NORTHGATE PHASE 1
Drainage Plan

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AN INTERNATIONAL PROFESSIONAL SERVICES ORGANIZATION

URS CORPORATION
1040 SOUTH EIGHTH STREET
COLORADO SPRINGS, COLORADO 80906
TEL: (303) 634-6699

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June 2, 1987

Mr. Chris Smith
Subdivision Administrator
City Engineering Division
City of Colorado Springs
Colorado Springs, CO 80901

Dear Sir:

In response to our meeting on May 28, 1987, this letter summarizes the differences between the engineer's estimate and the bid tabs for the Northgate Filing No. 1 concrete box culvert. The subdivision drainage report estimated the concrete box culvert and entrance at $189,031. The low bidder's cost for this item was $214,601 which is 8.0% over our estimate. The reimbursable earthwork for the CBC was estimated at $11,250. The low bidder's cost for this was $17,250 which is 53.3% over our estimate. The increase in cost for both of these items can be attributed to the saturated soil conditions that are present in the bottom of the creek. The inlet riprap unit price in the low bid is slightly less than the engineer's estimate. However, a quantity change between the approval of the drainage report and the drainage construction drawings resulted in an increase of 220% from the engineer's estimate. This increase was due to a city request to extend the riprap to the easement line on the upstream side of the CBC. Thus, the net increase in reimbursable drainage improvements for the CBC was from $212,595 in the drainage report to $240,251 in the negotiated low bid. This is an increase of 13%.

The attached spreadsheet summarizes the contractors bids and engineer's estimate. It should be noted that AA Construction had the low overall bid of the four bidders. After discussion with them, a revised low bid was obtained based upon a quantity error in the upstream riprap and a design change in the downstream, temporary improvements. This revised low bid is shown on the far right side of the sheet for AA Construction.

We appreciate your prompt attention to this matter. If you have any questions, please call me at 590-7377.

Sincerely,

Clyde L. Pikkaraine

Clyde L. Pikkaraine, P.E.
Project Manager

Bid Approved for Construction

By: _____

Date: 6/18/87

Please return one signed copy.

Approved for increase from $212,595 to $240,251 reimbursable cost for public facilities

attachment

cc: Kevin Walker
Kurt Schaake

NORTHGATE PHASE 1
CONCRETE BOX CULVERT BIDS
URS PROJECT NO. 5192
MAY 28, 1987

BID ITEMS	ENGINEER'S ESTIMATE $	K R SWERDFEGER BID AMOUNT $	IDEAL CONCRETE BID AMOUNT $	BABCOCK PLATTE VLY BID AMOUNT $	AA CONSTRUCTION BID AMOUNT $	LOW BID AMOUNT OVER EST. %	LOW BID AMOUNT OVER EST. %	LOW BID REVISED AMOUNT $	LOW BID REVISED AMOUNT OVER EST. %	
✓ BOX CULVERT W/ INLET	$198,719	$200,000	$189,031	$338,146	$214,601	8.0%	8.0%	$214,601	8.0%	
✓ INLET RIPRAP	$2,626	$15,180	$15,905	$16,500	$13,200	402.7%	402.7%	$8,400	219.9%	**
OUTLET RIPRAP (NON Reimb)	<$35,359>	$35,880	$37,599	$39,000	$31,200	-11.8%	-11.8%	<$31,200>	-11.8%	
OUTLET WINGWALLS (NON Reimb)	<$30,581>	$130,000	$27,895	$52,175	$52,196	70.7%	70.7%	<$41,747>	36.5%	
✓ EARTHWORK (REIMB.)	$11,250	$15,000	$24,075	$22,500	$17,250	53.3%	53.3%	$17,250	53.3%	
EARTHWORK (NON-REIMB.) ✓	<$44,550>	$59,400	$95,337	$89,100	$68,310	53.3%	53.3%	<$68,310>	53.3%	
REMOVE TEMP. CULVERT	$0	$7,800	$9,095	$3,000	$7,326	*	*	<$4,660 *>	*	
PERFORMANCE BOND	$0		$7,978			*	*		*	
	$323,085 ✓ 212,595	$463,260	$406,915	$560,421	$404,083 ✓	25.1%	25.1%	$386,168 ✓ 240,251	19.5% +13.01%	

NOTES:
* 1) THESE ITEMS WERE NOT INCLUDED IN THE ENGINEERS ESTIMATE
** 2) THE QUANTITY OF THE RIPRAP INCREASED FROM THE DRAINAGE REPORT
3) THE ENGINEER'S ESTIMATE DOES NOT INCLUDE 5% CONTINGENCY OR 10% ENGINEERING

MAX L. ROTHSCHILD, P.E.
DIRECTOR OF TRANSPORTATION

GEORGE MADRIL, L.S.
OPERATIONS ENGINEER

DONALD F. SMITH
ENGINEERING ADMINISTRATOR

CHARLES A. WHYTE
COUNTY SUPERINTENDENT

PHONE (303) 520-6460

EL PASO COUNTY

DEPARTMENT OF TRANSPORTATION

3170 CENTURY STREET
COLORADO SPRINGS, COLORADO 80907

October 20, 1986

Mr. Clyde L. Pikkaraine, P.E.
URS Corporation
1040 South Eighth Street
Colorado Springs, CO. 80906

RE: Northgate Phase 1 - Drainage Report and Plan

Dear Mr. Pikkaraine:

We have reviewed the above referenced report and plan. In that no platting is associated with this report, only grading and box culvert construction, El Paso County Department of Transportation approves of such report as long as the following conditions are adhered to.

1. Proper erosion and sediment control measures are implemented during all phases of construction such that no adverse effects are realized by any adjacent property owners.
2. Prior to construction, adequate easements and/or rights of way are acquired for all areas outside of Northgate property boundaries.
3. All required subsequent submittals be reviewed and approved by El Paso County prior to any additional construction, including the revised Black Squirrel Creek Drainage Basin Planning Study

If you should have any questions regarding this matter, please don't hesitate to contact us.

Sincerely,

Donald F. Smith
Engineering Administrator

By: Alan B. Morrice
Alan B. Morrice
Drainage Engineer

cc: Max L. Rothschild
Bob Adamczyk

DFS/ABM/amh

FLOODPLAIN DEVELOPMENT PERMIT

Owner O.S. Properties, Inc. Date Sept. 25, 1986

Contractor Not Bid Yet Phone

Address

Project Location Northgate Phase I, Near SE Corner SW 1/4 SE 1/4 Section 17, Township 12 South Range 66 West

Project Description: __ Residential __ Non-Residential __ Mobile Home
__ Subdivision __ New Construction __ Addition or Improvement __ Fill
__ Watercourse Alteration X Other Road Crossing of Black Squirrel Creek

ATTACH THE FOLLOWING INFORMATION WHERE APPLICABLE: Plans, in duplicate, drawn to scale showing the nature, dimensions, elevation, and location of the project; existing and proposed structures, fill, materials being stored, and drainage facilities.

SPECIFICALLY, THE FOLLOWING INFORMATION IS REQUIRED: (1) Mean Sea Level (MSL) elevation of the lowest floor of all structures; (2) MSL elevation to which structures are floodproofed; (3) Certification by a registered professional engineer or architect that the floodproofing methods meet approved standards; (4) A description of any watercourse alteration, and (5) base (100-year) flood elevation data.

****

TO BE COMPLETED BY THE FLOODPLAIN ADMINISTRATOR

****

The proposed development is located in the: X Floodway X Floodfringe

The Base Flood Elevation at the development site is: NA

Source Documents: Drainage Plan - Northgate Phase I

FIRM panel 40

PLAN REVIEW: Elevation to which the structure is to be elevated: NA ; floodproofed: _____.

ACTION: Permit denied: The proposed project does not meet the approved Floodplain Management Standards (explanation attached).

✓ Permit approved: I have reviewed the information submitted for the proposed project and find it in compliance with approved Floodplain Management Standards.

10-6-86
DATE

Earl Bunting
REGIONAL FLOODPLAIN ADMINISTRATOR

VARIANCE ACTION: __ Granted __ Denied Date:

BUILDING CONSTRUCTION DOCUMENTATION: The certified as-built elevation of the structure; lowest floor _____; floodproofed _____.

Certificates of a registered professional engineer or land surveyor documenting these elevations are attached.

Certificate of Occupancy or Compliance issued:

Comments Site is in unstudied A zone. This permit is for fill and construction

NORTHGATE PHASE 1

DRAINAGE REPORT

June 4, 1986
Revised: July 22,1986
Revised: September 3, 1986

Prepared for: The Olive Company
5450 Tech Center Drive - Suite 400
Colorado Springs, Colorado 80919
598-3000

Prepared by: URS Corporation
5450 Tech Center Drive - Suite 303
Colorado Springs, Colorado 80919
590-7377

URS
AN INTERNATIONAL PROFESSIONAL SERVICES ORGANIZATION

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1040 SOUTH EIGHTH STREET
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Northgate Phase 1
Drainage Report and Plan
URS Project No. 5206

DRAINAGE REPORT STATEMENTS

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 the negligent acts, errors or omissions on my part in preparing this report.

COLORADO REGISTERED
CLYDE L. PIKKARAINE
20450
PROFESSIONAL ENGINEER

Clyde L. Pikkaraine

Clyde L. Pikkaraine, P.E., Colorado 20450
URS Corporation

Date 9/4/86

Developer's Statement:

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

The Olive Company

BY: Kurt J. Walker

TITLE: Development Manager

9/4/86
Date

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

9/9/86
Date

Condition:

X See attached conditions for approval

__

CITY OF COLORADO SPRINGS
The "America the Beautiful" City
DEPARTMENT OF PUBLIC WORKS CITY ENGINEERING DIVISION (303) 578-6606
30 S. NEVADA SUITE 403 P.O. BOX 1575
COLORADO SPRINGS, COLORADO 80901

Re: Conditions of approval for Northgate Phase 1 Drainage Report:

1. This Drainage Report filed for rough-cut and drainage facility construction only as shown on Figure No. 1 (Northgate Parkway and Loop Road). No curb, gutter walks or street pavement construction will be allowed until this report is resubmitted with an analysis of site drainage and detention facilities.

2. A letter of credit is to be posted for the facilities shown in this report prior to approval of rough cut and drainage construction drawings.

3. Basin and bridge fees to be paid at the time of platting of the streets and adjoining parcels.

4. A floodplain permit for Northgate Parkway will be required prior to rough cut approval.

5. The major detention ponds as indicated in the Black Squirrel Basin Study are to be designed to provide sufficient detention to eliminate the need for additional public detention facilities downstream of the Northgate project.

6. No additional public detention facilities will be allowed in the miscellaneous basin shown on Figure No. 1. Sizing of outfall facilities will be subject to private detention facility requirements.

7. Subject to the requirements of El Paso County and the Colorado Department of Highways.

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

City Engineer Date

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I. PURPOSE AND SCOPE

Northgate is a 1500 acre mixed-use development on the north side of Colorado Springs. The first phase of Northgate consists of the south 380 acres of the development. The purpose of this drainage report is to obtain rough cut approval of Northgate Parkway and the Loop Road. The drainage facilities detailed in this report are those facilities in the roads only. See Figure 1 (attached) for the area involved. Since the roads will not be paved as part of this report, this report will be revised to include detention prior to paving of the roads.

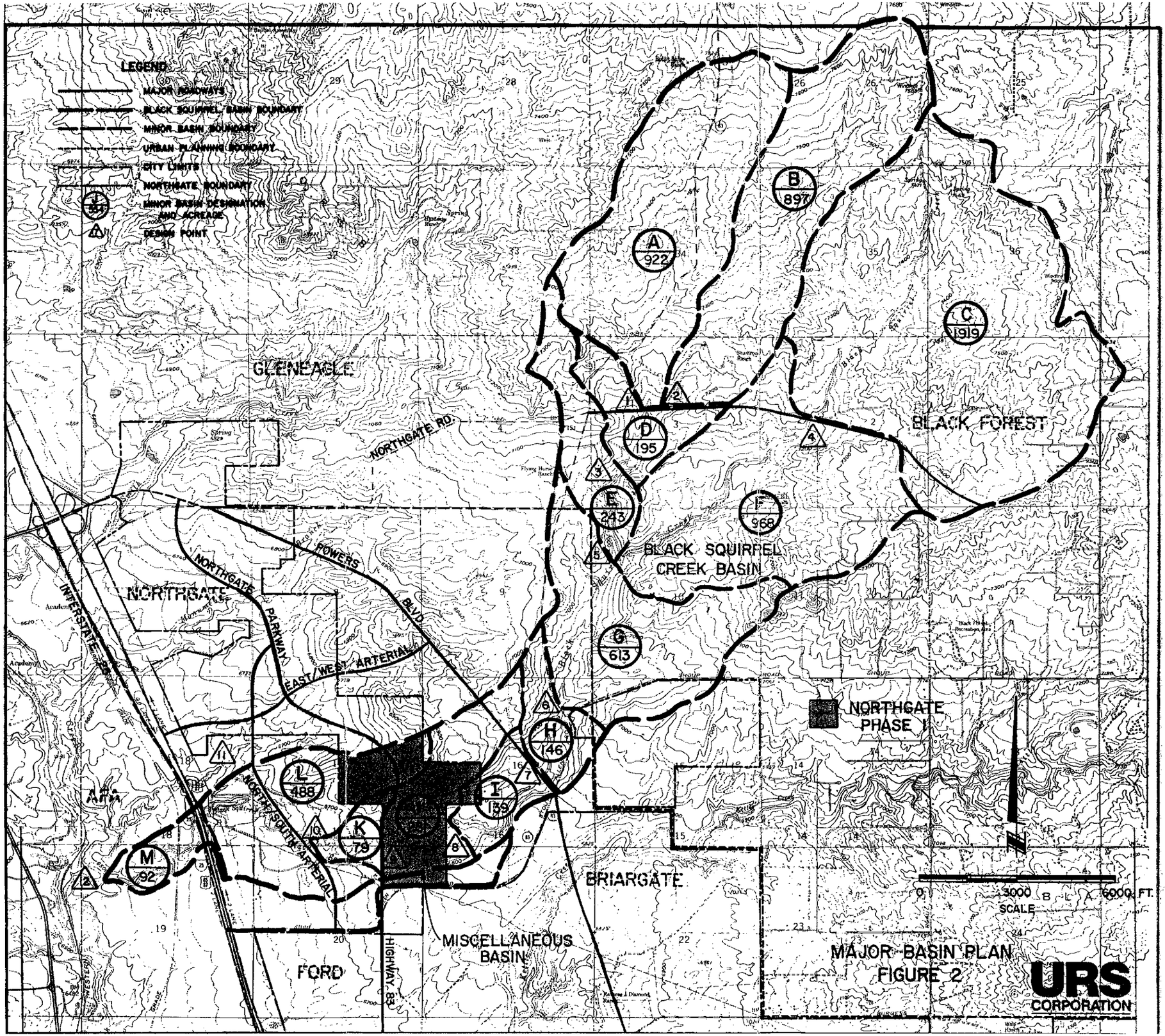
Conceptual drainage subbasins and flow patterns are presented to determine the areas tributary to the proposed rough cut area.

II. SITE DESCRIPTION AND LOCATION

Northgate Phase 1 is located within the southwest quarter of Section 16, the east half of Section 17, and the northeast quarter of Section 20, and the northwest quarter of Section 21, Township 12 south, Range 66 west of the 6th Principal Meridian, El Paso County, Colorado (Figure 2). Approximately 270 acres lie within the Black Squirrel Creek Basin and approximately 20 acres lie within an unstudied basin (tributary to the area north of existing Stout Allen Road).

The site slopes primarily from east to west at slopes of 1 to 2 percent. There are three existing discharge points from the site downstream. The southerly discharge point is from the unstudied basin between State Highway 83 and the Black Squirrel Creek Basin. The middle discharge has the largest flow and is the main channel of Black Squirrel Creek. The northerly discharge is a tributary of Black Squirrel Creek which meets the main channel of Black Squirrel Creek just upstream of Interstate 25 (subbasin L on Figure 2). The proposed rough cut area is limited to the unstudied basin and the main channel of Black Squirrel Creek. The northerly discharge is presented only to show that it is not tributary to the proposed rough cut area.

The soils within Northgate Phase No. 1 are classified by the U.S. Soil Conservation Service as hydrologic soil type B. Group


LEGEND
MAJOR ROADWAYS
BLACK SQUIRREL BASIN BOUNDARY
MINOR BASIN BOUNDARY
URBAN PLANNING BOUNDARY
CITY LIMITS
NORTHGATE BOUNDARY
MINOR BASIN DESIGNATION AND ACREAGE
DESIGN POINT
A 922
B 897
C 1919
D 195
E 243
F 968
G 613
H 146
I 139
J 884
K 79
L 488
M 92
GLENEAGLE
NORTHGATE RD.
BLACK FOREST
BLACK SQUIRREL CREEK BASIN
NORTHGATE
NORTHGATE PARKWAY
POWERS BLVD
EAST/WEST ARTERIAL
INTERSTATE 25
NORTH/SOUTH ARTERIAL
NORTHGATE PHASE I
BRIARGATE
MISCELLANEOUS BASIN
FORD
HIGHWAY 83
SCALE
3000 0 3000 6000 FT.
MAJOR BASIN PLAN
FIGURE 2
URS CORPORATION

B soils have moderate infiltration rates when thoroughly wetted and consist chiefly of moderately deep to deep, moderately well to well-drained soils with moderately fine to moderately coarse textures.

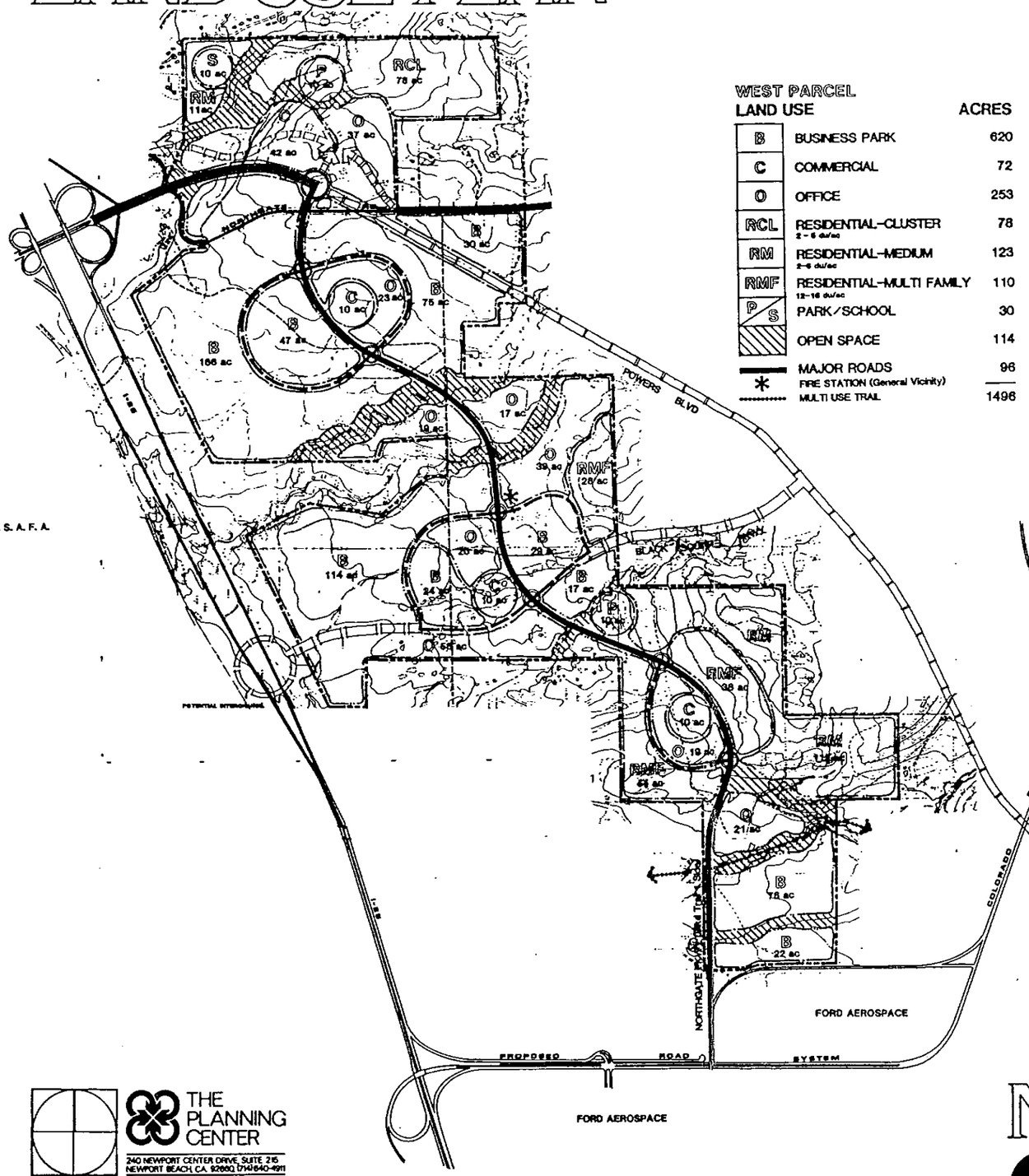
The main channel of Black Squirrel Creek is the only drainageway with an identified 100-year floodplain on the current FEMA maps. The Northgate Parkway crossing of Black Squirrel Creek is in the FEMA floodplain. The proposed crossing has been permitted through a nationwide permit with the US Army Corps of Engineers.

III. PLANNED DEVELOPMENT

Current City of Colorado Springs criteria requires drainage facilities to be sized for the future fully developed basin. The US Air Force Academy is located downstream of Northgate. This requires the modification of city criteria to include detention facilities to limit the downstream peak flows to historic levels. The approved Black Squirrel Creek Master Plan required three detention sites for the basin. Developed conditions for Northgate were obtained from the approved Land Use Map (Figure 3) for Northgate. Developed conditions for areas outside Northgate were considered to be the mixed use type of development presented in the Black Squirrel Creek Master Plan.

At this time, the developer intends to construct Northgate Parkway, the Loop Road, and the associated drainage facilities (Figure 1). These facilities will initially be within dedicated easements. Subsequently, land adjacent to the roads and the road right-of-ways will be platted. Therefore, according to City criteria, the developer must provide a subdivision drainage report or letter for each subsequent plat. It is the intent of this report to show conceptual drainage patterns so that drainage can be collected and conveyed to the three outfall points previously described. Future drainage reports should present detailed calculations as to how the overall drainage system will operate.

LAND USE PLAN



WEST PARCEL

LAND USE		ACRES
B	BUSINESS PARK	620
C	COMMERCIAL	72
O	OFFICE	253
RCL	RESIDENTIAL–CLUSTER 2 – 6 du/ac	78
RM	RESIDENTIAL–MEDIUM 2–6 du/ac	123
RMF	RESIDENTIAL–MULTI FAMILY 12–16 du/ac	110
P/S	PARK/SCHOOL	30
	OPEN SPACE	114
	MAJOR ROADS	96
*	FIRE STATION (General Vicinity)	
.....	MULTI USE TRAIL	
		1496

EAST PARCEL

LAND USE		ACRES
C	COMMERCIAL/OFFICE	13
RL	RESIDENTIAL–LOW 1–6 ac lots	134
RM	RESIDENTIAL–MEDIUM 2–6 du/ac	156
RMF	RESIDENTIAL–MULTI FAMILY 12–16 du/ac	29
P/S	PARK/SCHOOL	53
		385

THE PLANNING CENTER
240 NEWPORT CENTER DRIVE, SUITE 215
NEWPORT BEACH, CA. 92660 (714) 640-4911

APPROVED AUGUST 13, 1985

FIGURE 3

NORTHGATE

THE OLIVE COMPANY
5450 Tech Center Drive, Suite 400
Colorado Springs, Colorado 80919
Colorado Springs (303) 598-5000
Denver (303) 893-9555

IV. DESIGN CRITERIA

Determining runoff for a particular drainage basin needs to consider the effects of many different variables. In the absence of a reliable historic record of rainfall, runoff, and other pertinent variables, it is usually necessary to use a synthetic unit hydrograph method to determine the runoff that will occur for a given rainfall event. The SCS method of determining peak flood flows and hydrographs was used to estimate direct runoff for the major basins ($Q_{100} > 500$ cfs). For an explanation of the procedures used, see the "SCS National Engineering Handbook, Section 4". Due to the number of computations necessary to determine the hydrographs and hydrologic routing of the given storm events, the calculations were performed with the aid of the TR-20 computer program. For minor basins ($Q_{100} < 500$ cfs), storm runoff was calculated using City of Colorado Springs criteria as presented in the "Subdivision Policy Manual".

Present City of Colorado Springs criteria requires that the design of facilities where the 100-year storm exceeds 500 cfs to be for the 100-year design flow. Facilities where the 100-year storm is less than 500 cfs can be designed for the 5-year storm with a provision that the 100-year storm can be conveyed to the major facilities without damage to buildings or structures. For example, a 5-year capacity storm sewer may be built and the 100-year storm will be contained within a street right-of-way and the

storm sewer. Criteria for the major facilities ($Q_{100} \geq 500$ cfs) will require the design to be for the greater of the peak flows determined for the 100-year 24-hour storm and the 100-year 6-hour storm. Design of minor facilities ($Q_{100} < 500$ cfs) shall be for the 5-year 6-hour storm.

Drainage design standards and criteria reduce but do not eliminate all flood risks. Drainage design criteria are an indication of the presently acceptable level of risk in the Colorado Springs area as determined by the City of Colorado Springs. Rainfall and storms larger than the 100-year storm can and do occur.

As stated in the Black Squirrel Creek Master Plan, the 5-year and 100-year peak flows at the U.S. Air Force Academy boundary are required to be at historic levels or below. The 5-year and 100-year peak flows at the downstream property boundary of Northgate will also be limited to historic levels or below.

V. HYDROLOGY

Time of concentration for the upstream subbasins was determined by the following equation:

$$T = \left[\frac{11.9 \times L^3}{H} \right] .385$$

where T = time of concentration in hours

L = length of longest watercourse in miles

H = elevation difference in feet

As the calculations proceed downstream, individual travel times are added for each reach (minor systems) or hydrologically routed through each reach (major systems).

The rainfall depths of 2.7 and 4.6 inches were obtained from isopluvials for the project area for the 5-year 24-hour and 100-year 24-hour storm events, respectively. Table 1 shows the dimensionless precipitation distribution for the SCS Type IIA storm. The rainfall depths of 2.1 and 3.5 inches were obtained from the city's "Subdivision Policy Manual" for the 5-year 6-hour and 100-year 6-hour storm events, respectively.

A. Major Drainage (Black Squirrel Creek Basin)

Figure 2 depicts the major drainage basins for Black Squirrel Creek as presented in the master plan. The master plan proposed a large detention pond at design point 9 (Northgate Parkway and Black Squirrel Creek). After a preliminary

TABLE 1
24-HOUR RAINFALL DISTRIBUTION
SCS TYPE IIA STORM

Time (hours)	Distribution of Total Rainfall
0	0
2.00	0.010
4.00	0.030
4.50	0.050
5.00	0.060
5.50	0.100
6.00	0.700
6.50	0.750
7.00	0.780
8.00	0.820
9.00	0.840
9.50	0.850
10.00	0.860
10.50	0.865
11.00	0.870
11.50	0.885
11.75	0.888
12.00	0.890
12.50	0.900
13.00	0.905
13.50	0.910
14.00	0.915
16.00	0.940
20.00	0.980
24.00	1.000

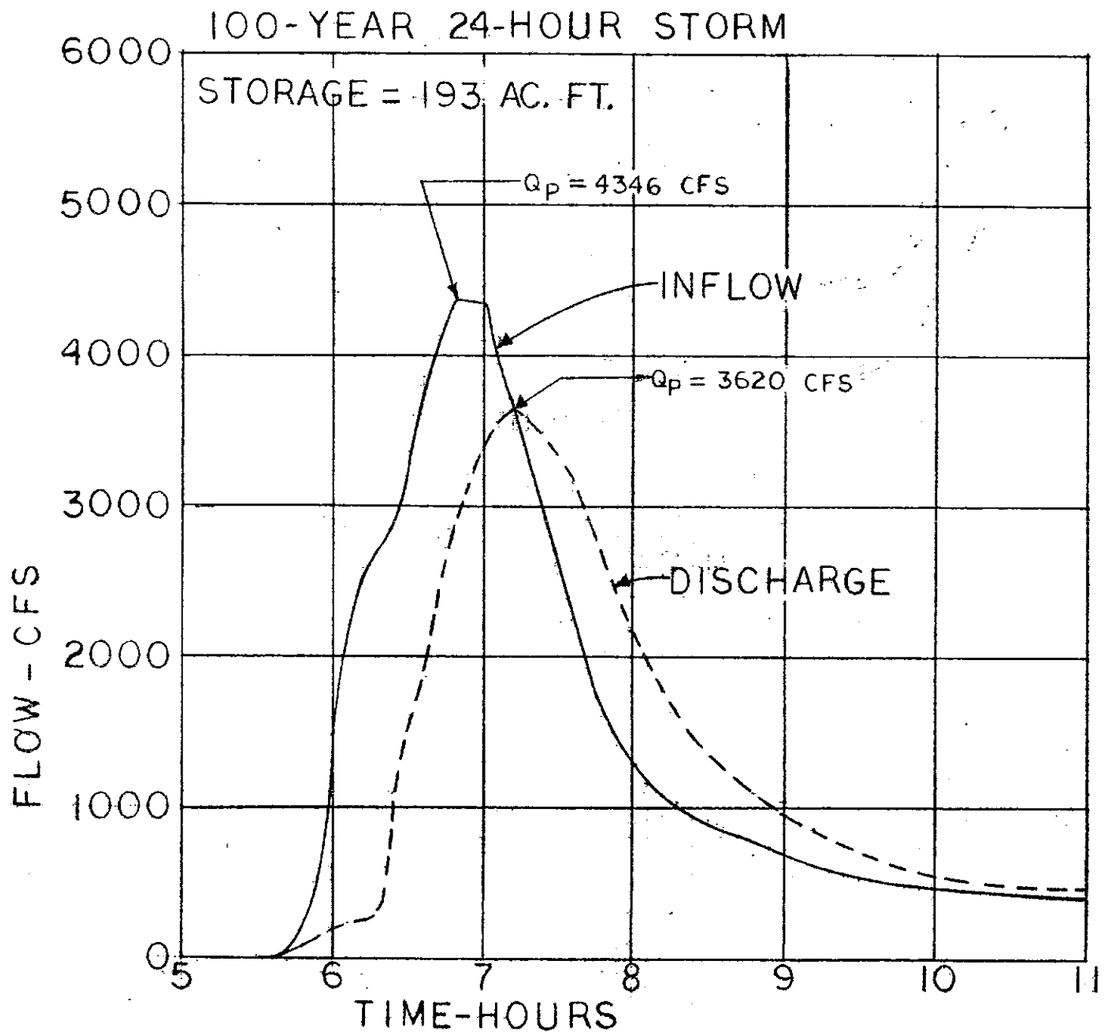
geotechnical investigation was performed by Woodward-Clyde Consultants, it was determined that a deep alluvial fan occurs on the north side of Black Squirrel Creek at the detention pond location shown in the master plan. The alluvial fan is expected to have low to moderate strength and moderate to high permeability. There is also a potential for differential settlement to occur for the height of the proposed dam. Therefore, the location of the detention pond was shifted to the east where the dam would not be placed on the alluvial fan. The proposed detention pond location is shown on Figure 1. The shift of the detention pond upstream requires that the pond overdetain the 100-year 24-hour storm in order to maintain the historic peak flows at the US Air Force Academy boundary. The 5-year 24-hour storm peak flows will be overdetained in this pond to maintain the historic peak flows at the Northgate west property line. Table 2 presents the historic flows at each design point on Figure 2 and developed flows for full development upstream of and including Northgate. The property downstream of Northgate will require detention of the 5-year storm in order to maintain historic peak flows at the Air Force Academy boundary. The Black Squirrel Creek Master Plan had a 5-year detention pond located off the main channel for the downstream property. No change to that concept is intended.

FIGURE 4

DETENTION POND HYDROGRAPH

DESIGN POINT 8 (FIGURE 2)

DET. POND NO. 2 OF BSC MASTER PLAN (RELOCATED)



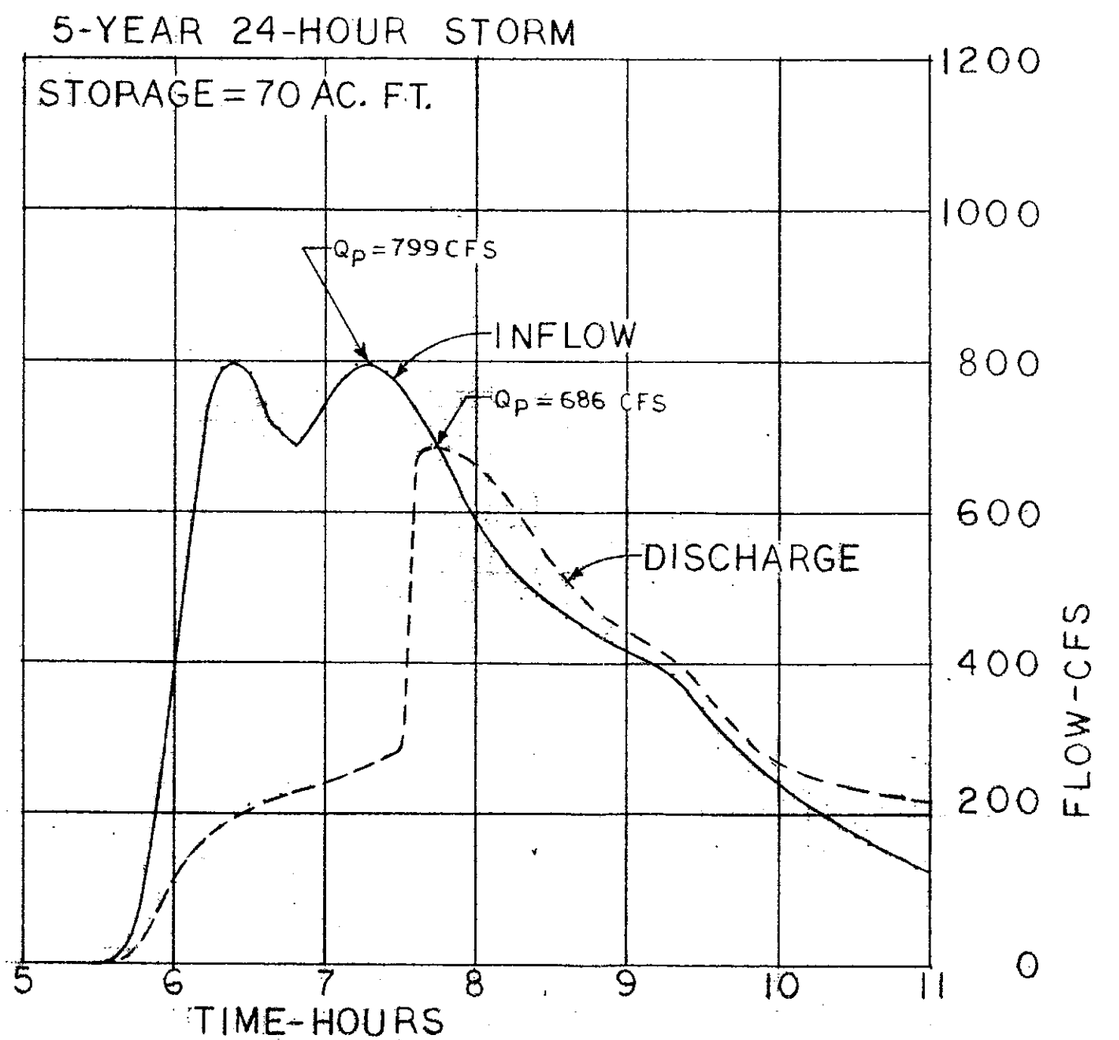


TABLE 2
BLACK SQUIRREL CREEK MAJOR BASIN PEAK FLOWS
NORTHGATE PHASE 1 DRAINAGE REPORT
REF:FIG. #2

PEAK FLOWS FOR THE 5-YEAR 24-HOUR STORM EVENT

FIG: #2 DESIGN POINT	HISTORIC FLOW (CFS)	DEVELOPED FLOW (CFS)	
1A	56	---	
1B	119	---	
2	---	247	
3	263	498	
4	---	551	
5	727	725 OUT	DETENTION POND #1
6	749	792	
7	---	887	
8	750	686 OUT	DETENTION POND #2
9	750	705	
10	---	708	
11	735	715	
12	727	714	

PEAK FLOWS FOR THE 100-YEAR 24-HOUR STORM EVENT

FIG: #2 DESIGN POINT	HISTORIC FLOW (CFS)	DEVELOPED FLOW (CFS)	
1A	307	422	
1B	773	1047	
2	-----	985	
3	1825	2194	
4	-----	2317	
5	4158	4029 OUT	DETENTION POND #1
6	4389	4329	
7	-----	4389	
8	4050	3620 OUT	DETENTION POND #2
9	4050	3698	
10	-----	3709	
11	3956	3772	
12	3949	3744	

NOTE: DEVELOPED FLOW BASED ON FULL DEVELOPMENT OF THE BASIN UPSTREAM AND INCLUDING NORTHGATE. THE PROPERTY DOWNSTREAM OF NORTHGATE REQUIRES DETENTION FOR THE 5-YEAR STORM WHEN DEVELOPED.

The detention pond design will be presented at a later date. Temporary (private) detention may be provided (within Northgate) on an interim basis prior to construction of the large detention pond shown on Figure 1.

B. Minor Drainage (Black Squirrel Creek Basin)

Figure 1 depicts the minor ($Q_{100} \leq$ 500 cfs) basins and design points. Table 3 is a summary of the peak flows for each subbasin. Table 4 summarizes the flows at each design point and delineates how much flow is picked up by each inlet, and what flow is in the storm sewer pipe versus bypassed in the street.

C. Minor Drainage (Miscellaneous Basin)

Currently, the flow from the unstudied basin sheet flows from east to west and eventually reaches an existing 24" RCP that crosses Interstate 25 north of Stout Allen Road. Due to the excessive cost of constructing additional pipes under Interstate 25 and the need to maintain historic peak flows onto the U.S. Air Force Academy, it is necessary for this unstudied basin to detain to historic levels. Therefore, the portion of Northgate Phase 1 in the basin will only release historic flows. On-site (private) detention will be provided for the Northgate area within this basin. Figure 1 depicts the minor ($Q_{100} <$500 cfs) basins and design points. Table 3 is a summary of the peak flows for each subbasin.

TABLE 3
SUMMARY OF SUBBASIN
HYDROLOGICAL DATA

BASIN	AREA (acres)	CN	Tc (hrs)	6 HOUR PEAK RUNOFF 5 YR (cfs)	6 HOUR PEAK RUNOFF 100 YR (cfs)	24 HOUR PEAK RUNOFF 5 YR (cfs)	24 HOUR PEAK RUNOFF 100 YR (cfs)
A	20.0	87	0.15	36.2	79.8	41.6	89.8
B	7.9	92	0.12	20.0	39.7	22.0	43.4
C1	0.4	98	0.05	1.5	2.6	1.5	2.7
C2	0.3	98	0.07	1.1	2.0	1.2	2.0
C3	0.7	98	0.06	2.6	4.6	2.7	4.8
D	4.5	92	0.11	11.7	23.2	12.9	25.5
E1	1.1	98	0.11	4.0	7.0	4.2	7.4
E2	0.3	98	0.03	1.1	2.0	1.5	2.7
E3	0.3	98	0.03	1.1	2.0	1.2	2.0
F	9.4	92	0.11	24.4	48.4	27.0	53.2
G	8.9	92	0.11	23.1	45.8	25.6	50.4
H1	1.4	98	0.08	5.2	9.1	5.4	9.5
H2	0.7	98	0.05	2.6	4.6	2.7	4.8
I	13.3	92	0.08	35.3	70.1	39.0	96.9
J	2.0	87	0.02	3.9	8.7	4.6	10.0
J1A	108.2	87	0.26	162.4	357.9	190.2	410.2
J1B	64.8	72	0.20	36.3	121.4	52.8	157.3
K	7.0	72	0.05	4.7	15.7	7.0	20.7
L	1.0	98	0.07	3.7	6.5	3.9	6.8
M	1.0	98	0.07	3.7	6.5	3.9	6.8
N	3.3	98	0.09	12.3	21.6	12.8	22.4
O	9.5	72	0.10	6.4	21.3	9.4	28.1
P	0.7	98	0.14	2.4	4.1	2.5	4.3
Q	4.0	98	0.24	11.7	20.4	11.9	21.0
R	2.1	98	0.13	7.4	12.9	7.5	13.3
S	2.0	87	0.03	3.9	8.7	4.6	10.0
T	29.2	92	0.14	71.4	142.0	78.0	153.6
U	6.2	92	0.09	16.5	32.7	18.2	35.8
V	21.5	87	0.30	30.4	68.3	35.3	76.2
W	7.7	92	0.19	20.3	40.7	22.8	44.6
X	0.6	98	0.05	2.2	3.9	2.3	4.1
Y	11.5	92	0.14	28.4	55.9	30.6	60.3

REF: FIG. #1

TABLE 4
SUMMARY OF STORM SEWER
HYDROLOGIC DATA

DESIGN POINT	CONTRIBUTING SUBBASINS & BYPASS FLOW	DRAINAGE AREA (acres)	CN	DIRECT RUNOFF 6-HR 5-YR STORM	To	Ts	Tp	Tc	6-HR (csm/in)	Q5 @ D.P. (cfs)	Q5 bypass (cfs)	Q5 lateral (cfs)	Q5 main (cfs)	REMARKS
BLACK SQUIRREL CREEK BASIN														
1	A	20.0	87	0.99	0.15			0.15	1170	36.2			36.2	OFFSITE RUNOFF **
2	B,C1	8.3	92.3	1.35		0.12		0.12	1220	21.4	(3.4)		18.0	6'& 8'D-10-R'S
	A,B,C1	28.3	88.6	1.08	0.15		0.06	0.21	1050	50.1	(3.4)		46.7	PIPE FLOW **
3	D,C2 +B.P.	4.8	92.4	1.36		0.11		0.11	1250	12.8 + 3.4	(6.5)	9.7		10' D-10-R
	A,B,C1,C2,D	33.1	89.2	1.12	0.15		0.10	0.25	1000	57.9	(6.5)		51.4	PIPE FLOW
4	F,E1	10.5	92.6	1.37		0.11		0.11	1250	28.1	(11.2)	16.9		22' D-10-R
	A,B,C1,C2,D,E1,F	43.6	90.0	1.19	0.15		0.12	0.27	960	77.2	(11.2)+(6.5)		59.4	PIPE FLOW
5	E2 +B.P.	0.3	98.0	1.87		0.05		0.05	1280	1.1 + 11.2	(4.9)	7.4		6' D-10-R
	A,B,C1,C2,D,E1,E2,F	43.9	90.0	1.18	0.15		0.15	0.30	920	74.5	(4.9)+(6.5)		63.1	PIPE FLOW
6A	E3,G +B.P.	9.2	92.2	1.34		0.11		0.11	1250	24.1 + 4.9	(11.6)	17.4		22' D-10-R
	A,B,C1,C2,D,E,F,G	53.1	90.4	1.20	0.15		0.16	0.31	910	90.6	(11.6)		79.0	PIPE FLOW
6B	C3 +B.P.	0.7	98.0	1.87		0.06		0.06	1280	2.6 + 6.5	(3.6)	5.5		4' D-10-R
	A,B,C,D,E,F,G	53.8	90.5	1.22	0.15		0.17	0.32	900	92.3	(11.6)+(3.6)		77.1	PIPE FLOW
6C	H1 +B.P.	1.4	98.0	1.87		0.08		0.08	1280	5.2 + 11.6 + 3.6	(8.2)	12.2		18' D-10-R
	A,B,C,D,E,F,G,H1	55.2	90.7	1.23	0.15		0.20	0.35	860	91.2	(8.2)		83.0	PIPE FLOW TO CBC
8	J,K,L	8.0	75.3	0.44	0.07	0.03		0.10	1280	7.0	(2.8)	4.2		4' D-10-R(FUTURE) **
	J,K,L,D	19.5	73.3	0.38	0.07	0.03		0.10	1280	14.8	(2.8)		12.0	PIPE FLOW **
9	M,N +B.P.	4.3	98.0	1.87		0.10		0.10	1280	16.1 + 2.8	(7.6)	11.3	11.3	6' D-10-R @ STREET SLOPE=3%
10	H2,P +B.P.	1.4	98.0	1.87		0.14		0.14	1180	4.8 + 8.2 + 7.6	0.0	20.6		10' SUMP D-10-R OVER CBC
11	Q,R	6.1	98.0	1.87		0.24		0.24	1000	17.8		17.8		8' SUMP D-10-R
12	J1A	108.2	87.0	0.99			0.26	0.26	970	162.4			162.4	OFFSITE RUNOFF **
	J1A,J1B	173.0	81.4	0.69			0.46	0.46	760	142.0			142.0	TOTAL INFLOW TO CHANNEL **
13	ALL OF BLACK SQUIRREL CREEK BASIN TO THIS POINT (FROM TR-20 RUN)									750* (5-YR) 4050* (100-YR)				
MISCELLANEOUS BASIN														
14	V	21.5	87	0.98	0.30			0.30	920	30.4				OFFSITE RUNOFF
15	V,W	29.2	88.3	1.07	0.30		0.02	0.32	900	43.8*			43.8*	FLOW @ EAST SIDE OF LOOP RD.
	X	0.6	98	1.87		0.05		0.05	1280	2.2*	0.0	2.2		2-4' SUMP D-10-R'S
16	V,W,X,Y	41.3	89.5	1.15	0.30		0.09	0.39	820	60.6*			60.6*	FLOW LEAVING SITE

*FLOWS LEAVING SITE MUST BE MAINTAINED TO HISTORIC LEVELS UNTIL DOWNSTREAM IMPROVEMENTS ARE BUILT
** FUTURE FACILITIES MAY BE PUBLIC OR PRIVATE, THIS HAS NOT BEEN DETERMINED AT THIS TIME.

REF: FIG. #1

VI. RECOMMENDED STORM DRAINAGE IMPROVEMENTS

A. Major Drainage (Black Squirrel Creek Basin)

The only major drainage ($Q_{100} > 500$ cfs) associated with the Northgate site are those facilities on the Black Squirrel Creek main channel. All other subbasins for Northgate Phase 1 have a flow of less than 500 cfs for the 100-year storm. A concrete box culvert is proposed under Northgate Parkway along with the entrance and outlet. The outlet lies in El Paso County. The design of the barrel and upstream entrance to the concrete box culvert was done in accordance with the U.S. Department of Transportation, Federal Highway Administration's "HEC No. 13 - Hydraulic Design of Improved Inlets for Culverts", dated August, 1972. The use of a slope-tapered inlet to the double 14' by 10' concrete box culvert reduced the overall cost of the culvert and inlet. The CBC was designed for the ultimate outlet to the future concrete-lined channel delineated in the Black Squirrel Creek Master Plan. At the present time, a temporary riprap outlet will be constructed. The design of the temporary outlet was done in accordance with the Denver Regional Council of Governments' "Urban Storm Drainage Criteria Manual", Volume II, Major Drainage, Section 5.6. The design calculations for the concrete box culvert (including entrance and outlet structures) are presented in Appendix A.

B. Minor Drainage

Minor drainage systems are proposed for the facilities required in Northgate Parkway and the Loop Road. Figure 1 (attached) and Table 5 delineate the proposed drainage improvements.

For the unstudied (miscellaneous) basin, proposed improvements include two inlets at the low point on the Loop Road and a cross-culvert/ storm sewer pipe crossing the road. The 36" cross-culvert will be used to carry the flow in the ditch section of State Highway 83 and the inlet flow across the Loop Road. Temporarily, the ditch will be diverted into this pipe and a drainage easement will be provided for the portion of the ditch on Northgate property.

The area in Black Squirrel Creek Basin south of the main channel will be routed into the main channel by way of a storm sewer system in the Loop Road, a storm sewer system in the proposed drainage and trail easement east of Northgate Parkway, and by sheet flow where the drainage subbasin flows directly to the creek. The storm sewer system will discharge directly into the Black Squirrel Creek box culvert.

The area north of the main channel of Black Squirrel Creek that flows to the main channel will mainly be picked up by an on-site drainage system. The height of fill required for Northgate

TABLE 5

PROPOSED MINOR STORM DRAINAGE IMPROVEMENTS & DESIGN DATA

DESIGN POINT	FACILITY TYPE	STREET GRADE (%)	PIPE GRADE (%)	PIPE LENGTH (ft)
1-2 *	30" RCP	5.6	2.0	550
	EAST DRAINAGE FACILITY TO BE CONSTRUCTED IN FUTURE			
2	6' & 8'D-10-R	5.6	--	---
2-3	30" RCP	0.7	1.0	455
3	10' D-10-R	0.7	--	---
	18" RCP	0.7	1.0	67
3-4	30" RCP	2.4	1.4	443
4	22' D-10-R	2.4	--	---
4-5	30" RCP	2.4	2.4	330
5	6' D-10-R	2.4	--	---
5-6A	30" RCP	2.4	3.3	282
	36" RCP	2.0	0.5	58
6A	22' D-10-R	2.4	--	---
	24" RCP	2.0	7.0	41
6A-6B	36" RCP	2.0	0.5	30
6B	4' D-10-R	2.4	--	---
	18" RCP	2.0	10.0	13
6B-6C	36" RCP	1.0	0.5	23
	42" RCP	1.0	0.5	23
6C	18 D-10-R	1.0	--	---
	18" RCP	1.0	10.0	26
6C-7	42" RCP	--	1.0	316
7	42" RCP (CBC INLET)	--	1.8	132
8 *	4'D-10-R (FUTURE)	6.0	--	---
9	8' D-10-R	3.0	--	---
9-10	18" RCP (CBC INLET)	2.7	2.7	480
10	10' D-10-R(CBC INLET)	1.0	--	---
	8' D-10-R (CBC INLET)	1.0	--	---
	24" RCP	--	1.0	15
13	DESIGN PT. 9 FOR OVERALL BASIN SEE FIGURE 2 & TABLE 2			
14-15 *	DRAINAGE FACILITY TO BE CONSTRUCTED IN FUTURE			
15	2-4' D-10-R(SUMPS)	1.8	--	---
	18" RCP	1.8	1.0	74
	36" RCP	1.7	1.0	100
15-16 *	DRAINAGE FACILITY TO BE CONSTRUCTED IN FUTURE			
16 *	DRAINAGE FACILITY CROSSING TO BE CONSTRUCTED IN FUTURE			

REF: FIG. #1

* CONCEPT ONLY, NOT TO BE SIZED OR CONSTRUCTED AT THIS TIME

Parkway in this area would prevent runoff from entering the road. The proposed storm sewer in Northgate Parkway will pick up flow in the road and subbasins J, K, and O.

The area that flows to the North Tributary of Black Squirrel Creek will have to drain through the future site to the northwest side of Phase 1 (see Figure 1).

VII. FINANCIAL SECTION

A. Drainage Fee

Permanent drainage improvements presented in this report and located within dedicated right-of-way or easements are considered to be reimbursable from the basin drainage fund. Private storm drainage facilities located outside dedicated right-of-way or easements, or temporary drainage facilities are not reimbursable from the basin drainage fund.

Proposed storm drainage improvements are listed in Table 6 together with corresponding estimated costs. Reimbursable storm drainage improvements are estimated to cost $276,245.00. Non-reimbursable storm drainage improvements are estimated to cost $70,523.00.

The required drainage fee, at this time, is $0 since no land is being platted. The 1986 fees for Black Squirrel Creek Basin and Miscellaneous Basin are $4782/acre and $2925/acre, respectively.

TABLE 6
DRAINAGE AND BRIDGE COSTS

ITEM NO.	ITEM DESCRIPTION	APPROX. QUANTITY	UNIT	UNIT COST	ITEM COST	TOTAL COST
BLACK SQUIRREL CREEK BASIN						
A.DRAINAGE FACILITY COSTS (REIMBURSABLE)						
	REINFORCED CONCRETE PIPE					
1.	18" DIA	586	L.F.	38.00	22,268	
2.	24" DIA	56	L.F.	51.00	2,856	
3.	30" DIA	1,510	L.F.	66.00	99,660	
4.	36" DIA	111	L.F.	76.00	8,436	
5.	42" DIA	471	L.F.	93.00	43,803	
	D-10-R CURB INLETS					
6.	4'	1	EA.	1,700.00	1,700	
7.	6'	2	EA.	1,800.00	3,600	
8.	8'	3	EA.	2,300.00	6,900	
9.	10'	2	EA.	2,700.00	5,400	
10.	18'	1	EA.	4,500.00	4,500	
11.	22'	2	EA.	5,500.00	11,000	
	WYES & BENDS					
12.	18" X 45 BEND	1	EA.	500.00	500	
13.	42" X 45 BEND	1	EA.	1,000.00	1,000	
14.	36" x 18" WYE	1	EA.	1,000.00	1,000	
15.	36" x 24" WYE	1	EA.	1,100.00	1,100	
16.	42" x 18" WYE	1	EA.	1,200.00	1,200	
17.	4' DIA. MANHOLES	6	EA.	1,400.00	8,400	
					TOTAL	$223,323
				5% CONSTRUCTION CONTINGENCY		$11,166
				10% ENGINEERING		$23,449
				TOTAL DRAINAGE FACILITY COSTS		$257,938
B.BRIDGE COSTS (REIMBURSABLE)						
18.	IMPROVED INLET & WINGWALLS	1	EA.	43,642.00	43,642	
19.	(14'-14')x 10' RCB	1	EA.	157,703.00	157,703	
20.	EARTHWORK*	7,500	YDS.	1.50	11,250	
					TOTAL	$212,595
				5% CONSTRUCTION CONTINGENCY		$10,630
				10% ENGINEERING		$22,322
				TOTAL DRAINAGE FACILITY COSTS		$245,547

* EARTHWORK REQUIRED TO DIRECT FLOW INTO INLET

TABLE 6-BRIDGE AND DRAINAGE COSTS (cont'd)

C.NON-REIMBURSIBLE COSTS						
	TEMPORARY IMPROVEMENTS					
21.	CBC OUTLET WINGWALLS & RIPRAP	1	EA.	65,940.00	65,940	
					SUBTOTAL	$65,940
				5% CONSTRUCTION CONTINGENCY		$3,297
				TOTAL NON-REIMBURSABLE COSTS		$69,237

MISCELLANEOUS BASIN						
A.DRAINAGE FACILITIES (REIMBURSABLE)						
	REINFORCED CONCRETE PIPE					
1.	18" DIA.	75	L.F.	38.00	2,850	
2.	36" DIA.	100	L.F.	76.00	7,600	
3.	36" x 18" WYES	2	EA.	1,000.00	2,000	
	D-10-R CURB INLETS					
4.	4'	2	EA.	1,700.00	3,400	
					SUBTOTAL	$15,850
				5% CONSTRUCTION CONTINGENCY		$793
				10% ENGINEERING		$1,664
				TOTAL DRAINAGE FACILITY COSTS		$18,307

B.BRIDGE COSTS (REIMBURSABLE)						
	NONE					
C.NON-REIMBURSABLE COSTS						
	TEMPORARY IMPROVEMENTS					
5.	RIPRAP D50=9",t=18"	20	C.Y.	$35.00	700	
					SUBTOTAL	$700
				5% CONSTRUCTION CONTINGENCY		$35
				TOTAL NON-REIMBURSABLE COSTS		$735

B. Bridge Fee

Arterial bridges required within the Black Squirrel Creek Basin are designated in the Master Plan. The proposed arterial bridge under Northgate Parkway and costs are presented in Table 6. Total arterial bridge costs are estimated to be $245,547.00.

The required bridge fee, at this time, is $0 since no land is being platted. The 1986 bridge fee for the Black Squirrel Creek Basin is $660/acre.

APPENDIX A:

Concrete Box Culvert Calculations

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URS JOB NO. 5206 PAGE 1 OF
DATE 4-29-86 BY CLP CHECKED BY (date)
CLIENT THE OLIVE CO.
PROJECT NORTHGATE DRAINAGE REPORT
SUBJECT MAJOR DRAINAGE - CBC UNDER NORTHGATE PKWY

REF: HEC-13 "HYDRAULIC DESIGN OF IMPROVED INLETS FOR CULVERTS" BY FHWA

$Q = 4050$ CFS

TRY $(14'-14') \times 10'$ CBC

$$\frac{Q}{NB} = \frac{4050}{(2)(14)} = 145$$

(FROM CHART 5)
$D_c = 8.6' < 10'$, OK

TRY INLET CONTROL NOMOGRAPH (CHART 7)

$H_f/D = 1.47$ (30°-75° WINGWALL FLARE)

$H_f = 14.7'$ (TOO HIGH)

SLOPE TAPERED INLET

TRY THROAT CONTROL CURVE (CHART 14)

$$\frac{Q}{NBD^{3/2}} = \frac{4050}{(2)(14)(10)^{1.5}} = 4.57$$

$H_t/D = 1.31$

$H_t = 13.1'$

TRY FACE CONTROL CURVE (CHART 16)

USE $H_f/D = 1.0$

$$\frac{Q}{B_f D^{3/2}} = 2.75$$

$$B_f = \frac{4050}{(2.75)(10)^{1.5}} = 46.6$$

WITH 4:1 TAPER

$$L_1 = \frac{(46.6 - 28)(4)}{2} = 37.2' \quad \text{USE } 38' \quad (B_f = 47')$$

CHECK OUTLET CONTROL
$Q/N = 2025$ CFS
$K_e = 0.2$
$A = 140$ SF
$L = 162'$

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SUBJECT MAJOR DRAINAGE - CBC UNDER NORTHGATE PKWY.

$H = 4.6'$

$H_o = \frac{D + D_c}{2} = \frac{(10') + (8.6')}{2} = 9.3'$

HEAD PROVIDED (W/ 3.5' DROP) = 5.5' > HEAD REQUIRED, OK

ANALYZE CBC PERFORMANCE & GRAPH

Q	(THROAT) $Q/NBD^{3/2}$	(THROAT) * H_t/D	(FACE) $Q/B_f D^{3/2}$	(FACE) H_f/D	(THROAT) HW	(FACE) HW
100	0.11	0.08	0.07	0.07	—	0.7
300	0.34	0.23	0.20	0.18	—	1.8
500	0.56	0.32	0.34	0.23	—	2.3
800	0.90	0.44	0.54	0.32	0.7	3.2
1200	1.36	0.57	0.81	0.43	2.0	4.3
1600	1.81	0.71	1.08	0.53	3.4	5.3
2000	2.26	0.82	1.35	0.62	4.5	6.2
2500	2.82	0.95	1.68	0.72	5.8	7.2
3000	3.39	1.07	2.02	0.82	7.0	8.2
3500	3.95	1.18	2.35	0.90	8.1	9.0
4000	4.52	1.30	2.69	0.98	9.3	9.8
4500	5.08	1.41	3.03	1.07	10.4	10.7

* TO OBTAIN HW ABOVE FACE, SUBTRACT 3.7'

FOR ALL FLOWS CONSIDERED, FACE CONTROLS THE HW

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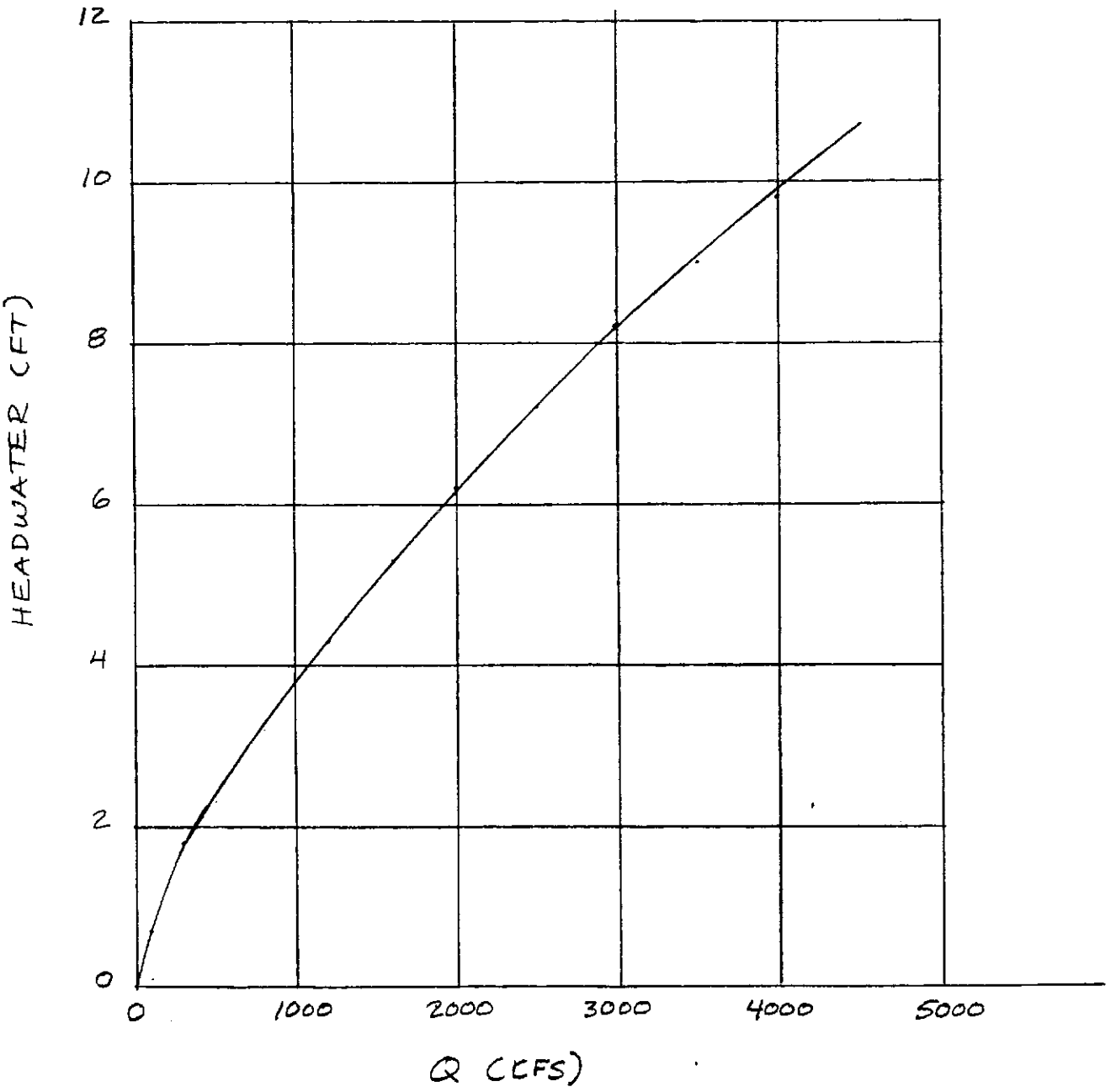
SUBJECT MAJOR DRAINAGE - CBC UNDER NORTHGATE PKWY.



URS COMPANY
Mailing Address:
3955 East Exposition Avenue • Suite 300 • Denver, Colorado 80209 • 303/744-1861

URS NO. 5206 BY CLP DATE 3-28-86 CHECKED BY _____ DATE _____

CLIENT THE OLIVE CO. PROJECT NORTHGATE DRAINAGE

SUBJECT ULTIMATE CBC OUTLET DESIGN

(14'-14') x 10' RCB

$Q = 4050$ CFS $\qquad q = \frac{4050}{28} = 144.6$ CFS/FT

$$D_c = \left(\frac{q^2}{g}\right)^{1/3} = \left(\frac{(144.6)^2}{32.2}\right)^{1/3}$$

$D_c = 8.66'$

$V_c = 16.7$ FPS

ENTRANCE TRANSITION

FROM HEC-13 INLET ANALYSIS

100 YR. W.S. EL. = 6721.43 @ FACE OF TRANSITION

$$V = \frac{Q}{A} = \frac{4050}{(10)(47.0)} = 8.6 \text{ FPS}$$

ENERGY GRADELINE = 6722.58

USE ENERGY EQUATION TO APPROXIMATE THE DEPTH @ THE THROAT OF THE BOX

$$z_1 + y_1 + \alpha_1 \frac{V_1^2}{2g} = z_2 + y_2 + \alpha_2 \frac{V_2^2}{2g} + h_f$$

$$h_f + y_2 + \alpha_2 \frac{V_2^2}{2g} = (z_1 - z_2) + y_1 + \alpha_1 \frac{V_1^2}{2g}$$

ASSUME:

$\alpha_1, \alpha_2 = 1.0$

$$h_f = C_e \frac{V_2^2}{2g}$$

$C_e = 0.3$

$$y_2 + 1.3 \frac{V_2^2}{2g} = 4.83 + 10.00 + \frac{(8.6)^2}{2(32.2)} = 16.0'$$

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DATE 3-31-86 BY CLP CHECKED BY ____ (date)
CLIENT THE OLIVE CO.
PROJECT NORTHGATE DRAINAGE
SUBJECT ULTIMATE CBC OUTLET DESIGN

SINCE $V_2 = \frac{Q}{A_2} = \frac{Q}{(28)\,Y_2}$

Y_2	V_2	$Y_2 + \frac{1.3V_2^2}{2g}$
8.0	18.1	14.6'
7.5	19.3	15.0'
7.0	20.7	15.6'
6.9	21.0	15.8'
6.8	21.3	15.9'
6.7	21.6	16.1'

TRY $S = 0.80\%$ FOR BOX, USE MANNING'S EQN

$D_N = 7.06'$
$A = 197.7$ SF
$V = 20.5$ FPS
$F_r = 1.36$

$Q = 4050$ CFS
$n = 0.015$

TRY $S = 0.70\%$ FOR BOX, USE MANNING'S EQN ← USE

$D_N = 7.42$
$A = 207.8$ SF
$V = 19.5$ FPS
$F_r = 1.26$

$Q = 4050$ CFS
$n = 0.015$

OUTLET TRANSITION

FLOW INTO CONCRETE-LINED CHANNEL (ULTIMATE)

$B = 20'$
$Z = 1.5:1$
$S = 0.59\%$

$Q = 4050$ CFS
$n = 0.015$

$D_N = 6.56'$
$A = 195.7$ SF
$V = 20.7$ FPS
$F_r = 1.42$

$D_c = 8.67'$
$A = 286.2$ SF
$V = 14.2$ FPS

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SUBJECT ULTIMATE CBC OUTLET DESIGN

MOMENTUM EQUATION

$$P_1 - P_2 + \cancel{W \sin\theta}^{\,0} - F_F = \frac{Q\gamma}{g}(\beta_2 V_2 - \beta_1 V_1)$$

WHERE: P_1, P_2 = PRESSURE FORCES ACTING ON UPSTREAM & DOWNSTREAM ENDS OF CONTROL VOLUME

W = WEIGHT OF WATER WITHIN CONTROL VOLUME

θ = CHANNEL SLOPE

F_F = SHEAR FORCES ON CHANNEL BOUNDARY

Q = DISCHARGE (CFS)

γ = UNIT WEIGHT OF WATER

g = GRAVITATION CONSTANT

V_1, V_2 = AVERAGE FLOW VELOCITIES AT SECTIONS 1 & 2

β_1, β_2 = MOMENTUM DISTRIBUTION COEFFICIENTS

SIMPLIFYING ASSUMPTIONS

1) HYDROSTATIC PRESSURE DISTRIBUTION
2) $W \sin\theta = F_F$ FOR SMALL θ
3) $\beta_1 = \beta_2 = 1.0$

KOCH-CARSTANJEN EQUATION (INCLUDES CENTERWALL OF BOX)

$$P_2 + \frac{\gamma Q V_2}{g} = P_3 - P_p + \frac{\gamma Q V_3}{g}$$

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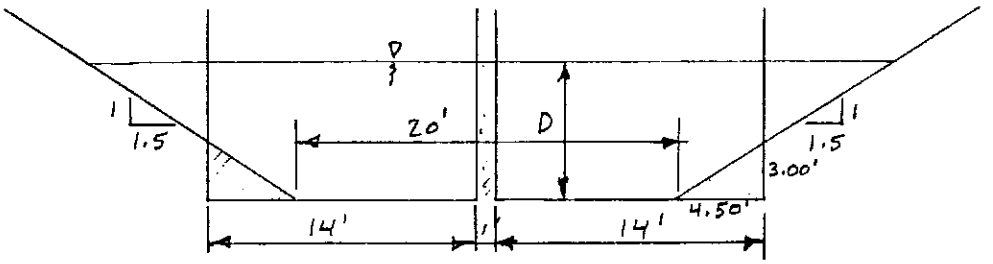
SECTION 2 & 3



FOR $D_2 = 7.42'$

$$P_2 + \frac{\gamma Q V_2}{g} = \left(\frac{(7.42)}{2}(62.4)(7.42)(28)\right) + \frac{(62.4)}{(32.2)}(4050)(19.5)$$

$$= 201,142 \text{ LB}$$

$$P_3 - P_P + \frac{\gamma Q V_3}{g} = \frac{D_3}{2}(62.4)D_3(29) + 2\frac{(D_3-3)}{3}(62.4)\frac{(D_3-3)^2}{2}(1.5)$$

$$- \frac{D_3}{2}(62.4)(D_3)(1)$$

$$+ \frac{(62.4)}{(32.2)}(4050)\frac{(4050)}{(20+1.5D_3)D_3}$$

D_3	P_3	P_P	$\frac{\gamma Q V_3}{g}$	$P_3 - P_P + \frac{\gamma Q V_3}{g}$
6.90'	44,928	1485	151,786	195,229
7.00'	46,332	1529	148,882	193,685
6.80'	43,550	1443	154,783	196,890
6.60'	40,869	1359	161,073	200,583
6.55'	40,214	1339	162,711	201,587
6.56'	40,344	1343	162,381	201,383
6.57'	40,475	1347	162,053	201,181 ←

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CHECK CRITICAL MOMENTUM @ SECTION 3

$D_c = 8.67'$

$P_3 - P_p + \frac{\gamma Q V_3}{g} = 182{,}436 \quad < \quad P_2 + \frac{\gamma Q V_2}{g}$ OK

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SUBJECT TEMPORARY CBC OUTLET DESIGN

OUTLET FOR (14'-14') x 10' RCB (SEE DRCOG "URBAN STORM DRAINAGE CRITERIA MANUAL")

$W = 28'$

$Y_N = 7.42'$

$H = 10'$

$H_a = 1/2 (H + Y_N) = 8.71'$

ASSUME $Y_t = 4'$

$$\frac{Q}{W H_a^{0.5}} = \frac{4050}{(28)(8.71)^{0.5}} = 49.0$$

$$Y_t/H_a = \frac{(4)}{(8.71)} = 0.46$$

FROM FIG. 5-8

USE TYPE VH RIP-RAP ($D_{50} = 24"$)

(THIS IS ALSO TRUE FOR $Y_t/H_a = 40$ AS RECOMMENDED IF A POSSIBLE HYDRAULIC JUMP COULD OCCUR)

$$\frac{Q}{W H_a^{3/2}} = \frac{4050}{(28)(8.71)^{3/2}} = 5.6$$

FROM FIG. 5-10

$$\frac{1}{2 + \tan\theta} = 1.8$$

FOR A VELOCITY OF 5.5 FPS

$$A_t = \frac{4050}{5.5} = 736 \text{ SF}$$

FROM EQUATION 5-9

$$L = \left(\frac{1}{2+\tan\theta}\right)\left(\frac{A_t}{Y_t} - W\right)$$

$$L = (1.8)\left(\frac{736}{4} - 28\right) = 281'$$

SINCE

$L > 10H$ USE $L = 10H = 100'$

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SUBJECT CBC COSTS

USE (14'-14') x 10' TYPE "A" RCB

BARREL COSTS

CONCRETE = (162')(4.077 CY/LF)($180/CY) = $118,885

STEEL = (162')(392.9 LB/LF)($0.50/LB) = $ 31,825

STRUCTURAL EXCAVATION = (162')(3')(1')/27 ($3.00/CY) = $ 54

STRUCTURAL BACKFILL = (162')(72 SF)/27 ($12.00/CY) = $ 5,184

HEADWALL & TOEWALL

CONCRETE = 2(31')(0.085 CY/LF)($180/CY) = $ 949

STEEL = 2(31')(26 LB/LF)($0.50/LB) = $ 806

INLET TRANSITION

CONCRETE = 3(39.2')(0.604 CY/LF)($180/CY) = $ 12,785

STEEL = 3(39.2')(67.3 LB/LF)($0.50/LB) = $ 3957

CONCRETE FLOOR = $\frac{(28+47.0)}{2(27)}$ (38)(1') ($180/CY) = $ 9500

STRUCTURAL BACKFILL = $\frac{2(39.2')(69.3\,SF)}{27}$ ($12.00/CY) = $ 2415

INLET WINGWALLS

CONCRETE = $2(45')\frac{(0.604\,CY/LF)}{2}$ ($180/CY) = $ 4892

STEEL = $2(45')\frac{(67.3\,LB/LF)}{2}$ ($0.50/LB) = $ 1514

STRUCTURAL BACKFILL = $\frac{2(45')(69.3\,SF)}{2(27)}$ ($12.00/CY) = $ 1386

CONCRETE FLOOR = $(20')\frac{(48.5+88.5)}{2(27)}(6/12)($180/CY)$ = $ 4567

RIP-RAP = $(12')\frac{(88.5+112.5)}{2(27)}(2')($23.40/CY)$ = $ 2090

RIP-RAP BEDDING = $(12')\frac{(88.5+112.5)}{2(27)}(1')($12.00/CY)$ = $ 536

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100 YEAR OUTLET COST (TEMPORARY)

WINGWALLS (130' LONG EACH, VARY FROM 10' HIGH TO 5' HIGH)

COST OF CONCRETE = $2\left[(130')\frac{(0.604+0.308)^{CY/LF}}{2}(\$180/CY)\right]$ = $21,341

COST OF STEEL = $2\left[(130')\frac{(67.3+12.1)^{LB/LF}}{2}(\$0.50/LB)\right]$ = $5161

COST OF BACKFILL = $2\left[(130')(35.3\,SF)\left(\frac{1}{27}\right)(\$12.00/CY)\right]$ = $4079

COST OF RIP-RAP @ $2\,D_{50} = t$ = $(50')(4')\frac{(29+106.5)}{2(27)}(\$23.40/CY)$ = $11,743

COST OF RIP-RAP @ $1.5\,D_{50} = t$ = $(50')(3')\frac{(106.5+184)}{2(27)}(\$23.40/CY)$ = $18,883

COST OF RIP-RAP FILTER BLANKET = $(100')(1')\frac{(29+184)}{2(27)}(\$12.00/CY)$ = $4733

$65,940

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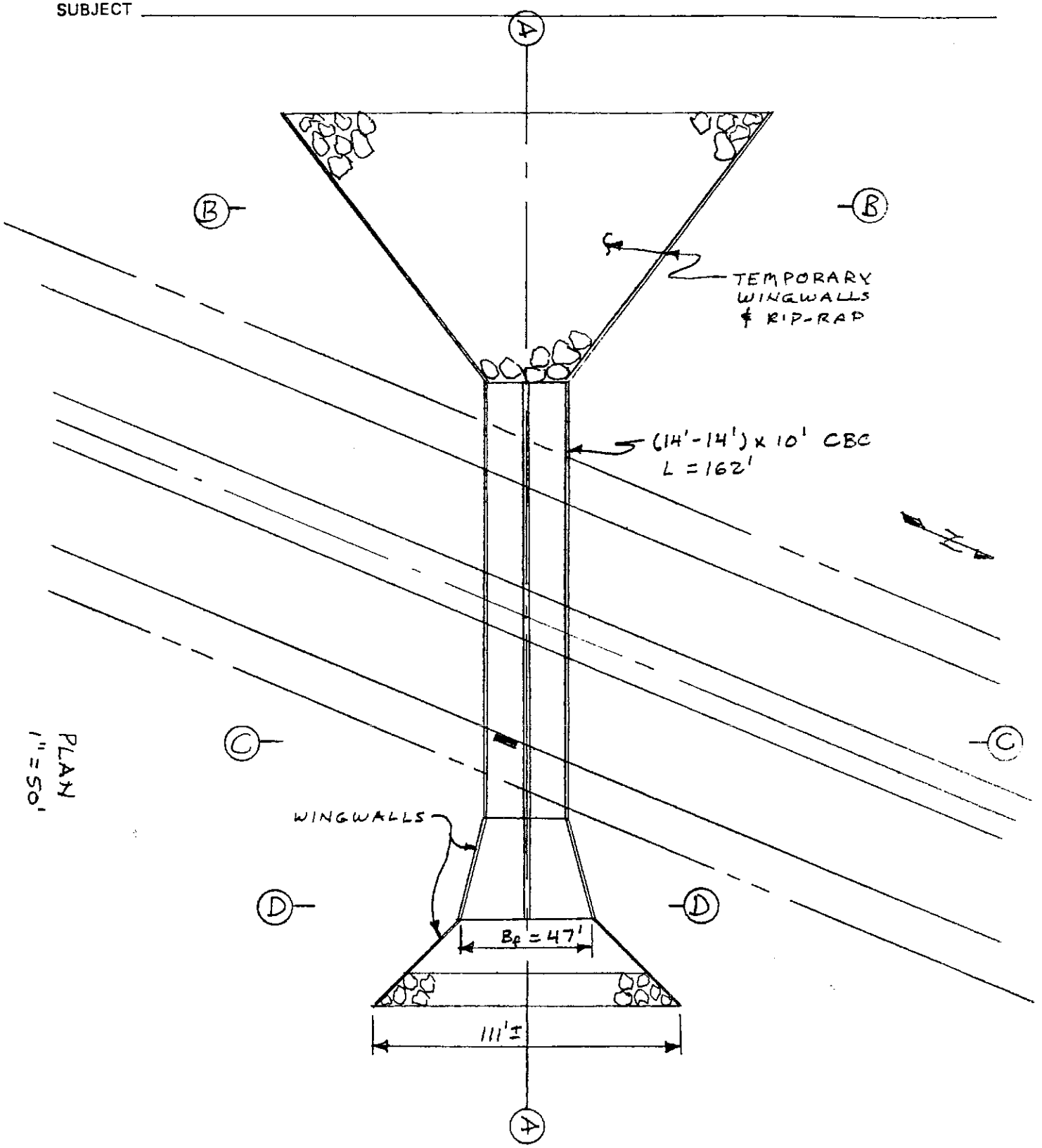

PLAN
1" = 50'

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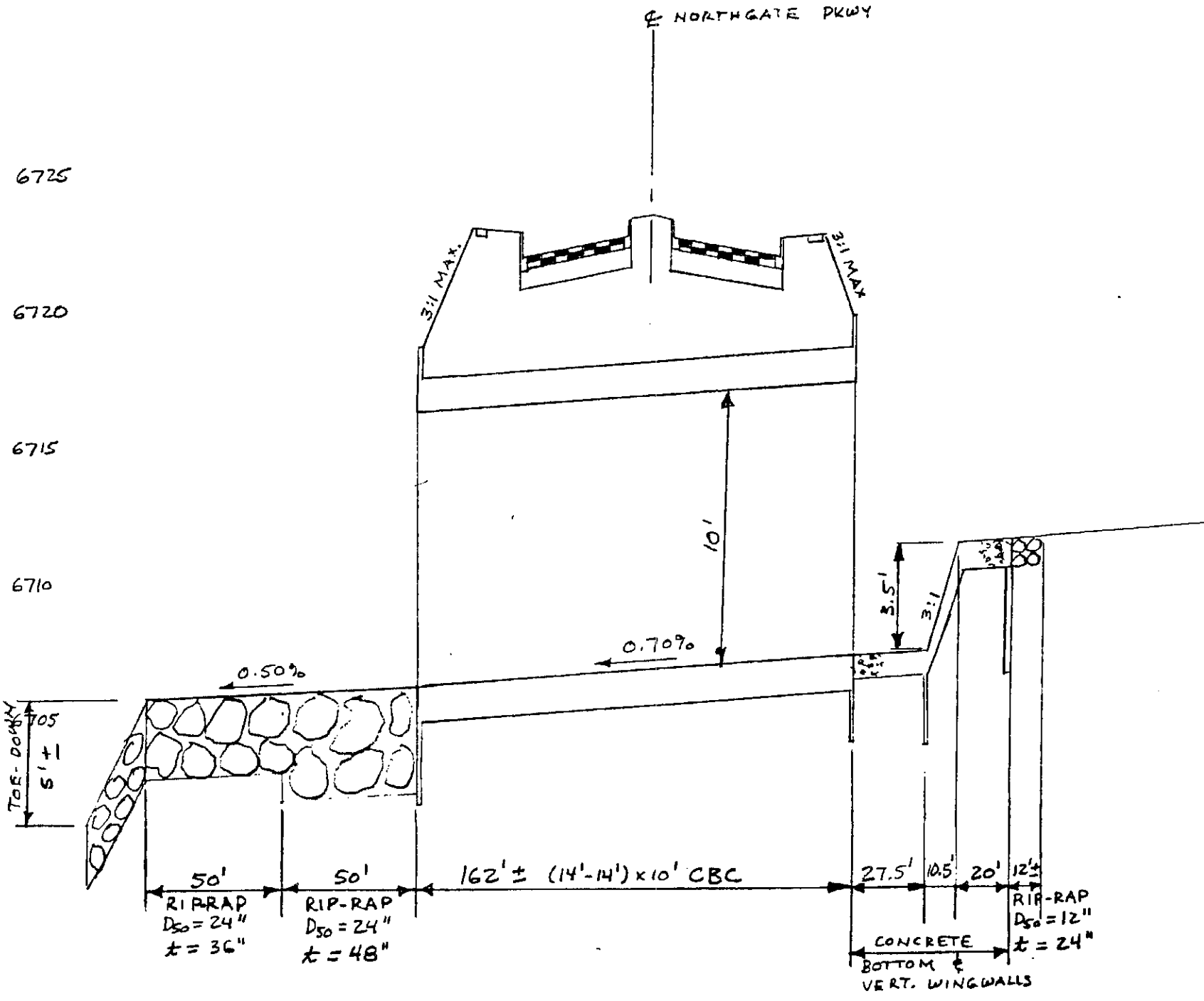
1" = 50' HORIZ.
1" = 5' VERT.



SECTION A-A

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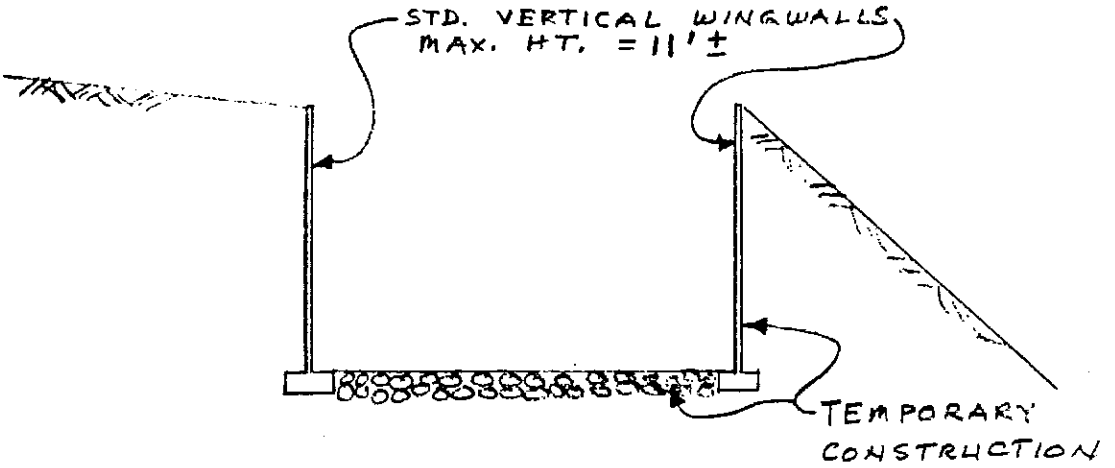
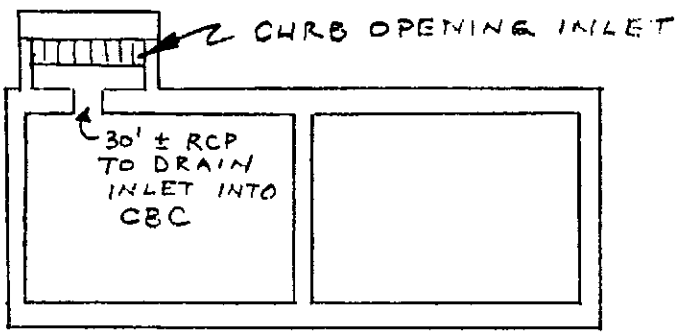


SECTION B-B

1" = 50' HORIZ
1" = 5' VERT.
(APPROX.)



SECTION C-C

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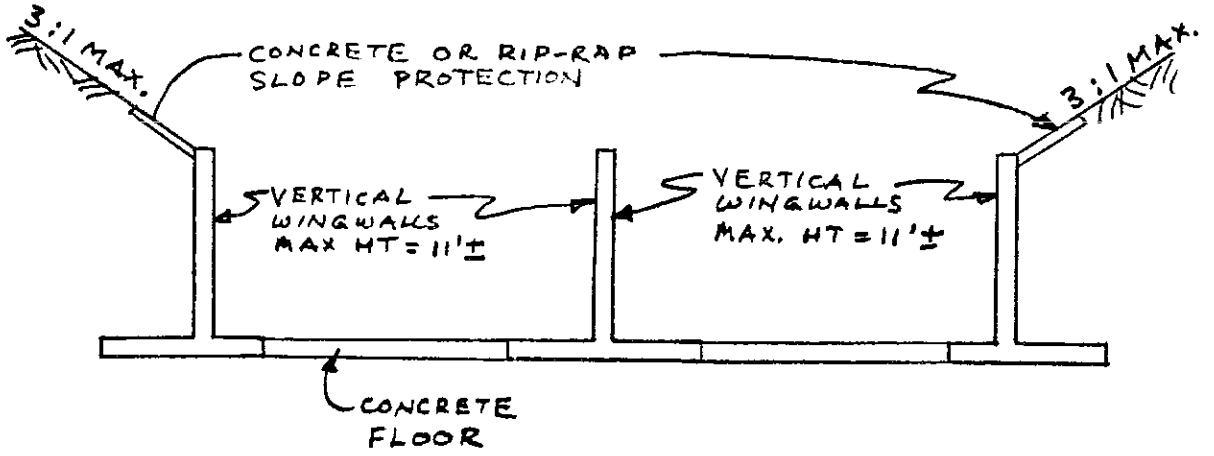
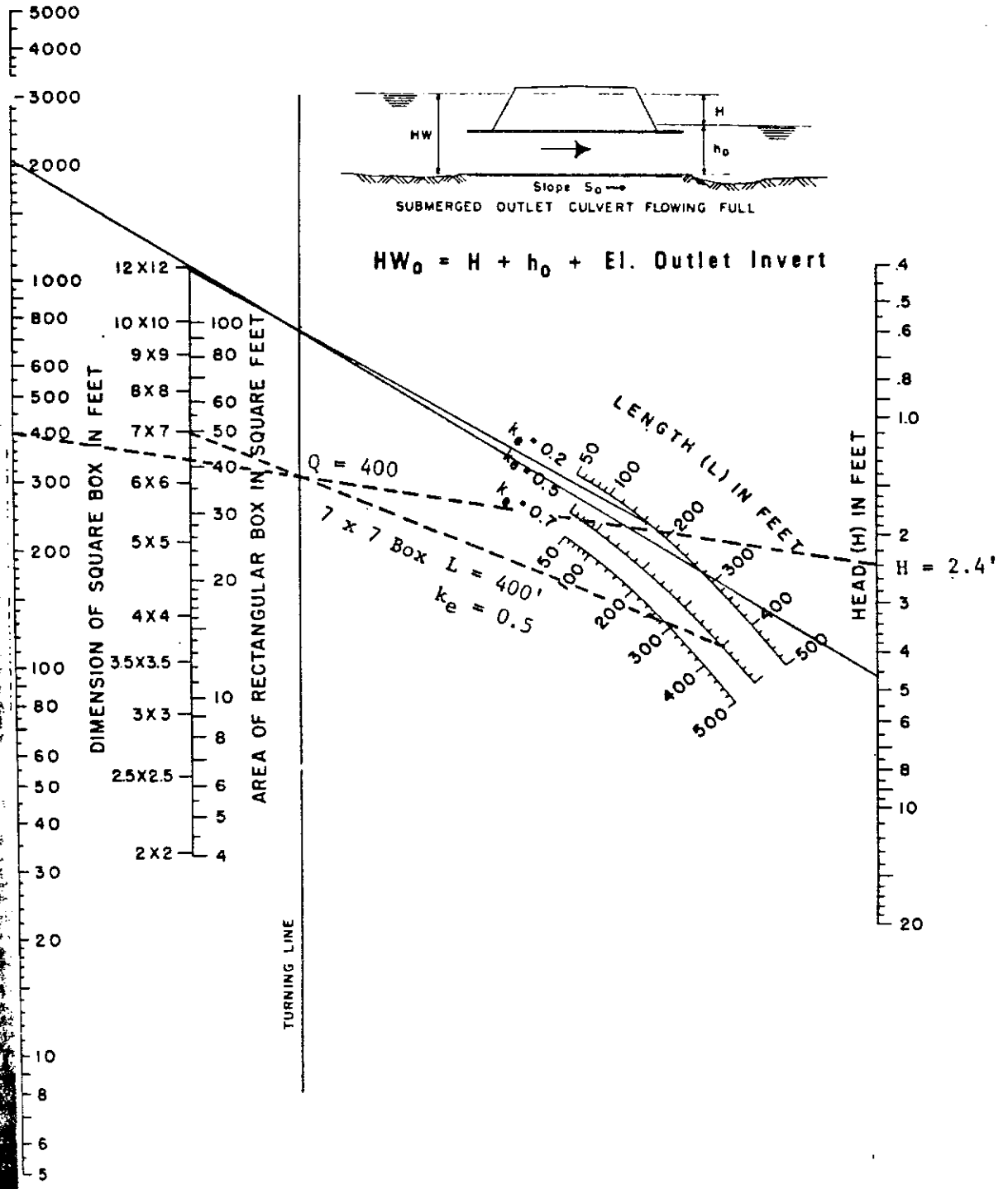
SUBJECT _____

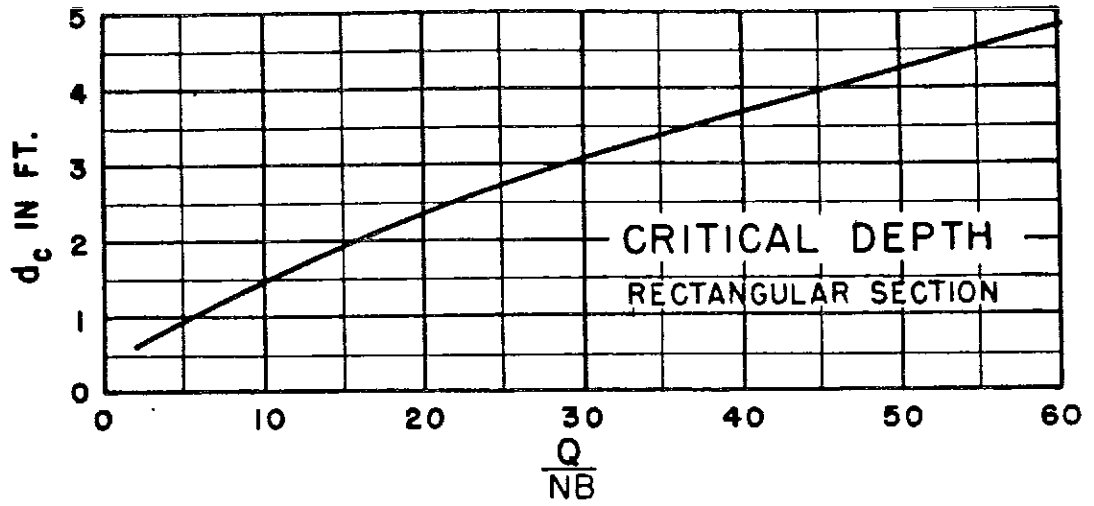


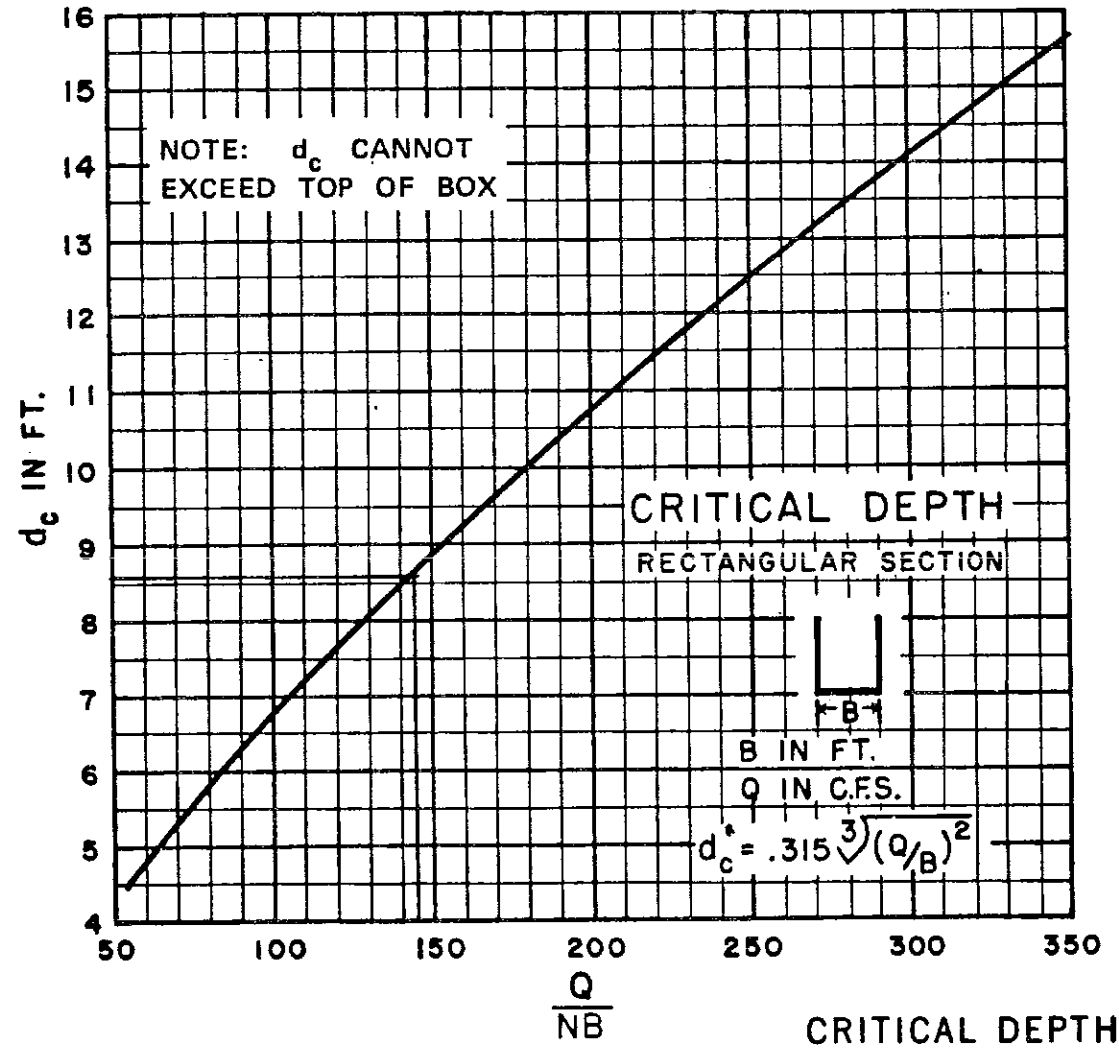
SECTION D-D
1" = 10'

Chart 1



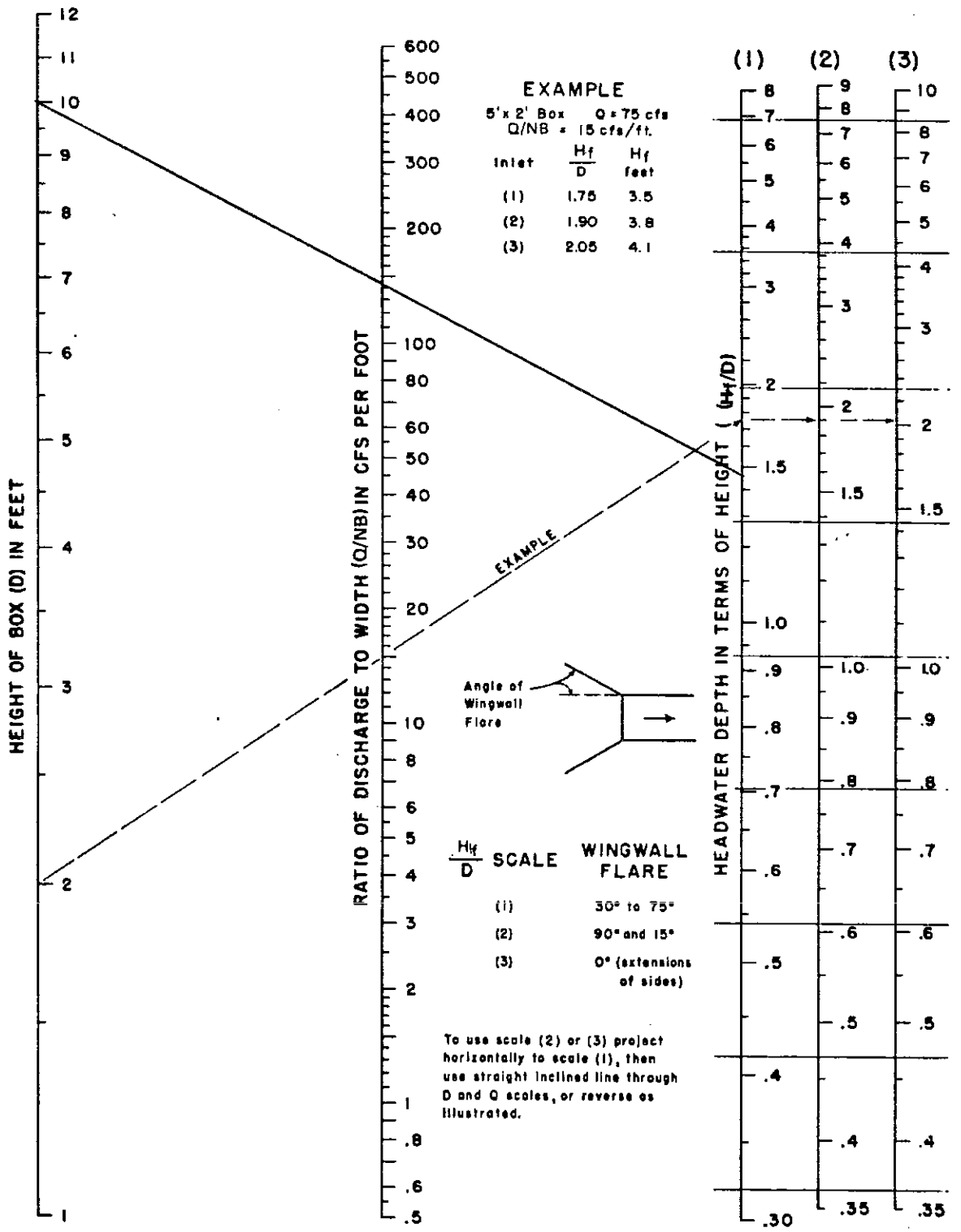
HEAD FOR
CONCRETE BOX CULVERTS
FLOWING FULL
n = 0.012



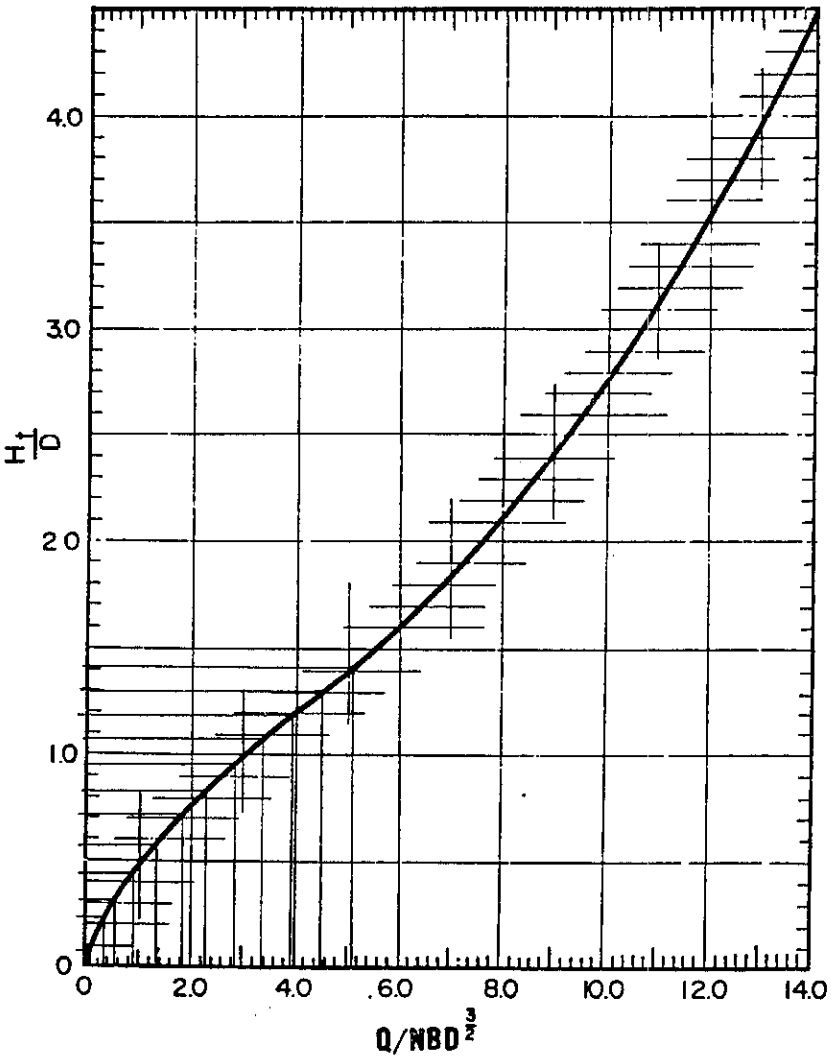


BUREAU OF PUBLIC ROADS JAN. 1963

CRITICAL DEPTH
RECTANGULAR SECTION



HEADWATER DEPTH FOR BOX CULVERTS WITH INLET CONTROL



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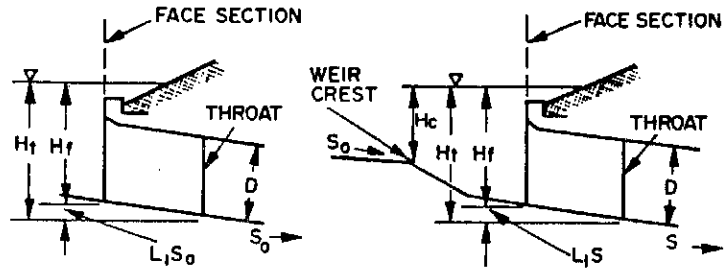
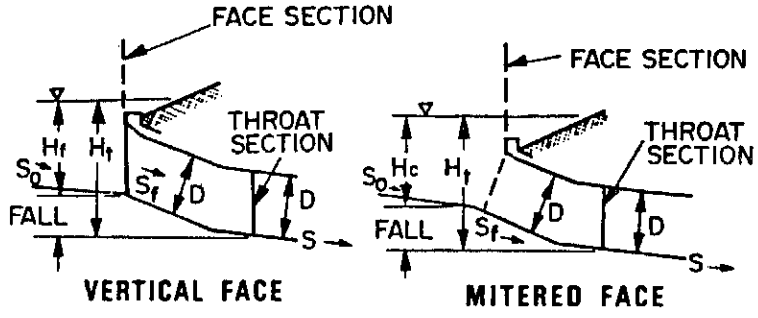
OCTOBER 1971

SIDE-TAPERED



WITH FALL

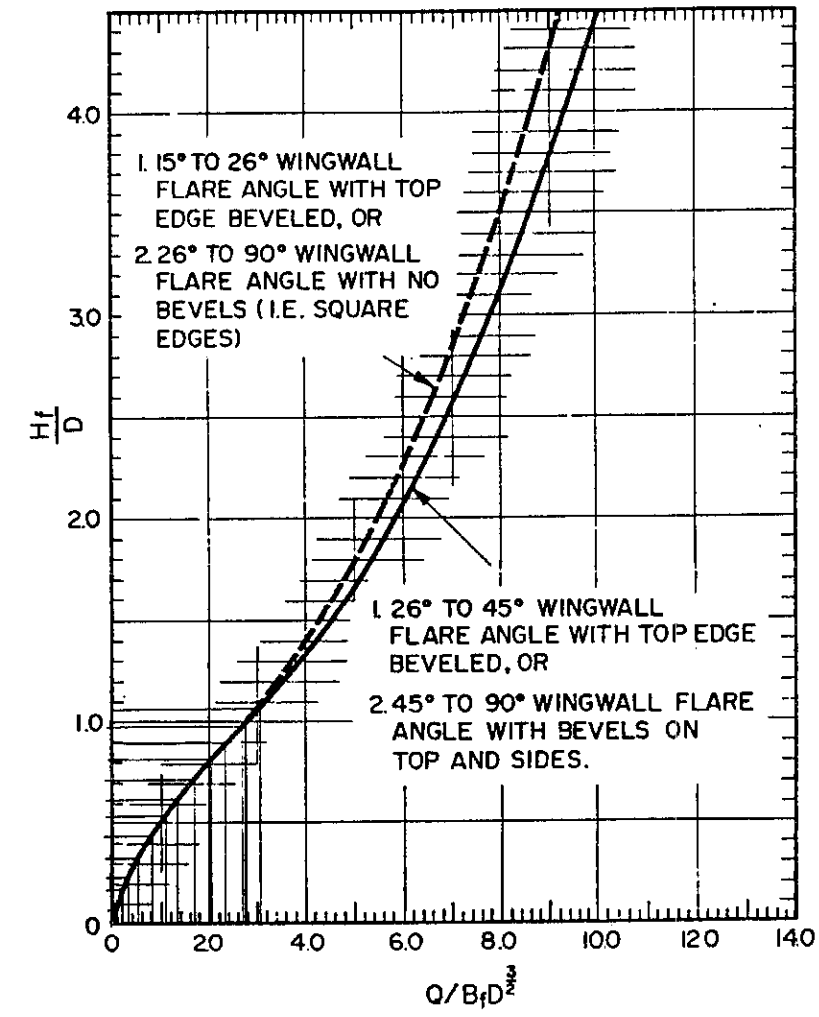
SLOPE-TAPERED

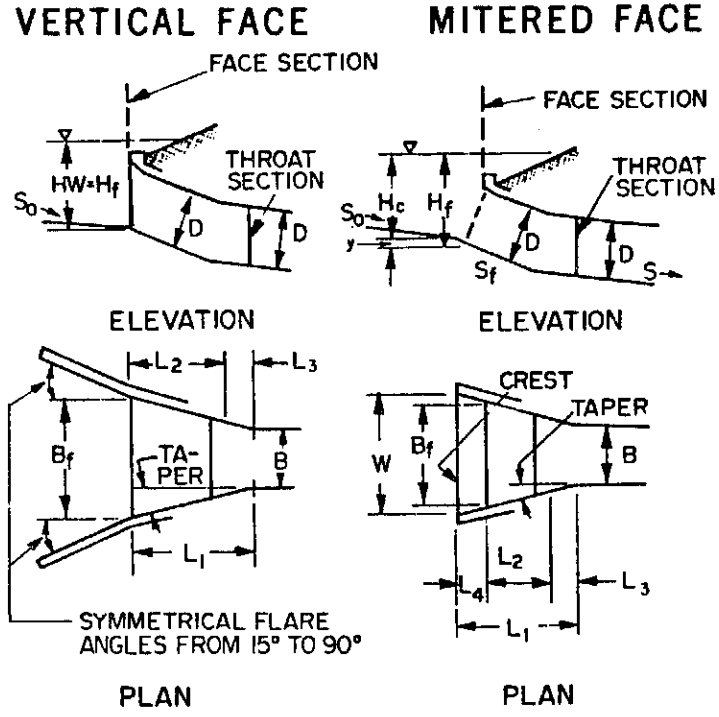


VERTICAL FACE

MITERED FACE

THROAT CONTROL CURVE FOR BOX CULVERTS TAPERED INLETS





FACE CONTROL CURVES FOR BOX CULVERTS SLOPE-TAPERED INLETS

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