

Final Drainage Report

E-470 Toll Plaza B Subdivision Filing No. 1

Prepared for:

Applegreen Limited

Prepared by:

Redland

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Littleton, Colorado 80120
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Approved For One Year From This Date

City Engineer

Date

Water Department

Date

ENGINEER'S CERTIFICATION

I hereby certify that this final drainage study for the E-470 Toll Plaza B Subdivision Filing No. 1 was prepared by me (or under my direct supervision) in accordance with the provisions of the City of Aurora *Storm Drainage Design and Technical Criteria Manual* for the owners thereof.

Mark Cevaal, PE
Registered Professional Engineer
State of Colorado P.E. No. 33123

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Appendix A – Vicinity Map, FIRM, Soils Data
Appendix B – Hydrologic and Hydraulic Calculations
Appendix C – Reference Materials
Appendix D – Final Drainage Plan

General Location and Description

This Final Drainage Report is only applicable to E-470 Toll Plaza B Subdivision Filing No. 1 (the Site). The project addresses sewer, water, storm and road infrastructure.

Location

E-470 Toll Plaza B Subdivision Filing No. 1 (the site) is located in the southwestern corner of southeastern quarter of Section 25, Township 4 South, Range 66 West of the Sixth Principal Meridian, County of Arapahoe, State of Colorado. Generally, the site is located within the E-470 Right of way and bounded by E-470 on the west. The site generally lies south of E Jewell Ave, north of E Hampden Ave, and West of S Gun Club Road. See vicinity map in Appendix A for more information.

The site is tributary to Murphy Creek to the northeast.

Proposed Development

The site slopes moderately from southwest to northeast at an average slope of approximately 1% to 2%. The soils located on the site are predominantly SCS Hydrologic Soil Group Classification C soils. These soil types have slow to moderate infiltration rates when thoroughly wetted. Hydrologic and hydraulic analysis within this report have assumed the soil classification for Type C soils. Please refer to Appendix A for the soil's information from the Web Soil Survey.

The existing site is the E470 Toll Plaza B. The overall study area composite imperviousness is 47.60%. Please refer to Appendix B for hydrologic and hydraulic calculations.

There are no irrigation canals or ditches located on the property. There is an existing swale along the eastern edge of the site that routes flows into an existing detention pond located north of the site.

A geotechnical study was prepared by Ground Engineering. – Geotechnical Evaluation Applegreen Project Northbound Parker Site, Aurora, Colorado, dated January 13, 2022. Nine borings were completed with the investigation and the general subsurface conditions were determined to consist of 5 to 18 feet of fill soils, native clays, weathered siltstone and claystone bedrock to a maximum exploration depth of 18 feet.

Drainage Design Criteria

Purpose

The purpose of this report is to ensure compliance with the original design assumptions. Information and references from the previously approved Final Drainage Report, E-470 STATION 643+00 TO 1157+00 (AREA 4) (Package No. A4-04-A), by MK Centennial has been included where applicable to E-470 Toll Plaza B Subdivision Filing No. 1.

Historic Drainage

Overall Basin Description

The site is tributary to Murphy Creek which is located to the north and east and flows in a northerly and westerly direction to a confluence with Coal Creek which flows in a northerly and westerly direction to a confluence with Sand Creek which continues to the northwest until its confluences with the South Platte River.

The site lies within FEMA Flood Zone X, according to FEMA Map No. 08005C0211L, September 04, 2020. Zone X (unshaded) is described as an area of minimal flood hazard, determined to be higher than the elevation of the 500-year flood. This map panel is included in Appendix A.

Drainage Patterns through Property

Drainage within the site is generally in a northerly direction. On-grade and sump inlets are proposed to intercept the surface runoff within the site. The runoff intercepted by these inlets will be conveyed by storm sewer and swales to the existing detention facility which has been constructed for the Site. The is located at the north end of the site, on the south side of Coal Creek and discharges to Coal Creek.

Hydraulic Criteria

System hydraulics are evaluated using the StormCAD modeling software. In order to accommodate a routed flow model, the flow application for the major event storm was applied allowing the software to apply rational calculations to the pipe network at user defined times of concentrations developed for the basin analysis. This method generates combined pipe flows for evaluation of the hydraulic performance. Our evaluation of the system included comparison of routed flows at specific regions along the pipe network to confirm that the flow rates are added in a manner consistent with the Rational analysis performed manually on forms SF-2 and SF-3. Street capacities and inlet sizing were evaluated using the Street Capacity and Inlet Sizing spreadsheet v4.05, developed by Mile High Flood District.

Outfalls Downstream of the Property

The pond releases runoff into an existing swale the runs east and north. The existing swale eventually releases into Murphy Creek, consistent with the existing site's historic runoff pattern. Please refer to Appendix C for the Pond design reference information from the approved Final Drainage Report, E-470 STATION 643+00 TO 1157+00 (AREA 4).

Design Criteria

References

The Site is included in a previously prepared drainage study:

Final Drainage Report, E-470 STATION 643+00 TO 1157+00 (AREA 4) (Package No. A4-04-A), by MK Centennial, April 1997.

This report has been prepared in accordance with the City of Aurora Storm Drainage Design and Technical Criteria Manual along with the Urban Drainage and Flood Control District (UDFCD) Urban Storm Drainage Criteria Manual.

Major Basin Description

No part of the proposed improvements lies within the current 100-year floodplain according to Maps No. 08001C0635H and 08001C0655J dated March 5, 2007 and February 2, 2017 respectively, by the Federal Emergency Management Agency.

There are no irrigation facilities located within 100-feet of the site.

Hydrologic Criteria

Rainfall data was obtained from the USDCM Volume 1, Chapter 5 Figures 5-1 and 5-6. The 2-year, 1-hour rainfall depth (P1) obtained was 0.99 inches, and the 100-year P1 used was 2.65 inches.

Impervious percentages, times of concentration, 2-year and 100-year peak runoff rates were determined using the UDFCD Standard Form 1-3 method spreadsheets. Please refer to Appendix B for Hydrologic and Hydraulic Calculations.

Detention and water quality volumes for existing the Pond were determined using the UDFCD's UD-Detention v3.07 spreadsheet. The 100-year detention volume design for the Pond is 1.930 acre-feet, which includes the Water Quality Volume, the EURV, and the 100 year.

Hydraulic Criteria

The 2-year and 100-year events are the respective design events for the minor and major storm frequencies. These two events will be used for sizing storm sewer inlets and pipes in the final drainage report.

The Bentley StormCAD V8i (SELECTseries 3) computer program was used to determine the water surface profiles for the storm sewer system in the final drainage report.

There are no major drainageways adjacent to the site.

Drainage Plan

General Concept

Onsite storm sewer will convey runoff north to existing Detention and Water Quality Pond. The pond was constructed as part of the Toll Plaza B improvements and does not currently treat for water quality. The outlet structure will be replaced with an outlet structure to provide Water Quality, EURV, and detain the 100-year event.

Specific Details – Basin Descriptions

Basin Descriptions

Basin A1

Basin	Design Point	Area (AC)	I%	C5	C100	Q (5 year)	Q (100 Year)
A1	A1	1.15	89.2%	0.77	0.85	0.79	1.72

Basin A1 consists of 1.15 acres and is composed of a parking lot, associated landscaping, fuel station, and a portion of the proposed building. Runoff from Basin A1 will sheet flow to a 10' Type R sump inlet at Design Point A1 on the northeastern corner of the site, which will intercept the minor storm event and major storm even storm runoff. The emergency overflow path from this inlet is down the existing dirt road and into the existing swale located in OS-2.

Basin A2

Basin	Design Point	Area (AC)	I%	C5	C100	Q (5 year)	Q (100 Year)
A2	A2	0.83	86.0%	0.74	0.84	1.95	6.24

Basin A2 consists of 0.83 acres and is composed of a parking lot, associated landscaping, and a portion of the proposed building. Runoff from Basin A2 will sheet flow to a Type 13 sump inlet at Design Point A2 in the middle of the site, which will intercept the minor storm event and major storm even storm runoff. The emergency overflow path from this inlet is north towards a 10' Type R inlet located at design point A1.

Basin A3

Basin	Design Point	Area (AC)	I%	C5	C100	Q (5 year)	Q (100 Year)
A3	A3	1.02	17.2%	0.62	0.78	1.94	7.11

Basin A3 consists of 1.02 acres and is composed of a parking lot, associated landscaping, and a portion of the proposed building. Runoff from Basin A3 will sheet flow into a cross pan in the middle of the roadway where it flows east to Design Point A3, which will intercept the minor storm event and major storm even storm runoff. The flows then routes into landscaping and into the existing swale.

Basin OS-1

Basin	Design Point	Area (AC)	I%	C5	C100	Q (5 year)	Q (100 Year)
OS-1	OS-1	3.42	17.2%	0.62	0.78	1.94	7.11

Basin OS-1 consists of 3.42 acres and is composed of existing E-470 roadway and the detention pond. Runoff from Basin OS-1 will sheet flow directly into the pond. The pond releases at design point OS-1. Emergency overflow for the pond is provided in the emergency spillway.

Basin OS-2

Basin	Design Point	Area (AC)	I%	C5	C100	Q (5 year)	Q (100 Year)
OS-2	OS-2	0.70	7.0%	0.03	0.16	0.06	0.92

Basin OS-2 consists of 0.70 acres and is composed of the existing swale, concrete transformer pad, and landscaping. Runoff from Basin OS-2 will sheet flow directly into the existing swale and routed down the swale to an existing 24" FES at design point OS-2. The emergency overflow path from the FES is North over the berm and into the pond.

Existing Basins**Existing Basin E3**

Basin	Design Point	Area (AC)	I%	C5	C100	Q (5 year)	Q (100 Year)
EX. E3	EX. E3	0.48	100.0%	0.86	0.89	1.34	3.86

Existing Basin E3 consists of 0.48 acres of the E-470 roadway. Runoff from Existing Basin E3 sheet flows into an existing Type R sump inlet at Design Point 8, which intercepts the minor storm event and major storm even storm runoff. Refer to Final Drainage Report, E-470 STATION 643+00 TO 1157+00 (AREA 4) (Package No. A4-04-A), by MK Centennial, April 1997 for design information.

Existing Basin M2

Basin	Design Point	Area (AC)	I%	C5	C100	Q (5 year)	Q (100 Year)
EX. M2	EX. M2	2.57	2.0%	0.05	0.49	0.09	11.37

Existing Basin M2 consists of 2.57 acres of the associated landscaping for the E-470 roadway. Runoff from Existing Basin M2 sheet flows into an existing Type C sump inlet at Design Point 7, which intercepts the minor storm event and major storm even storm runoff. Refer to Final Drainage Report, E-470 STATION 643+00 TO 1157+00 (AREA 4) (Package No. A4-04-A), by MK Centennial, April 1997 for design information.

Existing Basin M3

Basin	Design Point	Area (AC)	I%	C5	C100	Q (5 year)	Q (100 Year)
EX. M3	EX. M3	0.78	2.0%	0.05	0.49	0.03	3.45

Existing Basin M3 consists of 0.78 acres of the associated landscaping for the E-470 roadway. Runoff from Existing Basin M3 sheet flows into an existing Type C sump inlet at Design Point 15, which intercepts the minor storm event and major storm even storm runoff. Refer to Final Drainage Report, E-470 STATION 643+00 TO 1157+00 (AREA 4) (Package No. A4-04-A), by MK Centennial, April 1997 for design information.

Existing Basin W2

Basin	Design Point	Area (AC)	I%	C5	C100	Q (5 year)	Q (100 Year)
EX. W2	EX. W2	2.92	56.0%	0.49	0.71	4.25	18.73

Existing Basin W2 consists of 2.92 acres of the associated landscaping for the E-470 roadway and the E-470 roadway. Runoff from Existing Basin W2 sheet flows into an existing Type C sump inlet at Design Point 13, which intercepts the minor storm event and major storm even storm runoff. Refer to Final Drainage Report, E-470 STATION 643+00 TO 1157+00 (AREA 4) (Package No. A4-04-A), by MK Centennial, April 1997 for design information.

Existing Basin W3

Basin	Design Point	Area (AC)	I%	C5	C100	Q (5 year)	Q (100 Year)
EX. W3	EX. W3	0.41	100%	0.86	0.89	1.14	3.29

Existing Basin W3 consists of 0.41 acres of the E-470 roadway. Runoff from Existing Basin W3 sheet flows into an existing Type R sump inlet at Design Point 4, which intercepts the minor storm event and major storm even storm runoff. Refer to Final Drainage Report, E-470 STATION 643+00 TO 1157+00 (AREA 4) (Package No. A4-04-A), by MK Centennial, April 1997 for design information.

Existing Basin W4

Basin	Design Point	Area (AC)	I%	C5	C100	Q (5 year)	Q (100 Year)
EX. W4	EX. W4	0.55	100%	0.86	0.89	1.53	4.42

Existing Basin W4 consists of 0.55 acres of the E-470 roadway. Runoff from Existing Basin W3 sheet flows into an existing Type R sump inlet at Design Point 14, which intercepts the minor storm event and major storm even storm runoff. Refer to Final Drainage Report, E-470 STATION 643+00 TO 1157+00 (AREA 4) (Package No. A4-04-A), by MK Centennial, April 1997 for design information.

Specific Details – Detention Pond

The Water Quality Capture Volume for the detention pond is 0.247 acre-feet at stage 1.95 feet. The Excess Urban Run-Off Volume for the detention pond is 4.18 acre-feet at stage 2.82 feet. The 100-year for the detention pond is 0.699 acre-feet at stage 3.98 feet. The total required volume for the pond is 1.364 acre-feet and the existing pond provides a volume of 2.45 acre-feet with a stage of 5.5 feet.

Conclusions

Compliance with Standards

This report provides documentation of revisions to Final Drainage Report, E-470 STATION 643+00 TO 1157+00 (AREA 4) (Package No. A4-04-A), by MK Centennial, April 1997 and was prepared in accordance with the procedures and concepts outlined in the City of Aurora Storm Drainage Design and Technical Criteria Manual along with the Urban Drainage and Flood Control District (UDFCD) Urban Storm Drainage Criteria Manual.

Summary of Concept

No adverse effects to the surrounding properties or regional drainage facilities are anticipated from the development of this site. The proposed design, if properly maintained and constructed, will convey and protect the quality of the stormwater runoff up to and including the 100-year storm event. The runoff is conveyed in a safe manner to protect life and limit damage to property by utilizing appropriate storm sewer systems. A GESD plan will be completed for the site that details appropriate erosion control BMP's for the site. Street flow and inlet capacity is designed such that City of Aurora criteria pertaining to street and inlet capacity is met.

References

REFERENCES

1. City of Aurora Storm Drainage Design and Technical Criteria Manual.
2. Urban Drainage and Flood Control District, Denver, Colorado, Urban Storm Drainage Criteria Manual, Volume 1-3, latest online edition.
3. E-470 Station 1620+00 to 1900+00 Ultimate Roadway Preliminary Drainage Study, June 1996, prepared by MK Centennial



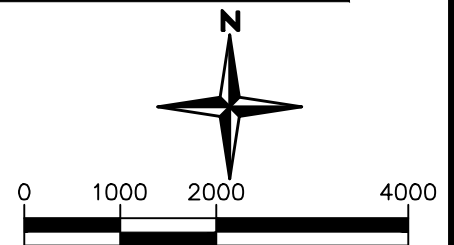
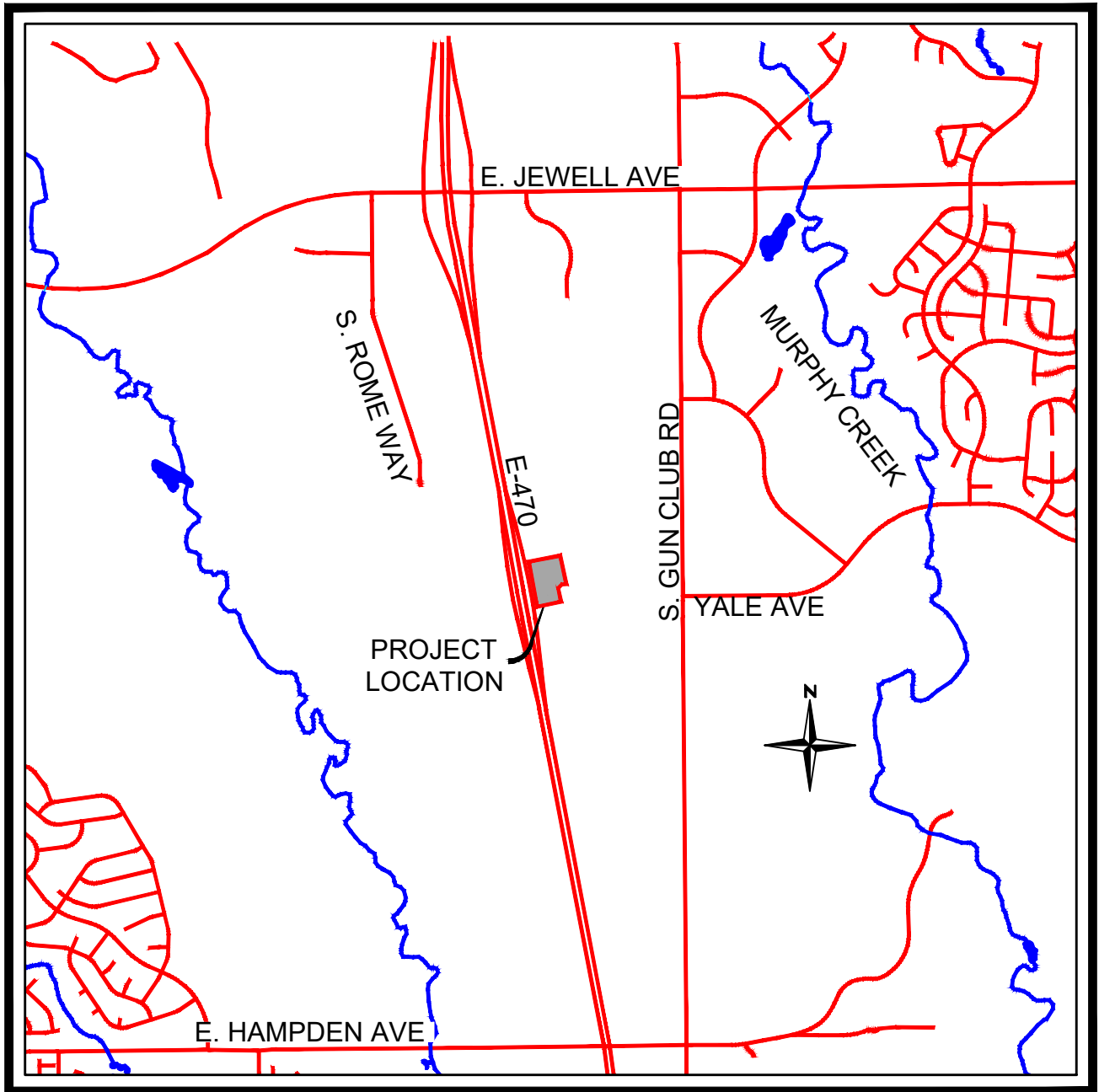
WHERE GREAT PLACES BEGIN

Final Drainage Report for Applegreen East Minor Subdivision

March 2022

Appendix A – Vicinity Map, FIRM Map, Zoning Map, Soils Data

I:\2021\21003 - Project Bronco\CADD\Exhibits\Aurora\21003.003 Vicinity Map.dwg tab: 8x11 Mar 17, 2022 - 4:55pm wconway



SCALE: 1" = 2000'



VICINITY MAP

PROJECT BRONCO - AURORA

AURORA

CO

DATE 2022-03-18

PROJ. NO. 21003.003

SHEET

VIC



104°43'7.11"W 39°39'15.96"N

FLOOD HAZARD INFORMATION

SEE FIS REPORT FOR DETAILED LEGEND AND INDEX MAP FOR DRAFT FIRM PANEL LAYOUT

SPECIAL FLOOD HAZARD AREAS	<div></div>	Without Base Flood Elevation (BFE) Zone A, V, A99
	<div></div>	With BFE or Depth Zone AE, AO, AH, VE, AR
	<div></div>	Regulatory Floodway
OTHER AREAS OF FLOOD HAZARD	<div></div>	0.2% Annual Chance Flood Hazard, Areas of 1% annual chance flood with average depth less than one foot or with drainage areas of less than one square mile Zone X
	<div></div>	Future Conditions 1% Annual Chance Flood Hazard Zone X
	<div></div>	Area with Reduced Flood Risk due to Levee See Notes Zone X
	<div></div>	Area with Flood Risk due to Levee Zone D
OTHER AREAS	<div></div>	NO SCREEN Area of Minimal Flood Hazard Zone X
	<div></div>	Effective LOMRs
GENERAL STRUCTURES	<div></div>	Area of Undetermined Flood Hazard Zone D
	<div></div>	Channel, Culvert, or Storm Sewer
	<div></div>	Levee, Dike, or Floodwall
OTHER FEATURES	<div></div>	Cross Sections with 1% Annual Chance
	<div></div>	Water Surface Elevation
	<div></div>	Coastal Transect
	<div></div>	Coastal Transect Baseline
	<div></div>	Profile Baseline
	<div></div>	Hydrographic Feature
	<div></div>	Base Flood Elevation Line (BFE)
	<div></div>	Limit of Study
	<div></div>	Jurisdiction Boundary

NOTES TO USERS

For information and questions about this Flood Insurance Rate Map (FIRM), available products associated with this FIRM, including historic versions, the current map date for each FIRM panel, how to order products, or the National Flood Insurance Program (NFIP) in general, please call the FEMA Map Information eXchange at 1-877-FEMA-MAP (1-877-336-6627) or visit the FEMA Flood Map Service Center website at <https://msc.fema.gov>. Available products may include previously issued Letters of Map Change, a Flood Insurance Study Report, and/or digital versions of this map. Many of these products can be ordered or obtained directly from the website.

Communities annexing land on adjacent FIRM panels must obtain a current copy of the adjacent panel as well as the current FIRM Index. These may be ordered directly from the Flood Map Service Center at the number listed above.

For community and countywide map dates, refer to the Flood Insurance Study Report for this jurisdiction.

To determine if flood insurance is available in this community, contact your Insurance agent or call the National Flood Insurance Program at 1-800-638-6620.

Basemap information shown on this FIRM was provided in digital format by the United States Geological Survey (USGS). The basemap shown is the USGS National Map: Orthoimagery. Last refreshed October, 2020.

This map was exported from FEMA's National Flood Hazard Layer (NFHL) on **3/9/2022 5:15 PM** and does not reflect changes or amendments subsequent to this date and time. The NFHL and effective information may change or become superseded by new data over time. For additional information, please see the Flood Hazard Mapping Updates Overview Fact Sheet at <https://www.fema.gov/media-library/assets/documents/118418>

This map complies with FEMA's standards for the use of digital flood maps if it is not void as described below. The basemap shown complies with FEMA's basemap accuracy standards. This map image is void if the one or more of the following map elements do not appear: basemap imagery, flood zone labels, legend, scale bar, map creation date, community identifiers, FIRM panel number, and FIRM effective date.

SCALE

Map Projection:
GCS, Geodetic Reference System 1980;
Vertical Datum: NAVD83
For information about the specific vertical datum for elevation features, datum conversions, or vertical monuments used to create this map, please see the Flood Insurance Study (FIS) Report for your community at <https://msc.fema.gov>

1 inch = 500 feet

1:6,000

0 250 500 1,000 1,500 2,000

0 50 100 200 300 400

Feet

Meters

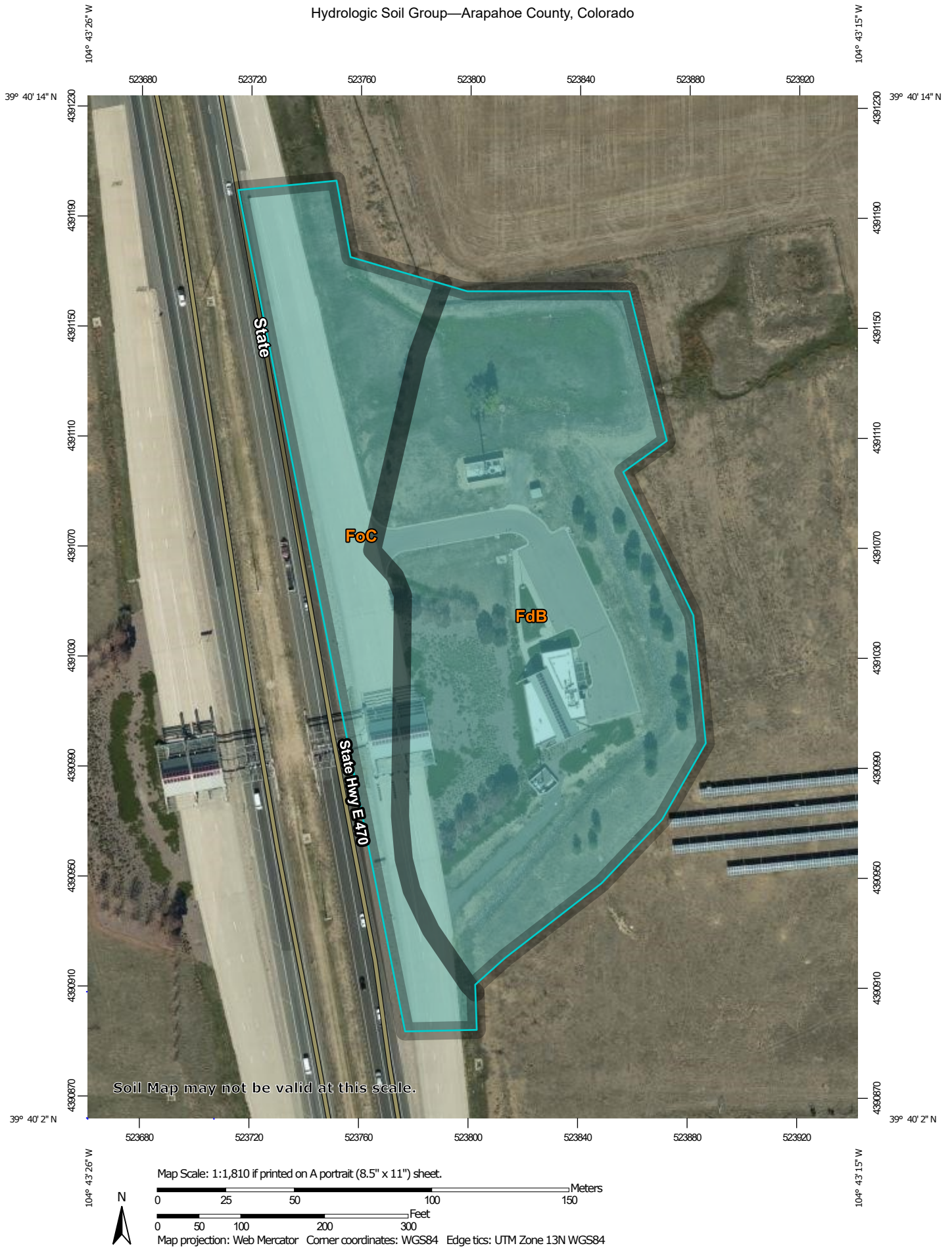
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NATIONAL FLOOD INSURANCE PROGRAM
FLOOD INSURANCE RATE MAP

PANEL 211 OF 675		
Panel Contains:		
COMMUNITY	NUMBER	PANEL
CITY OF AURORA	080002	0211
ARAPAHOE COUNTY	080011	0211









Hydrologic Soil Group—Arapahoe County, Colorado




MAP LEGEND**Area of Interest (AOI)**
 Area of Interest (AOI)
Soils**Soil Rating Polygons**





-  A
-  A/D
-  B
-  B/D
-  C
-  C/D
-  D
-  Not rated or not available

Soil Rating Lines

-  A
-  A/D
-  B
-  B/D
-  C
-  C/D
-  D
-  Not rated or not available

Soil Rating Points

-  A
-  A/D
-  B
-  B/D

-  C
-  C/D
-  D
-  Not rated or not available

Water Features
 Streams and Canals
Transportation

-  Rails
-  Interstate Highways
-  US Routes
-  Major Roads
-  Local Roads

Background
 Aerial Photography
MAP INFORMATION

The soil surveys that comprise your AOI were mapped at 1:20,000.

Warning: Soil Map may not be valid at this scale.

Enlargement of maps beyond the scale of mapping can cause misunderstanding of the detail of mapping and accuracy of soil line placement. The maps do not show the small areas of contrasting soils that could have been shown at a more detailed scale.

Please rely on the bar scale on each map sheet for map measurements.

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL:
Coordinate System: Web Mercator (EPSG:3857)

Maps from the Web Soil Survey are based on the Web Mercator projection, which preserves direction and shape but distorts distance and area. A projection that preserves area, such as the Albers equal-area conic projection, should be used if more accurate calculations of distance or area are required.

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: Arapahoe County, Colorado
Survey Area Data: Version 17, Aug 31, 2021

Soil map units are labeled (as space allows) for map scales 1:50,000 or larger.

Date(s) aerial images were photographed: Oct 3, 2018—Dec 4, 2018

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

Hydrologic Soil Group

Map unit symbol	Map unit name	Rating	Acres in AOI	Percent of AOI
FdB	Fondis silt loam, 1 to 3 percent slopes	C	5.5	70.1%
FoC	Fondis-Colby silt loams, 3 to 5 percent slopes	C	2.3	29.9%
Totals for Area of Interest			7.8	100.0%

Description

Hydrologic soil groups are based on estimates of runoff potential. Soils are assigned to one of four groups according to the rate of water infiltration when the soils are not protected by vegetation, are thoroughly wet, and receive precipitation from long-duration storms.

The soils in the United States are assigned to four groups (A, B, C, and D) and three dual classes (A/D, B/D, and C/D). The groups are defined as follows:

Group A. Soils having a high infiltration rate (low runoff potential) when thoroughly wet. These consist mainly of deep, well drained to excessively drained sands or gravelly sands. These soils have a high rate of water transmission.

Group B. Soils having a moderate infiltration rate when thoroughly wet. These consist chiefly of moderately deep or deep, moderately well drained or well drained soils that have moderately fine texture to moderately coarse texture. These soils have a moderate rate of water transmission.

Group C. Soils having a slow infiltration rate when thoroughly wet. These consist chiefly of soils having a layer that impedes the downward movement of water or soils of moderately fine texture or fine texture. These soils have a slow rate of water transmission.

Group D. Soils having a very slow infiltration rate (high runoff potential) when thoroughly wet. These consist chiefly of clays that have a high shrink-swell potential, soils that have a high water table, soils that have a claypan or clay layer at or near the surface, and soils that are shallow over nearly impervious material. These soils have a very slow rate of water transmission.

If a soil is assigned to a dual hydrologic group (A/D, B/D, or C/D), the first letter is for drained areas and the second is for undrained areas. Only the soils that in their natural condition are in group D are assigned to dual classes.

Rating Options

Aggregation Method: Dominant Condition

Component Percent Cutoff: None Specified

Tie-break Rule: Higher

Appendix B – Hydrologic and Hydraulic Computations

TABLE 1
RUNOFF COEFFICIENTS AND PERCENTS IMPERVIOUS

LAND USE OR SURFACE CHARACTERISTICS	PERCENT IMPERVIOUS	FREQUENCY			
		2	5	10	100
<u>Business:</u>					
Commercial Areas	95	.87	.87	.88	.89
Neighborhood Areas	85	.60	.65	.70	.80
<u>Residential:</u>					
Single-Family (**)	(*)	.40	.45	.50	.60
Multi-Unit (detached)	60	.45	.50	.60	.70
Multi-Unit (attached)	75	.60	.65	.70	.80
1/2 Acre Lot or Larger	(*)	.30	.35	.40	.60
Apartments	80	.65	.70	.70	.80
<u>Industrial:</u>					
Light Areas	80	.71	.72	.76	.82
Heavy Areas	90	.80	.80	.85	.90
<u>Parks, Cemeteries</u>	5	.10	.10	.35	.60
<u>Playgrounds</u>	10	.15	.25	.35	.65
<u>Schools</u>	50	.45	.50	.60	.70
<u>Railroad Yard Areas</u>	15	.40	.45	.50	.60
<u>Undeveloped Areas:</u>					
Historic Flow Analysis, Greenbelts, Agricultural	2	(See "Lawns")			
Off-Site Flow Analysis (when land use not defined)	45	.43	.47	.55	.65

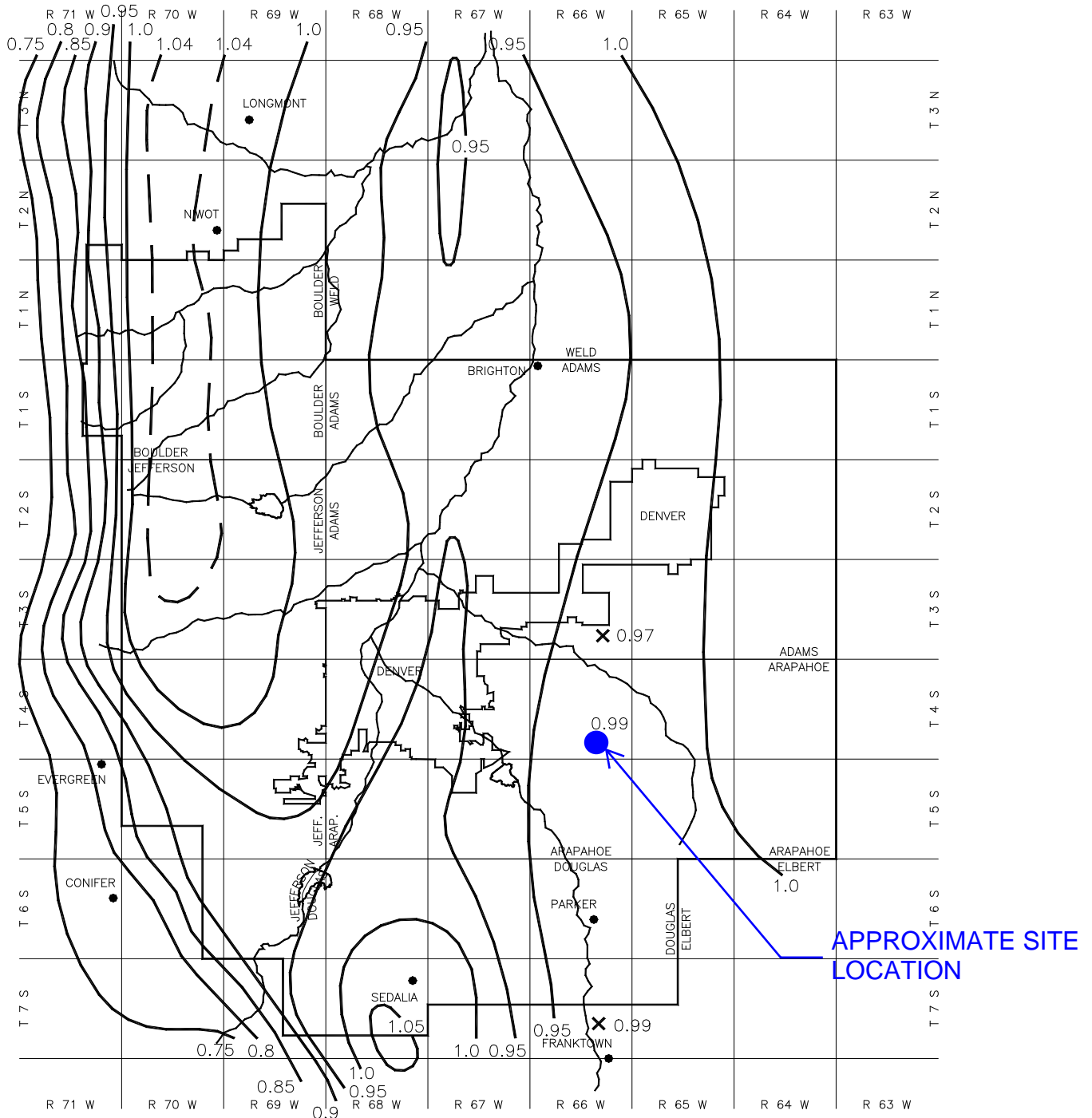


Figure 5-1. Rainfall depth-duration-frequency: 2-year, 1-hour rainfall

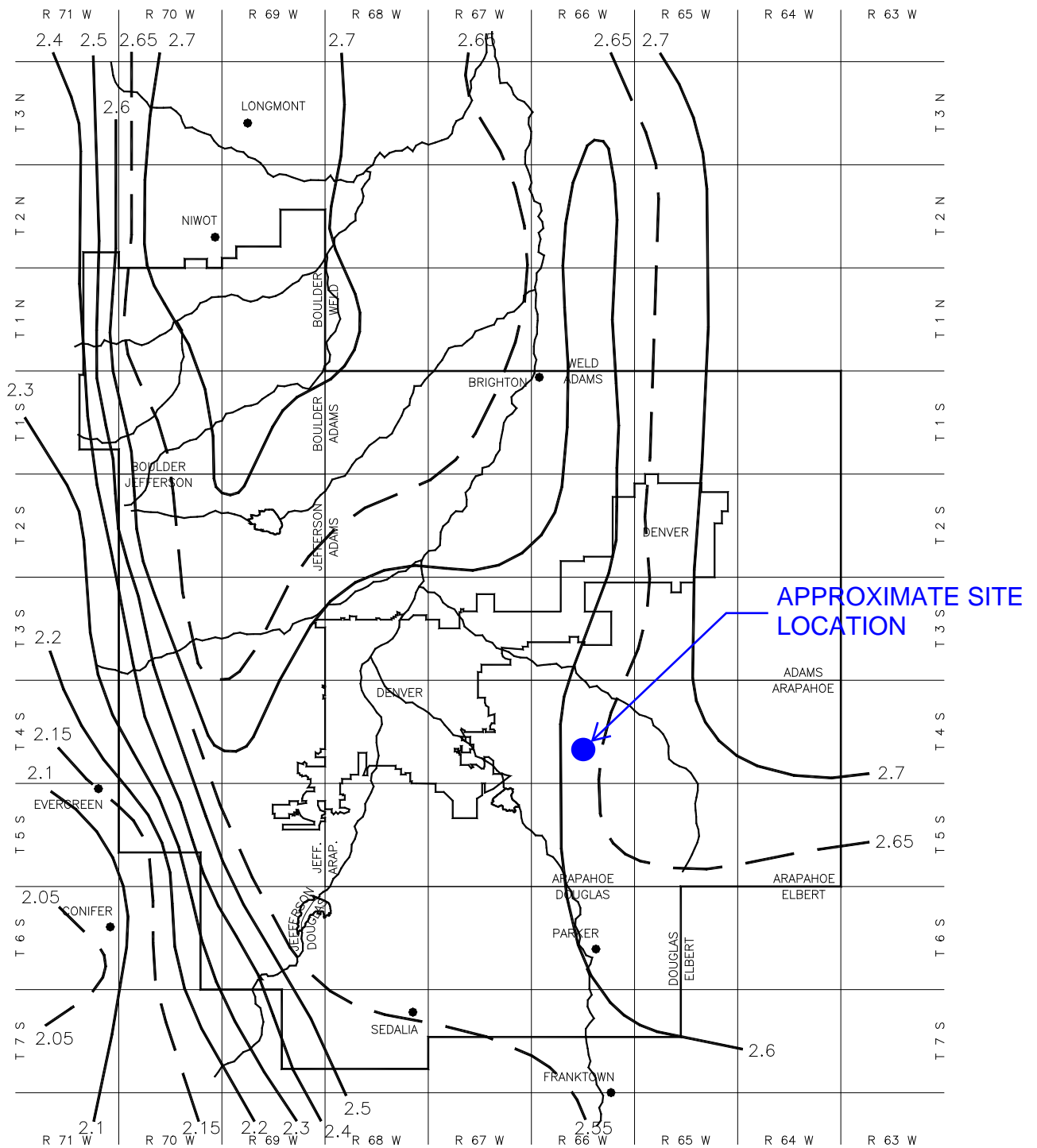


Figure 5-6. Rainfall depth-duration-frequency: 100-year, 1-hour rainfall



SF-1 RUNOFF COEFFICIENTS - DEVELOPED

PROJECT NAME: Existing - Project Bronco Commerce City North Bound
PROJECT NUMBER: 21003.004
CALCULATED BY: WPC
CHECKED BY: WPC

DATE: 3/18/2022

	Streets	Landscape	Roof/Walk/Concrete
LAND USE:	Area	Area	Area
IMPERVIOUS %	100%	2%	90%

OVERALL SITE STUDY AREA

DESIGN BASIN	DESIGN POINT	(AC)	(AC)	(AC)	TOTAL AREA (AC)	Cd(2)	Cd(5)	Cd(10)	Cd(100)	Impervious %
A1	A1	0.52	0.07	0.56	1.15	0.73	0.77	0.79	0.85	89.2%
A2	A2	0.37	0.08	0.38	0.83	0.70	0.74	0.77	0.84	86.0%
A3	A1	0.37	0.26	0.39	1.02	0.57	0.62	0.66	0.78	71.2%
A BASINS		1.26	0.41	1.33	3.00	0.65	0.67	0.68	0.75	82.2%
		42.0%	13.7%	44.3%	100.0%					
OS-1	OS-1	0.73	1.98	0.71	3.42	0.26	0.28	0.29	0.43	41.2%
OS-2	OS-2	0.66	0.04	0.04	0.70	0.03	0.03	0.03	0.16	7.0%
OS. BASINS		0.73	2.64	0.75	4.12	0.22	0.23	0.24	0.39	35.4%
		17.7%	64.1%	18.2%	100.0%					
EX. E3	EX. E3	0.48			0.48	0.83	0.86	0.87	0.89	100.0%
EX. M2	EX. M2		2.57		2.57	0.01	0.05	0.15	0.49	2.0%
EX. M3	EX. M3		0.78		0.78	0.01	0.05	0.15	0.49	2.0%
EX. W2	EX. W2	1.61	1.31		2.92	0.43	0.49	0.55	0.71	56.0%
EX. W3	EX. W3	0.41			0.41	0.83	0.86	0.87	0.89	100.0%
EX. W4	EX. W4	0.55			0.55	0.83	0.86	0.87	0.89	100.0%
EX. BASINS		3.05	4.66	0.00	7.71	0.26	0.27	0.29	0.43	40.8%
		39.6%	60.4%	0.0%	100.0%					



STANDARD FORM SF-2 - DEVELOPED
Time of Concentration

PROJECT NAME: Existing - Project Bronco Commerce City North Bound
PROJECT NUMBER: 21003.004
CALCULATED BY: WPC
CHECKED BY: WPC

DATE: 3/18/2022

SUB-BASIN DATA			INITIAL TIME (T _i)			TRAVEL TIME (T _t)						t _c CHECK (URBANIZED BASINS)			FINAL t _c		
DESIGN BASIN (1)	AREA Ac (2)	C ₅ (3)	LENGTH Ft* (4)	SLOPE % (5)	T _i Min. (6)	LENGTH Ft. (7)	SLOPE % (8)	C _v (9)	Land Surface (10)	VEL fps (11)	T _t Min. (12)	COMP. t _c (13)	TOTAL LENGTH (14)	$T_c = (26-17i) + \frac{L_t}{60(14i+9)} S_0^{1/2}$ (15)	Min.	C5	C100
A1	1.15	0.77	10	10.0%	0.9	230	2.4%	20.0	Paved Areas	3.1	1.2	2.1	240	11.0	5.0	0.77	0.85
A2	0.83	0.74	10	10.0%	1.0	260	2.8%	20.0	Paved Areas	3.3	1.3	2.3	270	11.6	5.0	0.74	0.84
A3	1.02	0.62	10	10.0%	1.3	450	1.7%	20.0	Paved Areas	2.6	2.9	4.2	460	14.3	5.0	0.62	0.78
OS-1	3.42	0.28	55	2.3%	8.5	950	2.1%	7.0	Short Pasture/Lawn	1.0	15.6	24.1	1005	19.8	24.1	0.28	0.43
OS-2	0.70	0.03	40	12.0%	5.4	350	2.1%	20.0	Paved Areas	2.9	2.0	7.4	390	25.1	7.4	0.03	0.16
EX. E3	0.48	0.86	40	2.0%	2.3	1	1.0%	20.0	Paved Areas	2.0	0.0	2.3	41	9.0	5.0	0.86	0.89
EX. M2	2.57	0.05	30	16.7%	4.1	1	1.0%	7.0	Short Pasture/Lawn	0.7	0.0	4.1	31	25.7	5.0	0.05	0.49
EX. M3	0.78	0.05	30	16.7%	4.1	1	1.0%	7.0	Short Pasture/Lawn	0.7	0.0	4.1	31	25.7	5.0	0.05	0.49
EX. W2	2.92	0.49	30	33.0%	1.9	1	1.0%	20.0	Paved Areas	2.0	0.0	1.9	31	16.5	5.0	0.49	0.71
EX. W3	0.41	0.86	40	2.0%	2.3	1	1.0%	20.0	Paved Areas	2.0	0.0	2.3	41	9.0	5.0	0.86	0.89
EX. W4	0.55	0.86	40	2.0%	2.3	1	1.0%	20.0	Paved Areas	2.0	0.0	2.3	41	9.0	5.0	0.86	0.89

* L = 500' max for non-urban land uses and 300' max for urban land uses

Table RO-2—Conveyance Coefficient, C_v

Type of Land Surface	Conveyance Coefficient, C _v
Heavy meadow	2.5
Tillage/field	5
Short pasture and lawns	7
Nearly bare ground	10
Grassed waterway	15
Paved areas and shallow paved swales	20

$$T_t = \frac{0.395(1.1 - C)L^{1/2}}{S^{1/3}}$$

$$T_t = \frac{L}{60V}$$

$$t_c = \frac{L}{180} + 10$$

$$V = C_v S_w^{0.5}$$



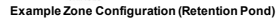
DATE: 3/18/2022

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Basin Summary Table - Developed						
Basin	Area (AC)	Runoff Coefficients		I (%)	Peak Flows (cfs)	
		C5	C100		Q5	Q100
A1	1.15	0.77	0.85	89.2%	2.82	8.78
A2	0.83	0.74	0.84	86.0%	1.95	6.24
A3	1.02	0.62	0.78	71.2%	1.94	7.11
Basin Summary Table - Undeveloped						
Basin	Area (AC)	Runoff Coefficients		I (%)	Peak Flows (cfs)	
		C5	C100		Q5	Q100
OS-1	3.42	0.28	0.43	41.2%	1.59	6.95
OS-2	0.70	0.03	0.16	7.0%	0.06	0.92
Basin Summary Table - Undeveloped						
Basin	Area (AC)	Runoff Coefficients		I (%)	Peak Flows (cfs)	
		C5	C100		Q5	Q100
EX. E3	0.48	0.86	0.89	100.0%	1.34	3.86
EX. M2	2.57	0.05	0.49	2.0%	0.09	11.37
EX. M3	0.78	0.05	0.49	2.0%	0.03	3.45
EX. W2	2.92	0.49	0.71	56.0%	4.25	18.73
EX. W3	0.41	0.86	0.89	100.0%	1.14	3.29
EX. W4	0.55	0.86	0.89	100.0%	1.53	4.42

MHFD-Detention, Version 4.05 (January 2022)

Basin ID: _____

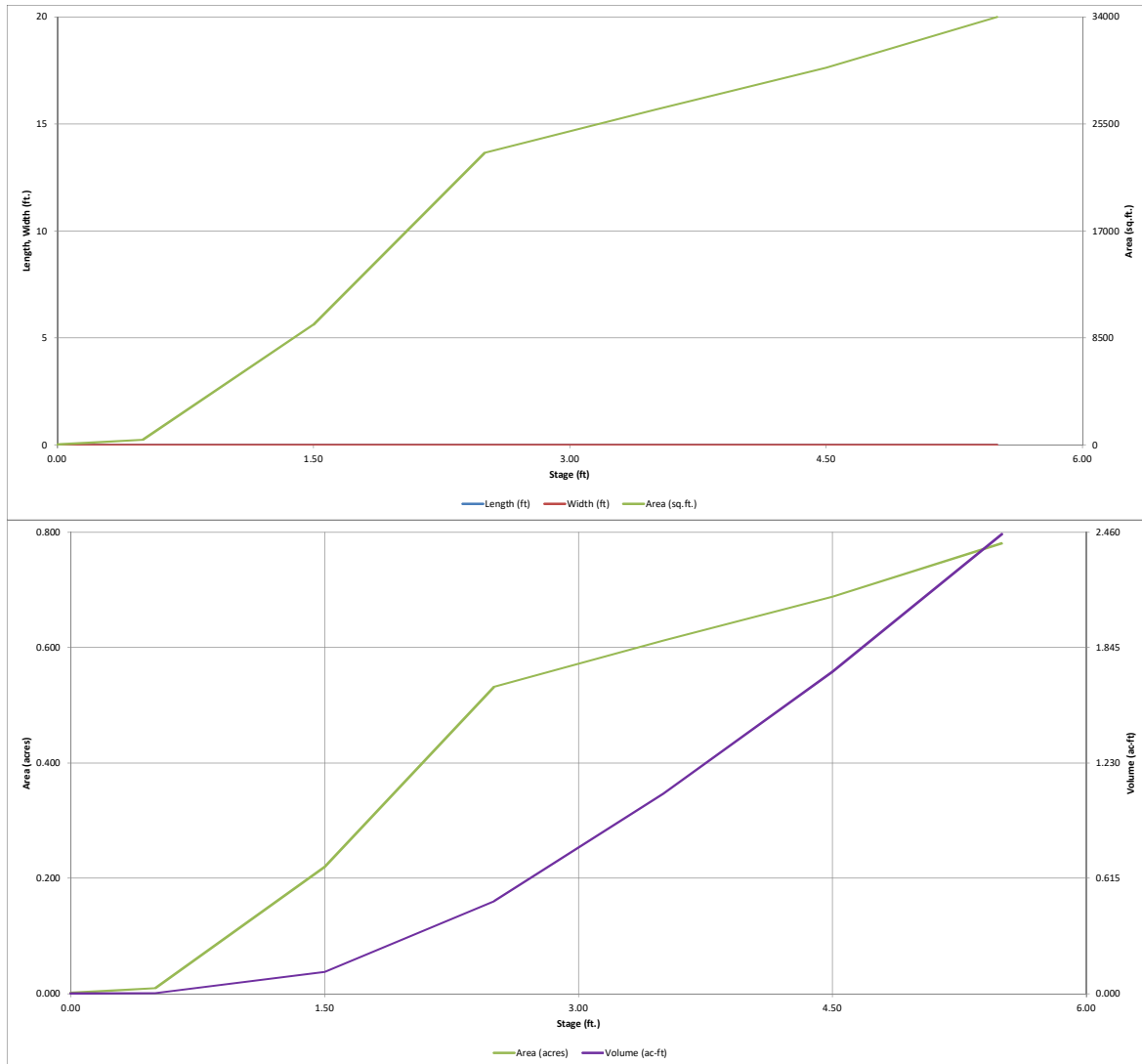


	acre-feet
	acre-feet
0.99	inches
	inches
	inches
	inches
2.65	inches
	inches

3/18/2022, 3:10 PM

DETENTION BASIN STAGE-STORAGE TABLE BUILDER

MHFD-Detention, Version 4.05 (January 2022)

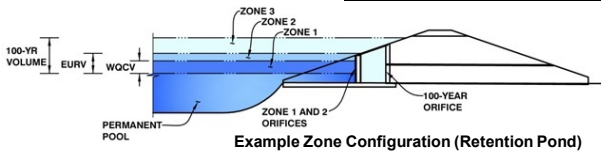


DETENTION BASIN OUTLET STRUCTURE DESIGN

MHFD-Detention, Version 4.05 (January 2022)

Project:

Basin ID:



Example Zone Configuration (Retention Pond)

	Estimated Stage (ft)	Estimated Volume (ac-ft)	Outlet Type
Zone 1 (WQCV)	1.95	0.247	Orifice Plate
Zone 2 (EURV)	2.82	0.418	Orifice Plate
Zone 3 (100-year)	3.98	0.699	Weir&Pipe (Restrict)
Total (all zones)		1.364	

User Input: Orifice at Underdrain Outlet (typically used to drain WQCV in a Filtration BMP)

Underdrain Orifice Invert Depth = ft (distance below the filtration media surface)
Underdrain Orifice Diameter = inches

Calculated Parameters for Underdrain
Underdrain Orifice Area = ft²
Underdrain Orifice Centroid = feet

User Input: Orifice Plate with one or more orifices or Elliptical Slot Weir (typically used to drain WQCV and/or EURV in a sedimentation BMP)

Centroid of Lowest Orifice = ft (relative to basin bottom at Stage = 0 ft)
Depth at top of Zone using Orifice Plate = ft (relative to basin bottom at Stage = 0 ft)
Orifice Plate: Orifice Vertical Spacing = inches
Orifice Plate: Orifice Area per Row = sq. inches

Calculated Parameters for Plate
WQ Orifice Area per Row = ft²
Elliptical Half-Width = feet
Elliptical Slot Centroid = feet
Elliptical Slot Area = ft²

User Input: Stage and Total Area of Each Orifice Row (numbered from lowest to highest)

	Row 1 (required)	Row 2 (optional)	Row 3 (optional)	Row 4 (optional)	Row 5 (optional)	Row 6 (optional)	Row 7 (optional)	Row 8 (optional)
Stage of Orifice Centroid (ft)	0.12	1.14	2.15					
Orifice Area (sq. inches)	1.48	1.48	1.92					

	Row 9 (optional)	Row 10 (optional)	Row 11 (optional)	Row 12 (optional)	Row 13 (optional)	Row 14 (optional)	Row 15 (optional)	Row 16 (optional)
Stage of Orifice Centroid (ft)								
Orifice Area (sq. inches)								

User Input: Vertical Orifice (Circular or Rectangular)

Invert of Vertical Orifice = ft (relative to basin bottom at Stage = 0 ft)
Depth at top of Zone using Vertical Orifice = ft (relative to basin bottom at Stage = 0 ft)
Vertical Orifice Diameter = inches

Calculated Parameters for Vertical Orifice
Vertical Orifice Area = ft²
Vertical Orifice Centroid = feet

User Input: Overflow Weir (Dropbox with Flat or Sloped Grate and Outlet Pipe OR Rectangular/Trapezoidal Weir and No Outlet Pipe)

Overflow Weir Front Edge Height, H_o = ft (relative to basin bottom at Stage = 0 ft)
Overflow Weir Front Edge Length = feet
Overflow Weir Grate Slope = H:V
Horiz. Length of Weir Sides = feet
Overflow Grate Type =
Debris Clogging % = %

Calculated Parameters for Overflow Weir
Height of Grate Upper Edge, H_u = feet
Overflow Weir Slope Length = feet
Grate Open Area / 100-yr Orifice Area =
Overflow Grate Open Area w/o Debris = ft²
Overflow Grate Open Area w/ Debris = ft²

User Input: Outlet Pipe w/ Flow Restriction Plate (Circular Orifice, Restrictor Plate, or Rectangular Orifice)

Depth to Invert of Outlet Pipe = ft (distance below basin bottom at Stage = 0 ft)
Outlet Pipe Diameter = inches
Restrictor Plate Height Above Pipe Invert = inches

Calculated Parameters for Outlet Pipe w/ Flow Restriction Plate
Outlet Orifice Area = ft²
Outlet Orifice Centroid = feet
Half-Central Angle of Restrictor Plate on Pipe = radians

User Input: Emergency Spillway (Rectangular or Trapezoidal)

Spillway Invert Stage = ft (relative to basin bottom at Stage = 0 ft)
Spillway Crest Length = feet
Spillway End Slopes = H:V
Freeboard above Max Water Surface = feet

Calculated Parameters for Spillway
Spillway Design Flow Depth = feet
Stage at Top of Freeboard = feet
Basin Area at Top of Freeboard = acres
Basin Volume at Top of Freeboard = acre-ft

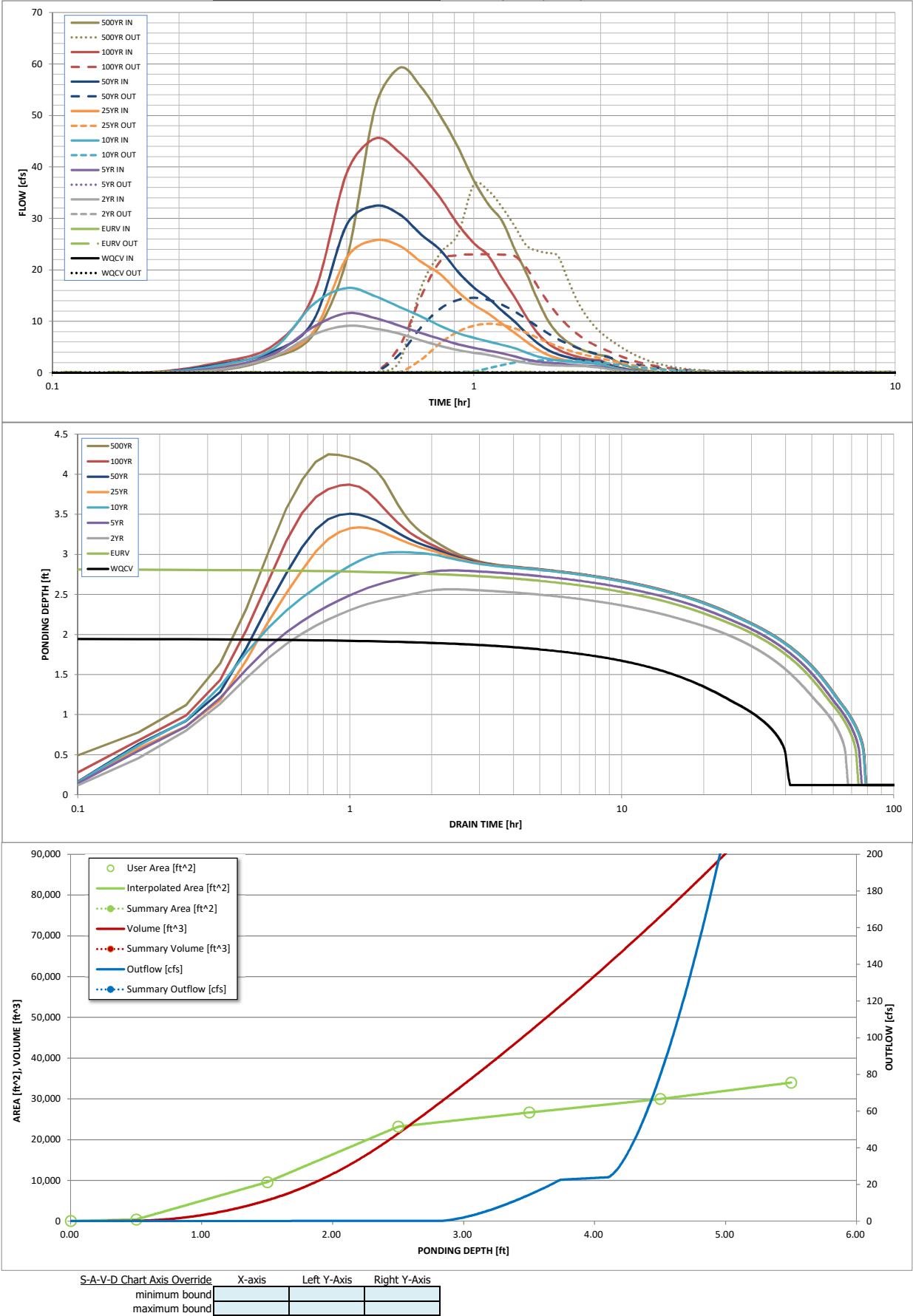
Routed Hydrograph Results

The user can override the default CUHP hydrographs and runoff volumes by entering new values in the Inflow Hydrographs table (Columns W through AF).

	WQCV	EURV	2 Year	5 Year	10 Year	25 Year	50 Year	100 Year	500 Year
Design Storm Return Period =	N/A	N/A	0.99	1.13	1.39	1.77	2.08	2.65	3.30
One-Hour Rainfall Depth (in) =	N/A	N/A	0.99	1.13	1.39	1.77	2.08	2.65	3.30
CUHP Runoff Volume (acre-ft) =	0.247	0.665	0.556	0.688	0.972	1.484	1.868	2.632	3.458
Inflow Hydrograph Volume (acre-ft) =	N/A	N/A	0.556	0.688	0.972	1.484	1.868	2.632	3.458
CUHP Predevelopment Peak Q (cfs) =	N/A	N/A	0.8	2.0	5.1	12.0	16.4	24.9	34.0
OPTIONAL Override Predevelopment Peak Q (cfs) =	N/A	N/A							
Predevelopment Unit Peak Flow, q (cfs/acre) =	N/A	N/A	0.05	0.14	0.34	0.81	1.11	1.68	2.29
Peak Inflow Q (cfs) =	N/A	N/A	9.2	11.6	16.5	25.8	32.5	45.6	59.3
Peak Outflow Q (cfs) =	0.1	0.2	0.2	0.2	2.5	9.5	14.6	23.1	36.6
Ratio Peak Outflow to Predevelopment Q =	N/A	N/A	N/A	0.1	0.5	0.8	0.9	0.9	1.1
Structure Controlling Flow =	Plate	Plate	Plate	Plate	Overflow Weir 1	Overflow Weir 1	Overflow Weir 1	Outlet Plate 1	Spillway
Max Velocity through Grate 1 (fps) =	N/A	N/A	N/A	N/A	0.2	0.8	1.3	2.0	2.2
Max Velocity through Grate 2 (fps) =	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Time to Drain 97% of Inflow Volume (hours) =	38	67	62	69	70	66	63	59	55
Time to Drain 99% of Inflow Volume (hours) =	40	71	66	73	75	74	73	71	69
Maximum Ponding Depth (ft) =	1.95	2.82	2.56	2.80	3.03	3.34	3.51	3.87	4.25
Area at Maximum Ponding Depth (acres) =	0.36	0.56	0.54	0.56	0.57	0.60	0.61	0.64	0.67
Maximum Volume Stored (acre-ft) =	0.248	0.668	0.526	0.651	0.781	0.963	1.066	1.291	1.539

DETENTION BASIN OUTLET STRUCTURE DESIGN

MHFD-Detention, Version 4.05 (January 2022)



DETENTION BASIN OUTLET STRUCTURE DESIGN

Outflow Hydrograph Workbook Filename: _____

Inflow Hydrographs

The user can override the calculated inflow hydrographs from this workbook with inflow hydrographs developed in a separate program.

	SOURCE	CUHP	CUHP	CUHP	CUHP	CUHP	CUHP	CUHP	CUHP	CUHP
Time Interval	TIME	WQCV [cfs]	EURV [cfs]	2 Year [cfs]	5 Year [cfs]	10 Year [cfs]	25 Year [cfs]	50 Year [cfs]	100 Year [cfs]	500 Year [cfs]
5.00 min	0:00:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	0:05:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	0:10:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.10	0.53
	0:15:00	0.00	0.00	0.69	1.02	1.52	1.20	1.70	2.09	2.93
	0:20:00	0.00	0.00	3.12	3.63	4.64	3.30	4.12	5.29	7.50
	0:25:00	0.00	0.00	7.45	8.97	13.37	8.04	10.22	15.21	22.30
	0:30:00	0.00	0.00	9.16	11.60	16.50	22.46	28.88	38.98	51.60
	0:35:00	0.00	0.00	8.61	10.65	14.91	25.79	32.47	45.56	59.28
	0:40:00	0.00	0.00	7.63	9.17	12.81	24.68	30.80	42.83	55.52
	0:45:00	0.00	0.00	6.32	7.75	10.98	21.57	26.88	38.56	49.92
	0:50:00	0.00	0.00	5.24	6.60	9.12	19.16	23.85	33.94	43.87
	0:55:00	0.00	0.00	4.45	5.57	7.73	15.79	19.68	28.89	37.40
	1:00:00	0.00	0.00	3.92	4.86	6.83	13.26	16.60	25.22	32.74
	1:05:00	0.00	0.00	3.50	4.32	6.12	11.53	14.49	22.74	29.54
	1:10:00	0.00	0.00	2.92	3.82	5.45	9.54	12.08	18.44	24.07
	1:15:00	0.00	0.00	2.39	3.21	4.81	7.81	9.97	14.72	19.32
	1:20:00	0.00	0.00	1.95	2.61	3.96	6.05	7.69	10.87	14.23
	1:25:00	0.00	0.00	1.66	2.21	3.20	4.58	5.80	7.74	10.18
	1:30:00	0.00	0.00	1.51	2.00	2.75	3.50	4.45	5.76	7.63
	1:35:00	0.00	0.00	1.43	1.87	2.46	2.84	3.61	4.56	6.07
	1:40:00	0.00	0.00	1.39	1.67	2.25	2.42	3.07	3.77	5.02
	1:45:00	0.00	0.00	1.36	1.51	2.10	2.14	2.70	3.22	4.30
	1:50:00	0.00	0.00	1.34	1.40	2.00	1.95	2.46	2.84	3.80
	1:55:00	0.00	0.00	1.16	1.31	1.87	1.83	2.29	2.57	3.44
	2:00:00	0.00	0.00	1.02	1.21	1.68	1.74	2.18	2.40	3.21
	2:05:00	0.00	0.00	0.76	0.90	1.23	1.29	1.60	1.76	2.35
	2:10:00	0.00	0.00	0.56	0.65	0.88	0.92	1.15	1.27	1.69
	2:15:00	0.00	0.00	0.40	0.47	0.63	0.66	0.82	0.92	1.22
	2:20:00	0.00	0.00	0.29	0.33	0.45	0.47	0.59	0.66	0.87
	2:25:00	0.00	0.00	0.20	0.23	0.31	0.33	0.41	0.46	0.61
	2:30:00	0.00	0.00	0.14	0.15	0.22	0.23	0.28	0.32	0.42
	2:35:00	0.00	0.00	0.09	0.10	0.14	0.16	0.19	0.21	0.28
	2:40:00	0.00	0.00	0.05	0.06	0.09	0.10	0.12	0.13	0.17
	2:45:00	0.00	0.00	0.02	0.03	0.04	0.05	0.06	0.07	0.09
	2:50:00	0.00	0.00	0.01	0.01	0.02	0.02	0.02	0.02	0.03
	2:55:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	3:00:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	3:05:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	3:10:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	3:15:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	3:20:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	3:25:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	3:30:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	3:35:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	3:40:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	3:45:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	3:50:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	3:55:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	4:00:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	4:05:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	4:10:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	4:15:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	4:20:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	4:25:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	4:30:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	4:35:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	4:40:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	4:45:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	4:50:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	4:55:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	5:00:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	5:05:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	5:10:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	5:15:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	5:20:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	5:25:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	5:30:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	5:35:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	5:40:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	5:45:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	5:50:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	5:55:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	6:00:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

DETENTION BASIN OUTLET STRUCTURE DESIGN

MHFD-Detention, Version 4.05 (January 2022)

Summary Stage-Area-Volume-Discharge Relationships

The user can create a summary S-A-V-D by entering the desired stage increments and the remainder of the table will populate automatically.

The user should graphically compare the summary S-A-V-D table to the full S-A-V-D table in the chart to confirm it captures all key transition points.

[illegible]

Appendix C – Reference Materials

OCR

PP64345

Final Drainage Report

E-470 STATION 643+00 TO 1157+00 (AREA 4) (Package No. A4-04-A)

January 1997

Prepared for:

Platte River Constructors, Ltd.

Submitted to:

**E-470 Public Highway Authority
Urban Drainage & Flood Control District
Arapahoe County
City of Aurora
East Cherry Creek Valley Water & Sanitation District**

Prepared by:

MK CENTENNIAL

CENTENNIAL ENGINEERING, INC.

**MK CENTENNIAL
15000 W. 64th Avenue
P.O. Drawer 1307
Arvada, Colorado 80001**

Ref. 1470.43

Smoky Hill Rd
To
Gun Club Rd

**FINAL DRAINAGE REPORT
E-470 STATION 643+00 TO 1157+00
(AREA 4)**

January 1997

Prepared for:

Platte River Constructors, Ltd.

Submitted to:

**E-470 Public Highway Authority
Urban Drainage & Flood Control District
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City of Aurora
East Cherry Creek Valley Water & Sanitation District**

Prepared by:

**MK Centennial
P.O. Drawer 1307
Arvada, CO 80001**

Ref: 1470.43

**FINAL DRAINAGE REPORT
E-470 STATION 643+00 TO 1157+00
(AREA 4)**

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**FINAL DRAINAGE REPORT
E-470 STATION 643+00 TO 1157+00
(AREA 4)**

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Full-Size Drainage Basin Map Included in Back Pocket

TECHNICAL APPENDIX

- A. RATIONAL AND STORM SEWER CALCULATIONS
- B. CULVERT HYDRAULIC CALCULATIONS
- C. CUHP/SWMM CALCULATIONS (on Diskette in Back Pocket)

1.0 INTRODUCTION

1.1 The E-470 Tollway

The proposed E-470 tollway is the eastern segment of a planned circumferential highway around the Denver metropolitan area. The E-470 tollway is approximately 48 miles long, extending from a connection with I-25 south at C-470 to a connection with I-25 north at 158th Avenue. As currently planned, E-470 will be constructed in stages to an ultimate eight-lane controlled access tollway with potential for light rail or other HOV use in the median. The current project begins at Parker Road and extends east and north to 120th Avenue. The project has been divided into areas for purposes of design and construction phasing. The alignment adopted by the E-470 Authority is shown in Figure 1.1.

From Smoky Hill Road north to I-70 in Area 4, the proposed E-470 alignment is along the west side of Gun Club Road. Beginning in Section 19 and the southwest corner of Section 18, Township 5 South, Range 65 West, the alignment runs north through Sections 13, 12 and 1 of Township 5 South, Range 66 West, and Sections 36, 25, 24, 13, 12, and 1 of Township 4 South, Range 66 West of the 6th Principal Meridian. The total length of the project in Area 4 is about 9 miles. There is a Toll Plaza proposed in Area 4 at about Yale Avenue (extended) just west of Gun Club Road. Area 4 is completely within Arapahoe County and crosses some areas within the city limits of Aurora, and within the East Cherry Creek Valley Water and Sanitation District.

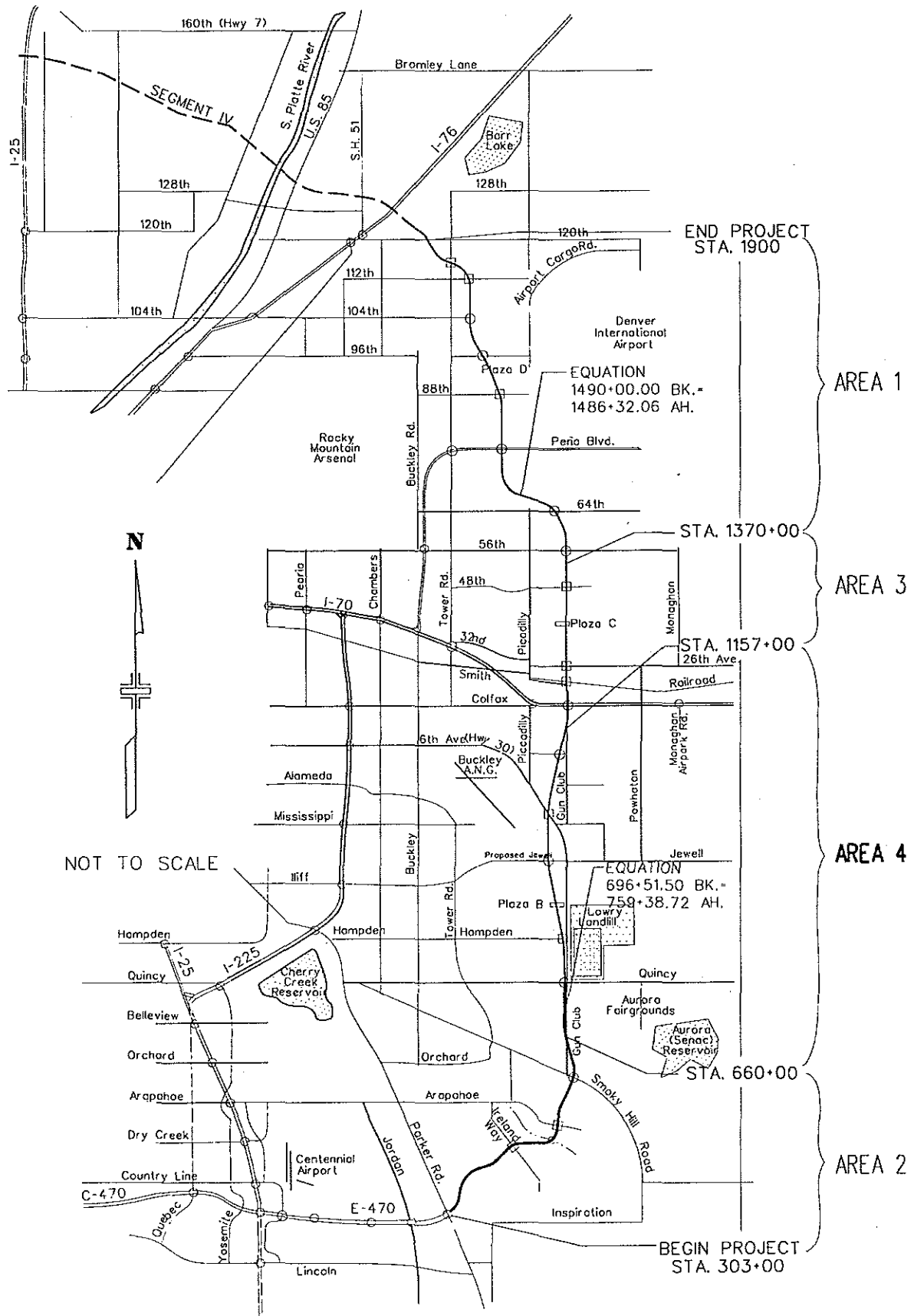
1.2 Purpose of This Report

An analysis of the off-site drainage basins affecting E-470 in Area 4 has been conducted to determine runoff hydrographs and peak discharges for use in design of structures to convey stormwater safely across the E-470 alignment. This report documents the background information and data compiled for use in the hydrologic analysis, discusses routing and modeling assumptions, and presents hydrographs and peak discharges recommended for use in designing structures for E-470. The limits of the project addressed in this report are bounded by the northern edge of the E-470/Smoky Hill Road Interchange, Station 643+00, to the southern edge of the E-470/I-70 Interchange, approximately Station 1157+00. This area of the project lies entirely within the Sand Creek watershed, crossing three tributaries to Sand Creek: East Toll Gate Creek, Murphy Creek and Coal Creek.

1.3 Previous Studies and Reports

In September, 1996, MK Centennial prepared a hydrology report for the off-site basins draining toward and away from E-470.

In August, 1985, Simons, Li and Associates prepared a Hydrology Report for the proposed Aurora Annexation area which included the upper Toll Gate Creek basin, Murphy Creek and Coal Creek, Reference 3. The Colorado Urban Hydrograph Procedure (CUHP) was used to develop hydrologic calculations for the 2-year, 10-year, 50-year and 100-year discharges based on existing and "future" basin development conditions. In March, 1986, Simons and Li also published a report addressing evaluation of alternative plans for the drainageways within the Annexation area, Reference 4.



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FIG. 1.1
E-470 ALIGNMENT

Preliminary designs for major drainageway improvements to East Toll Gate Creek, Murphy Creek and Coal Creek were prepared by Kiowa Engineering and included in two Master Plan reports for the City of Aurora Annexation Area, one for the Upper Sand Creek Basin and one for the upper Toll Gate Creek Basin, (Master Plans), References 9 and 5 respectively.

The East Cherry Creek Valley (ECCV) Water and Sanitation District has jurisdiction of drainage and flood control facilities within the District boundaries. East Toll Gate Creek is within the ECCV District where E-470 crosses at Quincy Avenue. The ECCV District has a Master Plan for portions of East Toll Gate Creek which was prepared by McLaughlin Water Engineers in May 1986, Reference 7. Hydrology for this master plan was developed using the MITCAT computer model.

In addition to the master plans, Flood Hazard Area Delineation (FHAD) reports were published for Sand Creek and Murphy Creek by the Urban Drainage and Flood Control District in 1977 and 1975, References 11 and 12, respectively. The Murphy Creek FHAD hydrology was developed using the CUHP while the Corps of Engineers used the Stormwater Management Model (SWMM) to develop hydrology for Sand Creek.

Having been prepared at different points in time for varying entities, there are differences between these Master Plans and Flood Hazard Area Delineation reports in runoff models used, basic criteria, land use planning assumptions and results. Hydrologic data and information from the Kiowa Master Plans for the Upper Sand Creek and Upper Tollgate Creek basins are the most current and generally most applicable throughout Area 4. Therefore, these CUHP/SWMM models have been used as the basis for development of design hydrology for E-470 structures in Area 4, except at the main channels of Murphy Creek and Coal Creek. Murphy Creek and Coal Creek floodplains are shown on the Arapahoe County Flood Insurance Rate Maps, and E-470 structures will be designed for 100-year discharges as published in the Flood Insurance Study, Reference 13, which are the largest discharges of all the studies available.

2.0 PROJECT AREA

2.1 Drainage Basins

Sand Creek is a right bank, plains tributary to the South Platte River. The basin is approximately 32 miles long and varies up to 6 miles in width. It encompasses a total of 189 square miles. Elevations vary between 5,120 feet above mean sea level (msl) to a maximum elevation of 6,800 feet (msl) at the upper limits of the Coal Creek basin in Elbert County.

On a north-south alignment just west of Gun Club Road, E-470 traverses the East Toll Gate Creek, Murphy Creek and Coal Creek drainage basins, which are all tributaries to Sand Creek. These tributaries flow generally from southeast to northwest and are intermittent. The drainage basins are illustrated on the Drainage Basin Map, Drawing 1.

Between Stations 643 and 845, E-470 is within the East Toll Gate Creek basin and crosses the main channel within the proposed E-470/Quincy Avenue Interchange. The tributary basin area upstream of E-470 is approximate 1.5 square miles. The channel here is relatively well defined and the floodplain wide and shallow. Parts of the floodplain are cultivated for crop production. A triple barrel (9'-12'-9'x8") concrete box culvert (CBC) has been constructed under Quincy Avenue.

From Station 845 to 1063, E-470 crosses the Murphy Creek basin. E-470 encounters the main stem of Murphy Creek just north of the proposed State Highway 30 overcrossing, at Station 1045. The tributary basin upstream of E-470 is 9.3 square miles.

From Station 1063 to 1157, E-470 is within the lower part of the Coal Creek basin. Coal Creek is the largest drainageway crossed by E-470 in Area 4. E-470 will cross the main channel of Coal Creek at approximately Alameda Avenue (extended). The total tributary area of Coal Creek upstream of E-470 here is about 94 square miles.

These off-site drainage basins were delineated using U.S. Geological Survey quadrangle topographic mapping at a scale of 1:24000 with 10-foot contour intervals. Subbasins were delineated to match as closely as possible the subbasin delineations shown in the Kiowa Engineering Master Plans, References 5 and 9, and were then modified as necessary for the proposed E-470 alignment and grading.

2.2 Land Use

The tributary drainage basins are mostly undeveloped with some areas devoted to crop production and livestock grazing. In all of the basins, the land consists of gently rolling hills with slopes varying from 0 to 4 percent. Predominant vegetative cover within the basins are dry land crops and native grasses. Cottonwood trees and willows exist in and near the drainageways. There is a large lot residential subdivision (Dove Hill) east of Gun Club Road on the East Toll Gate Creek basin.

In the upper part of Murphy Creek, the Aurora/Denver landfill occupies two square miles on the east side of Gun Club Road, and the Plains Conservation Center is one square mile

of dedicated open space on the west side of Gun Club Road. The old Aurora land fill occupies a quarter section in the lower West Murphy Creek tributary adjacent to State Highway 30.

There are also large lot residential subdivisions existing on the east side of Gun Club Road (Gun Club Estates, Thunderbird Estates, etc.) in the Coal Creek basin.

The E-470 Tollway will have an influence on surrounding land development. This influence was not considered in the Master Plans prepared for East Toll Gate Creek, Murphy Creek or Coal Creek, since the current alignment of the tollway was adopted after completion of the Master Plans. In order to estimate runoff from future development within the tributary areas to E-470, the City of Aurora and Arapahoe County Planning Offices were contacted to determine current and proposed zoning within the project area, and to determine if there are any active development plans for lands adjacent to E-470. As of the date of this report, the only active development plans are for the Murphy Creek Development which is located in two sections just north of the Lowry landfill on the east side of Gun Club Road. This development is upstream of the E-470 crossing at the main channel of Murphy Creek.

Projected land use information obtained from Aurora and Arapahoe County was compiled into the Land Use Map, Drawing 3, which was used to develop estimates of future impervious areas as a percentage of the total tributary basin area. A review of the Land Use Map during meetings held with the Planning Departments of Aurora and Arapahoe County confirmed each proposed use along the E-470 corridor. A percent impervious value for each land use proposed in the upstream basin was established at these meetings, and is consistent with impervious percentages used in the Master Plans. Proposed land uses and corresponding imperviousness are shown on Drawing 3.

2.3 Geology and Soils

The USDA Soils Conservation Service (SCS) publishes a soil survey, Reference 8, from which hydrologic soil groups were identified within the Project Area. The hydrologic soil groups for the E-470 project are shown on Drawing 2. The SCS classifies soils into four hydrologic soil groups, identified as Group "A," "B," "C," and "D", based on their permeability and hydrologic characteristics.

Soils in the E-470 project area are generally classified as either Group "B" or Group "C" hydrologic soils having permeabilities ranging from medium to high. Loamy soils (hydrologic soil Group C) exist in the upper areas of the Murphy Creek and East Toll Gate Creek basins. The Coal Creek alluvium has moderate slopes with sandy and gravelly soils (hydrologic Group B). There are no Group "A" or "D" hydrologic soils within the drainage basins traversed by E-470.

3.0 E-470 STORM DRAINAGE DESIGN CRITERIA

3.1 Criteria

Generally, storm drainage improvements have been designed using Arapahoe County Storm Drainage and Technical Criteria Manual, Reference 1, and the CDOT Roadway Design Manual, Reference 6. The Urban Drainage and Flood Control District Drainage Criteria Manual (USDCM), Reference 2, was also used.

The CUHP/SWMM hydrology developed by Kiowa Engineering for the Upper Sand Creek and upper Toll Gate Creek basins (References 5 and 9) was used as the basis for the development of design hydrology for E-470 off-site basins because it is the most recent and has been adopted by the Urban Drainage and Flood Control District and the City of Aurora. The Urban Storm Drainage Criteria Manual (USDCM), Reference 2, was used as a reference for establishing parameters and for modeling guidelines.

Design Storms. The on-site major and minor storm recurrence intervals for design are 100-years and 10-years, respectively. Rainfall data for use in the Rational Method were obtained from Table 502 and Figure 501 the Arapahoe County Storm Drainage Design and Technical Criteria Manual, Reference 1.

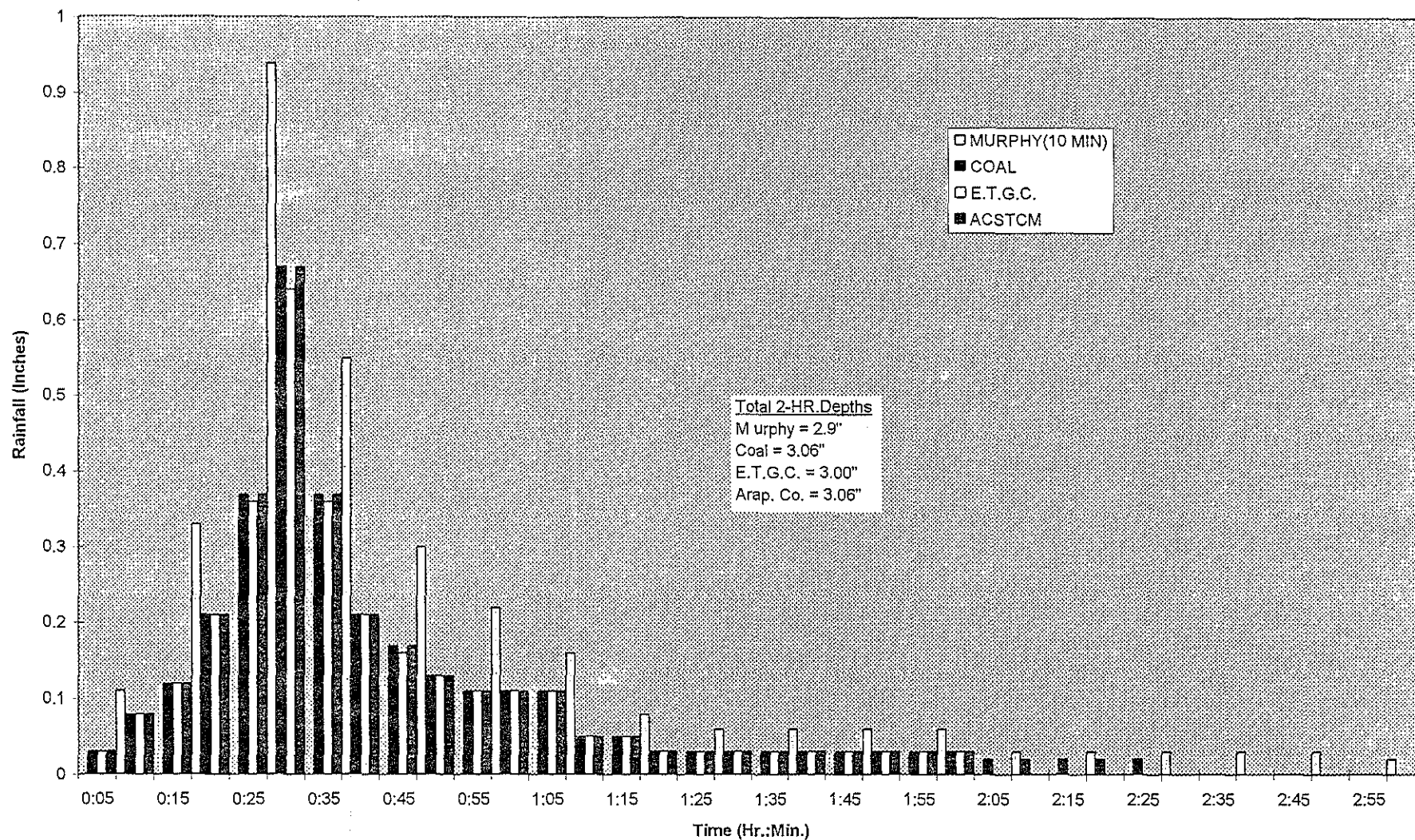
The off-site major and minor storm recurrence intervals for E-470 design are 100-years and 10-years, respectively. The Master Plans include hyetographs for 2-year, 5-year, 10-year and 100-year design storms, and rainfall data were obtained from the Urban Drainage and Flood Control District archive files. Rainfall hyetographs for the 100-year and 10-year design storms are shown in Figures 3.1 and 3.2. Master Plan rainfall distributions for Coal Creek were in 15-minute increments and were not used for E-470 because of the relatively small part of the basin under consideration. Instead, five minute increment distributions, taken from the Arapahoe County Criteria Manual, Reference 1, for basins less than 5 square miles in area, were used for the subbasins in the Coal Creek watershed. The rainfall distribution in the Murphy Creek model is in 10-minute increments. The total rainfall is the same for both distributions.

Land Use. The E-470 Public Highway Authority currently requires storm drainage facilities handling off-site runoff to be designed for the 100-year event based on future, fully developed conditions without storm water detention. The E-470 Authority also permits consideration of detention in design of structures for E-470 where detention is proposed with the approval of local jurisdictions. Peak design discharges from off-site basins for E-470 generally assume future fully developed conditions without storm water detention, except at Quincy Avenue. Existing conditions basin hydrology was used at Quincy Avenue because the existing 100-year flow rate is higher than the future flow rate with regional detention.

The Rational Method was used to calculate discharges from on-site drainage basins.

Runoff Coefficients. Runoff coefficients for pavement and developed areas used in the Rational Method and typical percentages of impervious area for use in the CUHP model were obtained from Table 3-1 of the USDCM. For E-470 on-site basins, composite C

100-year Rainfall Hyetographs

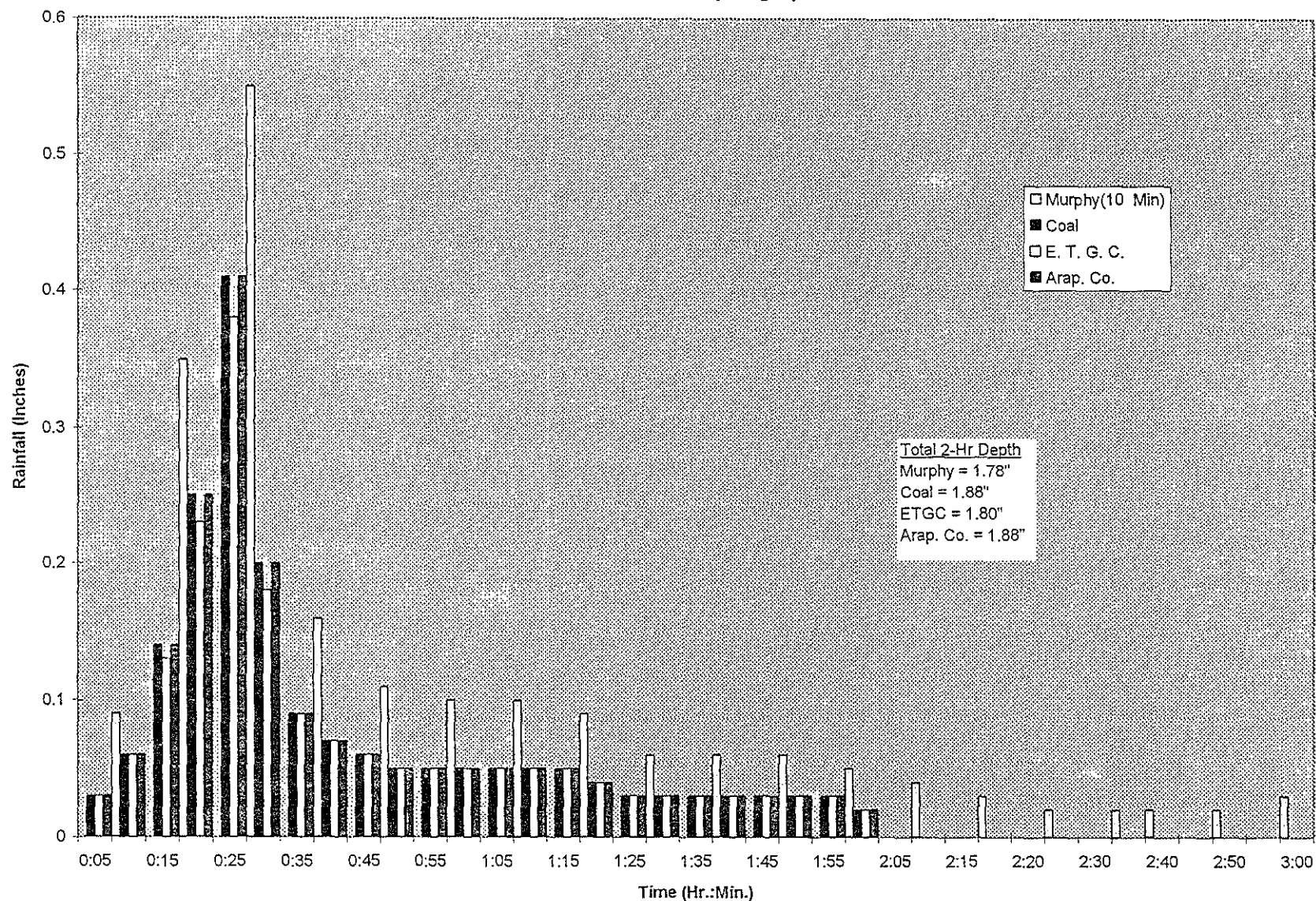


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FIGURE 3.1

10-Year Rainfall Hyetographs



values were calculated using weighted areas of pavement and seeded soils within each subbasin. C values for E-470 on-site seeded areas assume clay soils.

Time of Concentration. The time of concentration for use in the Rational Formula was calculated using the procedure described in Chapter 3 of the USDCM.

Hydrology Procedure. The Colorado Urban Hydrograph Procedure (CUHP) computer program was used to model the hydrologic response of off-site drainage basins (Reference 16). CUHP hydrographs were routed through the stream reaches and proposed structures using the Stormwater Management Model (SWMM), Reference 17.

3.2 Land Use and Basin Imperviousness

The E-470 Public Highway Authority currently requires storm drainage facilities handling off-site runoff to be designed for the 100-year event based on future, fully developed conditions without stormwater detention. The E-470 Authority permits consideration of off-site detention in design of structures for E-470 where such detention is proposed with the approval of local jurisdictions.

Three runoff scenarios were evaluated in this analysis: 1) existing basin development conditions, 2) future, fully developed basin conditions without detention, and 3) future, fully developed basin conditions with regional detention where proposed in the Master Plans.

For East Toll Gate Creek subbasins 1 through 9, Murphy Creek subbasins 301 through 351, and Coal Creek subbasins 85 through 87, the percentages of impervious basin area for existing and future, fully developed conditions were derived by measuring the areas in each subbasin of each category of existing and projected land use as shown on Drawing 3. Each category of land use was assigned an average percent impervious value according to criteria established in conjunction with Aurora and Arapahoe County. Weighted imperviousness calculations for each subbasin are listed in Table 3.1.

The adjustments made to projected land use subsequent to meetings with Arapahoe County and Aurora resulted in some redistribution of impervious acreage within the basins. In the East Toll Gate basin, the overall total number of impervious acres remained at approximately 478 as in the Kiowa Engineering Master Plan. The McLaughlin Engineers Master Plan for East Toll Gate Creek estimated a total of 739 acres of impervious area.

In the Murphy Creek basin, the overall total number of impervious acres dropped from 3,277.5 acres as modeled by Kiowa Engineering to 2,860 acres modeled in this analysis. The 418-acre difference is due to changes in land use projections made by the City of Aurora affecting subbasins M310 through M319, on the east side of the Lowry Landfill. This area went from a High Density Mixed Use (95% impervious) designation to Low Density Residential (40% impervious) designation because of its proximity to the landfill. This change does not affect E-470.

TABLE 3.1 - BASIN IMPERVIOUSNESS
EAST TOLL GATE CREEK, MURPHY CREEK, COAL CREEK

BASIN I.D.	BASIN AREA	LAND USE							IMPERVIOUSNESS							WEIGHTED BASIN IMPERVIOUSNESS		
		EXISTING DEV. ACRES / FUTURE DEV. ACRES							EXISTING % / FUTURE %							PREDEVELOPED 1%	FUTURE 1%	
		ACRES	HDMU	INDUST.	COMM.	MD RES.	LD RES.	LF/PARKS	OPEN	HDMU	INDUST.	COMM.	MD RES.	LD RES.	LF/PARKS			OPEN
ETGC-1	102.4	0	0	0	0	0	0	0	102.4	2	2	2	2	2	2	2	2	2
		10	0	0	0	0	30.4	0	62	95	85	60	45	40	10	2	2	22
ETGC-2	35.2	0	0	0	0	0	0	0	35.2	2	2	2	2	2	2	2	2	2
		0	0	0	0	13.4	18.8	0	3	95	85	60	45	40	10	2	2	39
ETGC-102	57.6	0	0	0	0	0	0	0	57.6	2	2	2	2	2	2	2	2	2
		0	0	0	0	13.4	44.2	0	0	95	85	60	45	40	10	2	2	41
ETGC-3	179.2	0	0	0	0	0	0	0	179.2	2	2	2	2	2	2	2	2	2
		28	0	0	0	0	26	57.2	68	95	85	60	45	40	10	2	2	25
ETGC-4	40.3	0	0	0	0	0	0	0	40.3	2	2	2	2	2	2	2	2	2
		0	0	0	0	15.5	24.8	0	0	95	85	60	45	40	10	2	2	42
ETGC-104	88.3	0	0	0	0	0	0	0	88.3	2	2	2	2	2	2	2	2	2
		0	0	0	0	15.5	72.8	0	0	95	85	60	45	40	10	2	2	41
ETGC-5	97.9	0	0	0	0	0	0	0	97.9	2	2	2	2	2	2	2	2	4
		0	0	0	0	21	40.7	0	36.2	95	85	60	45	40	10	2	2	27
ETGC-6	368	0	0	0	0	0	0	0	368	2	2	2	2	2	2	2	2	6
		0	0	88.3	102.4	57.7	0	119.6	95	85	60	45	40	10	2	2	2	34
ETGC-105	74.9	0	0	0	0	0	0	0	74.9	2	2	2	2	2	2	2	2	6
		0	0	0	0	34.6	25.6	0	14.7	95	85	60	45	40	10	2	2	35
ETGC-7	97.9	0	0	0	0	0	0	0	97.9	2	2	2	2	2	2	2	2	2
		0	0	0	0	0	89	0	8.9	95	85	60	45	40	10	2	2	37
ETGC-8	58.3	0	0	0	0	0	0	0	58.3	2	2	2	2	2	2	2	2	2
		0	0	23	20.1	0	13	2.2	95	85	60	45	40	10	2	2	2	41
ETGC-108	156.2	0	0	0	0	0	0	0	156.2	2	2	2	2	2	2	2	2	2
		0	0	32.4	10.8	46.2	0	66.8	95	85	60	45	40	10	2	2	2	28
ETGC-9	101.8	0	0	0	0	0	0	0	101.8	2	2	2	2	2	2	2	2	2
		0	0	0	0	0	94.8	0	7	95	85	60	45	40	10	2	2	37
MC-301	111.4	0	0	0	0	0	0	0	111.4	2	2	2	2	2	2	2	2	2
		111.4	0	0	0	0	0	0	0	95	85	60	45	40	10	2	2	95
MC-302	90.2	0	0	0	0	0	0	0	90.2	2	2	2	2	2	2	2	2	2
		45.2	0	0	0	0	0	0	45	95	85	60	45	40	10	2	2	49
MC-303	90.2	0	0	0	0	0	0	0	90.2	2	2	2	2	2	2	2	2	2
		54.2	0	0	0	0	0	0	36	95	85	60	45	40	10	2	2	58
MC-304	92.2	0	0	0	0	0	0	0	92.2	2	2	2	2	2	2	2	2	2
		52	0	0	0	0	9	26.2	5	95	85	60	45	40	10	2	2	60
MC-305	26.2	0	0	0	0	0	0	0	26.2	2	2	2	2	2	2	2	2	2
		2	0	0	0	0	0	12.2	12	95	85	60	45	40	10	2	2	13
MC306	50.6	0	0	0	0	0	0	0	50.6	2	2	2	2	2	2	2	2	2
		50.6	0	0	0	0	0	0	0	95	85	60	45	40	10	2	2	95
MC-307	142.1	0	0	0	0	0	0	0	142.1	2	2	2	2	2	2	2	2	2
		142.1	0	0	0	0	0	0	0	95	85	60	45	40	10	2	2	95
MC-308	58.9	0	0	0	0	0	0	0	58.9	2	2	2	2	2	2	2	2	2
		31	0	0	0	0	0	9.9	18	95	85	60	45	40	10	2	2	52
MC-309	138.9	0	0	0	0	0	0	0	138.9	2	2	2	2	2	2	2	2	2
		0	0	0	0	0	0	132.9	6	95	85	60	45	40	10	2	2	10
MC-310	358.4	0	0	0	0	0	0	0	358.4	2	2	2	2	2	2	2	2	2
		193.4	0	0	0	0	0	85	80	95	85	60	45	40	10	2	2	54
MC-311	177.3	0	0	0	0	0	0	0	177.3	2	2	2	2	2	2	2	2	2
		0	0	109.3	0	0	0	10	58	95	85	60	45	40	10	2	2	38
MC-312	109.4	0	0	0	0	0	0	0	109.4	2	2	2	2	2	2	2	2	2
		0	0	0	0	0	0	109.4	0	95	85	60	45	40	10	2	2	10
MC-313	198.4	0	0	0	0	0	0	0	198.4	2	2	2	2	2	2	2	2	2
		0	0	0	0	0	0	195.4	4	95	85	60	45	40	10	2	2	10
MC-314	163.2	0	0	0	0	0	0	0	163.2	2	2	2	2	2	2	2	2	2
		3	0	45.2	0	0	0	60	55	95	85	60	45	40	10	2	2	23

TABLE 3.1 - BASIN IMPERVIOUSNESS
EAST TOLL GATE CREEK, MURPHY CREEK, COAL CREEK

BASIN I.D.	BASIN AREA ACRES	LAND USE EXISTING DEV. ACRES / FUTURE DEV. ACRES							IMPERVIOUSNESS EXISTING % / FUTURE %							WEIGHTED BASIN IMPERVIOUSNESS	
		HOMU	INDUST.	COMM.	MD RES.	LD RES.	LF/PARKS	OPEN	HDMU	INDUST.	COMM.	MD RES.	LD RES.	LF/PARKS	OPEN	PREDEVELOPED 1%	FUTURE 1%
MC-315	90.2	0	0	0	0	0	0	90.2	2	2	2	2	2	2	2	2	
		0	0	0	0	51.2	39	0	95	85	60	45	40	10	2		27
MC-316	137.6	0	0	0	0	0	0	137.6	2	2	2	2	2	2	2	2	
		0	0	35.6	0	43	0	59	95	85	60	45	40	10	2		29
MC-317	115.2	0	0	0	0	0	0	115.2	2	2	2	2	2	2	2	2	
		0	0	70.2	0	0	45	0	95	85	60	45	40	10	2		40
MC-318	282.2	0	0	0	0	0	0	282.2	2	2	2	2	2	2	2	2	
		0	0	15	0	127	63.2	77	95	85	60	45	40	10	2		24
MC-319	256.6	0	0	0	0	0	0	256.6	2	2	2	2	2	2	2	2	
		0	0	0	0	206	50.6	0	95	85	60	45	40	10	2		34
MC-320	50.6	0	0	0	0	0	0	50.6	2	2	2	2	2	2	2	2	
		0	0	0	0	0	33.6	17	95	85	60	45	40	10	2		7
MC-321	161.3	0	0	0	0	0	0	161.3	2	2	2	2	2	2	2	2	
		0	0	42	0	0	119.3	0	95	85	60	45	40	10	2		23
MC-322	106.2	0	0	0	0	0	0	106.2	2	2	2	2	2	2	2	2	
		0	0	0	0	0	106.2	0	95	85	60	45	40	10	2		10
MC-323	69.1	0	0	0	0	0	0	69.1	2	2	2	2	2	2	2	2	
		0	0	28	0	0	41.1	0	95	85	60	45	40	10	2		30
MC-324	111.4	0	0	0	0	0	0	111.4	2	2	2	2	2	2	2	2	
		0	0	7.5	0	0	103.9	0	95	85	60	45	40	10	2		13
MC-325	89.6	0	0	0	0	0	0	89.6	2	2	2	2	2	2	2	2	
		0	0	0	0	0	86.6	3	95	85	60	45	40	10	2		10
MC-326	45.4	0	0	0	0	0	0	45.4	2	2	2	2	2	2	2	2	
		0	0	0	0	0	28.4	17	95	85	60	45	40	10	2		7
MC-327	152.3	0	0	0	0	0	0	152.3	2	2	2	2	2	2	2	2	
		0	0	26.5	13.9	0	109.9	2	95	85	60	45	40	10	2		22
MC-328	23.0	0	0	0	0	0	0	23	2	2	2	2	2	2	2	2	
		0	0	0	0	0	12.9	10.1	95	85	60	45	40	10	2		6
MC-329	55.0	0	0	0	0	0	0	55	2	2	2	2	2	2	2	2	
		0	0	0	0	0	41	14	95	85	60	45	40	10	2		8
MC-330	47.4	0	0	0	0	0	0	47.4	2	2	2	2	2	2	2	2	
		0	0	0	2.8	0	44.6	0	95	85	60	45	40	10	2		12
MC-230	5.1	0	0	0	0	0	0	5.1	2	2	2	2	2	2	2	2	
		0	0	0	1	0	4.1	0	95	85	60	45	40	10	2		17
MC-331	75.5	0	0	0	0	0	0	75.5	2	2	2	2	2	2	2	2	
		0	0	0	9.3	0	66.2	0	95	85	60	45	40	10	2		14
MC-231	87.1	0	0	0	0	0	0	87.1	2	2	2	2	2	2	2	2	
		0	0	13	32.5	0	41.6	0	95	85	60	45	40	10	2		31
MC-332	60.2	0	0	0	0	0	0	60.2	2	2	2	2	2	2	2	2	
		0	0	0	7.2	0	53	0	95	85	60	45	40	10	2		14
MC-333	106.9	0	0	0	0	0	0	106.9	2	2	2	2	2	2	2	2	
		0	0	37	0	0	62.9	7	95	85	60	45	40	10	2		27
MC-334	126.7	0	0	0	0	0	0	126.7	2	2	2	2	2	2	2	2	
		0	0	16	0	0	110.7	0	95	85	60	45	40	10	2		16
MC-335	234.9	0	0	0	0	0	0	234.9	2	2	2	2	2	2	2	2	
		83	0	22	0	0	129.9	0	95	85	60	45	40	10	2		45
MC-336	32.6	0	0	0	0	0	0	32.6	2	2	2	2	2	2	2	2	
		0	0	32.6	0	0	0	0	95	85	60	45	40	10	2		60
MC-337	79.4	0	0	0	0	0	0	79.4	2	2	2	2	2	2	2	2	
		0	0	47.3	0	0	0	32.1	95	85	60	45	40	10	2		37
MC-338	196.5	0	0	0	0	0	0	196.5	2	2	2	2	2	2	2	2	
		24	0	138.5	34	0	0	0	95	85	60	45	40	10	2		62

TABLE 3.1 - BASIN IMPERVIOUSNESS
EAST TOLL GATE CREEK, MURPHY CREEK, COAL CREEK

BASIN I.D.	BASIN AREA ACRES	LAND USE							IMPERVIOUSNESS							WEIGHTED BASIN IMPERVIOUSNESS	
		EXISTING DEV. ACRES / FUTURE DEV. ACRES							EXISTING % / FUTURE %							PREDEVELOPED	FUTURE
		HDMU	INDUST.	COMM.	MD RES.	LD RES.	LF/PARKS	OPEN	HDMU	INDUST.	COMM.	MD RES.	LD RES.	LF/PARKS	OPEN	1 %	1 %
MC-339	90.9	0	0	0	0	0	0	90.9	2	2	2	2	2	2	2	2	
		0	0	84.4	6.5	0	0	0	95	85	60	45	40	10	2		59
MC-340	212.5	0	0	0	0	0	0	212.5	2	2	2	2	2	2	2	2	
		0	0	0	212.5	0	0	0	95	85	60	45	40	10	2		45
MC-341	289.3	0	0	0	0	0	0	289.3	2	2	2	2	2	2	2	2	
		0	0	211.4	7.9	0	0	70	95	85	60	45	40	10	2		46
MC-241	70.4	0	0	0	0	0	0	70.4	2	2	2	2	2	2	2	2	
		0	0	58	12.4	0	0	0	95	85	60	45	40	10	2		57
MC-342	197.8	0	0	0	0	0	0	197.8	2	2	2	2	2	2	2	2	
		0	0	30	47.1	40.2	0	80.5	95	85	60	45	40	10	2		29
MC-343	206.1	0	0	0	0	0	0	206.1	2	2	2	2	2	2	2	2	
		56	0	0	150.1	0	0	0	95	85	60	45	40	10	2		59
MC-344	273.3	0	0	0	0	0	0	273.3	2	2	2	2	2	2	2	2	
		0	0	0	273.3	0	0	0	95	85	60	45	40	10	2		45
MC-345	108.8	0	0	0	0	0	0	108.8	2	2	2	2	2	2	2	2	
		0	0	6	90.8	0	0	12	95	85	60	45	40	10	2		41
MC-245	149.8	0	0	0	0	0	0	149.8	2	2	2	2	2	2	2	2	
		0	0	46.8	0	15	0	88	95	85	60	45	40	10	2		24
MC-346	83.8	0	0	0	0	0	0	83.8	2	2	2	2	2	2	2	2	
		0	0	68.3	15.5	0	0	0	95	85	60	45	40	10	2		57
MC-246	140.2	0	0	0	0	0	0	140.2	2	2	2	2	2	2	2	2	
		0	0	124.7	15.5	0	0	0	95	85	60	45	40	10	2		58
MC-146	51.2	0	0	0	0	0	0	51.2	2	2	2	2	2	2	2	2	
		0	0	41.9	9.3	0	0	0	95	85	60	45	40	10	2		57
MC-347	128.7	0	0	0	0	0	0	128.7	2	2	2	2	2	2	2	2	
		0	0	119.4	9.3	0	0	0	95	85	60	45	40	10	2		59
MC-348	171.5	0	0	0	0	0	0	171.5	2	2	2	2	2	2	2	2	
		0	0	52.4	21.7	97.4	0	0	95	85	60	45	40	10	2		47
MC-248	102.4	0	0	0	0	0	0	102.4	2	2	2	2	2	2	2	2	
		0	0	5.6	21.7	75.1	0	0	95	85	60	45	40	10	2		42
MC-349	193.9	0	0	0	0	0	0	193.9	2	2	2	2	2	2	2	2	
		0	0	73	0	120.9	0	0	95	85	60	45	40	10	2		33
MC-350	649.6	0	0	0	0	0	0	649.6	2	2	2	2	2	2	2	2	
		0	0	15	0	634.6	0	0	95	85	60	45	40	10	2		19
CC-83	170.2	0	0	0	0	0	0	170.2	2	2	2	2	2	2	2	2	
		0	0	92.9	11.9	23	0	42.4	95	85	60	45	40	10	2		42
CC-84	102.4	0	0	0	0	0	0	102.4	2	2	2	2	2	2	2	2	
		0	72.4	0	0	30	0	0	95	85	60	45	40	10	2		72
CC-85	92.4	0	0	0	0	0	0	92.4	2	2	2	2	2	2	2	2	
		0	86.1	6.3	0	0	0	0	95	85	60	45	40	10	2		83
CC-87	198.4	0	0	0	0	0	0	198.4	2	2	2	2	2	2	2	2	
		0	119	0	18.6	60.8	0	0	95	85	60	45	40	10	2		67

3.3 Computational Analysis

The hydrologic analysis consisted of delineating sub-basins, stream reaches, major hydraulic elements and land use patterns, both existing and future, and applying design rainfall events to them. Major drainage basins were subdivided into smaller sub-basins at E-470 according to existing topography. On-site drainage basins were delineated based on grading plans generated for this project. Basin parameters such as length, width and average slope were measured from available contour mapping or roadway plan and profile sheets.

Peak discharges for E-470 on-site basins were computed using 10-year and 100-year rainfall intensities for the ultimate E-470 roadway. On-site facilities not carrying flows which originate off-site are sized for the 10-year event, and the impacts of the 100-year event were evaluated. On-site basin coefficients and Rational Method calculations for 10-year and 100-year runoff are contained in Appendix A. The Rational calculations in Appendix A are organized to correspond to the drainage basins and facilities as shown on Drawings 4 through 11.

3.4 Infiltration and Abstraction Losses

Infiltration rates for each hydrologic soil group present in the project area are as follows:

	<u>Group B</u>	<u>Group C</u>
Initial infiltration rate (in/hr)	4.5	3.0
Final infiltration rate (in/hr)	0.6	0.5
Decay rate (in/hr)	0.0018	0.0018

Infiltration rates for each subbasin were taken from the Master Plan. Initial and final infiltration rates of each subbasin for use in the CUHP are a weighted average based on the percent of each soil group within the subbasin.

Subbasin runoff abstraction losses used in the CUHP include an impervious area storage loss of 0.05 to 0.1 inches and a pervious area storage loss of 0.35 to 0.40 inches.

3.5 Hydrologic Analysis

The hydrologic analysis consisted of the following tasks:

1. Obtain archival CUHP/SWMM files from the UD&FCD, execute and check output.
2. Obtain county and city land use plans.
3. Modify CUHP/SWMM data for E-470 alignment and updated land use.
4. Execute CUHP/SWMM models for E-470 basin and updated land use data.
5. Review the results for reasonableness and consistency.
6. Execute SWMM model for detention routing.

The objective of the analysis was to define the peak runoff rates and volumes generated off the project area to be conveyed through E-470 by cross-culverts located at the design points,

and to document the effect E-470 will have on downstream reaches of East Toll Gate Creek and Murphy Creek. Computer input and output listings for all CUHP and SWMM models generated by this analysis are in Appendix C, a computer diskette contained in a pocket at the back of this report. The results of the SWMM models are listed on Table 3.2.

East Toll Gate Creek: Revisions to the Master Plan CUHP models for E-470 were made only to subbasins 1 through 9. East Toll Gate Creek reaches downstream from Hampden Avenue are outside the influence of E-470. Subbasin parameters for the revised East Toll Gate Creek CUHP model are listed in Table 3.3.

Hydrographs from the CUHP runs for existing and future subbasins 1 through 9 were routed through existing and proposed drainage channels and culverts using SWMM. The Master Plan SWMM input files obtained from archives at the Urban Drainage and Flood Control District were modified for E-470 design points and structures. The Modified East Toll Gate Creek SWMM routing schematic is illustrated in Figures 3.3 and 3.4.

Flood hydrographs for existing and developed conditions at Channel Elements 108 and 10 are shown in Figures 3.5 and 3.6, respectively. These figures show a comparison of the original Master Plan hydrographs with the revisions made for E-470.

Murphy Creek: E-470 traverses the upper portions of subbasins 327, 330, 331, 339 and 341 before entering the West Murphy Creek tributary as identified in the Master Plan. Revised subbasin parameters for the Murphy Creek CUHP model are listed in Table 3.3.

Hydrographs from the CUHP runs for the entire Murphy Creek watershed were routed through existing and proposed drainage channels and culverts using SWMM. The Master Plan SWMM input files obtained from archives at the Urban Drainage and Flood Control District were modified for E-470 design points and structures. The Modified Murphy Creek SWMM routing schematics are illustrated in Figures 3.7 and 3.8.

Flood hydrographs for existing and proposed conditions at Design Point 10 and channel element 351 are shown in Figures 3.9 and 3.10, respectively. These figures show a comparison of the original Master Plan hydrographs with the revisions made for E-470.

Coal Creek: Besides the main Coal Creek channel, E-470 crosses only two subbasins in the Coal Creek watershed before entering the First Creek watershed in Area 3. Revised CUHP storm hydrographs and peak discharges were computed for 10-year and 100-year rainfall for only these subbasins. The remainder (majority) of Coal Creek was not remodeled because the FEMA 100-year discharge of 19,500 cfs will be used for design of the E-470 bridges. CUHP parameters for the revised Coal Creek subbasins are listed in Table 3.3. CUHP hydrographs at the design points are used directly with no SWMM routing.

3.6 Detention Routing

East Toll Gate Creek: Both Master Plans propose regional detention ponds in the East Toll Gate Creek basin upstream and downstream of E-470. Three of the proposed ponds are in the basin upstream of E-470, and one pond is proposed downstream of E-470 against the Hampden Avenue embankment. The largest pond (115 acre feet) is proposed against the

TABLE 3.2 DRAINAGE BASIN SUMMARY RUNOFF
EAST TOLL GATE CREEK, COAL CREEK AND MURPHY CREEK

DESIGN POINT		STATION	BASIN	AREA	PEAK FLOW - CFS										REMARKS
E-470	MST. PLAN	FEET	IDENTIFICATION	AC.	EXISTING		E-470 PROJECT		SLA MST. PLAN EXIST.		SLA MST. PLAN FUTURE		FEMA		
					10-YEAR	100-YEAR	10-YEAR	100-YEAR	10-YEAR	100-YEAR	10-YEAR	100-YEAR	100-YEAR		
21		659+80 LT.	ETGC-104	88.3	44	166	80	203 *						E-470 CULVERT	
22	200	805+00 RT.	ETGC-6	969.0	194	954 *	234	618	83	468	197	900	N/A	E-470 / QUINCY AVENUE CULVERT	
23		821+40 RT.	ETGC-8	58.2	23	87	43	106 *						E-470 CULVERT	
5		913+80 LT.	MC-231	92.2	29	112	45	126 *						E-470 CULVERT	
6		937+20 LT.	MC-241	70.4	29	106	64	142 *						E-470 CULVERT	
7		OFFSITE	MC-246	140.2	56	205	328	592 *						JEWELL AVENUE CULVERT	
8		OFFSITE	MC-346	83.8	35	127	76	174 *						JEWELL AVENUE CULVERT	
9		OFFSITE	MC-348	306.6	19	224	206	489 *						SH-30 CULVERT	
10	345	1044+00 RT.	MC-345	6,054.5	586	3,344	1,413	4,095 *	419	2,815	1,277	3,700	3,800	E-470 CULVERT	
11		1094+00 RT.	CC-85	92.4	50	192	389	441 *						E-470 CULVERT	
12		1121+00 RT.	CC-87	198.4	84	271	480	855 *						E-470 CULVERT	
13	83	1078+00 RT.	CC-83	47,449	173	9,593	5,560	16,972	173	9,593	5,560	18,600	19,500*	FLOW UNDER E-470 BRIDGE	
* E-470 DESIGN FLOW															

* E-470 DESIGN FLOW

TABLE 3.3 - CUIP DRAINAGE BASIN PARAMETERS
EAST TOLL GATE CREEK, COAL CREEK, AND MURPHY CREEK

EXISTING AND FUTURE BASIN CONDITIONS

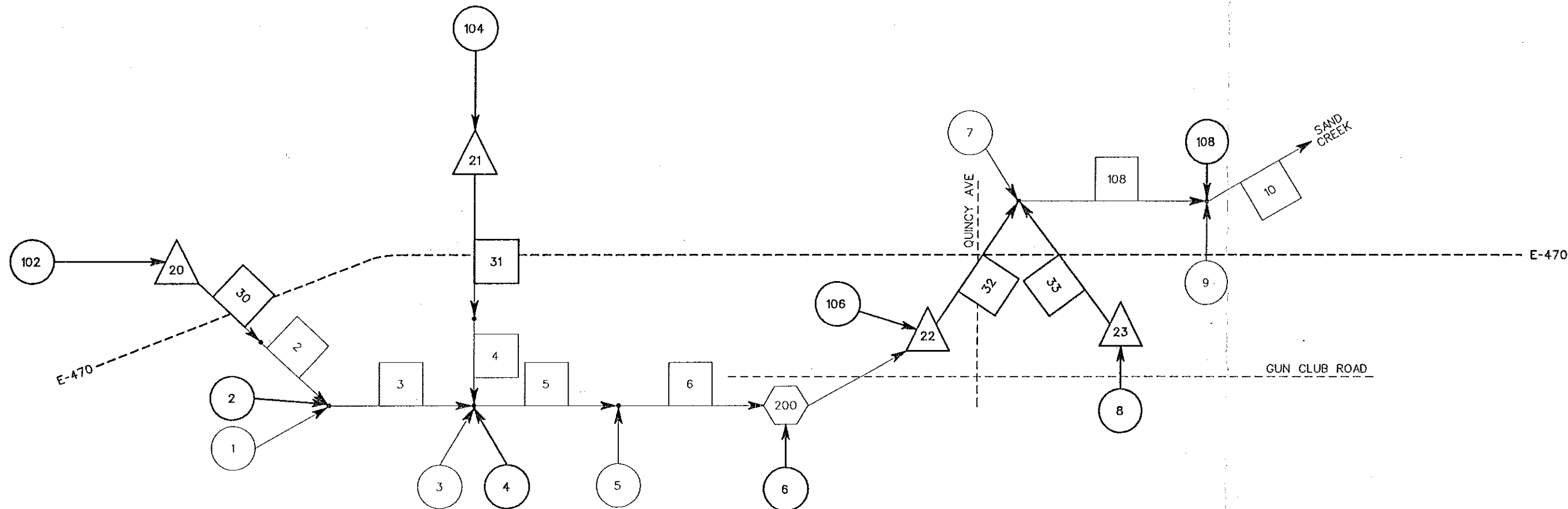
BASIN ID.	AREA	LENGTH	CENTROID	EXIST IMP	FUTURE IMP	SLOPE	Tc	HYDROLOGIC SOIL GROUP	RETENTION - IN.		INFILTRATION			REMARKS
	SQ. MI.	MI.	DIST. MI.	%	%	FT/FT	MINS.		PERVIOUS	IMPERVIOUS	INITIAL - IN.	FINAL - IN.	DECAY	
ETGC-1	0.160	0.739	0.360	2	22	0.041		B	0.4	0.05	4.5	0.6	0.0018	
ETGC-2	0.055	0.625	0.246	2	39	0.042	41.1	B	0.4	0.05	4.5	0.6	0.0018	
ETGC-102	0.090	0.511	0.322	2	41	0.042	38.6	B	0.4	0.05	4.5	0.6	0.0018	DESIGN POINT 20
ETGC-3	0.280	0.871	0.455	2	25	0.028		C	0.4	0.1	3.0	0.5	0.0018	
ETGC-4	0.063	0.814	0.407	2	42	0.036	47.5	C	0.4	0.1	3.0	0.5	0.0018	
ETGC-104	0.138	0.511	0.284	2	41	0.036	40.8	C	0.4	0.1	3.0	0.5	0.0018	DESIGN POINT 21
ETGC-5	0.153	0.587	0.284	4	27	0.027		C	0.4	0.1	3.0	0.5	0.0018	
ETGC-6	0.575	1.174	0.701	6	34	0.019		C	0.4	0.1	3.0	0.5	0.0018	DESIGN POINT 22
ETGC-106	0.117	1.250	0.474	6	35	0.019	70.9	C	0.4	0.1	3.0	0.5	0.0018	
ETGC-7	0.153	0.734	0.355	2	37	0.023		C	0.4	0.1	3.0	0.5	0.0018	
ETGC-8	0.091	0.455	0.152	2	41	0.017	53.0	C	0.4	0.1	3.0	0.5	0.0018	DESIGN POINT 23
ETGC-108	0.244	1.099	0.549	2	28	0.017		C	0.4	0.1	3.0	0.5	0.0018	
ETGC-9	0.159	0.829	0.425	2	37	0.027		C	0.4	0.1	3.0	0.5	0.0018	
CC-83	0.266	0.474	0.227	2	42	0.006		C	0.4	0.1	3.0	0.5	0.0018	DESIGN POINT 13
CC-183	0.164	0.436	0.227	2	40	0.006		C	0.4	0.1	3.0	0.5	0.0018	
CC-84	0.160	0.610	0.380	2	72	0.022		B	0.4	0.05	4.5	0.6	0.0018	
CC-85	0.144	0.303	0.152	2	83	0.010	21.8	B	0.4	0.05	4.5	0.6	0.0018	DESIGN POINT 11
CC-185	0.104	0.455	0.284	2	85	0.010	61.7	B	0.4	0.05	4.5	0.6	0.0018	
CC-86	0.130	0.950	0.410	2	8	0.005	123.0	B	0.4	0.05	4.5	0.6	0.0018	
CC-87	0.310	0.758	0.314	2	67	0.007		C	0.4	0.1	3.0	0.5	0.0018	DESIGN POINT 12
CC-187	1.090	1.326	0.701	2	80	0.007		C	0.4	0.1	3.0	0.5	0.0018	
MC-301	0.174	0.790	0.410	2	95	0.041		B	0.4	0.05	4.5	0.6	0.0018	
MC-302	0.141	0.760	0.310	2	49	0.043		B	0.4	0.05	4.5	0.6	0.0018	
MC-303	0.141	0.650	0.350	2	58	0.051		B	0.4	0.05	4.5	0.6	0.0018	
MC-304	0.144	0.640	0.450	2	60	0.037		B	0.4	0.05	4.5	0.6	0.0018	
MC-305	0.041	0.400	0.180	2	13	0.048	33.4	B	0.4	0.05	4.5	0.6	0.0018	
MC-306	0.079	0.440	0.210	2	95	0.056	32.4	B	0.4	0.05	4.5	0.6	0.0018	
MC-307	0.222	1.030	0.440	2	95	0.035		B	0.4	0.05	4.5	0.6	0.0018	
MC-308	0.092	0.470	0.260	2	52	0.056	32.6	B	0.4	0.05	4.5	0.6	0.0018	
MC-309	0.217	0.850	0.480	2	10	0.036		B	0.4	0.05	4.5	0.6	0.0018	
MC-310	0.560	1.220	0.540	2	54	0.030		C	0.4	0.1	3.0	0.5	0.0018	
MC-311	0.277	0.930	0.460	2	38	0.024		C	0.4	0.1	3.0	0.5	0.0018	
MC-312	0.171	0.760	0.450	2	10	0.036		C	0.4	0.1	3.0	0.5	0.0018	
MC-313	0.310	1.040	0.440	2	10	0.026		C	0.4	0.1	3.0	0.5	0.0018	
MC-314	0.255	0.930	0.330	2	23	0.026		C	0.4	0.1	3.0	0.5	0.0018	
MC-315	0.141	0.750	0.380	2	27	0.031		C	0.4	0.1	3.0	0.5	0.0018	
MC-316	0.215	1.020	0.460	2	29	0.023		C	0.4	0.1	3.0	0.5	0.0018	
MC-317	0.180	0.980	0.450	2	40	0.029		C	0.4	0.1	3.0	0.5	0.0018	
MC-318	0.441	1.590	0.840	2	24	0.020		C	0.4	0.1	3.0	0.5	0.0018	
MC-319	0.401	1.190	0.590	2	34	0.021		C	0.4	0.1	3.0	0.5	0.0018	
MC-320	0.079	0.470	0.280	2	7	0.028	42.7	C	0.4	0.1	3.0	0.5	0.0018	
MC-321	0.252	0.760	0.350	2	23	0.032		C	0.4	0.1	3.0	0.5	0.0018	
MC-322	0.166	0.820	0.440	2	10	0.010		C	0.4	0.1	3.0	0.5	0.0018	
MC-323	0.108	0.420	0.230	2	30	0.034	38.3	C	0.4	0.1	3.0	0.5	0.0018	
MC-324	0.174	0.750	0.400	2	13	0.015		C	0.4	0.1	3.0	0.5	0.0018	
MC-325	0.140	0.740	0.380	2	10	0.023	56.7	C	0.4	0.1	3.0	0.5	0.0018	
MC-326	0.071	0.610	0.240	2	7	0.029	46.4	C	0.4	0.1	3.0	0.5	0.0018	
MC-327	0.238	1.020	0.530	2	22	0.024		C	0.4	0.1	3.0	0.5	0.0018	
MC-328	0.036	0.420	0.180	2	6	0.016	52.0	C	0.4	0.1	3.0	0.5	0.0018	
MC-329	0.086	0.830	0.440	2	8	0.019	64.9	C	0.4	0.1	3.0	0.5	0.0018	
MC-330	0.074	0.720	0.360	2	12	0.024	52.5	C	0.4	0.1	3.0	0.5	0.0018	
MC-230	0.008	0.133	0.065	2	17	0.024	34.7	C	0.4	0.1	3.0	0.5	0.0018	
MC-331	0.118	0.606	0.360	2	14	0.022	51.1	C	0.4	0.1	3.0	0.5	0.0018	
MC-231	0.136	1.193	0.568	2	31	0.022	65.9	C	0.4	0.1	3.0	0.5	0.0018	DESIGN POINT 5
MC-332	0.094	0.758	0.379	2	14	0.021	55.1	C	0.4	0.1	3.0	0.5	0.0018	
MC-333	0.167	1.080	0.610	2	27	0.017		C	0.4	0.1	3.0	0.5	0.0018	

TABLE 3.3 - CUHP DRAINAGE BASIN PARAMETERS
EAST TOLL GATE CREEK, COAL CREEK, AND MURPHY CREEK

EXISTING AND FUTURE BASIN CONDITIONS

BASIN ID.	AREA		LENGTH		CENTROID		EXIST IMP.		FUTURE IMP.		SLOPE FT/FT	Tc MINS.	HYDROLOGIC SOIL GROUP	RETENTION - IN.		INFILTRATION			REMARKS
	SQ. MI.	MI.	MI.	DIST. MI.	%	%	%	%	%	%				PERVIOUS	IMPERVIOUS	INITIAL - IN.	FINAL - IN.	DECAY	
MC-334	0.198	0.930	0.450	2	16	0.027							C	0.4	0.1	3.0	0.5	0.0018	
MC-335	0.367	1.160	0.550	2	45	0.021							C	0.4	0.1	3.0	0.5	0.0018	
MC-336	0.051	0.440	0.180	2	60	0.035					39.3		C	0.4	0.1	3.0	0.5	0.0018	
MC-337	0.124	0.740	0.340	2	37	0.015					69.3		C	0.4	0.1	3.0	0.5	0.0018	
MC-338	0.307	1.140	0.560	2	62	0.022							C	0.4	0.1	3.0	0.5	0.0018	
MC-339	0.142	0.663	0.379	2	59	0.023							C	0.4	0.1	3.0	0.5	0.0018	
MC-340	0.332	1.470	0.930	2	45	0.017							C	0.4	0.1	3.0	0.5	0.0018	
MC-341	0.452	1.515	0.663	2	46	0.016							C	0.4	0.1	3.0	0.5	0.0018	
MC-241	0.110	0.474	0.227	2	57	0.020					51.0		C	0.4	0.1	3.0	0.5	0.0018	DESIGN POINT 6
MC-342	0.309	1.620	0.930	2	29	0.012							C	0.4	0.1	3.0	0.5	0.0018	
MC-343	0.322	1.610	0.680	2	59	0.018							C	0.4	0.1	3.0	0.5	0.0018	
MC-344	0.427	1.630	0.780	2	45	0.014							C	0.4	0.1	3.0	0.5	0.0018	
MC-345	0.170	0.606	0.189	2	41	0.011							C	0.4	0.1	3.0	0.5	0.0018	DESIGN POINT 10
MC-245	0.234	0.758	0.379	2	24	0.011							C	0.4	0.1	3.0	0.5	0.0018	
MC-346	0.131	0.530	0.265	2	57	0.021					49.8		C	0.4	0.1	3.0	0.5	0.0018	DESIGN POINT 6
MC-246	0.219	0.644	0.322	2	58	0.021							C	0.4	0.1	3.0	0.5	0.0018	DESIGN POINT 7
MC-146	0.080	0.417	0.208	2	57	0.021					46.4		C	0.4	0.1	3.0	0.5	0.0018	
MC-347	0.201	0.810	0.379	2	59	0.024							C	0.4	0.1	3.0	0.5	0.0018	
MC-348	0.268	1.061	0.436	2	47	0.015							C	0.4	0.1	3.0	0.5	0.0018	DESIGN POINT 9
MC-248	0.160	0.568	0.189	2	42	0.015							C	0.4	0.1	3.0	0.5	0.0018	DESIGN POINT 4
MC-349	0.303	1.340	0.560	2	33	0.021							C	0.4	0.1	3.0	0.5	0.0018	
MC-350	1.015	1.800	1.040	2	19	0.018							C	0.4	0.1	3.0	0.5	0.0018	
MC-351	0.373	1.520	0.470	2	8	0.016							C	0.4	0.1	3.0	0.5	0.0018	

NOTE: BOLD INDICATES REVISION FOR E-470 TO
BASE SWMM MODEL OBTAINED FROM URBAN
DRAINAGE AND FLOOD CONTROL DISTRICT.



LEGEND

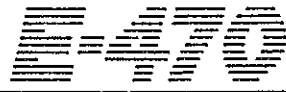
- 71 SUB-BASIN ELEMENT
- 5 DESIGN POINT
- 48 CHANNEL ELEMENT
- 100 DETENTION ELEMENT (FUTURE CONDITION)
- E-470 REFERENCE LOCATION

DATE OF PLOT: 01/27/97

DESIGN FILE: w:\47040\plan\dra400.dgn

DESIGNED BY:	DATE:	ISSUE RECORD							
		NO.	BY	PURPOSE	DATE	NO.	BY	PURPOSE	DATE
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CHECKED BY:	W.B.N.:								

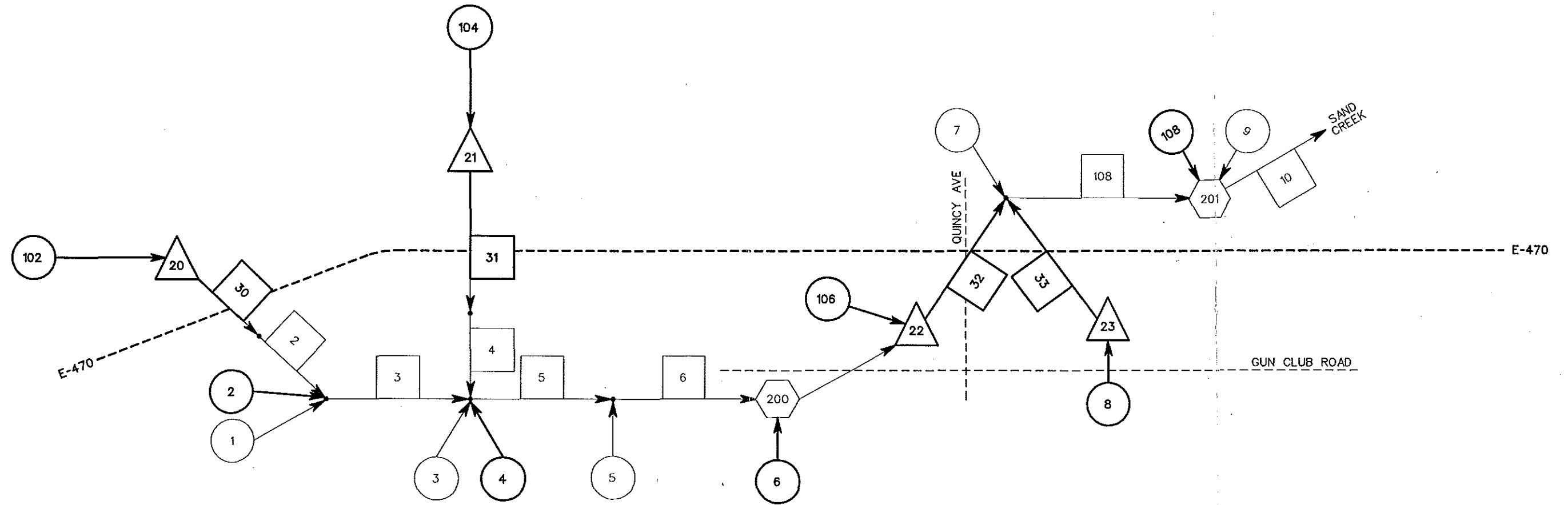
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


EXISTING SWMM ROUTING SCHEMATIC
E-470 EAST TOLL GATE CREEK BASIN

FIGURE
3.3

NOTE: BOLD INDICATES REVISION FOR E-470 TO
BASE SWMM MODEL OBTAINED FROM URBAN
DRAINAGE AND FLOOD CONTROL DISTRICT.



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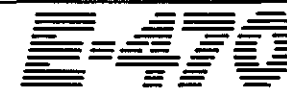
-  SUB-BASIN ELEMENT
-  DESIGN POINT
-  CHANNEL ELEMENT
-  DETENTION ELEMENT (FUTURE CONDITION)
-  REFERENCE LOCATION

DATE OF PLOT: 01/27/97

DESIGN FILE: w:\47040\plan\dra4002.dgn

DESIGNED BY:	DATE:	ISSUE RECORD					
DRAFTED BY:	CAD FILE NAME:	NO.	BY	PURPOSE	DATE	NO.	BY
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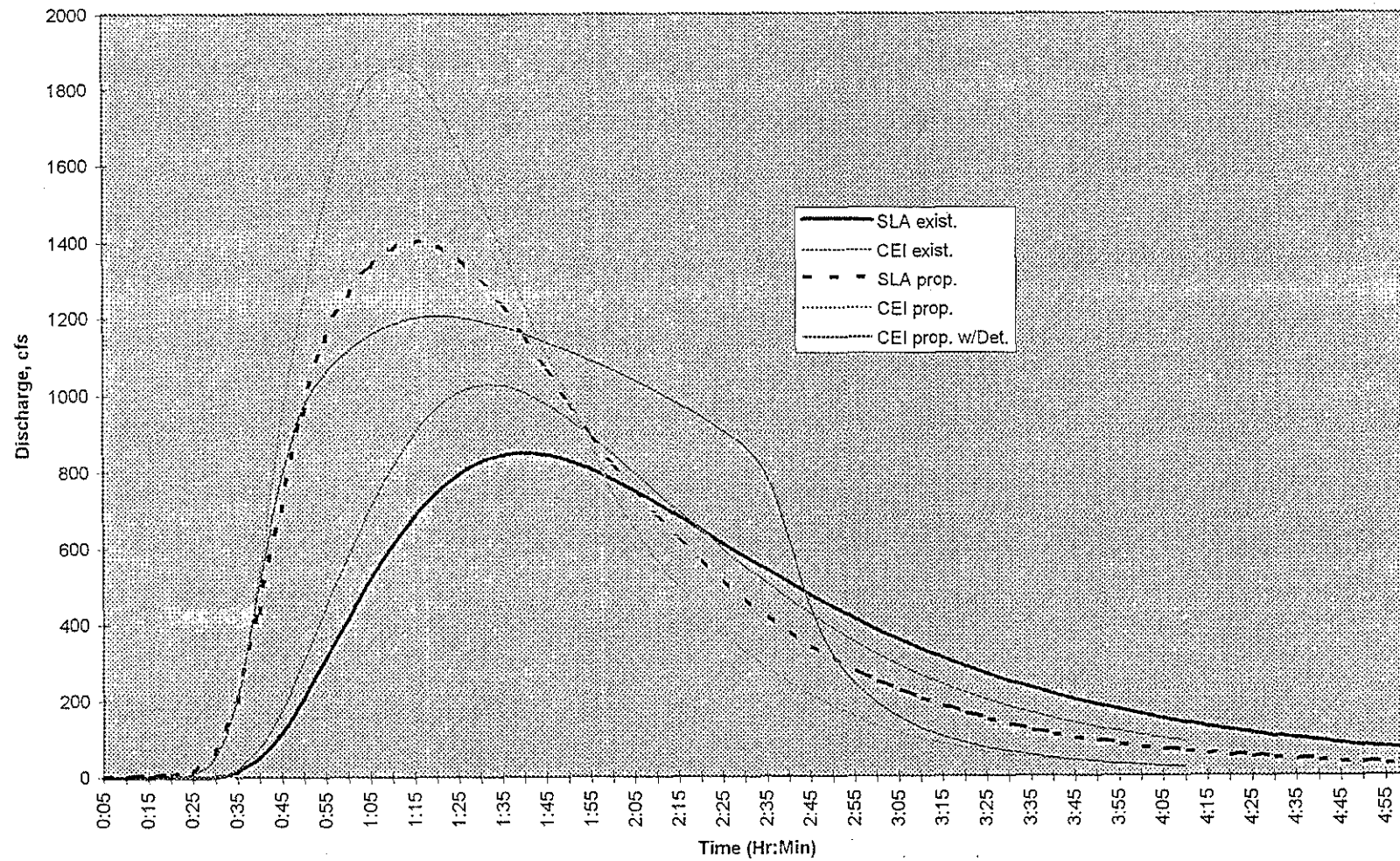


PROPOSED SWMM ROUTING SCHEMATIC
E-470 EAST TOLL GATE CREEK BASIN

FIGURE
3.4

EAST TOLL GATE CREEK
QUINCY AVENUE

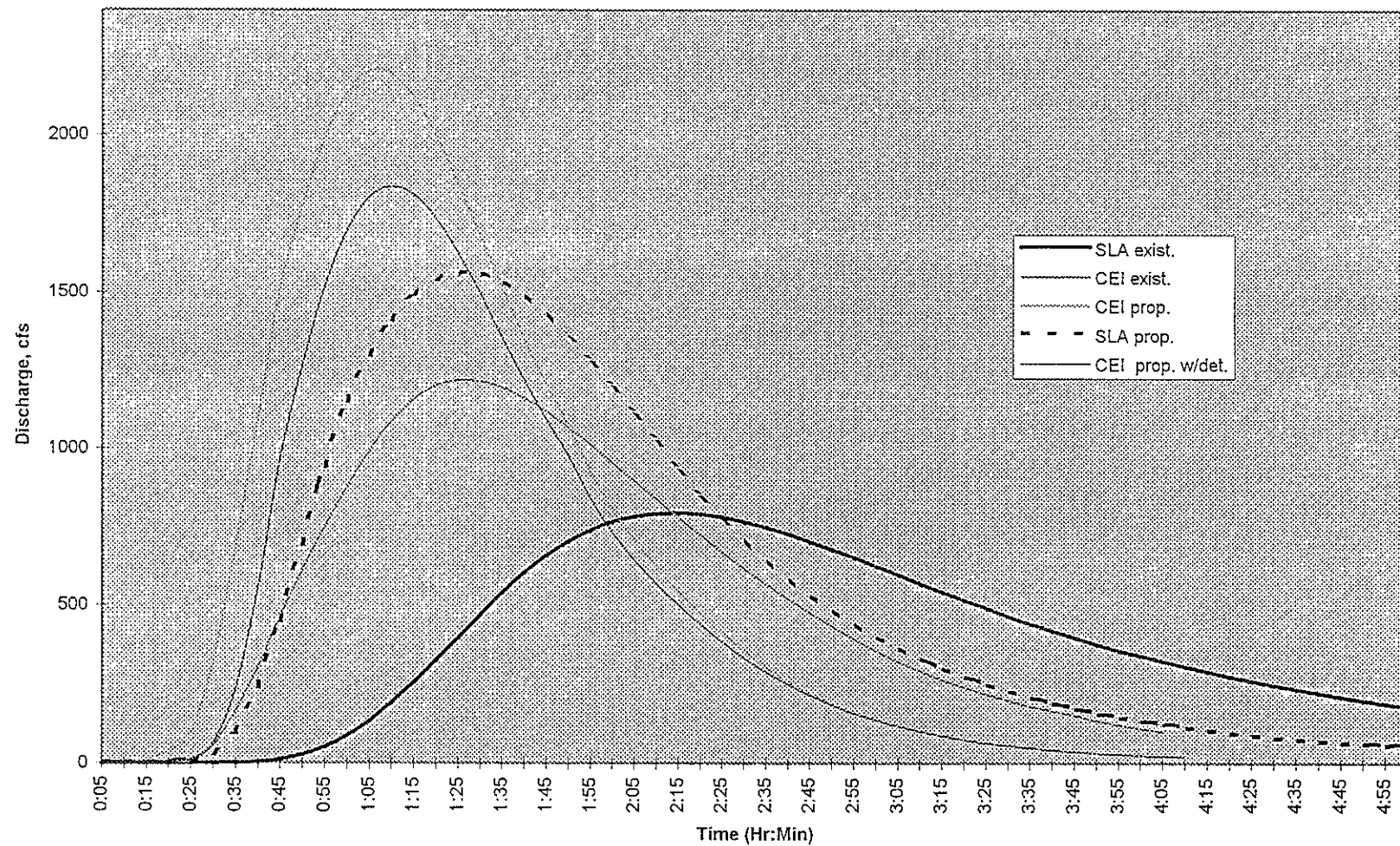
EXISTING AND FUTURE BASIN

100-YR FLOOD HYDROGRAPHS
DESIGN POINT 108

EAST TOLL GATE CREEK
HAMPDEN AVENUE

EXISTING AND FUTURE BASIN

100-YR FLOOD HYDROGRAPHS
DESIGN ELEMENT 10



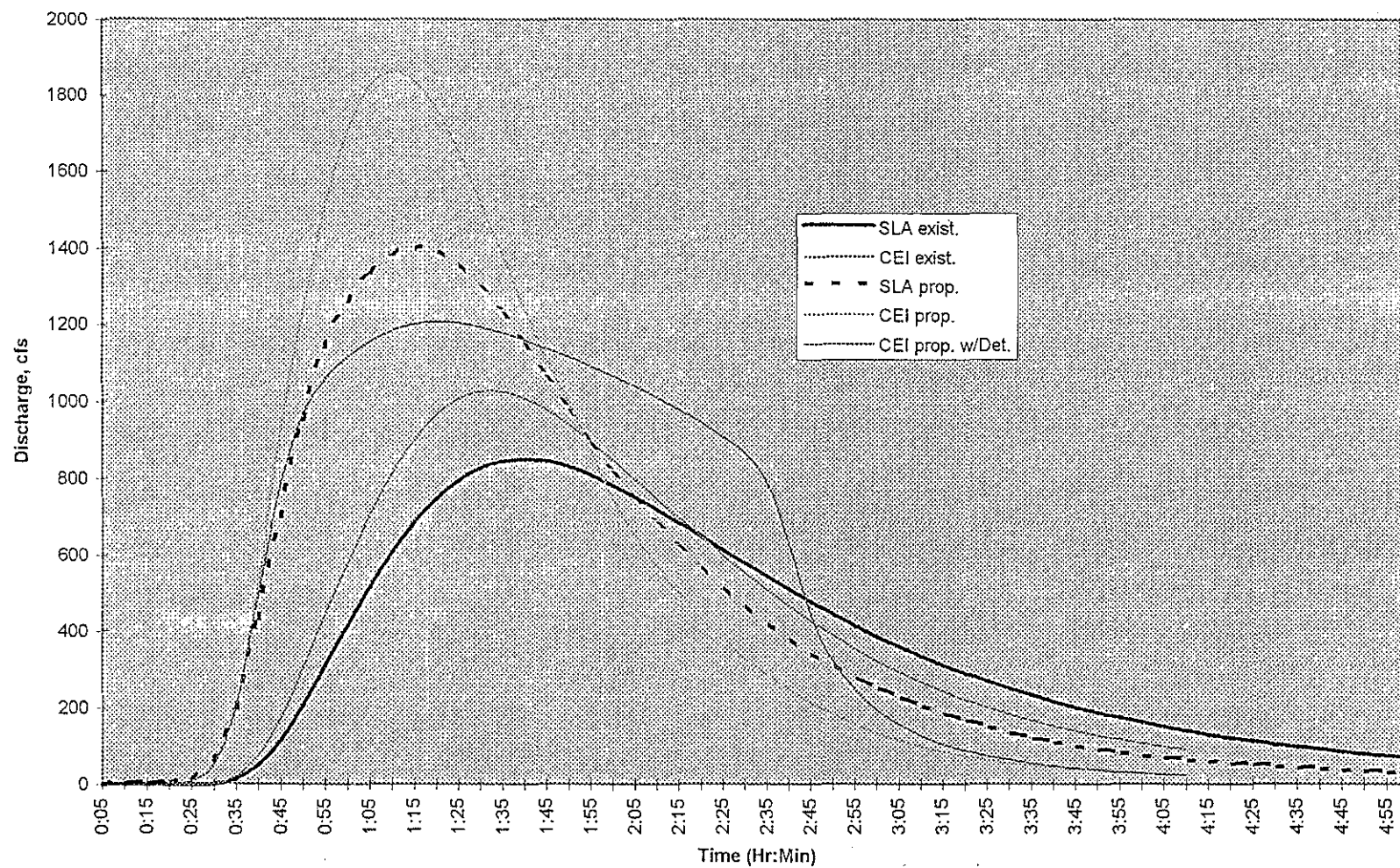
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FIGURE 3.6

EAST TOLL GATE CREEK
QUINCY AVENUE

EXISTING AND FUTURE BASIN

100-YR FLOOD HYDROGRAPHS
DESIGN POINT 108

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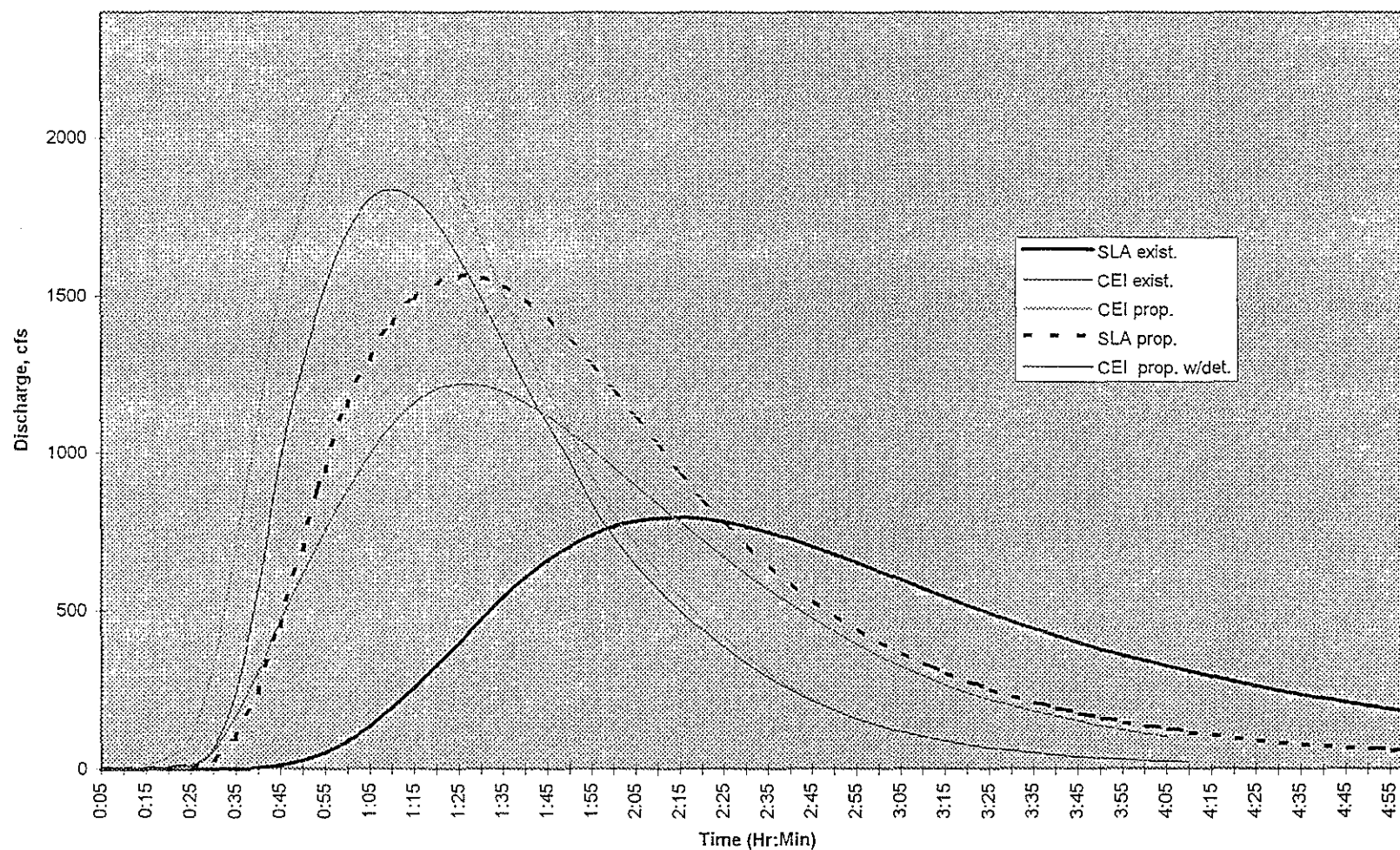
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FIGURE 3.5

EAST TOLL GATE CREEK
HAMPDEN AVENUE

EXISTING AND FUTURE BASIN

100-YR FLOOD HYDROGRAPHS
DESIGN ELEMENT 10

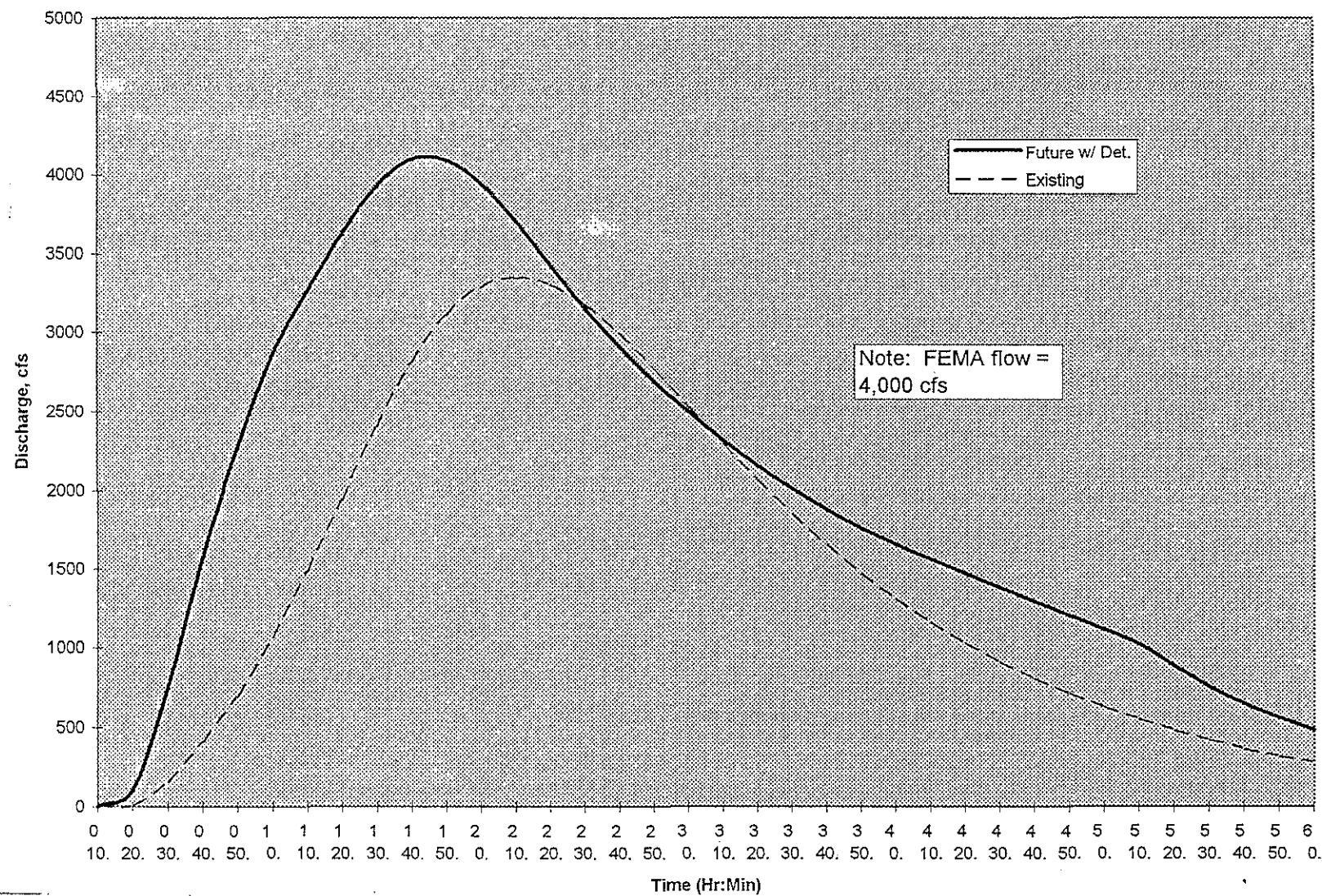


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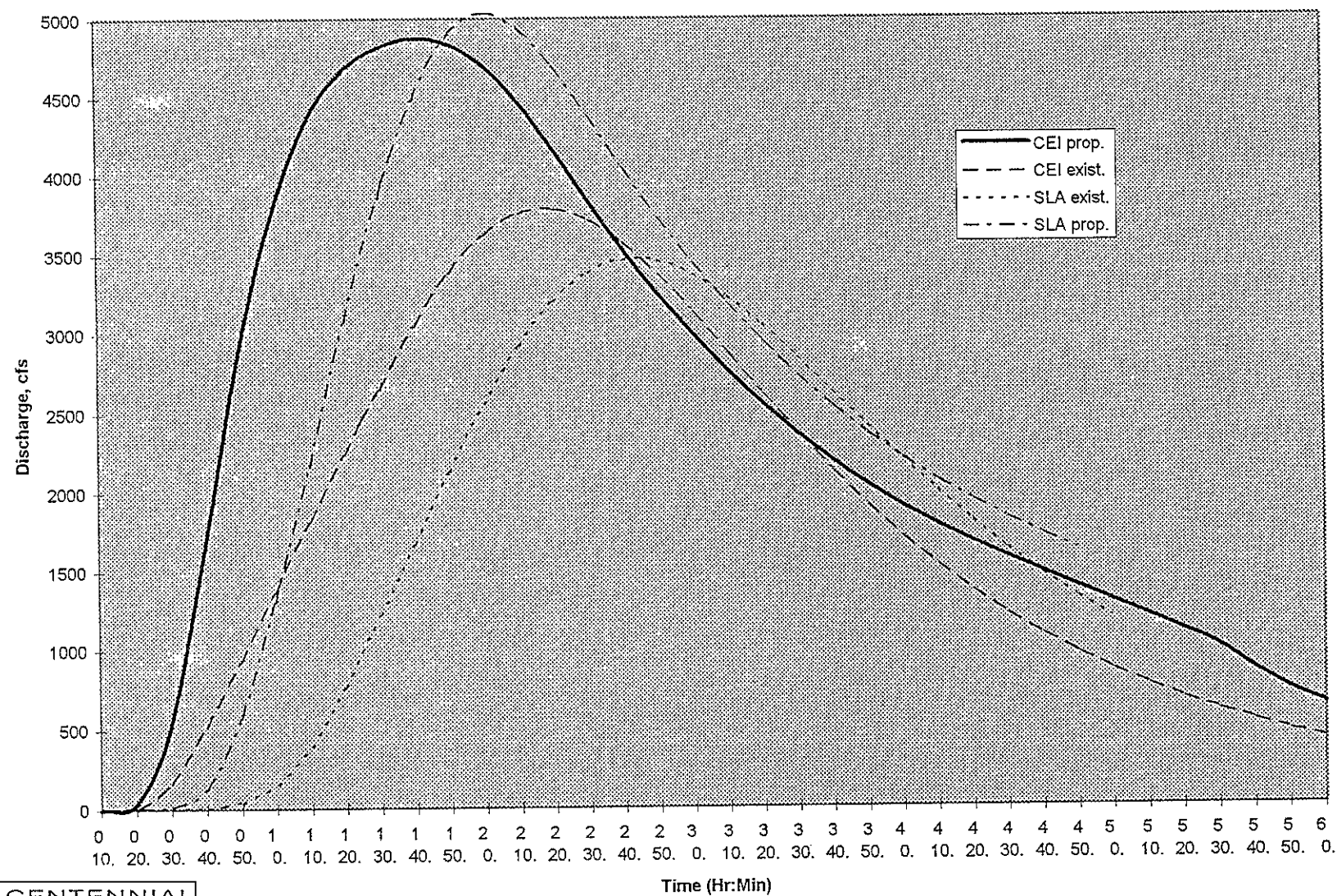
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FIGURE 3.6

EXISTING AND FUTURE BASIN

100-YR FLOOD HYDROGRAPHS
MURPHY CREEK at E-470 (DP10)

EXISTING AND FUTURE BASIN

100-YR FLOOD HYDROGRAPHS
MURPHY CREEK OUTFALL (DP351)

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FIGURE 3.10

Gun Club Road embankment just upstream of E-470 at Quincy. In total, the Master Plans propose 180-acre feet of detention in the East Toll Gate Creek basin, of which 138-acre feet of detention is proposed upstream of E-470.

Approximately 60-acre feet of detention will be constructed with the E-470 project. The detention will be located between E-470 and Gun Club Road south of Quincy Avenue. The pond will be expanded east of Gun Club Road in the future when required.

The revised, future conditions hydrographs were routed through the proposed detention ponds using the SWMM program. Criteria for the detention ponds were developed from information shown on Master Plan Drawings, Sheets E-3 and E-4. Results of the analysis do not match the criteria, however, because inflow hydrographs are much less than Master Plan flows. The Kiowa Engineering Master Plan makes reference to the McLaughlin Engineers Master Plan for East Toll Gate Creek, and indicates that the ECCV hydrology has been used for detention pond sizing. However, no CUHP/SWMM files are available in the UD&FCD archives to document the detention pond sizes indicated in the Master Plan.

Murphy Creek and Coal Creek: No regional detention is proposed in the subbasins or tributaries to Murphy Creek or Coal Creek crossed by E-470. Regional detention and retention on the Lowry Landfill is proposed in the Murphy Creek basin on the main channel upstream of E-470. Detention at Quincy and Hampden was modeled as in all Master Plan SWMM runs for proposed conditions. However, retention on the Lowry Landfill was not modeled for this analysis.

4.0 HYDRAULICS

4.1 Criteria

Cross Culverts. The 100-year discharge for future, fully developed conditions was used to size the culverts and storm sewers handling off-site drainage, except at Quincy as previously noted. Criteria used to size culverts is based on the maximum headwater to depth ratio (HW/D) according to CDOT, Reference 6, except at cross roads where Arapahoe County criteria was used. The HW/D criterium applies only to typical culvert installations consisting of end sections, or headwalls and wingwalls. The HW/D criterium does not apply to drop inlets (Type "C" or "D"), and may be exceeded where detention is proposed against the roadway embankment. Culvert hydraulic calculations were done using the FHWA HY-8 Computer Analysis Program (Reference 10). Headwater depth calculations for cross-culverts are listed in Appendix B.

All proposed culverts are to be reinforced concrete pipes (RCP) or concrete box culverts (CBC). End sections are to be used for cross culverts 48 inches and smaller unless special conditions warrant otherwise. Concrete headwalls and wingwalls are to be provided for all reinforced concrete box culverts and reinforced concrete pipes greater than 48 inches in diameter. Riprap erosion protection will be provided on culvert outlets where required due to high velocities.

Headwalls for pipe culverts are perpendicular to the pipe. Headwalls for reinforced concrete box culverts (CBC) are perpendicular to the culvert unless the skew angle is less than 60 degrees in which case the culvert headwall is parallel to the roadway.

Open channel design and culvert hydraulics are based on design principles as outlined in Chow's Open Channel Hydraulics (Reference 14).

Type "C" and Type "D" Inlets. Type "C" and "D" inlets are provided to drain the median along the E-470 mainline and interchange infield areas not subject to pedestrian traffic. They are also used at the toe of the embankment to intercept runoff from smaller off-site areas. Capacities are based on the nomograph in Figure 804c in the Roadway Design Manual, Reference 6.

Concrete aprons are to be provided around all Type "C" and Type "D" inlets. Dikes are placed immediately downstream of all inlets on continuous grades to provide a minimum of one foot of ponding above the inlet grate prior to spilling.

Special (6:1) Concrete Headwalls. A special, sloped, grated headwall for use in the 6:1 median and roadside clear zone slopes has been adapted from the Kansas Department of Transportation standards for use on this project. This concrete headwall is designed for a 24" RCP and has 5 standard Type C grates which are bolted between the wingwalls on a 6:1 slope in the "clear zone". Use of this headwall is proposed in areas between Smoky Hill Road and Toll Plaza "B" where E-470 is in cut to drain the median to the outside ditch. This headwall intercepts runoff from the median at a shallow depth and substantially reduces the depth required in the roadside ditches in cut areas to drain the median.

Roadside ditches. Roadside ditches are provided along the mainline and ramps to 1) avoid saturating the roadway subgrade, and 2) prevent storm runoff from encroaching onto the travel lanes during the major storm event by intercepting and conveying storm runoff from the E-470 pavement and off-site drainage areas to the outfall drainageway. Typical roadside ditch sections and special ditches are shown in the roadway plans. All unlined ditches are designed for flow velocities to be under 5 feet per second for the design storm. Drop structures are proposed in certain ditches to keep longitudinal slopes within acceptable limits.

4.2 Storm Drainage Improvements for Off-Site Storm Runoff

4.2.1 Conclusions

East Toll Gate Creek: Both the Kiowa Engineering and McLaughlin Engineers Master Plans propose facilities in East Toll Gate Creek at Quincy Avenue be designed for existing conditions discharges, while relying on regional detention to be constructed at Gun Club Road to control runoff from future development. Consequently, the conclusion of this analysis is that existing conditions discharges should be used for design of the box culvert at Quincy Avenue (Design Point 22). Overall, the 10-year and 100-year existing basin peak discharges at Design Point 22 and Channel Element 10 are approximately 15 percent higher than the Master Plan existing basin discharges. Adjustments to the existing basin imperviousness and revised routing account for these differences. The revised CUHP/SWMM model appears reasonable and suitable for design. Master Plan criteria for the Gun Club Road detention pond should be reevaluated when it is to be fully implemented (see Detention Discussion, Section 3.6).

Murphy Creek: E-470 will bisect the West Murphy Creek tributary and affected flood routing at State Highway 30. The Master Plan indicates a new cross-culvert to be constructed under State Highway 30 which will connect the West Murphy Creek tributary directly to the main channel of Murphy Creek upstream of E-470. The SWMM routing of the West Murphy Creek channel was revised to make this connection and to route remnant subbasins on the west side of E-470 to outfall into the existing West Murphy Creek tributary channel adjacent to SH-30.

This routing will not adversely increase discharges in the main Murphy Creek channel between E-470 and Picadilly Road, but will have a beneficial effect on the West Murphy Creek tributary channel adjacent to SH-30 downstream from E-470. The main channel of Murphy Creek at E-470 will require a box culvert designed for the 100-year discharge of 4,095 cfs, slightly higher than the Arapahoe County Flood Insurance Study flow of 4,000 cfs. This is greater than the 100-year future detained flow of 3,800 cfs indicated in the Master Plan because future retention on the Lowry Landfill was not considered in this analysis.

Coal Creek: Revisions to Coal Creek hydrologic models are relatively minor because E-470 crosses a narrow part of the basin. Two design points are of primary

interest, design point 11 on the south and design point 12 on the north side of the E-470/Sixth Avenue Interchange. Design discharges for the main Coal Creek channel were not evaluated in this analysis.

4.2.2 Design Runoff and Hydrographs

Peak discharges for use in design of E-470 cross culverts are listed in the Summary Runoff Table on Drawing 1. Design hydrographs are shown in Figures 4.1 through 4.3 for Design Points 22, 9 and 10. These peak discharges are based on future, fully developed conditions without detention, except at the main channels of East Toll Gate Creek and Murphy Creek. These locations include the benefit of proposed regional detention upstream of Gun Club Road as proposed in the Master Plan. In all cases, the design discharge for E-470 is equal to or greater than the existing basin 100-year discharge at that location.

4.2.3 Improvements

Eleven existing drainageways require culverts crossing under E-470 or cross-roads between Station 643 and Station 1157, as shown on Drawings 4-11. Drainage cross culverts were designed based upon existing and proposed topography, and compatibility with future development plans. Required cross-culverts constructed in the initial E-470 phase are summarized in Table 4.1.

Generally in Area 4, existing drainageways are moderate to steep, with channel gradients varying up to 3%. E-470 cross-culverts are designed with longitudinal slopes from 0.3 to 3% percent to keep outlet velocities below 15 feet per second. Riprap erosion protection is provided at the culvert outlets and at the inlets where entrance conditions warrant.

The culvert hydraulic calculations listed in Appendix B are the headwater depth calculations for the cross-culverts.

Major culvert crossings are discussed as follows:

Smoky Hill Interchange

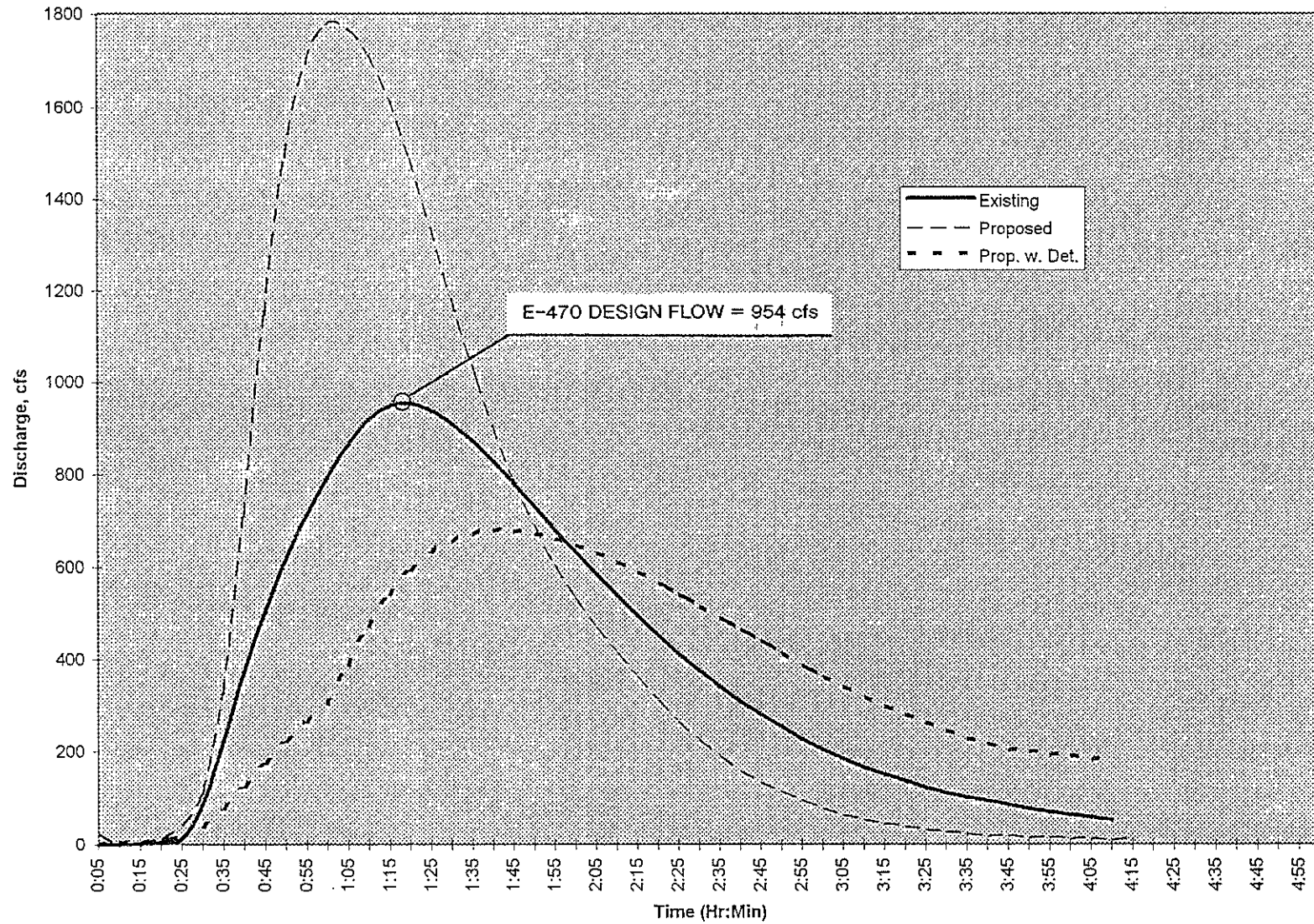
North of Smoky Hill Interchange at Station 660, a 66-inch RCP is proposed to drain an 88-acre basin to East Toll Gate Creek. To keep the culvert gradient mild, the inlet will be depressed.

Quincy Avenue

A single cell 8 x 8 box culvert drains the detention pond at East Toll Gate Creek (see Section 3.6). The 8 x 8 connects to the western cell of a 9-12-9 x 8 box culvert. The center 12 x 8 and eastern 9 x 8 will be plugged. The western 9 x 8 will be extended downstream to clear the proposed roadway embankment.

EAST TOLL GATE CREEK
E-470 AT QUINCY AVENUE

EXISTING AND FUTURE BASIN

100-YR FLOOD HYDROGRAPHS
E-470 DESIGN POINT 22

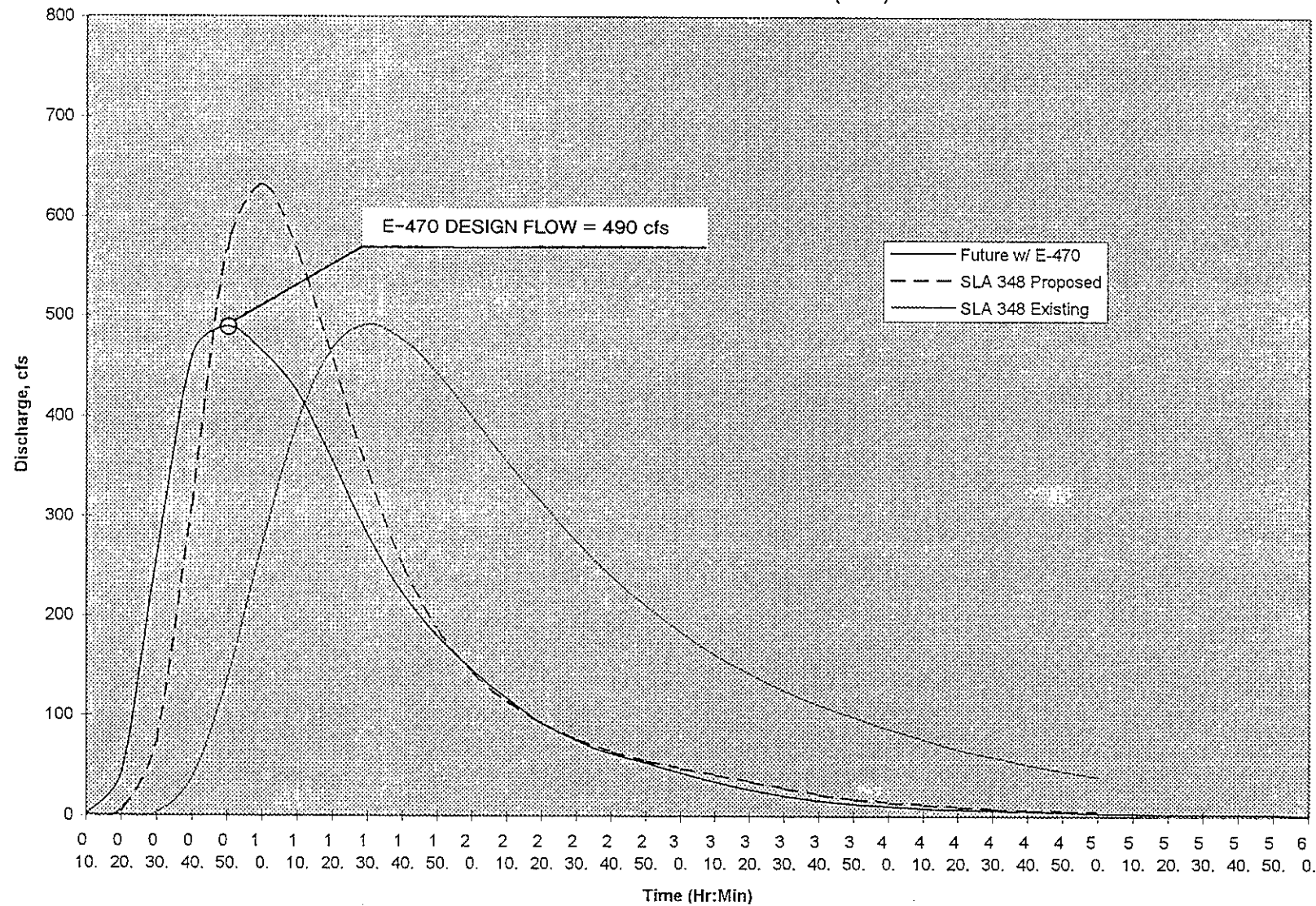
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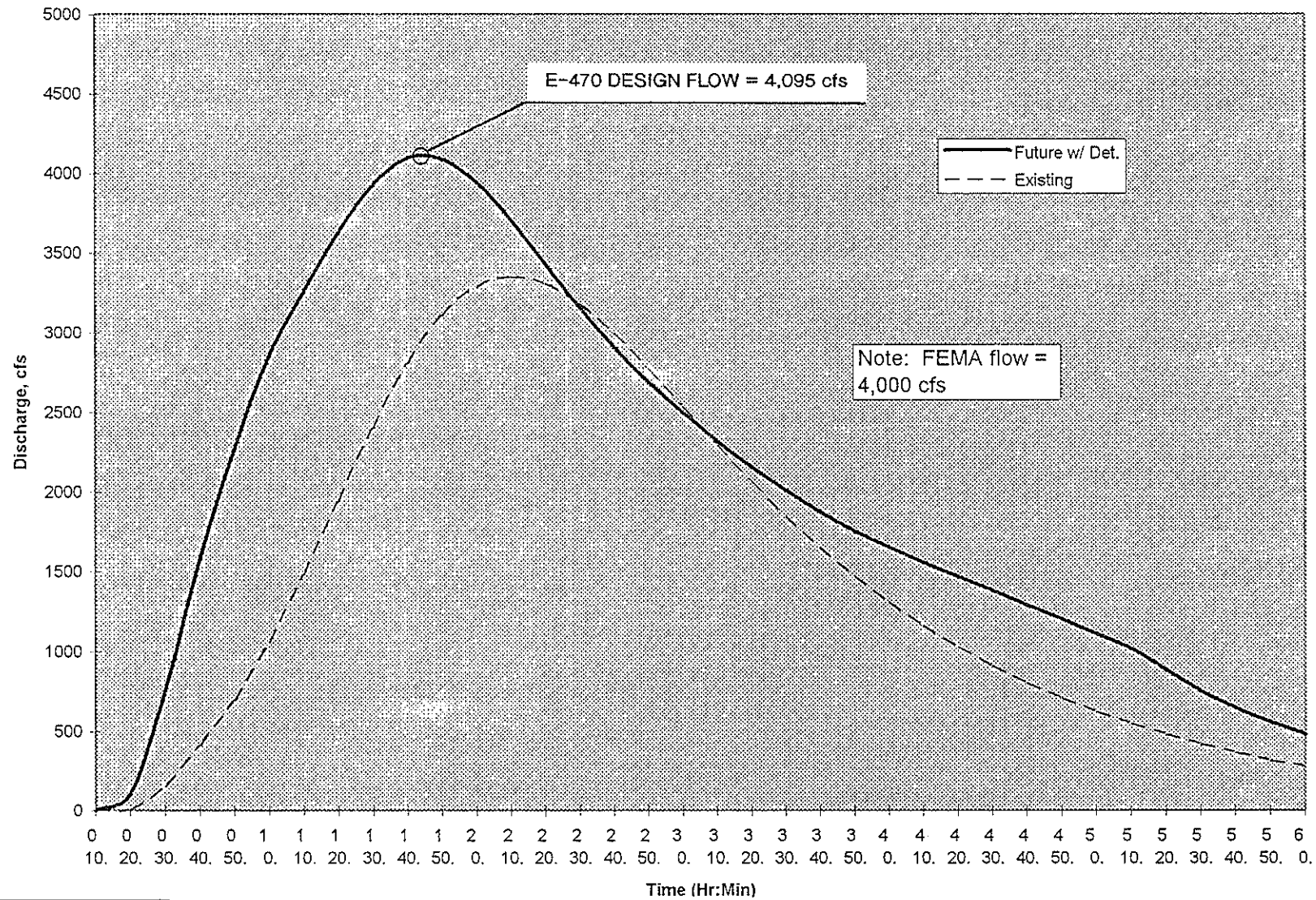
FIGURE 4.I

EXISTING AND FUTURE BASIN
NO DETENTION

100-YR FLOOD HYDROGRAPHS
WEST MURPHY CREEK AT SH30 (DP9)



100-YR FLOOD HYDROGRAPHS
MURPHY CREEK at E-470 (DP10)



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FIGURE 4.3

E-470 DESIGN AREA 4
STATION 643+00 TO 1157+00
ARAPAHOE COUNTY

TABLE 4.1 - CROSS CULVERT SUMMARY

1/27/97

E-470 DESIGN POINT	ROADWAY STATION	DRAINAGEWAY	100-YEAR DESIGN (CFS)	DESIGN CONCEPT		CULVERT PROFILE			
		(TRIBUTARY NAME) (BASIN IDENTIFICATION)		STRUCTURE (SIZE, TYPE)	END TREATMENT	DHW ELEV.	AHW ELEV.	OUTLET VELOCITY	OUTLET DEPTH
21	660+25	EAST TOLL GATE CREEK TRIBUTARY ETGC-104	203	66"X172' RCP	HEADWALLS & WINGWALLS RIPRAP AT OUTLET	5942.34	5942.71	17.77	2.67
22	804+70	EAST TOLL GATE CREEK (MAIN CHANNEL) ETGC-6	954	8'X8'X770' CBC	HEADWALLS & WINGWALLS RIPRAP AT OUTLET	5817.81	5819.66	21.88	4.03
23	821+40	EAST TOLL GATE CREEK TRIBUTARY ETGC-8	106	48"X420' RCP	FLARED END SECTION RIPRAP AT OUTLET	5809.53	5809.59	20.74	1.70
5	914+10	MURPHY CREEK TRIBUTARY MC-231	126	54"X1295' RCP	FLARED END SECTION RIPRAP AT OUTLET	5719.95	5720.56	10.12	3.29
6	937+25	MURPHY CREEK TRIBUTARY MC-241	142	54"X216' RCP	HEADWALLS & WINGWALLS RIPRAP AT OUTLET	5710.09	5710.14	17.26	2.31
7	20+82 (JEWELL AVE)	MURPHY CREEK TRIBUTARY MC-246	592	8'X8'X158' CBC	HEADWALLS & WINGWALLS RIPRAP AT OUTLET	5650.24	5653.50	20.15	3.67
8	29+35 (JEWELL AVE)	MURPHY CREEK TRIBUTARY MC-346	174	60"X185' RCP	HEADWALLS & WINGWALLS RIPRAP AT OUTLET	5638.07	5639.43	8.86	5.00
9	35+47 (S.H. 30)	MURPHY CREEK TRIBUTARY MC-348	489	8'X8'X90' CBC	HEADWALLS & WINGWALLS RIPRAP AT OUTLET	5569.59	5569.81	12.51	4.89
10	1043+72	MURPHY CREEK (MAIN CHANNEL) MC-345	4,095	6-9'X9'X204' CBC	HEADWALLS & WINGWALLS RIPRAP AT OUTLET	5547.53	5547.55	11.81	6.42
11	1094+00	COAL CREEK TRIBUTARY CC-85	441	2-72"X336' RCP	HEADWALLS & WINGWALLS RIPRAP AT OUTLET	5528.65	5529.70	15.69	2.99
12	1121+11	COAL CREEK TRIBUTARY CC-87	855	2-8'X6'X239' CBC	HEADWALLS & WINGWALLS RIPRAP AT OUTLET	5537.12	5537.14	16.08	3.32

CULVSUM.XLS

NOTE: DESIGN POINTS ARE BASED ON MAJOR DRAINAGE BASINS. SEE DRAINAGE BASIN MAP, APPENDIX C

Toll Plaza B

Two separate cross drains (double 42-inch RCP's and a single 54-inch RCP) are proposed at Toll Plaza B to convey large off-site basins through E-470.

Jewell Avenue

A single cell 8 x 8 box culvert under Jewell Avenue and a single cell 10 x 6 box culvert under the Jewell Avenue access road drain the Jewell Avenue interchange area from the south to the north towards Murphy Creek.

A 60-inch RCP conveys water from the south to the north under the east leg of Jewell Avenue.

SH30

North of SH30, E-470 crosses Murphy Creek. A 6 cell 9 x 9 box culvert is proposed in the main channel to pass Murphy Creek through E-470. East of E-470, SH30 crosses a tributary to Murphy Creek. A single cell 8 x 8 box culvert is proposed under SH30.

Coal Creek

E-470 crosses Coal Creek at approximately Station 1080. A 390-foot three-span bridge is proposed for the crossing (Hydraulic Analysis Report by MK Centennial, Reference 15).

6th Avenue

Two double 72-inch RCP cross culverts are proposed in the 6th Avenue interchange area. One under E-470 at Station 1094, the second under the access road at Station 18+75. Two double 8 x 6 cross culverts are also proposed in the 6th Avenue Interchange. One under E-470 at Station 1121, the second under the access road at Station 46+75. These culverts convey large drainage basins through E-470 to Coal Creek.

5.0 EROSION AND SEDIMENTATION CONTROL

5.1 Existing Site Conditions

Present land use in the project area consists primarily of crop and grazing lands. Predominant vegetative cover within the alignment is dry land crops or native grasses. There are no active streams or bodies of water within the project area. There are a few residences in the vicinity of the project, but otherwise there are no developed properties adjacent to the project.

A geotechnical investigation for this project indicates that topsoil within the project limits ranges from a total absence in some of the agricultural fields to as much as 6 or more inches in some of the drainageways. Manmade fills exist at the cross road locations.

5.2 E-470 Construction and Schedule

Grading and drainage structure construction will repeatedly follow this sequence throughout the project as the work progresses from location to location.

1. Slope staking will be completed defining the limits of earthwork and/or drainage work within the ROW or construction easement.
2. Temporary erosion control and sediment control measures will be installed or constructed.
3. Area will be cleared and grubbed.
4. Topsoil will be stripped and stockpiled.
5. Bases of fills will be moisture conditioned/subgrade prepped.
6. Embankments will be constructed and diversion drainage ditches will be constructed adjacent to fills.
7. RCP and box culverts will be installed.
8. Embankments will be constructed to top of common fill. Cuts will be brought to subgrade.
9. Unsuitable material will be identified and subexcavated within the roadway prism.
10. Select embankment material will be placed on top of common fill to pavement subgrade.
11. Subgrade will be toleranced.
12. Top 7" to 8" of subgrade will be chemically stabilized.

13. Chemically treated subgrade will be toleranced to ± 0.1 foot of finish subgrade for paving.
14. As back slopes of cuts and slopes of fills become available, fine grading and spreading of topsoil will take place. Permanent seeding operations will directly follow.
15. Finish shoulder grading and seeding will be completed as paving operations are completed.

5.3 Erosion Control Plan

The primary source of wind and water erosion will be from denuded and disturbed areas during construction of the project. BMP's consisting primarily of silt fence on embankments, temporary sedimentation basins, hay bale inlet protection and check structures in cut areas, and permanent seeding will be utilized to minimize the impact of grading. Once permanent seeding and paving are complete, the potential for wind and water erosion will be minimized.

Erosion and Sediment Control plans will be prepared for this project to show the location and type of temporary erosion control measures to be installed during construction. These BMP's will be installed generally following Colorado Department of Transportation's specifications in Section 208.

Active areas of earthwork operations will be watered a minimum of once per day and compacted according to the earthwork specifications contained in the contract. Disturbed areas where construction activities will not occur for a period of 30 or more days shall be stabilized within seven calendar days of the last day of operation. Throughout construction, as unpaved areas are completed topsoil placement and permanent seeding or landscaping operations will commence.

Mud and dirt carry-out onto paved roads will be prevented by construction of gravel entry ways as shown on the erosion control plans. Cleanup of paved surfaces will occur as necessary by sweeping.

All construction roads on site will be unpaved and will be within the cleared and grubbed areas where earthwork operations will take place. Construction roads will be for access and for hauling equipment and material from one work area to another. The only exception to this would be haul roads utilized during operations involving wasting of excess excavated material off-site or the import of embankment material from off-site sources.

Wind erosion from all active haul roads for this project will be controlled through sprinkling or use of chemical dust palliatives.

Adequate dust control equipment will be on site to control airborne dust caused by construction activities. The majority of earthwork activities involve one way hauls of 5,000 feet or less. Conventional earthmoving equipment (scrapers) will be used in excavating and

hauling this material. The haul roads utilized during this mode of construction will be continuously changing as embankments are filled and areas of excavation are removed. Sprinkling is the only feasible means of controlling dust during this type of earthmoving operation.

The use of chemical dust palliatives to control dust will be used on "long term" unsurfaced haul roads within the ROW or Utility Easements. Conditions may develop where the same haul road is utilized to transport material over an extended period. In these cases chemical dust palliatives will be used to control airborne dust.

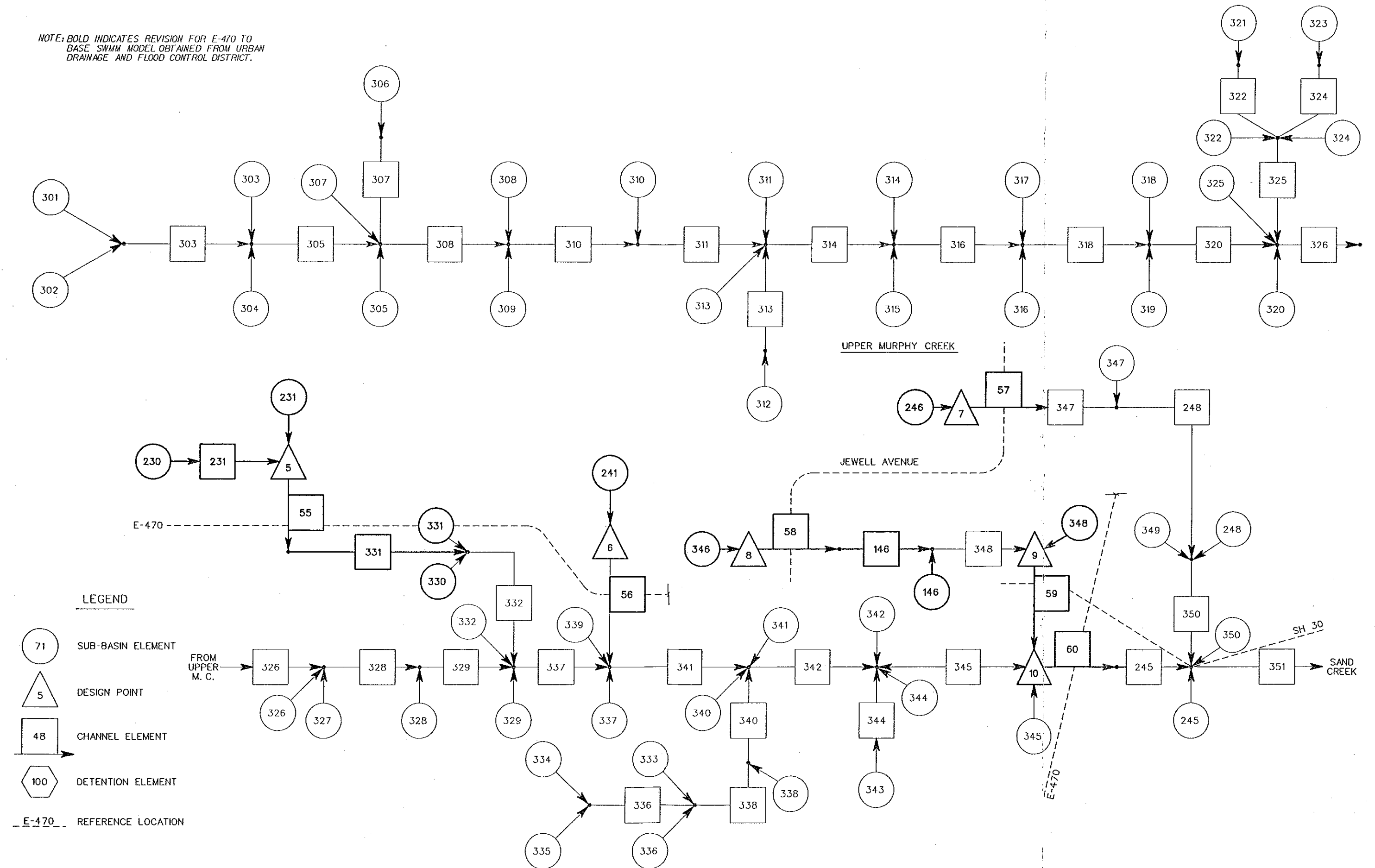
6.0 REFERENCES

1. WRC Engineering, Inc.; Arapahoe County Storm Drainage Design and Technical Criteria Manual; Urban Drainage & Flood Control District; January, 1986.
2. Wright-McLaughlin Engineers, Inc.; Urban Storm Drainage Criteria Manual; Urban Drainage & Flood Control District; 1969.
3. Simons, Li and Associates; City of Aurora Proposed Annexation Area Drainage Masterplan - Hydrology Report; City of Aurora; August 1985.
4. Simons, Li and Associates; Drainage Basin Plan for Annexation Study Area, Phase I - Development of Alternatives; City of Aurora; March 1986.
5. Kiowa Engineering Corp.; Upper Tollgate Creek Basin, Outfall Planning Study, Prelim. Design; City of Aurora; August 1990.
6. Colorado Department of Transportation; Roadway Design Manual; CDOT; 1990.
7. McLaughlin Water Engineers, LTD.; No Name Creek, No Name Creek Tributary, East Tollgate Creek & Murphy Creek Tributary Basins, Master Drainage Plan; East Cherry Creek Valley Water and Sanitation District; May 1986.
8. U.S.D.A. Soil Conservation Service; Soil Survey of Arapahoe County, Colorado; November, 1974.
9. Kiowa Engineering Corp.; Upper Sand Creek Basin, Outfall Planning Study, Prelim. Design; City of Aurora; August 1990.
10. Federal Highway Administration, HY-8 Version 4 Culvert Hydraulics Program.
11. U.S. Army Corps of Engineers; Flood Hazard Area Delineation, Murphy Creek; Urban Drainage & Flood Control District; March 1977.
12. Gingery & Assoc.; Flood Hazard Area Delineation, Murphy Creek; Urban Drainage and Flood Control District; October 1975.
13. Federal Emergency Management Agency; Flood Insurance Study, Arapahoe County; August 1985.
14. Chow, Ven Te; Open Channel Hydraulics; McGraw Hill; New York; 1969.
15. MK Centennial, Inc.; Hydraulic Analysis Report E-470 Bridges at Coal Creek; December 1996.
16. Boyle Engineering Corporation; Colorado Urban Hydrograph Procedure Computer Program - PC Version; Urban Drainage and Flood Control District; Denver; January, 1985.

17. Environmental Protection Agency and U.S. Army Corps of Engineers; Storm Water Management Model (SWMM); Urban Drainage and Flood Control District; 1987.

w:\1470dm\147040d\reports\drdra4.wp

NOTE: BOLD INDICATES REVISION FOR E-470 TO
BASE SWMM MODEL OBTAINED FROM URBAN
DRAINAGE AND FLOOD CONTROL DISTRICT.

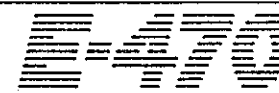


DATE OF PLOT: 01/21/97

DESIGN FILE: w:\470\plan\dra4003.dgn

DESIGNED BY:	DATE:	ISSUE RECORD							
DRAFTED BY:	CAD FILE NAME:	NO.	BY	PURPOSE	DATE	NO.	BY	PURPOSE	DATE
CHECKED BY:	W.B.H.								

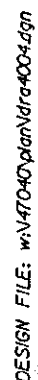
MK CENTENNIAL
CENTENNIAL ENGINEERING, INC.



EXISTING SWMM ROUTING SCHEMATIC
MURPHY CREEK

FIGURE
3.7

NOTE: LOWRY LANDFILL BASINS 321 THROUGH 325
NOT INCLUDED IN MASTER PLAN PROPOSED
CONDITIONS RUN.



E-470 REFERENCE LOCATION

MK CENTENNIAL
CENTENNIAL ENGINEERING INC.

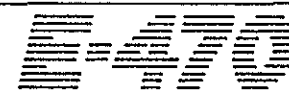


FIGURE 3.8

APPENDIX A

RATIONAL CALCULATIONS

STORM DRAINAGE SYSTEM DESIGN (RATIONAL METHOD PROCEDURE)														Design Storm: 10 - YEAR										Calc. by: MEB Chk'd by: ALM Date: 1/27/97			
LOCATION: DRAWING 7				INITIAL DESIGN				ARAPAHOE COUNTY																			
STATION	DESIGN POINT	DIRECT RUNOFF							TOTAL RUNOFF				DITCH OR PIPE	n	ROUGHNESS	DITCH				PIPE			TRAVEL TIME			REMARKS	
		BASIN	AREA (AC)	COEFF. (C)	Tc (Min.)	C*A	I (in./hr.)	Q (cfs)	Sum Tc (min.)	I (in./hr.)	Sum CA	Total Q (cfs)				SLOPE %	FLOW (CFS)	FRONT SLOPE	BOTTOM WIDTH	BACK SLOPE	FLOW (CFS)	MIN. SLOPE %	PIPE SIZE (IN.)	LENGTH (FT)	VEL. (FPS)		TRAVEL TIME Tt
						2.46			49.9	1.88	2.46	4.6	D	0.040			4.6	6.0	2.0	3.0		1.53%		1225	2.23	9.2	FLOW FROM DP 33 (DRAWING #6)
892+25/14.0	1	M1	1.18	0.13	15.1	0.15	3.73	0.6	15.1	3.73	0.15	0.6	P	0.012							0.6	2.00%	24	64	4.18	0.3	TYPE "K" INLET
									59.1	1.88	2.61	4.4	D	0.040			4.4	6.0	2.0	3.0		0.49%		2150	1.40	25.6	DITCH TO DP 2
914+00/150.0	2	E1	15.30	0.37	36.7	5.66	2.29	13.0	84.7	1.31	5.81	7.6	D	0.040			7.6	3.0	2.0	3.0		5.00%		120	4.10	0.5	TYPE "D" INLET
																											CONNECT TO 54" RCP
						4.46			21.5	3.12	4.46	13.9	D	0.040			13.9	6.0	2.0	3.0		1.53%		3225	2.82	19.1	FLOW FROM DP 34 (DRAWING #6)
914+50/180.0	3	W1	18.71	0.37	38.0	6.92	2.24	15.5	40.6	2.15	6.92	14.9	P	0.012							14.9	0.30%	54	1300	2.00	10.8	54" FLARED END SECTION
917+00/70.0	4	W3	0.41	0.90	9.1	0.37	4.63	1.7	9.1	4.63	0.37	1.7	P	0.012							1.7	0.30%	24	66	2.93	0.4	TYPE "R" INLET
917+00/0.0	7	M2	2.57	0.13	23.9	0.32	2.95	0.9	23.9	2.95	0.69	2.0	P	0.012							2.0	0.30%	24	66	3.07	0.4	TYPE "C" INLET
917+00/70.0	8	E3	0.48	0.90	10.2	0.43	4.43	1.9	24.3	2.92	1.12	3.3	P	0.012							3.3	0.30%	24	264	3.54	1.2	TYPE "R" INLET
									25.5	2.84	1.12	3.2	D	0.040			3.3	4.0	4.0	0.0		2.30%		450	2.41	3.1	DITCH TO DP 17
917+00/330.0	17	E7	1.78	0.27	15.1	0.48	3.73	1.8	28.6	2.66	1.60	4.3	P	0.012							4.3	0.30%	24	22	3.80	0.1	24" FLARED END SECTION
																											OUTFALL INTO DETENTION POND
919+85/150.0	9	E2	0.86	0.90	9.4	0.77	4.57	3.5	9.4	4.57	0.77	3.5	P	0.012							3.5	2.00%	24	132	7.07	0.3	TYPE "R" INLET
920+06/372.0	19	E9	0.61	0.56	11.4	0.34	4.23	1.4	11.4	4.23	0.34	1.4	P	0.012							1.4	2.00%	24	86	5.39	0.3	TYPE "R" INLET
919+85/288.0	12	E8	0.78	0.13	11.1	0.10	4.28	0.4	11.7	4.19	1.21	5.1	P	0.012							5.1	3.20%	24	28	9.33	0.1	TYPE "C" INLET
11+43/15.0	11	E5	0.14	0.90	5.0	0.13	5.60	0.7	11.7	4.18	1.34	5.6	P	0.012							5.6	3.20%	24	28	9.58	0.0	TYPE "R" INLET
11+43/15.0	10	E6	0.12	0.90	5.0	0.11	5.60	0.6	11.8	4.18	1.45	6.0	P	0.012							6.0	2.00%	24	110	8.27	0.2	TYPE "R" INLET
																											OUTFALL INTO DETENTION POND
923+50/138.0	13	W2	2.69	0.59	13.7	1.59	3.91	6.2	13.7	3.91	1.59	6.2	P	0.012							6.2	2.00%	24	68	8.34	0.1	TYPE "C" INLET
923+50/66.0	14	W4	0.55	0.90	10.8	0.50	4.33	2.1	13.8	3.89	2.08	8.1	P	0.012							8.1	2.00%	24	64	9.00	0.1	TYPE "R" INLET
923+50/0.0	15	M3	0.78	0.13	12.9	0.10	4.01	0.4	14.0	3.87	2.18	8.4	P	0.012							8.4	2.00%	24	66	9.09	0.1	TYPE "C" INLET
923+50/66.0	16	E4	0.54	0.90	10.8	0.49	4.33	2.1	14.1	3.86	2.67	10.3	P	0.012							10.3	2.00%	24	110	9.62	0.2	TYPE "R" INLET
																											DITCH TO DETENTION POND
930+50/90.0	18	W5	1.52	0.70	11.6	1.06	4.20	4.5	11.6	4.20	1.06	4.5	D	0.040			4.5	3.0	4.0	3.0		1.80%		700	2.27	5.1	SPECIAL DITCH TO DP 6

STORM DRAINAGE SYSTEM DESIGN

(RATIONAL METHOD PROCEDURE)

Design Storm: 100 YEAR

Calc. by: MEB

Chk'd by: ALM

Date: 1/27/97

LOCATION: DRAWING 7

INITIAL DESIGN

ARAPAHOE COUNTY

STATION	DESIGN POINT	DIRECT RUNOFF							TOTAL RUNOFF				DITCH OR PIPE	n	DITCH					PIPE			TRAVEL TIME			REMARKS
		BASIN	AREA (AC)	COEFF. (C)	Tc (Min.)	CvA	I (in./hr.)	Q (cfs)	Sum Tc (min.)	I (in./hr.)	Sum CA	Total Q (cfs)			SLOPE %	FLOW (CFS)	FRONT SLOPE	BOTTOM WIDTH	BACK SLOPE	FLOW (CFS)	MIN. SLOPE %	PIPE SIZE (IN.)	LENGTH (FT)	VEL. (FPS)	TRAVEL TIME Tt	
						4.65			39.2	3.56	4.65	16.6	D	0.040						1.53%		1225	3.07	6.7	FLOW FROM DP 33 (DRAWING #6)	
892+25/14.0	1	M1	1.18	0.30	15.1	0.35	6.04	2.1	15.1	6.04	0.35	2.1	P	0.012		16.6	6.0	2.0	3.0	2.1	2.00%	24	64	6.09	0.2	TYPE "K" INLET
									45.9	3.22	5.00	16.1	D	0.040		16.1	6.0	2.0	3.0		0.49%		2150	1.96	18.3	DITCH TO DP 2
914+00/150.0	2	E1	15.30	0.50	36.7	7.65	3.71	28.4	64.2	2.58	8.00	20.6	D	0.040		20.6	3.0	2.0	3.0		5.00%		120	5.34	0.4	TYPE "D" INLET
																									CONNECT TO 54" RCP	
						6.00			21.0	5.12	6.00	30.7	D	0.040		30.7	6.0	2.0	3.0		1.53%		3225	3.45	15.6	FLOW FROM DP 34 (DRAWING #6)
914+50/-180.0	3	W1	18.71	0.50	38.0	9.36	3.63	34.0	36.6	3.72	9.36	34.8	P	0.012						34.8	0.30%	54	1300	2.19	9.9	54" FLARED END SECTION
917+00/-70.0	4	W3	0.41	0.93	9.1	0.38	7.49	2.9	9.1	7.49	0.38	2.9	P	0.012						2.9	0.30%	24	86	3.41	0.3	TYPE "R" INLET
917+00/0.0	7	M2	2.57	0.30	23.9	0.77	4.77	3.7	23.9	4.77	1.15	5.5	P	0.012						5.5	0.30%	24	66	4.06	0.3	TYPE "C" INLET
917+00/70.0	8	E3	0.48	0.93	10.2	0.45	7.17	3.2	24.2	4.74	1.60	7.6	P	0.012						7.6	0.30%	24	264	4.40	1.0	TYPE "R" INLET
									25.2	4.63	1.60	7.4	D	0.040		7.6	4.0	4.0	0.0		2.30%		450	3.41	2.2	DITCH TO DP 17
917+00/330.0	17	E7	1.78	0.41	15.1	0.73	6.04	4.4	27.4	4.42	2.33	10.3	P	0.012						10.3	0.30%	24	22	4.71	0.1	24" FLARED END SECTION
																									OUTFALL INTO DETENTION POND	
919+85/150.0	9	E2	0.86	0.93	9.4	0.80	7.40	5.9	9.4	7.40	0.80	5.9	P	0.012						5.9	2.00%	24	132	8.23	0.3	TYPE "R" INLET
920+06/372.0	19	E9	0.81	0.65	11.4	0.40	6.85	2.7	11.4	6.85	0.40	2.7	P	0.012						2.7	2.00%	24	86	6.56	0.2	TYPE "R" INLET
919+85/288.0	12	E8	0.78	0.30	11.1	0.23	6.93	1.6	11.6	6.79	1.43	9.7	P	0.012						9.7	3.20%	24	28	11.21	0.0	TYPE "C" INLET
11+43/15.0	11	E5	0.14	0.93	5.0	0.13	9.06	1.2	11.7	6.78	1.56	10.6	P	0.012						10.6	3.20%	24	28	11.49	0.0	TYPE "R" INLET
11+43/15.0	10	E6	0.12	0.93	5.0	0.11	9.06	1.0	11.7	6.77	1.67	11.3	P	0.012						11.3	2.00%	24	110	9.86	0.2	TYPE "R" INLET
																									OUTFALL INTO DETENTION POND	
923+50/-138.0	13	W2	2.69	0.68	13.7	1.83	6.32	11.6	13.7	6.32	1.83	11.6	P	0.012						11.6	2.00%	24	68	9.93	0.1	TYPE "C" INLET
923+50/-66.0	14	W4	0.55	0.93	10.8	0.51	7.00	3.6	13.8	6.30	2.34	14.7	P	0.012						14.7	2.00%	24	64	10.58	0.1	TYPE "R" INLET
923+50/0.0	15	M3	0.78	0.30	12.9	0.23	6.49	1.5	13.9	6.28	2.57	16.2	P	0.012						16.2	2.00%	24	66	10.85	0.1	TYPE "C" INLET
923+50/66.0	16	E4	0.54	0.93	10.8	0.50	7.00	3.5	14.0	6.26	3.08	19.2	P	0.012						19.2	2.00%	24	110	11.31	0.2	TYPE "R" INLET
																									DITCH TO DETENTION POND	
930+50/-90.0	18	W5	1.52	0.77	11.6	1.17	6.80	8.0	11.6	6.80	1.17	8.0	D	0.040		8.0	3.0	4.0	3.0		1.80%		700	2.71	4.3	SPECIAL DITCH TO DP 6

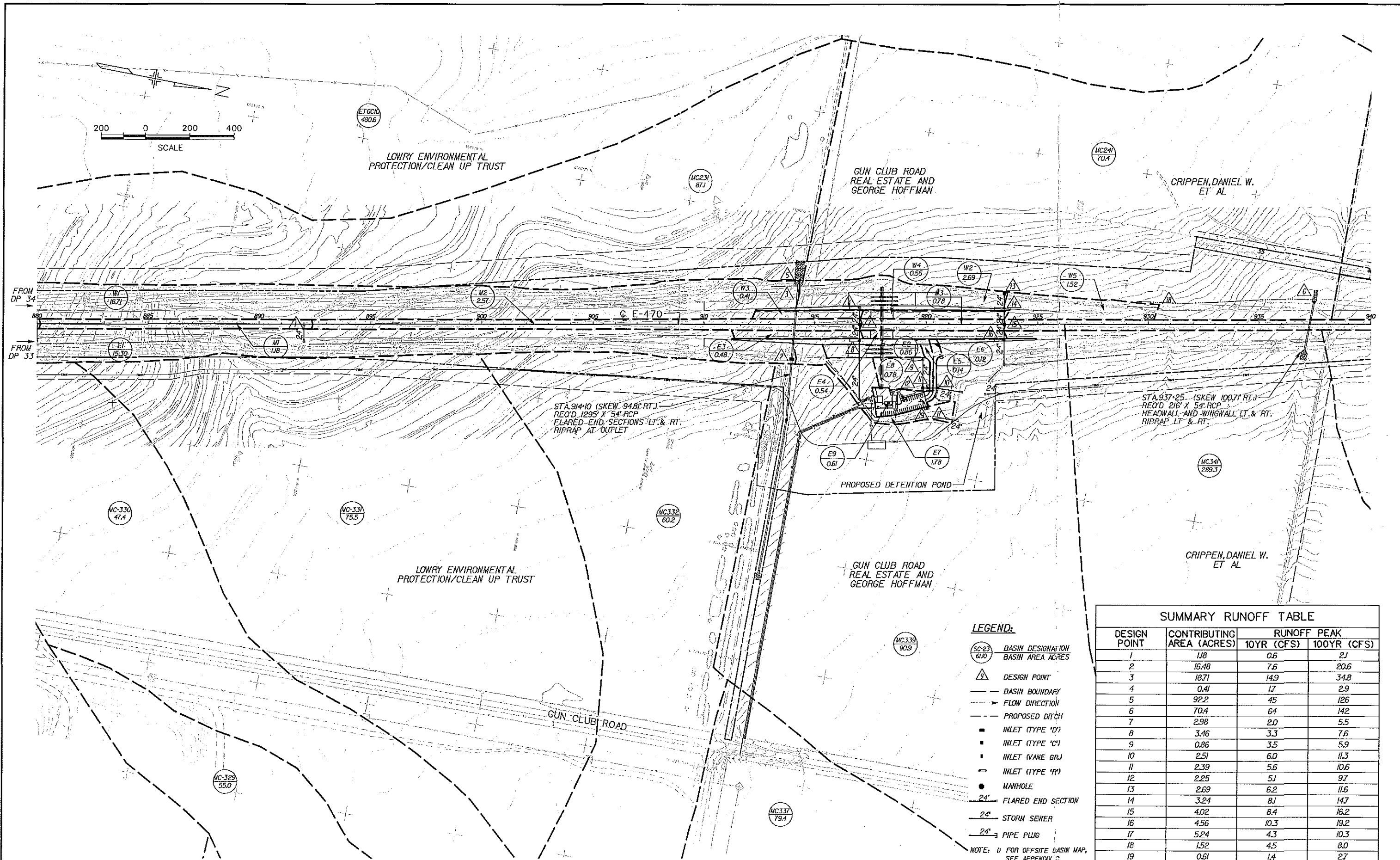
COMPOSITE 'C' FACTORS												
LOCATION: DRAWING 7			INITIAL DESIGN			BY: MEB			DATE: 1/27/97			
BASIN	AREAS (FT^2)			PAVED 'C' FACTOR			UNPAVED 'C' FACTOR			COMPOSITE 'C' FACTOR		
DESIGNATION	PAVED	UNPAVED	TOTAL	5 YEAR	10 YEAR	100 YEAR	5 YEAR	10 YEAR	100 YEAR	5 YEAR	10 YEAR	100 YEAR
E1	206,640	459,785	666,425	0.88	0.90	0.93	0.055	0.125	0.30	0.31	0.37	0.50
E2	37,345	0	37,345	0.88	0.90	0.93	0.055	0.125	0.30	0.88	0.90	0.93
E3	20,895	0	20,895	0.88	0.90	0.93	0.055	0.125	0.30	0.88	0.90	0.93
E4	23,570	0	23,570	0.88	0.90	0.93	0.055	0.125	0.30	0.88	0.90	0.93
E5	6,135	0	6,135	0.88	0.90	0.93	0.055	0.125	0.30	0.88	0.90	0.93
E6	5,340	0	5,340	0.88	0.90	0.93	0.055	0.125	0.30	0.88	0.90	0.93
E7	14,115	63,300	77,415	0.88	0.90	0.93	0.055	0.125	0.30	0.21	0.27	0.41
E8	0	34,180	34,180	0.88	0.90	0.93	0.055	0.125	0.30	0.06	0.13	0.30
E9	15,060	11,710	26,770	0.88	0.90	0.93	0.055	0.125	0.30	0.52	0.56	0.65
W1	257,935	557,095	815,030	0.88	0.90	0.93	0.055	0.125	0.30	0.32	0.37	0.50
W2	70,310	46,850	117,160	0.88	0.90	0.93	0.055	0.125	0.30	0.55	0.59	0.68
W3	17,875	0	17,875	0.88	0.90	0.93	0.055	0.125	0.30	0.88	0.90	0.93
W4	23,835	0	23,835	0.88	0.90	0.93	0.055	0.125	0.30	0.88	0.90	0.93
W5	48,935	17,095	66,030	0.88	0.90	0.93	0.055	0.125	0.30	0.67	0.70	0.77
M1	0	51,450	51,450	0.88	0.90	0.93	0.055	0.125	0.30	0.06	0.13	0.30
M2	0	111,785	111,785	0.88	0.90	0.93	0.055	0.125	0.30	0.06	0.13	0.30
M3	0	33,800	33,800	0.88	0.90	0.93	0.055	0.125	0.30	0.06	0.13	0.30

E-470 DESIGN AREA 4B
STATION 880+00 TO 940+00

TIME OF CONCENTRATION - MAIN LINE

TIME OF CONCENTRATION														REMARKS
LOCATION: DRAWING 7			INITIAL DESIGN			BY: MEB				DATE: 1/27/97				FORMULAS: $T_i = 1.8 (1.1 - C_5) L^{0.5} / S^{1/3}$ $T_t = (11.8 L^{1/3} / H)^{0.385} \times 60$
SUB-BASIN DATA			INIT./OVERLAND TIME (T _i)			TRAVEL TIME (T _t)				TOTAL	T _c Check (Urbanized Basins)		FINAL T _c	
DESIGNATION	C ₅	AREA (AC)	LENGTH (FT)	SLOPE %	T _i (Min.)**	LENGTH (FT)	DIF. BL.	VEL. (FPS)	T _t (Min.)**	T _i + T _t (Min.)	LGTH. (FT)	= (L/180) +	(minutes)	
E1	0.31	15.30	70.00	33.00	3.71	5300.00	57.00	2.68	32.97	36.7	5370.00	39.8	36.7	
E2	0.88	0.86	85.00	2.00	2.90	440.00	2.20	1.13	6.52	9.4	525.00	12.9	9.4	
E3	0.88	0.48	40.00	2.00	1.99	580.00	2.80	1.18	8.17	10.2	620.00	13.4	10.2	
E4	0.88	0.54	40.00	2.00	1.99	650.00	3.20	1.22	8.85	10.8	690.00	13.8	10.8	
E5	0.88	0.14	85.00	2.00	2.90	150.00	3.00	1.50	1.67	4.6	235.00	11.3	5.0	
E6	0.88	0.12	85.00	2.00	2.90	150.00	3.00	1.50	1.67	4.6	235.00	11.3	5.0	
E7	0.21	1.78	85.00	2.00	11.78	840.00	15.00	2.13	6.57	18.3	925.00	15.1	15.1	
E8	0.06	0.78	30.00	2.00	8.18	275.00	4.50	1.59	2.87	11.1	305.00	11.7	11.1	
E9	0.52	0.61	100.00	1.20	9.84	150.00	2.00	1.28	1.95	11.8	250.00	11.4	11.4	
W1	0.32	18.71	70.00	33.00	3.68	5420.00	55.00	2.63	34.30	38.0	5490.00	40.5	38.0	
W2	0.55	2.69	30.00	33.00	1.69	950.00	4.50	1.32	12.03	13.7	980.00	15.4	13.7	
W3	0.88	0.41	40.00	2.00	1.99	490.00	2.40	1.14	7.13	9.1	530.00	12.9	9.1	
W4	0.88	0.55	40.00	2.00	1.99	650.00	3.20	1.22	8.85	10.8	690.00	13.8	10.8	
W5	0.67	1.52	30.00	33.00	1.33	680.00	2.50	1.11	10.25	11.6	710.00	13.9	11.6	
M1	0.06	1.18	30.00	16.67	4.03	1225.00	12.00	1.85	11.06	15.1	1255.00	17.0	15.1	
M2	0.06	2.57	30.00	16.67	4.03	2475.00	12.00	1.65	24.93	29.0	2505.00	23.9	23.9	
M3	0.06	0.78	30.00	16.67	4.03	650.00	3.20	1.22	8.85	12.9	680.00	13.8	12.9	

DESIGN FILE: W:\47040\plan\dr-46011.dgn DATE OF PLOT: 01/28/97



LEGEND:

- SC-23 BASIN DESIGNATION
- 6100 BASIN AREA ACRES
- DESIGN POINT
- BASIN BOUNDARY
- FLOW DIRECTION
- PROPOSED DITCH
- INLET (TYPE 'D')
- INLET (TYPE 'C')
- INLET (VANE GR)
- INLET (TYPE 'R')
- MANHOLE
- 24" FLARED END SECTION
- 24" STORM SEWER
- 24" PIPE PLUG

NOTE: 1) FOR OFFSITE BASIN MAP, SEE APPENDIX C

SUMMARY RUNOFF TABLE

DESIGN POINT	CONTRIBUTING AREA (ACRES)	RUNOFF PEAK	
		10YR (CFS)	100YR (CFS)
1	1.18	0.6	2.1
2	16.48	7.6	20.6
3	18.71	14.9	34.8
4	0.41	1.7	2.9
5	92.2	45	126
6	70.4	64	142
7	2.98	2.0	5.5
8	3.46	3.3	7.6
9	0.86	3.5	5.9
10	2.51	6.0	11.3
11	2.39	5.6	10.6
12	2.25	5.1	9.7
13	2.69	6.2	11.6
14	3.24	8.1	14.7
15	4.02	8.4	16.2
16	4.56	10.3	19.2
17	5.24	4.3	10.3
18	1.52	4.5	8.0
19	0.61	1.4	2.7

DESIGNED BY:	MEB	DATE:		ISSUE RECORD			
DRAFTED BY:	RKM	CAD FILE NAME:		NO.	BY	PURPOSE	DATE
CHECKED BY:	ALM	W.B.N.:					

MK CENTENNIAL
CENTENNIAL ENGINEERING, INC.



PRELIMINARY DRAINAGE PLAN
STATION 880+00 TO 940+00 INITIAL ROADWAY

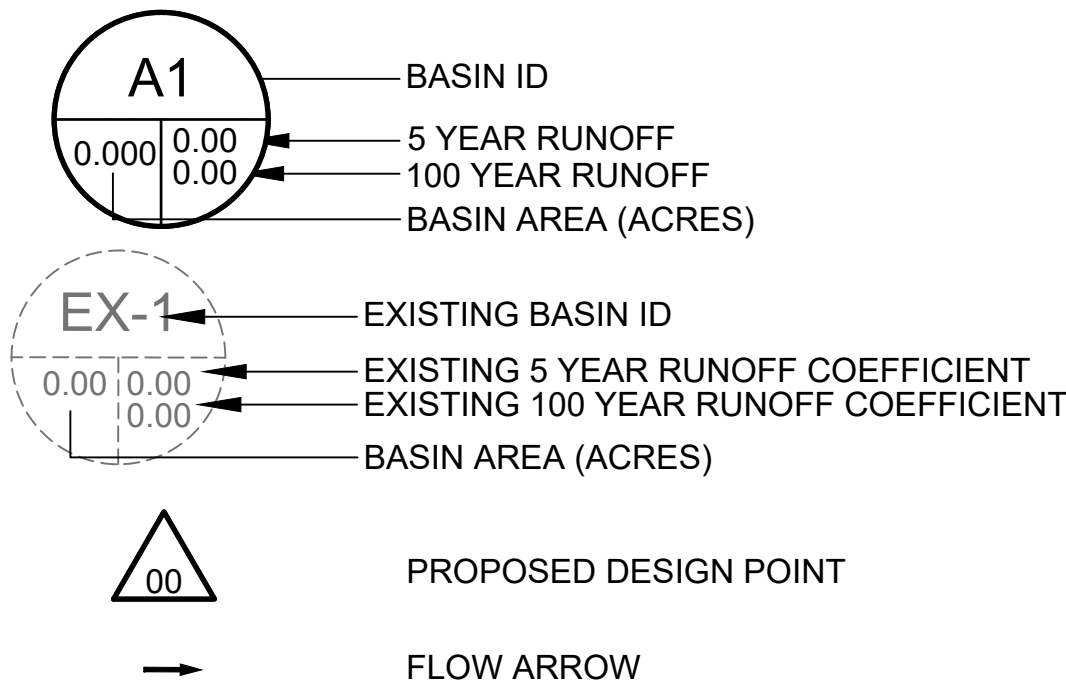
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Appendix D – Final Drainage Plan

I:\2021\21003 - Project Bronco\CA00\Sheet Sets\21003.003 Aurora Proposed Drainage Map-working.dwg tab: DRAINAGE MAP 1 Mar 30, 2022 - 11:09am wconway

DRAINAGE LEGEND

- 5281--- EXISTING MINOR CONTOUR
- 5280--- EXISTING MAJOR CONTOUR
- 5281--- PROPOSED MINOR CONTOUR
- 5280--- PROPOSED MAJOR CONTOUR
- PROPOSED STORM SEWER LINE
- PROPOSED OPEN CHANNEL
- FEMA--- FEMA 100-YEAR FLOOD PLAIN
- FEMA ZONE X
- PROPOSED BASIN BOUNDARY

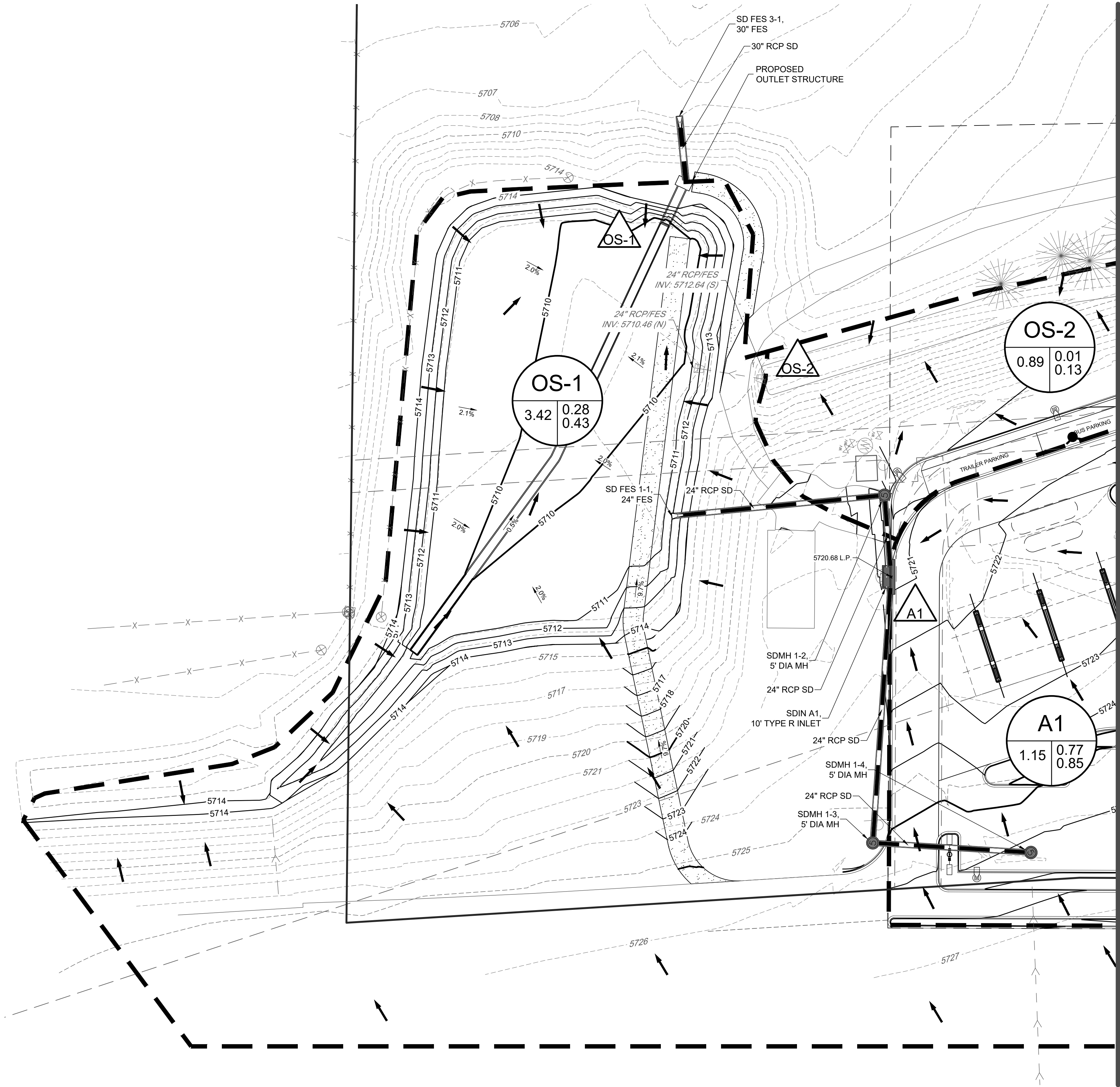
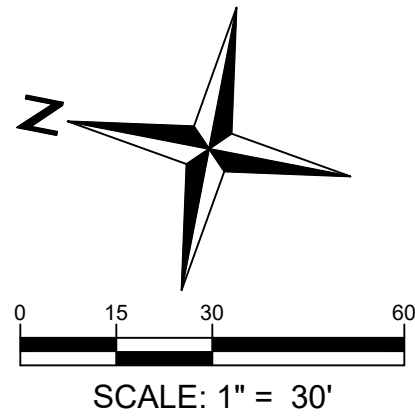


RUNOFF SUMMARY TABLE					
DESIGN POINT	DESIGN BASIN	AREA (AC)	Peak Flows (cfs)		STRUCTURE
			Q5	Q100	
A1	A1	1.15	2.82	8.78	10' TYPE R INLET
A2	A2	0.83	1.95	6.24	10' TYPE R INLET
A3	A3	0.94	2.16	7.01	CHASE

Approved For One Year From This Date

City Engineer Date

Water Department Date



PROJECT BRONCO - AURORA

PROPOSED DRAINAGE PLAN

SHEET

DNG-1

DRAWN	WPC
CHECKED	MC
APPROVED	MC
PROJECT NO.	21003.003
HORIZ. SCALE	1" = 30'
VERT. SCALE	NA

NOTES

DATE NO.

I:\2021\21003 - Project Bronco\CA00\Sheet Sets\21003.003 Aurora Proposed Drainage Map--working.dwg tab: DRAINAGE MAP 2 Mar 30, 2022 - 11:09am wconway

DRAINAGE LEGEND

- 5281--- EXISTING MINOR CONTOUR
- 5280--- EXISTING MAJOR CONTOUR
- 5281--- PROPOSED MINOR CONTOUR
- 5280--- PROPOSED MAJOR CONTOUR
- PROPOSED STORM SEWER LINE
- PROPOSED OPEN CHANNEL
- FEMA --- FEMA 100-YEAR FLOOD PLAIN
- FEMA --- FEMA ZONE X
- PROPOSED BASIN BOUNDARY

- A1** BASIN ID
- 0.000 0.00 5 YEAR RUNOFF
- 0.00 100 YEAR RUNOFF
- 0.00 BASIN AREA (ACRES)
- EX-1** EXISTING BASIN ID
- 0.00 0.00 EXISTING 5 YEAR RUNOFF COEFFICIENT
- 0.00 EXISTING 100 YEAR RUNOFF COEFFICIENT
- 0.00 BASIN AREA (ACRES)
- 00** PROPOSED DESIGN POINT
- FLOW ARROW

RUNOFF SUMMARY TABLE					
DESIGN POINT	DESIGN BASIN	AREA (AC)	Peak Flows (cfs)		STRUCTURE
			Q5	Q100	
A1	A1	1.15	2.82	8.78	10' TYPE R INLET
A2	A2	0.83	1.95	6.24	10' TYPE R INLET
A3	A3	0.94	2.16	7.01	CHASE

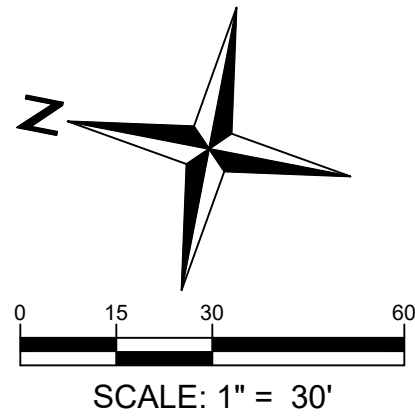
Approved For One Year From This Date

City Engineer

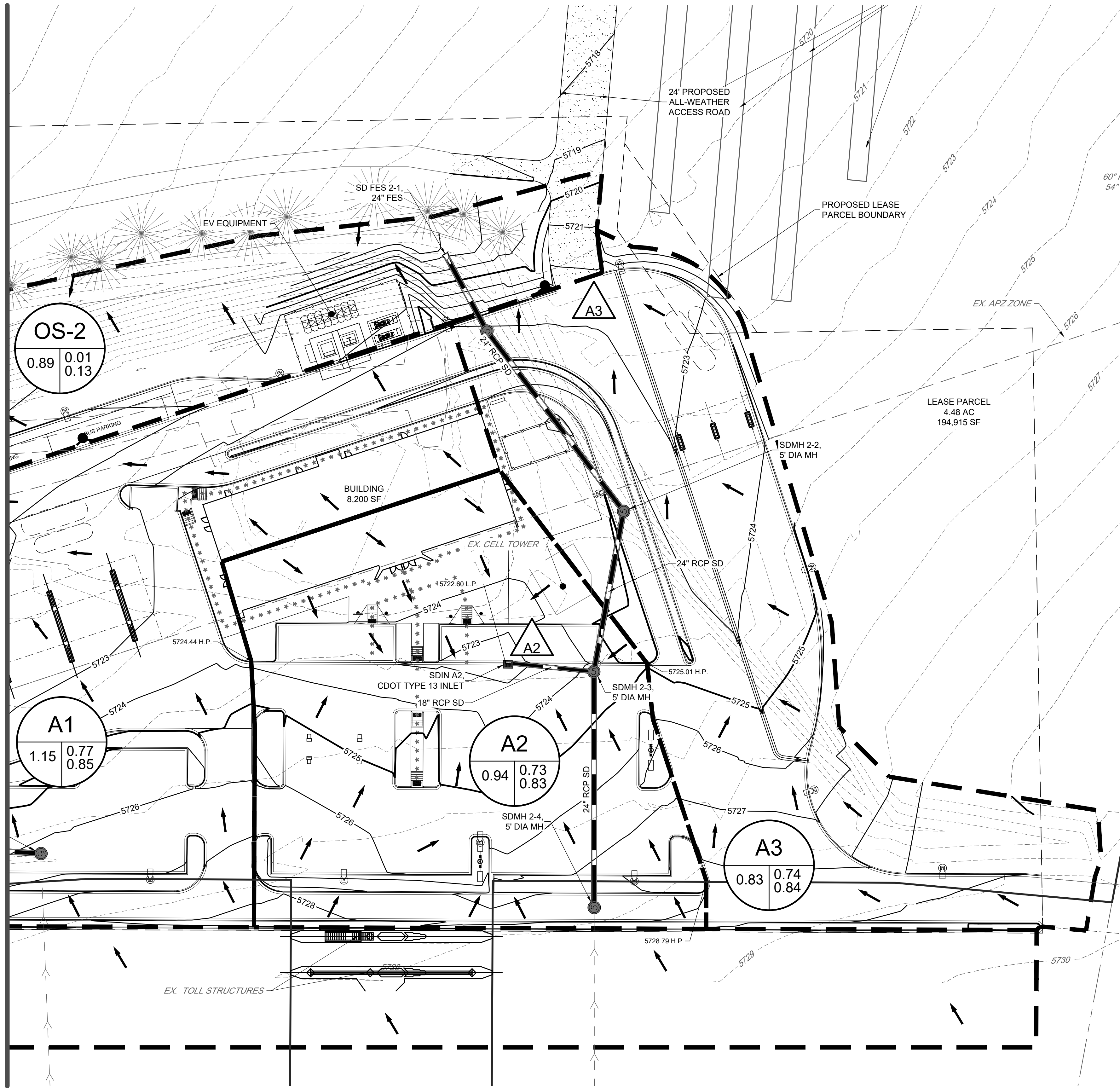
Water Department

Date

Date



MATCHLINE - SEE SHEET DNG-1



PROJECT BRONCO - AURORA

PROPOSED DRAINAGE PLAN

SHEET

DNG-2

DRAWN	WPC
CHECKED	MC
APPROVED	MC
PROJECT NO.	21003.003
HORIZ. SCALE	1" = 30'
VERT. SCALE	NA

NOTES

DATE NO.