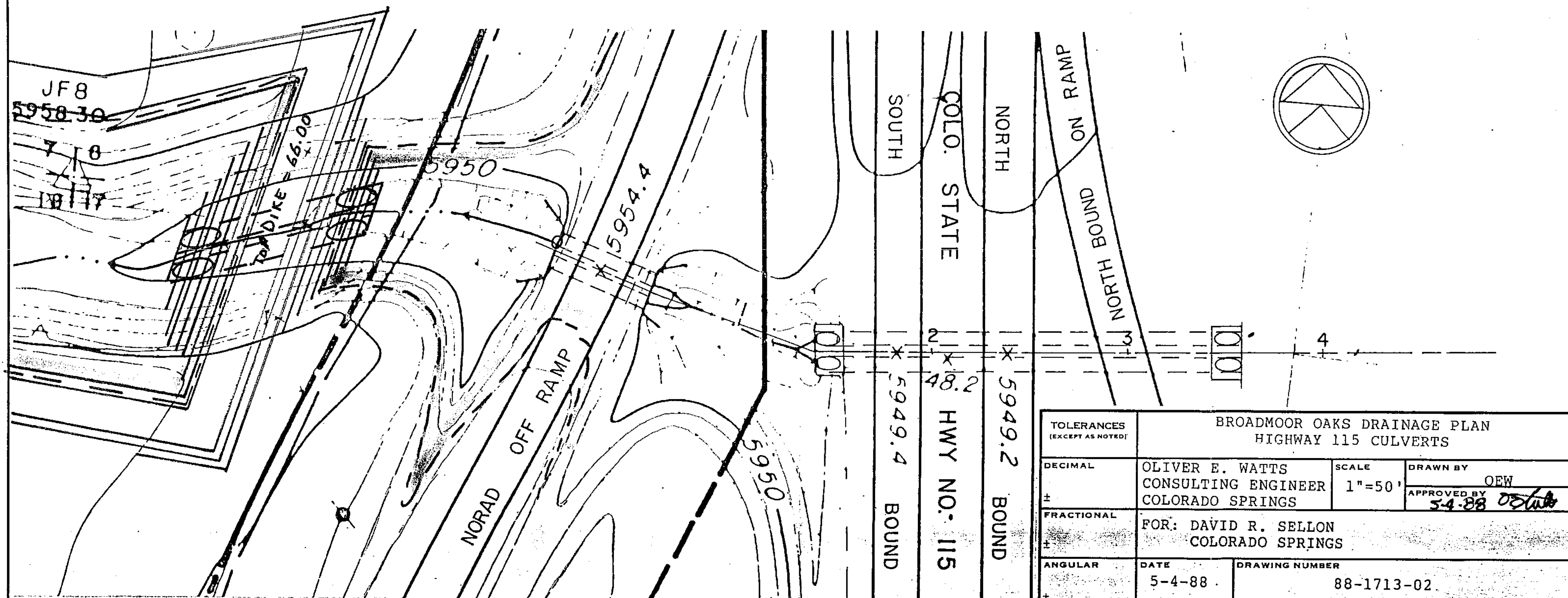


HEADWATER DEPTH FOR C. M. PIPE CULVERTS WITH INLET CONTROL

BUREAU OF PUBLIC ROADS JAN. 1963



DATE	SYM	REVISION RECORD	AUTH.	DR.	CK.



TOLERANCES (EXCEPT AS NOTED)	BROADMOOR OAKS DRAINAGE PLAN HIGHWAY 115 CULVERTS		
DECIMAL ±	OLIVER E. WATTS CONSULTING ENGINEER COLORADO SPRINGS	SCALE 1"=50'	DRAWN BY OEW APPROVED BY 5-4-88 OEWatts
FRACTIONAL ±	FOR: DAVID R. SELLON COLORADO SPRINGS		
ANGULAR ±	DATE 5-4-88	DRAWING NUMBER 88-1713-02	

K+E CRYSTALENE ® 11x17 ENGINEERS' STANDARD FORM

MADE IN U.S.A.