Final Master Development Drainage Plan
For Entire Site

and

Final Drainage Report

for

NAZARENE BIBLE COLLEGE

Colorado Springs, El Paso County, Colorado

March 21, 2002
Revised April 24, 2002
Revised July 11, 2002

Prepared for:

BICO Properties, Inc.
1111 Academy Park Loop
Colorado Springs, CO 80910

Prepared by:

ACCURATE EngiSurv LLC
515 Courtney Way, Suite D
Lafayette, CO 80026
303-665-5505

ENGINEER'S / OWNER'S CERTIFICATION

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 of Colorado Springs / El Paso County 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.

COLORADO REGISTERED MARK J. HEFTA 29829 7/17/02 PROFESSIONAL ENGINEER

Mark J. Hefta, PE
State of Colorado No. 29829

Developer's Statement:

I, the developer, have read and will comply with all of the requirements specified in this drainage report and plan.

State of Colorado
County of El Paso
Genette Irsik
4/26/02

Business Name: Nazarene Bible College

By: Matt Burk

Title: Vice President for Finance

Address: 1111 Academy Park Loop
Colorado Springs, Co 80910

GENETTE IRSIK NOTARY PUBLIC STATE OF COLORADO

My Commission Expires
07/01/2003

City of Colorado Springs Statement:

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

For the City Engineer: [signature] Date: 7/23/02

Conditions:

Financial assurances that cover the cost of private drainage facilities (page 13) must be posted prior to building permit issuance.

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NAZARENE BIBLE COLLEGE

General Location and Description

Location

The proposed project includes the construction of eleven (11) apartment buildings, clubhouse, pool and parking area with enclosed garages and carports, two (2) driveway entrances, and recreational facilities. Also included is a proposed public storage facility adjacent to the apartment complex, and consideration of future development of the remaining open areas within the drainage area. Detention pond and associated utilities are also included in this project. The property is located in Section 23, Township 14 South, Range 66 West of the Principal Meridian, City of Colorado Springs, County of El Paso, State of Colorado. The property is bounded on the west and north by Nazarene Bible College, on the east by Murray Boulevard, and on the south by the Melody Anne Eckhardt Subdivision. A vicinity map is presented on Sheet 1 of 2 of the Drainage Plan.

The proposed project is located in a major drainageway of the Sand Creek Major Drainage Basin. Existing drainage structures primarily consist of curb and gutter along Murray Boulevard. Primary flow of the site consists of overland flow that collects at a 42-inch RCP at the southeast corner of the property, flows south then east around the Melody Anne Eckhardt apartment complex to the south and discharges into the existing storm sewer system along Murray Boulevard. This runoff is carried south to the existing storm sewer at Fountain Boulevard, then east, discharging into Sand Creek.

Property Description

The total site consists of 34.4 acres, 16.6 acres of which are proposed for development of the apartment complex and public storage facilities. The topography of the eastern portion of the site generally slopes from west to east with steep slopes on the west side and becoming more gradual on the east side of the site. The topography of the west side slopes northwest to southeast at an approximate slope of seven percent. The undeveloped portion of the property consists primarily of fairly developed native brush, grass and vegetation with larger trees in the southwest corner.

According to the El Paso County Soil Survey, the soils on the site consist of Ellicott loamy coarse sand and Sampson loam. These soils have a low runoff potential and moderate runoff potential respectively. Figure 1 presents general vegetation and soil type map of the area. There are no known or visible irrigation facilities located on the property.

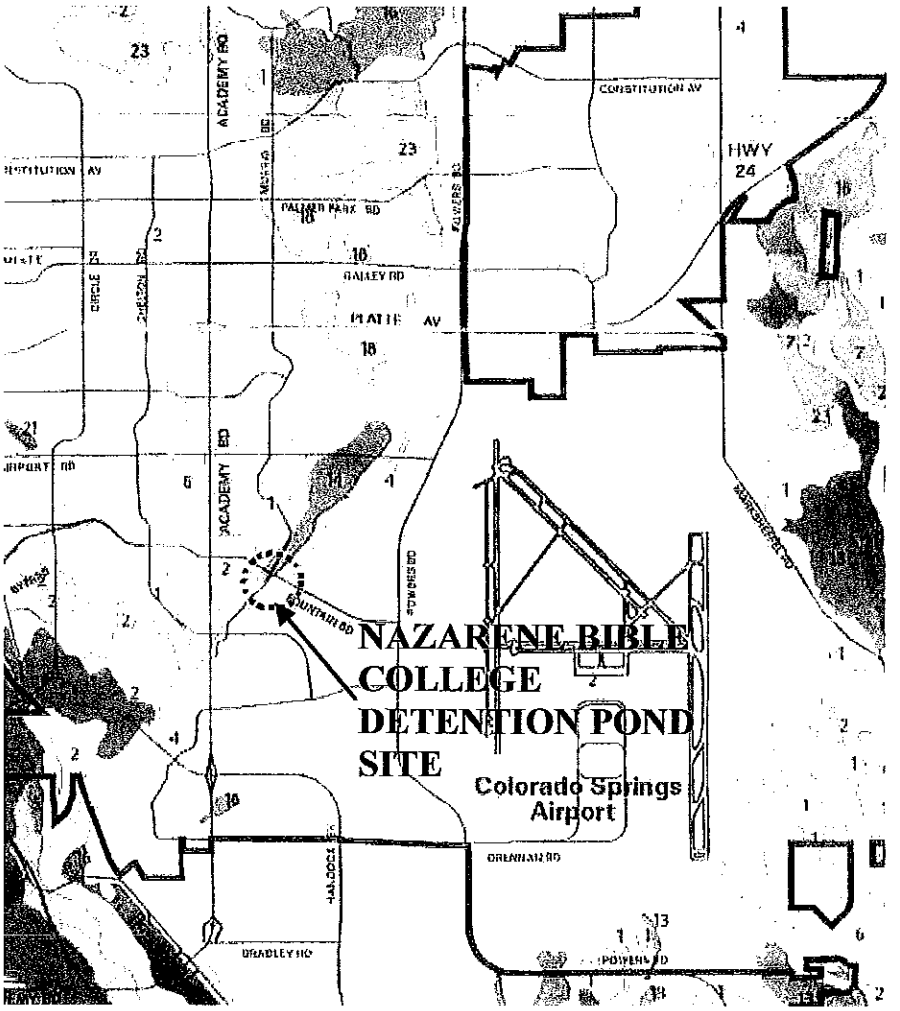
The first portion of this site to be developed is area D1b, the proposed apartment complex. The area will included apartment building, parking areas and garages along with open areas throughout the site. Area D1a, public storage units, will be developed subsequent to the apartment complex. Areas D2a and D2b are proposed future developments. It is anticipated that area D2a will be developed into multi-family residences with associated streets, parking areas and open areas. Area D2b is anticipated to future business or campus area. Table 1 presents a summary of the proposed and future drainage basins for this property.

TABLE 1 – DRAINAGE BASIN CHARACTERISTICS

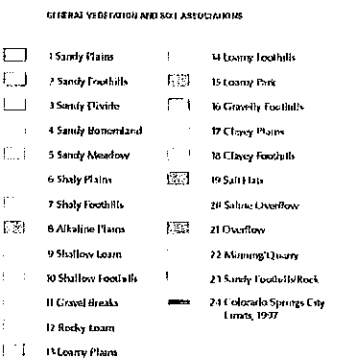
Basin	Area (acres)	5-year Runoff Coeff. "C"	100-year Runoff Coeff. "C"	Description
D1a	3.7	0.90	0.90	Proposed Storage Units
D1b	12.9	0.70	0.80	Proposed Apartment Complex
D2a	5.8	0.55	0.70	Future Multifamily Units
D2b	12.0	0.55	0.70	Future Development
Total/*Average*	34.4	*0.60*	*0.80*	

FIGURE 1 – COLORADO SPRINGS – GENERAL VEGETATION AND SOIL ASSOCIATIONS

Final Drainage Report
Nazarene Bible College



LEGEND



Drainage Basin and Sub-Basins

Major Basin Description

The major drainage basin for the proposed project is 34.4 acres in this Master Development Drainage Plan (MDDP) in the Sand Creek Drainage Basin.

The proposed facility is not located in a FEMA regulated flood plain. Figure 2 presents the FEMA Flood Insurance Rate Map (Map Number 08041CO753 F; effective March 17, 1997) for this area. The soil types for the major drainage basin are primarily Hydrologic Soil Group B.

Sub-Basin Description

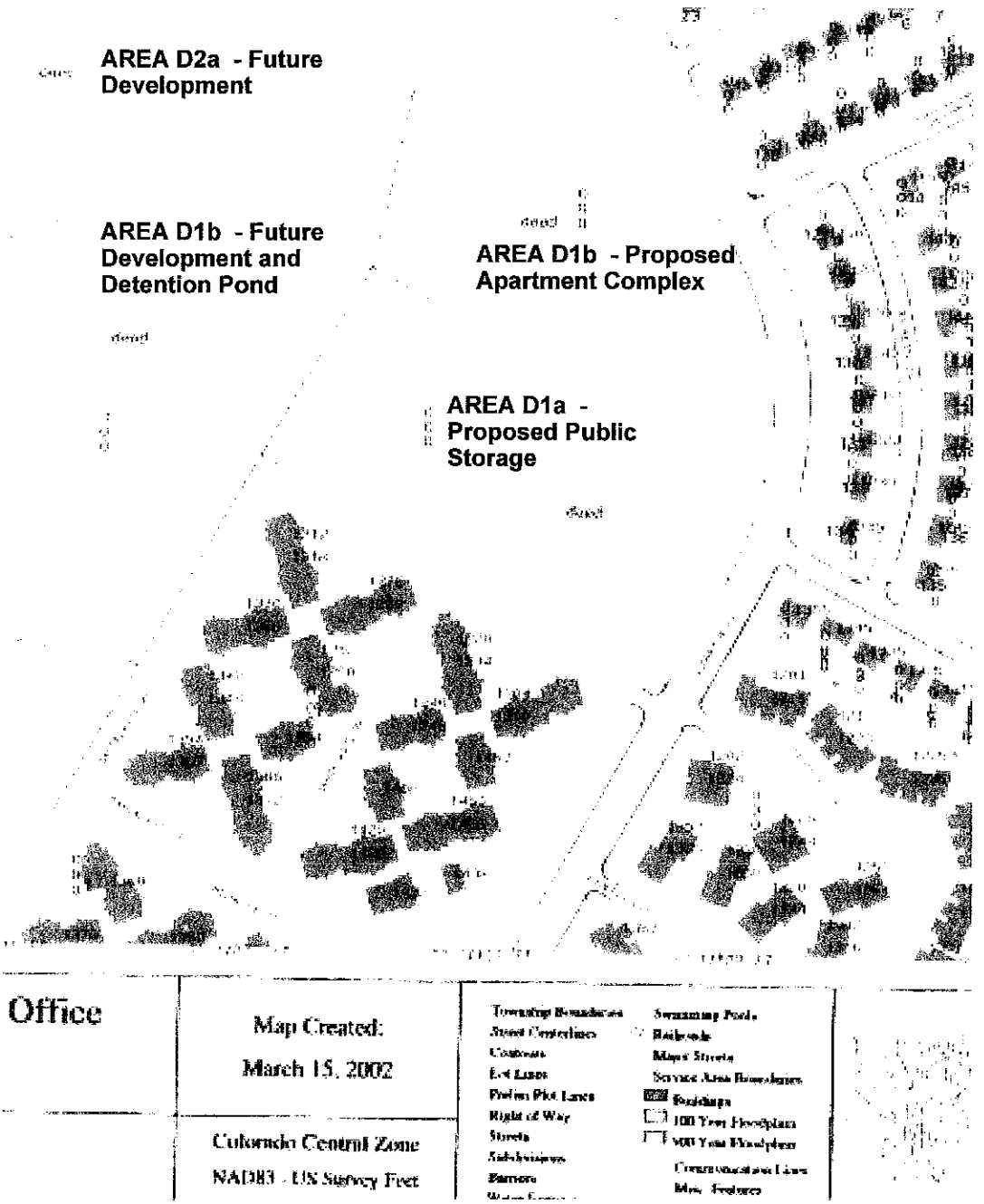
The sub-basin described herein relates to the proposed apartment complex and the adjacent proposed public storage facility. This area constitutes 16.6 acres. Historically, drainage patterns tend to flow overland to the south with localized channeling. There are no clearly defined natural drainage channels on this portion of the property. Flows reach a low point in the sub-basin in the southwestern most portion of the property where it flows into a 42-inch RCP pipe. Flow is transported through the existing storm sewer system to the public system at Murray Boulevard, then south an existing system along Fountain Boulevard, then east, discharging into Sand Creek.

Off-site drainage consists of undeveloped land north and west of the complex. Drainage patterns likewise consist of flow overland to the south with localized channeling and are considered in this MDDP. This off-site drainage coupled with the sub-basin identified above, constitute the limits of the MDDP.

Therefore, a proposed detention basin is required for the area of this MDDP. This pond is necessary to restrict flows to their historic rates identified in this report.

FIGURE 2 – FLOODPLAIN MAP

Final Drainage Report
Nazarene Bible College



Note: from Pikes Peak Regional Building Department, Regional Floodplain Office

Drainage Design Criteria

Development Criteria Reference

The City of Colorado Springs has adopted the City of Colorado Springs and El Paso County Drainage Criteria Manual (CSDCM). The design storm used for this report is the 5-year storm and the major storm is the 100-year storm. This MDDP identifies the historic flows for the entire basin. Since the MDDP identifies the proposed site as containing this detention pond, the calculations discussed in this report include these properties in sizing the pond and outlet structure.

Hydrologic Criteria

The design storm used is the 5-year storm event and the major storm is the 100-year storm event. All calculations have been included in Appendix A including pre- and post-development flows, detention pond volumes, and release rates. Drainage design will be accomplished using the Rational Method. Detention pond design was performed using the information in the CSDCM and is likewise included in this report.

Drainage Facility Design

General Concept

As discussed earlier in this report, off-site runoff will flow overland onto the project site, into the proposed curb and gutter, and into the detention pond. Therefore, the major basin size is 34.4 acres. The sub-basin will be approximately 16.6 acres. Specifically, Nazarene Bible College Apartment Complex is 12.9 acres; the public storage area is 3.7 acres. There will be no other areas contained in this basin.

Curb and gutters on the proposed driveways and swales through the landscaped areas will contain drainage within the sub-basin. Drainage flows from the adjacent, off-site facilities will flow overland to the proposed driveways as well. Runoff in the driveway gutters will discharge into the detention pond. Overland runoff will flow directly into the detention pond. Discharge from the detention pond will empty into the existing 42-inch storm sewer system at the southwest portion of the site.

Calculations

The existing and proposed design point for this report is the existing 42-inch RCP pipe at the southwestern portion of the site.

Historical Flow

Using the City of Colorado Springs / El Paso County Drainage Criteria Manual (CSDCM), the rainfall intensities for the calculated T_c (35.3 min.) can be attained.

	5-Year	100-Year
Rainfall Intensities	2.1 in/hr	4.0 in/hr

The historic conditions of the site consist of some brush in poor and fair condition. Using the Rational Method, precipitation for the area, the curve number, and the time of concentration, a peak flow (Q) can be calculated for both the design storm (5-Year) and the major storm (100-Year). The peak flow and the time of the peak flow for the start of the storm are for both sites.

	5-Year Peak Flow (cfs)	100-Year Peak Flow (cfs)
Entire basin	18.1	48.2

Developed Flow

Offsite undeveloped areas were assumed to be apartment complexes similar to that as shown in Figure 1. Developed flow is identified only of the sub-basin area (apartment complex and self-storage facility). The site will consist of asphalt, roof, and landscaped areas.
Referring to Appendix A, the new intensities and flows for the developed area and the entire property are identified. A summary of the results is presented below.

T_c =14.3 min.

	5-Year	100-Year
Rainfall Intensities	3.6 in/hr	6.6 in/hr

	5-Year Peak Flow (cfs)	100-Year Peak Flow (cfs)
Entire basin	80.7	171.8

Detention Pond

Since development flows exceed the historic flows, a detention pond is required. For the proposed detention pond, the flow requirements for the five-year storm event is the historical flow, 18.1 cfs. For the 100-year storm event, the flow is 48.2 cfs. Figure 2 presents the layout of the proposed detention pond.

The outlet structure will consist of a principal spillway pipe with orifice plate for the five-year flows, a riser pipe for the 100-year flow, a trash rack, and an emergency spillway. The orifice opening will be 2.46 square feet and will be set at bottom of pond. The equation for the amount of flow allowed in by a set of orifices is:

$$Q = 4\{CA(2gH)^{1/2}\}$$

where Q = discharge, in cfs.
C = orifice coefficient; 0.6.
A = the cross-sectional area of the pipe, in ft^2.
g = gravitational acceleration constant, 32.2 ft/sec^2.
H = head above the centerline of the orifice, in ft.

The riser pipe will be 36-inch in diameter and set at an elevation to discharge 100-year flows. The pipe will be open on top for the principal spillway with the trash rack on top of the pipe. The equation for the principal spillway on the top of the riser pipe is:

$$Q = CLH^{3/2}$$

where Q = discharge, in cfs.
C = weir coefficient, 3.1.
L = the pipe circumference, in ft.
H = the depth of flow over the riser pipe crest, in ft.

The emergency spillway inlet structure will be a 6' square concrete box. The equation for the emergency spillway is:

$$Q = CLH^{3/2}$$

where Q = discharge, in cfs.
C = weir coefficient, 3.1.
L = the length of the weir, in ft.
H = the depth of flow over the emergency spillway, in ft.

The total discharge using all of the outlets can be tabulated, along with the Stage Storage Curve. The emergency spillway will not be activated during a five- or 100-year storm. Using the tabulated information on total discharge and storage, plus using the peak flow of the proposed development, the Rational Method can calculate the peak flow out of detention pond and the time of the peak flow from the start of the storm.

	Outlet
5-Year Required Peak Flow (cfs)	18.1
5-Year Proposed Peak Flow (cfs)	18.1
100-Year Required Peak Flow (cfs)	48.2
100-Year Proposed Peak Flow (cfs)	48.2

These outflows are within the requirements of the historic flow. The water elevation during the five-year storm is 6021.2. The water elevation during the 100-year storm is 6022.9. The emergency spillway crest is 6024.0. The top the detention pond berm is 6025.0.

Emergency Spillway

In the event of a storm in excess of the 100-year design or if the detention pond outlet is plugged, an emergency spillway has been designed to carry the excess flow at the 100-year rate, less historic discharge, 124 cfs. Because of space constraints with existing adjacent developments, the spillway will consist of a concrete inlet structure and a 36" Smooth PVC (SPVC) pipe. This spillway will run south from the southern edge of the detention pond to intersect the existing 54" RCP located in Fountain Boulevard. The lip of the emergency spillway inlet structure within the pond will be at elevation 6024. This will provide approximately one foot of storage above the 100-year design elevation of 6022.9 feet plus one foot of freeboard above the emergency outlet.

Conclusions

This Master Development Drainage Plan is in compliance with the specifications set forth in the City of Colorado Springs / El Paso County Drainage Criteria Manual. The storm flows generated by this site will be carried within the driveway so that adverse effects on downstream basins are prevented. The flows released from the detention pond will be at or below historic amounts. Based on the results of this report, construction of the proposed apartment complex should not adversely affect the downstream storm water conditions.

Drainage, Bridge, and Detention Pond Facility Fees for Filing No.2, presented in Table 2 – Summary of Drainage Fees, are based upon the "2002 DRAINAGE, BRIDGE AND POND FEES" issued by the City of Colorado Springs, Colorado.

TABLE 2 – SUMMARY OF DRAINAGE FEES

Item	Fee / Acre	Fee
Drainage Fee	$6915.00	$112,023.00
Bridge Fee	$412.00	$6,674.40
Pond Fee	$448.00	$7,257.60
Facilities Fee	$1,543.00	$24,996.60
TOTAL		**$150,951.60**

The Opinion of Probable Construction Costs (OPCC) for the proposed improvements are presented Table 3 – OPCC:

ACCURATE EnglSurv LLC
515 Courtney Way, Suite D
Lafayette, CO 80026
303-665-5505 • FAX 303-665-5160

Land Engineers
Land Surveyors
Land Planners

NAZARENE BIBLE COLLEGE DETENTION POND
COLORADO SPRINGS, COLORADO

PRIVATE DRAINAGE FACILITIES - NON-REIMBURSABLE

OPINION OF PROBABLE CONSTRUCTION COST (OPCC)

	Item	Quantity	Units	Unit Cost	Total Cost
1	Bond & Insurance	1.00	ls	$1,000.00	$1,000.00
2	Mobilization, Travel, etc.	1.00	ls	$1,000.00	$1,000.00
3	~~Site - Seeding and Mulching~~ *intentionally deleted*	~~1.00~~	ls	$0	$0
4	Site - Clearing & Grubbing	1.00	ls	$1,000.00	$1,000.00
5	Site - Excavation	4,000.00	cy	$1.00	$4,000.00
6	Site - Backfilling and Compaction	7,000.00	cy	$1.00	$7,000.00
7	Site - Cleanup, Grading & Drain	1.00	ls	$2,000.00	$2,000.00
8	36" Dia. RCP for Detention Pond Drain Structure	50.00	lf	$44.00	$2,200.00
9	Detention Pond Drain Structure	1.00	ls	$3,400.00	$3,400.00
10	Emergency Outlet Structure	1.00	ls	$3,400.00	$3,400.00
11	36" Dia. RCP for Emergency Outlet Structure	950.00	lf	$44.00	$41,800.00
12	Connection to Existing 54" Dia @ Fountain Blvd.	1.00	ls	$1,500.00	$1,500.00
				Subtotal	$68,300.00
				10% Contin.	$6,830.00
				OPCC	$75,130.00

8/29/02 UPDATED -

The unit costs shown herein are based on bids submitted by sub-contractors to Greystar Construction West, LLC and are not necessarily reflective of unit costs based on current market rate.

APPENDIX A – CALCULATIONS

Title: Historic Evaluation
Project Name: Nazarene BC - Detention | By: Mark Hefta | Date: 03/11/02
Project No.: 1NAZ0101 | Checked: | Date:

Reference Standards

1. City of Colorado Springs & El Paso County "Drainage Criteria Manual"
2. Introduction to Hydrology, 2nd Edition, Harper & Row
3. Wastewater Engineering: Collection and Pumping of Wastewater, Metcalf & Eddy, Inc.

Nazazrene Bible College - Site Information

					% of Site	C (2-year)	C (5-year)	C (10-year)	C (100yr)
Site Area:	1,498,464	sq. ft. =	34.40	acres	100%	-	0.25	0.25	0.35
Existing Bldg. Area:		sq. ft. =	-	acres	0%				
Existing Driveways:		sq. ft. =	-	acres	0%				
Ex. Graveled Ways:					0%				
Ex. Walkways:		sq. ft. =	-	acres	0%				
Ex. Undeveloped:	1,498,464	sq. ft. =	34.40	acres	100%		0.25	0.25	0.35
Total Area:	1,498,464	sq. ft. =	34.40	acres					
Impervious Area:	-	sq. ft. =	-	acres	Developed:		0.90	0.90	0.90
or		0% of site							

Time of Concentration (tc)

Overland Flow Times Developed from

T = 1.8*(1.1-C)*(D)^1/2/(S^1/3), where

T = time (minutes)
C = runoff coefficient (dimensionless)
D = Maximum travel length in subbasin
S = slope (%)

use Rational Formula

Qp = CIA, where

Qp = peak runoff rate (cfs)
C = runoff coefficient (dimensionless)
I = average rainfall intensity (in./hr.), lasting for a critical period of time, tc
tc = time of concentration
A = size of drainage area (acres)

Calculate 10 - Year Qp for each subbasin {see "ToC Table" for development of values}

Subbasin	C	ti minutes	I Intensity in./hr.	A	Qp cfs	"C"	Weighted "Tc"	"I"
N1 - 5	0.25	39.5	1.9	10.90	5.2	0.25	35.3	2.1
N2 - 5	0.25	33.3	2.2	23.50	12.9			
					18.1			

Calculate 10 - Year Qp for each subbasin {see "ToC Table" for development of values}

Subbasin	C	ti minutes	I Intensity in./hr.	A	Qp cfs	"C"	Weighted "Tc"	"I"
N1 - 10	0.30	37.1	2.4	10.90	7.7	0.30	33.7	2.5
N2 - 10	0.30	32.2	2.6	23.50	18.3			
					26.0			

Calculate 100-Year Qp for each subbasin {see "ToC Table" for development of values}

Subbasin	C	ti minutes	I Intensity in./hr.	A	Qp cfs	"C"	Weighted "Tc"	"I"
N1 - 100	0.35	34.8	3.8	10.9	14.5	0.35	32.2	4.0
N2 - 100	0.35	31.0	4.1	23.5	33.7			
					48.2			

Printed: 7/11/02

Title: Historic Runoff Evaluation
Project Name: Nazarene Bible College
Project No.: 1NAZ0101

By: Mark Hefta
Checked:

Date: 03/11/02
Date:

17.2 TIME OF CONCENTRATION - STANDARD FORM SF - 2

Subdivision Nazarene Bible College Detention Pond

Prepared by: Mark Hefta, P. E.

Date: January 4, 2002

Sub-Basin Data			Initial/Overland Time (ti)			Travel Time (tt)				tc Check (Urbanized Basins)		Final tc	Remarks
Design	C5	Area	Length	Slope	ti	Length	Slope	Velocity	tt	TOTAL LENGTH	tc=(L/180) +10	tc=ti+tt	
		Acres	Feet	%	Minutes	Feet	%	FPS	Minutes	Feet	Minutes	Minutes	
1	2	3	4	5	6	7	8	9	10	11	12	13	
N1 - 5	0.25	10.90	910	1.6	39.5	-	-	-	-			39	Area 1 - Historical Site (5-year)
N1 - 10	0.30	10.90	910	1.6	37.1	-	-	-	-			37	Area 1 - Historical Site (10-year)
N1 - 100	0.35	10.90	910	1.6	34.8	-	-	-	-			35	Area 1 - Historical Site (100-Year)
N2 - 5	0.25	23.50	660	8.0	19.7	820	1.2%	1.00	13.7			33	Area 2 - Historic Site (10 Year)
N2 - 10	0.30	23.50	660	8.0	18.5	820	1.2%	1.00	13.7			32	Area 2 - Historic Site (10 Year)
N2 - 100	0.35	23.50	660	8.0	17.3	820	1.2%	1.00	13.7			31	Area 2 - Historic Site (100-Year)

Notes:

Title: Runoff Evaluation
Project Name: Nazarene B.C. - Detention | By: Mark Hefta | Date: 03/11/02
Project No.: 1NAZ0101 | Checked: | Date:

Reference Standards

1. Urban Drainage and Flood Control District
2 City of Colorado Springs & El Paso County "Drainage Criteria Manual"
2. Introduction to Hydrology, 2nd Edition, Harper & Row
3. Wastewater Engineering: Collection and Pumping of Wastewater, Metcalf & Eddy, Inc.

Site Information

Site Area:	1,498,464	sq. ft. =	34.40	acres
Existing Bldg. Area:	-	sq. ft. =	-	acres
Existing Paved Area:	-	sq. ft. =	-	acres
New Bldg. Area.:	190,000	sq. ft. =	4.36	acres
New Paved Area:	350,000	sq. ft. =	8.03	acres
Total Area:	1,498,464	sq. ft. =	34.40	acres
Impervious Area:	540,000	sq. ft. =	12.40	acres
or	36%	of site		

Time of Concentration (tc)

Overland Flow Times Developed from

T = 1.8*(1.1-C)*(D)^1/2/(S^1/3), where

T = time (minutes)
C = runoff coefficient (dimensionless)
D = Maximum travel length in subbasin
S = slope (%)

use Rational Formula

Qp = CIA, where

Qp = peak runoff rate (cfs)
C = runoff coefficient (dimensionless)
I = average rainfall intensity (in./hr.), lasting for a critical period of time, tc
tc = time of concentration
A = size of drainage area (acres)

Calculate 5-Year Qp for each subbasin {see "ToC Table" for development of values}

Subbasin	C	ti minutes	I Intensity in./hr.	A	Qp cfs	Discharge Point	Weighted "C"	Weighted "Tc"	Weighted "I"
D1a - 5	0.90	8.9	4.4	3.7	14.7		0.6	14.3	3.6
D1b - 5	0.70	13.9	3.7	12.9	33.4				
D2a - 5	0.55	15.0	3.4	5.8	10.8				
D2b - 5	0.55	16.1	3.3	12.0	21.8				
				34.4	80.7	cfs			

Calculate 10-Year Qp for each subbasin {see "ToC Table" for development of values}

Subbasin	C	ti minutes	I Intensity in./hr.	A	Qp cfs	Discharge Point	Weighted "C"	Weighted "Tc"	Weighted "I"
D1a - 10	0.90	8.9	5.0	3.7	16.7	A	0.7	14.1	4.0
D1b - 10	0.75	13.7	4.1	12.9	39.7				
D2a - 10	0.60	15.0	3.9	5.8	13.6				
D2b - 10	0.60	15.7	3.7	12.0	26.6	B			
					96.5	cfs			

Calculate 100-Year Qp for each subbasin {see "ToC Table" for development of values}

Subbasin	C	ti minutes	I Intensity in./hr.	A	Qp cfs	Discharge Point	Weighted "C"	Weighted "Tc"	Weighted "I"
D1a-100	0.90	8.9	7.3	3.7	24.3	A	0.8	12.0	6.6
D1b-100	0.80	11.7	6.6	12.9	68.1				
D2a-100	0.70	13.2	6.3	5.8	25.6				
D2b-100	0.70	12.5	6.4	12.0	53.8	B			
					171.8	cfs			

RUNOFF SUMMARY TABLE

Area Designation	Area (acres)	5 - Year Runoff (cfs)	10 - Year Runoff (cfs)	100 - Year Runoff (cfs)
D1	16.6	48	56	92
D2	17.8	33	40	79
TOTALS:	34.4	81	97	172

Title: Runoff Evaluation
Project Name: Nazarene Bible College
Project No.: 1NAZ0101

By: Mark Hefta
Checked:

Date: 03/11/02
Date:

17.2 TIME OF CONCENTRATION - STANDARD FORM SF - 2

Subdivision Nazarene Bible College Detention

Prepared by: Mark Hefta, P. E.

Date: "March 11, 2002

Sub-Basin Data			Initial/Overland Time (ti)			Travel Time (tt)				tc Check (Urbanized Basins)		Final tc	Remarks
Design	C5	Area	Length	Slope	ti	Length	Slope	Velocity	tt	TOTAL LENGTH	tc=(L/180) +10	tc=ti+tt	
1	2	Acres 3	Feet 4	% 5	Minutes 6	Feet 7	% 8	FPS 9	Minutes 10	Feet 11	Minutes 12	Minutes 13	
D1a - 5	0.90	3.70	650	1.1	8.9	-	1.0	3.0	-	650	14	9	Proposed Storage Units-5yr
D1b - 5	0.70	12.90	700	1.8	15.7	-	1.0	3.0	-	700	14	14	Proposed Apt. Complex-5yr
D1a - 10	0.90	3.70	650	1.1	8.9	-	1.0	3.0	-	650	14	9	Proposed Storage Units -10yr
D1b - 10	0.75	12.90	700	1.8	13.7	-	1.0	3.0	-	700	14	14	Proposed Apt. Complex-10yr
D1a-100	0.90	3.70	650	1.1	8.9	-	1.0	3.0	-	650	14	9	Proposed Storage Units -100yr
D1b-100	0.80	12.90	700	1.8	11.7	-	1.0	3.0	-	700	14	12	Proposed Apt. Complex-100yr
D2a - 5	0.55	5.80	900	4.4	18.1	-	2.25	3.50	-	900	15	15	Future MultiFamily - 5yr
D2b - 5	0.55	12.00	1,100	6.9	17.2	-	2.25	3.50	-	1,100	16	16	Future Development - 5yr
D2a - 10	0.60	5.80	900	4.4	16.5	-	2.25	3.50	-	900	15	15	Future MultiFamily - 10yr
D2b - 10	0.60	12.00	1,100	6.9	15.7	-	2.25	3.50	-	1,100	16	16	Future Development - 10yr
D2a-100	0.70	5.80	900	4.4	13.2	-	2.25	3.50	-	900	15	13	Future MultiFamily - 100yr
D2b-100	0.70	12.00	1,100	6.9	12.5	-	2.25	3.50	-	1,100	16	13	Future Development - 100yr

Notes:

Title: Pipe Line Flows
Project Name: Nazarene Bible College | By: Mark Hefta | Date: 03/11/02
Project No.: 1NAZ0101 | Checked: | Date:

Manning Equation for round pipe flowing full.
V=1.49/n R^2/3 S^1/2
or
Q = (0.463/n) * D^(8/3) * S^0.5

Review sizing requirements for Storm Sewer Lines
Given flowrate find required diameter

Resolve Manning Equation for diameter (D) using flowrate (Q)
D =(Q * n/0.463/(S^.5))^(3/8)

	Segment 1 - New Storm Sewer			Segment 2 - Existing Storm Sewer		
	5-year	10-year	100-year	5-year	10-year	100-year
	cfs	cfs	cfs	cfs	cfs	cfs
Flood Q (cfs)	18.1	26.0	48.2	138.1	146.0	168.2
req'd dia.(feet) =	1.40	1.61	2.03	3.31	3.38	3.57
or dia. (inches) =	18	20	25	40	42	43

	Segment 1 - New Storm Sewer		
n =	0.010	no units	
S =	0.025	ft/ft	

	Segment 2 - Existing Storm Sewer		
add'l flow =	120.0	cfs (existing flow)	
n =	0.010	no units	
S =	0.015	ft/ft	

Notes:
Segment 1 - Discharge from New Detention Basin (@ historic rate)
Segment 2 - Capacity of Existing Sanitary Sewer Line which Connects with 54-inch line in Murray Blvd.

Review Sizing Requirement for New Emergency Spillway
(assume developed flow less historic flow)

	Segment 1 - New Storm Sewer		
	5-year	10-year	100-year
	cfs	cfs	cfs
Flood Q (cfs)	62.6	70.5	123.5
req'd dia.(feet) =	2.31	2.42	2.98
or dia. (inches) =	28	30	36

	Segment 1 - New Storm Sewer		
n =	0.010	no units	
S =	0.021	ft/ft	

Title: Detention Evaluation - Rational Hydrograph
Project Name: Nazarene Bible College
Project No.: 1NAZ0101
By: Mark Hefta
Checked:
Date: 03/11/02
Date:

Determine Existing Stormwater Hydrographs

	5-Year Event		10-Year Event		100-Year Event	
	Area = 34.40 acres		Area = 34.40 acres		Area = 34.40 acres	
	C = 0.25		C = 0.30		C = 0.35	
Storm Rainfall Duration (min)	Storm Rainfall Intensity (in/hr)	Flood Peak Runoff Rate (cfs)	Storm Rainfall Intensity (in/hr)	Flood Peak Runoff Rate (cfs)	Storm Rainfall Intensity (in/hr)	Flood Peak Runoff Rate (cfs)
5.0	5.3	54.7	6.0	61.9	9.0	108.4
10.0	4.1	42.3	4.6	47.5	7.0	84.3
15.0	3.5	36.1	3.9	40.2	5.9	71.0
20.0	3.0	31.0	3.5	35.6	5.1	61.4
25.0	2.7	27.9	3.1	32.0	4.6	55.4
30.0	2.4	24.8	2.7	27.9	4.1	49.4
35.0	2.2	22.7	2.5	25.8	3.7	44.5
40.0	1.9	19.6	2.3	23.7	3.5	42.1
45.0	1.8	18.6	2.2	22.7	3.2	38.5
50.0	1.7	17.5	2.0	20.6	3.0	36.1

Determine Developed Stormwater Hydrographs

5-Year Event

Area = 34.40 acres
C = 0.64

Time (min)	Time (sec)	Intensity (in/hr)	Q dev (cfs)	V in cu. ft.	V out cu. ft.	Storage cu. ft.
5	300	5.3	117.4	47,193	5,431	41,762
10	600	4.1	90.8	73,015	10,862	62,154
15	900	3.5	77.5	93,495	16,292	77,203
20	1,200	3.0	66.5	106,852	21,723	85,129
25	1,500	2.7	59.8	106,145	27,154	78,991
30	1,800	2.4	53.2	110,299	32,585	77,714
35	2,100	2.2	48.7	115,726	38,015	77,711
40	2,400	1.9	42.1	112,571	43,446	69,125
45	2,700	1.8	39.9	118,607	48,877	69,730
50	3,000	1.7	37.7	123,314	54,308	69,007
					MAX:	85,129 cubic feet
Tc =	808 seconds		Include	0%	add'l =	85,129 cubic feet

Printed: 7/11/02

Determine Developed Stormwater Hydrographs

10-Year Event

Area = 34.40 acres

C = 0.69

Time (min)	Time (sec)	Intensity (in/hr)	Q dev (cfs)	V in cu. ft.	V out cu. ft.	Storage cu. ft.
5	300	6.0	142.1	57,128	7,804	49,324
10	600	4.6	109.0	87,597	15,609	71,988
15	900	3.9	92.4	111,400	23,413	87,987
20	1,200	3.5	81.7	120,257	31,217	89,039
25	1,500	3.1	73.4	130,084	39,022	91,062
30	1,800	2.7	63.9	132,484	46,826	85,658
35	2,100	2.5	59.2	140,434	54,630	85,803
40	2,400	2.3	54.5	145,542	62,435	83,107
45	2,700	2.2	52.1	154,846	70,239	84,607
50	3,000	2.0	47.4	154,980	78,044	76,937
					MAX:	91,062 cubic feet

Tc = 799 seconds Include 0% add'l = 91,062 cubic feet

100-Year Event Area: 34.40 acres

C = 0.76

Time (min)	Time (sec)	Intensity (in/hr)	Q dev (cfs)	V in cu. ft.	V out cu. ft.	Storage cu. ft.
5	300	9.0	235.0	94,466	14,466	80,000
10	600	7.0	182.8	146,947	28,932	118,015
15	900	5.9	154.0	185,783	43,398	142,386
20	1,200	5.1	133.2	191,278	57,863	133,415
25	1,500	4.6	120.1	208,557	72,329	136,228
30	1,800	4.1	107.1	218,003	86,795	131,208
35	2,100	3.7	96.6	225,717	######	124,456
40	2,400	3.5	91.4	240,931	######	125,204
45	2,700	3.2	83.6	245,346	######	115,153
50	3,000	3.0	78.3	253,510	######	108,852
					MAX:	142,386 cubic feet

Tc = 695 seconds Include 0% add'l = 142,386 cubic feet

Restricted Developed Release Rates to Historic Release Rate

Historic Release Rate:		Developed Rate		Difference (Storage)	
5-Year	18.1 cfs	80.7	cfs	62.6	cfs
10-Year	26.0 cfs	96.5	cfs	70.5	cfs
00-Year	48.2 cfs	171.8	cfs	123.5	cfs

Review Orifice Plate for Discharge

A = Q/(Cd(2gh)^.5), where

A = opening of orifice, sq. ft.

Q = flowrate (cfs) developed above

Cd = 0.60 orifice coefficient

g = 32.2 ft/sec^2 gravitational constant

h = head on orifice plate, from centerline, feet

	5-year	10-year	100-year
h (feet)	2.33	2.49	3.90
A (square feet)=	2.46	3.42	5.07
or Diameter (inches) =	21.2	25.0	30.5

Assuming a	8.0	inch diameter orrifice, develop layout
I. E. of first Outlet:	6019.00	msl
5-yr Flood Elevation:	6021.20	msl
10-yr Flood Elevation:	6021.50	msl
100-yr Flood Elevation:	6022.90	msl

Review Outlet Design for 5-yr Histroic Discharge

	Diameter (inches)	Centerline Elev. (msl)	No. of Orrifices	Head on Oriffice(ft)	Oriffice Q (cfs) ea.	Orrifice Q (cfs) total	Cummul. Q (cfs)
1st Outlet	8.0	6019.50	4	1.7	2.2	8.77	8.8
2nd Outlet	8.0	6020.00	3	1.2	1.8	5.52	14.3
3rd Outlet	8.0	6020.50	4	0.7	1.4	5.62	19.9
4th Outlet	8.0	6021.00	3	0.2	0.8	2.25	22.2

Review Outlet Design for 10-yr Histroic Discharge

	Diameter (inches)	Centerline Elev. (msl)	No. of Orrifices	Head on Oriffice(ft)	Oriffice Q (cfs) ea.	Orrifice Q (cfs) total	Cummul. Q (cfs)
1st Outlet	8.0	6019.50	4	2.0	2.4	9.51	9.5
2nd Outlet	8.0	6020.00	3	1.5	2.1	6.18	15.7
3rd Outlet	8.0	6020.50	4	1.0	1.7	6.72	22.4
4th Outlet	8.0	6021.00	3	0.5	1.2	3.57	26.0

Review Weir Flow

Q = CLH^1.5 solving for H ===>>> H = (Q /C/L)^(1/1.5)

Q = flowrate (cfs) developed above

C = 3.3 weir coeffient, no units

L = 9.4 length of weir, feet

H = depth of flow over weir, feet [solve for below]

Review Water Depths on Weir for Each Option

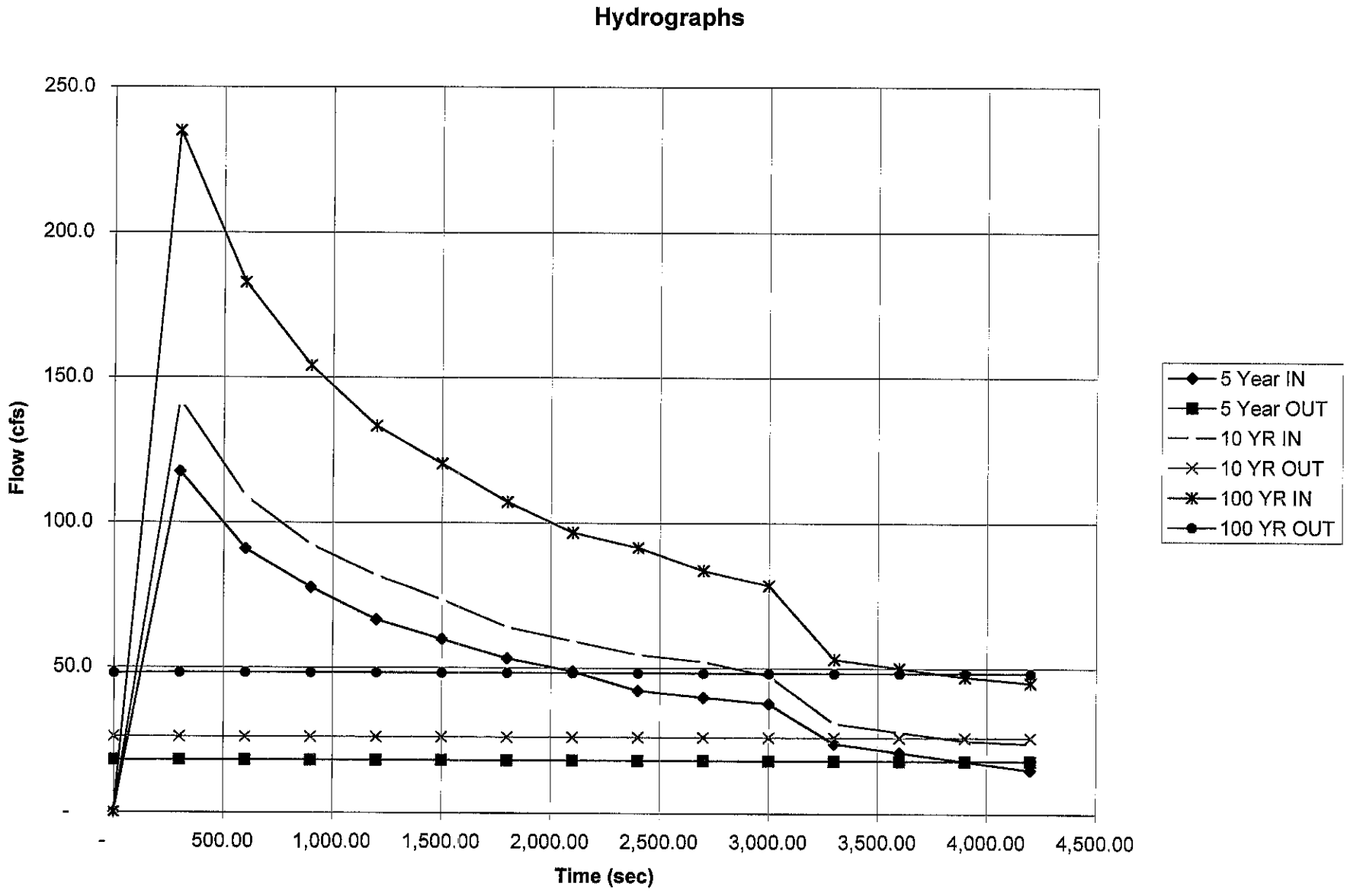
	5-year	10-year	100-year
Height of Water over Weir:	0.70	0.89	1.34

Review Orrifice and Weir Flows at 100-yr condition

100 yr- Flood Elevation: 6,022.90 msl

Q remaining for 100-yr flow:	22.25	cfs
Assume Weir Length:	4.50	feet
Head on Weir:	1.31	feet
Therefore, set weir at:	6021.59	msl

Plot Curves Time (sec)	5 -Year Flow In (cfs)	5 -Year Flow Out (cfs)	10 -Year Flow In (cfs)	10 -Year Flow out (cfs)	100 -Year Flow In (cfs)	100 -Year Flow Out (cfs)
-	-	18.0	-	26.00	-	48.00
300	117	18	142	26	235	48
600	91	18	109	26	183	48
900	78	18	92	26	154	48
1,200	66	18	82	26	133	48
1,500	60	18	73	26	120	48
1,800	53	18	64	26	107	48
2,100	49	18	59	26	97	48
2,400	42	18	54	26	91	48
2,700	40	18	52	26	84	48
3,000	38	18	47	26	78	48
3,300	*24*	*18*	*31*	*26*	*53*	*48*
3,600	*21*	*18*	*28*	*26*	*50*	*48*
3,900	*18*	*18*	*25*	*26*	*47*	*48*
4,200	*15*	*18*	*24*	*26*	*45*	*48*


Hydrographs
250.0
200.0
150.0
100.0
50.0
-
Flow (cfs)
-
500.00
1,000.00
1,500.00
2,000.00
2,500.00
3,000.00
3,500.00
4,000.00
4,500.00
Time (sec)
5 Year IN
5 Year OUT
10 YR IN
10 YR OUT
100 YR IN
100 YR OUT

Title: Detention Basin Design / Hydraulics
Project Name: Nazarene B.C. Detention Pond
Project No.: 1NAZ0101
By: Mark Hefta
Checked:
Date: 03/11/02
Date:

Review Size and Layout Detention Basin, based upon 5-Year and 100-year events
Assume Rectangular Basin to Conform with Site Constraints

Allow	100%	credit for WQCV
Required Water Quality Capture Volume:	-	cubic feet
Required 5-Year Detention Volume:	85,129	cubic feet
Required 10-Year Detention Volume:	91,062	cubic feet
Required 100-Year Detention Volume:	142,386	cubic feet
5-Year plus WQCV =	85,129	cubic feet
10-Year plus WQCV =	91,062	cubic feet
or 100-Year plus 1/2 WQCV =	142,386	cubic feet
Therefore use:	142,386	cubic feet
Main Detention Basin Area:	36,500	square feet
Secondary Detention Basin Area:	-	square feet
WQCV depth:	-	feet (in Main Detention Area Only)
5-Year depth:	2.33	feet
10-Year depth:	0.16	feet
100-Year depth:	1.41	feet
Total Water Depth:	3.90	feet

Determine Time to Drain Basin Volume with Low Flow Outlet

5-Year Release Rate:	18.1	cfs
Total Volume less WQCV:	142,386	cubic feet
Drain Time:	2.2	hours

Title: Swale Hydraulics
Project Name: Nazarene B. C. Detention Pond | By: Mark Hefta | Date: 07/06/02
Project No.: 1NAZ0101 | Checked: | Date:

Review Emergency Spillway Flows for Each Storm Event

	Historic		Developed		Difference	
5-Year	18	cfs	81	cfs	63	cfs
10-Year	26	cfs	97	cfs	71	cfs
100-Year	48	cfs	172	cfs	124	cfs

Swale Characteristics

Channel shape	Vertical	Horizontal	Slope		
Left bank slope	1	4.0	0.25		
Right band slope	1	4.0	0.25		
Bottom width		10.0			
Longitudinal slope	1	67.0	0.0149		
5-Year Depth of Flow		1.24	feet	Adjust by trial and error	
10-Year Depth of Flow		1.36	feet	until Q's match	
100-Year Depth of Flow		1.77	feet		

Manning Equation for Trapezoidal or "V" channel
V=1.49/n R^2/3 S^1/2
where

	5-Year	10-Year	100-Year	
n = roughness coefficient =	0.05	0.05	0.05	
R = A/WP =	0.91	0.99	1.23	feet
A = cross sectional area of channel =	18.45	21.06	30.33	sq. ft.
WP = wetted perimeter =	20.18	21.24	24.63	feet
S = slope =	0.015	0.015	0.015	feet/foot
V = velocity =	3.4	3.6	4.2	fps
Calculated Q = VA =	63.3	76.2	126.9	cfs
check	N.G.	N.G.	N.G.	
Developed Q =	62.6	70.5	123.5	cfs

Review Swale A (adjacent to Public Storage)

Channel shape	Vertical	Horizontal	Slope		
Left bank slope	1	15.0	0.07		
Right band slope	1	10.0	0.10		
Bottom width		2.0			
Longitudinal slope	0.8	100.0	0.0080		
5-Year Depth of Flow		0.80	feet	Adjust by trial and error	
10-Year Depth of Flow		0.84	feet	until Q's match	
100-Year Depth of Flow		0.98	feet		

	5-year	10-year	100-year	
Flows (cfs)	14.70	16.70	24.30	
n = roughness coefficient =	0.05	0.05	0.05	
R = A/WP =	0.44	0.46	0.53	feet
= cross sectional area of channel =	9.60	10.55	13.97	sq. ft.
WP = wetted perimeter =	22.07	23.12	26.58	feet
S = slope =	0.008	0.008	0.008	feet/foot
V = velocity =	1.5	1.6	1.7	fps
Calculated Q = VA =	14.7	16.7	24.2	cfs
check	OK	OK	OK	
Developed Q =	14.7	16.7	24.3	cfs

Title: Calculate Drainage Fees
Project Name: Nazarene B. C. Detention Pond — By: Mark Hefta — Date: 03/11/02
Project No.: 1NAZ0101 — Checked: — Date:

Determine Drainage Fees - Filing No. 2

Sand Creek Basin

Area:		16.20	acres
Drainage Fee Rate:	$	6,915.00	per acre
Drainage Fee =	$	112,023.00	
Bridge Fee Rate:	$	412.00	per acre
Bridge Fee =	$	6,674.40	
Pond Fee Rate:	$	448.00	per acre
Pond Fee =	$	7,257.60	
Facilities Fee Rate:	$	1,543.00	per acre
Facilities Fee =	$	24,996.60	
TOTAL FEES =	$	150,951.60	

APPENDIX B – FIGURES