



# FINAL DRAINAGE REPORT

## **King Soopers Fuel #30**

Lot 1, Block 1, First National Bank of Aurora  
Subdivision Filing No. 1  
Aurora, Colorado

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PREPARED FOR:  
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PREPARED BY:  
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Attn: Jessica Greenough, PE

DATE:  
July 16, 2021

### **ENGINEER'S STATEMENT**

*I affirm that this report and plan for the Final drainage design for King Soopers Fuel #30 was prepared by me (or under my direct supervision) in accordance with the provisions of the City of Aurora Storm Drainage and Technical Criteria Manual for the owners thereof. I understand that the City of Aurora does not and will not assume liability for drainage facilities designed by others.*

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Jessica Greenough, PE 53368  
For and on behalf of Galloway & Company, Inc.

---

Date

### **DEVELOPER'S CERTIFICATION**

*"KRF Idaho, LLC hereby certifies that the drainage facilities for King Soopers Fuel #30 shall be constructed according to the design presented in this report. I understand that the City of Aurora does not and will not assume liability for the drainage facilities designed and/or certified by my engineer and that the City of Aurora reviews drainage plans pursuant to the Municipal Code; but cannot, on behalf of KRF Idaho, LLC, guarantee that final drainage design review will absolve KRF Idaho, LLC and/or their successors and/or assigns of future liability for improper design."*

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Authorized Signature  
KRF Idaho, LLC

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Date

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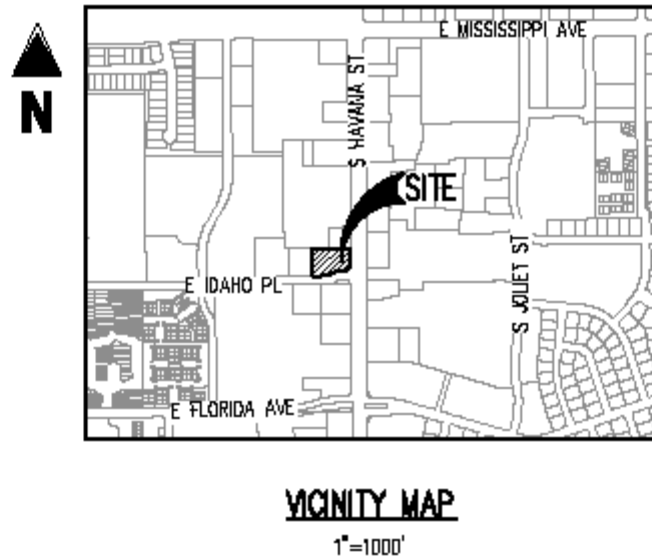
### Appendices:

- A. Hydrologic Calculations
- B. Hydraulic Calculations
- C. Drainage Map
- D. Exhibits and Figures

## I. Introduction

### Location

The King Soopers fuel site is located at 1369 South Havana Street in Aurora, Colorado at the northwest corner of South Havana Street and East Idaho Place. The site is more specifically located at Lot 1, Block 1, First National Bank of Aurora Subdivision Filing No. 1. The site is contained within the northeast quarter of Section 22, Township 4 South, Range 67 West of the 6<sup>th</sup> Principal Meridian, City of Aurora, County of Arapahoe, State of Colorado. The site consists of one parcel. It is rectangular in shape. The parcel currently contains 10 ATMs and a bank. The site is bounded by South Havana Street to the east, East Idaho Place to the south, an existing KS Auto Repair and Body shop owned by Mayad LLC to the west, and an existing Shortline Collision Center owned by Hicks Properties 1301 LLC to the north.



### Description of Property

The project site consists of approximately 1.01 acres of asphalt paving, landscaping, building, and canopy. The existing ground generally slope from southeast to northwest, with slopes ranging from 0.5% to 8%.

The NRCS Web Soil Survey of Arapahoe County, Colorado indicates site soils to be 100% Bijou sandy loam, wet, 0 to 3 percent slopes, hydrologic soil group A. Refer to Appendix D for soil survey information.

A review of the Flood Insurance Rate Map (FIRM) by the Federal Agency Management Agency (FEMA) panel 08005C0178K, shows the entire proposed development within an area of minimal flood hazard. (Reference Appendix A). D

### Drainage Studies Relevant to the Site

Existing drainage studies applicable to the site include the approved *First National Bank of Aurora Filings One and Two Final Drainage Study* prepared by J. W. Williams & Associates, Inc. and approved February 3, 1982 (Approved Drainage Study). Excerpts from this report are included in Appendix D for reference.

## **II. Drainage Basins and Sub-Basins**

### **Existing Basin Description**

The project site and the existing site to the west were designed as a self-contained watershed per the Approved Drainage Study. This self-contained watershed consists of one (1) major basin which contains approximately 1.01 acres of commercial area. The basin comprises the entire site and drains northwest to an existing regional retention pond. There are no existing detention or water quality facilities located on the project site. The proposed development will remain tributary to the existing regional retention pond and on-site water quality features will be designed to provide pre-treatment for site runoff.

### **Proposed Sub-Basin Descriptions**

The proposed drainage plan for the site consists of xx major drainage basins (1.01 acres). The three 100-series basins consist of stormwater runoff from Lot 1 that is routed to proposed on-site water quality features prior to draining to the existing regional retention pond. The one 200-series basin consists of stormwater runoff from Lot 1 that drains to the existing regional retention pond without pre-treatment from on-site water quality. The one 300-series basin consists of offsite stormwater runoff that drains to the existing regional retention pond. This area was included for the weir calculation under the existing fence. The two 400-series basins consist of drainage from small areas along S. Havana Street and E. Idaho Place that are free released into the roadways.

Basin 102 (0.12 acres) is located in the central portion of the site. It consists of landscaping and concrete and asphalt pavement. Runoff from Basin 102 will flow to grass swale GS-1 (Design Point 1). From there runoff will flow under the existing fence near the northwest corner of the site (Design Point 4) and west to the existing regional detention pond. The overall composite imperviousness of this basin is 52.8% with composite coefficients of 0.76 and 0.81 in the 2- and 100-year storm events, respectively. Total runoff from this basin is 0.3 cfs and 0.7 cfs in the 2- and 100-year storm events, respectively.

Basin 104 (0.33 acres) is located on the east side of the site. It consists of roof area, concrete and asphalt pavement, and landscaping. Runoff from Basin 104 will flow to grass swale GS-2 (Design Point 2). From there runoff will flow under the existing fence near the northwest corner of the site (Design Point 4) and west to the existing regional detention pond. The overall composite imperviousness of this basin is 45.5% with composite coefficients of 0.82 and 0.86 in the 2- and 100-year storm events, respectively. Total runoff from this basin is 0.9 cfs and 2.4 cfs in the 2- and 100-year storm events, respectively.

Basin 106 (0.18 acres) is located in the northern central portion of the site. It consists of roof area, concrete and asphalt pavement, and landscaping. Runoff from Basin 106 will flow to grass swale GS-3, where it will combine with flows from grass swale GS-2 (Design Point 3). From there runoff will flow under the existing fence near the northwest corner of the site (Design Point 4) and west to the existing regional detention pond. The overall composite imperviousness of this basin is 72.3% with composite coefficients of 0.74 and 0.87 in the 2- and 100-year storm events, respectively. Total runoff from this basin is 0.5 cfs and 1.4 cfs in the 2- and 100-year storm events, respectively.

Basin 202 (0.32 acres) is located on the west side of the site. It consists of roof area, concrete and asphalt pavement, and landscaping. Runoff from Basin 202 will be conveyed via sheet flow and existing curb and gutter to the existing fence near the northwest corner of the site (Design Point 4). From there runoff will flow west to the existing regional detention pond. The overall composite imperviousness of this basin is 92.5% with composite coefficients of 0.83 and 0.88 in the 2- and 100-year storm events, respectively. Total runoff from this basin is 0.9 cfs and 2.5 cfs in the 2- and 100-year storm events, respectively.

Basin 302 (0.05 acres) is located west of the site and consists of offsite area within the shared access drive. It consists of asphalt drive lane. Runoff from Basin 302 will be conveyed via existing curb and gutter to the existing fence near the northwest corner of the site (Design Point 4). From there runoff will flow west to the existing regional retention pond. The overall composite imperviousness of this basin is 100% with composite coefficients of 0.87 and 0.93 in the 2- and 100-year storm events, respectively. Total runoff from this basin is 0.1 cfs and 0.4 cfs in the 2- and 100-year storm events, respectively.

Basin 402 (0.03 acres) is located on the east side of the site. It consists of sidewalk and landscaping. Runoff from Basin 402 will free release east to the S. Havana Street right-of-way. From there runoff is ultimately routed to existing City of Aurora storm infrastructure. The overall composite imperviousness of this basin is 32.8% with composite coefficients of 0.29 in both the 2- and 100-year storm events. Total runoff from this basin is 0.03 cfs and 0.1 cfs in the 2- and 100-year storm events, respectively.

Basin 404 (0.03 acres) is located on the south side of the site. It consists of sidewalk, drive lanes, and landscaping. Runoff from Basin 404 will free release south to the E. Idaho Place right-of-way. From there runoff is ultimately routed to existing City of Aurora storm infrastructure. The overall composite imperviousness of this basin is 27.8% with composite coefficients of 0.34 in both the 2- and 100-year storm events. Total runoff from this basin is 0.03 cfs and 0.1 cfs in the 2- and 100-year storm events, respectively.

### III. Design Criteria

#### Regulations

The proposed drainage design complies with the City of Aurora *Storm Drainage Design & Technical Criteria Manual* (TCM) and the Mile High Flood District *Urban Storm Drainage Criteria Manual* (USDCM).

#### Hydrologic Criteria

Figures RA-1 through RA-6 of the USDCM were used to determine the rainfall intensity frequency values for the City of Aurora, Colorado. The design point rainfall values listed below were utilized in design calculations.

	Average Recurrence Interval (years)					
Duration	2	5	10	25	50	100
60-min	0.99 in	1.39 in	1.63 in	2.00 in	2.30 in	2.60 in

The rational method as defined **in the TCM and USDCM was** used to calculate peak flows as the tributary areas are less than 90 acres. The rational method has proven to be accurate for basins of this size and is based on the following formula:

$$Q = CIA$$

Where:

Q = Peak Discharge (cfs)

C = Runoff Coefficient

I = Runoff Intensity (in/hr)

A = Drainage Area (ac)

Rainfall intensity was calculated using the intensity formula (Equation 5.5) in the TCM. Impervious area percentages and composite runoff coefficients were taken from Table 1 of the TCM. Appendix A contains percent imperviousness, runoff coefficient, and runoff calculations for all sub-basins. The 2-year runoff coefficient was used for the minor storm event and the 100-year runoff coefficient was used for the major storm event.

## Hydraulic Criteria

There are no proposed underground storm improvements on the site. Runoff from a portion of the site will be conveyed through a series of grass swales in an open channel condition, so Manning's equation was used to calculate swale capacities via Flowmaster V8i (refer to Appendix B). All site runoff will outfall at the northwest corner of the site under an existing locked chain link gate. A weir calculation for the existing gate with a clogging factor of 50% is provided in Appendix B for reference.

## **IV. Drainage Plan**

### General Concept

The proposed site is a redevelopment of an existing commercial site. There is an existing regional retention pond west of the property that was originally designed to accommodate all runoff from the site. Based on discussions with the City of Aurora the proposed site will continue to utilize the existing regional retention pond. A series of grass swales has been implemented on-site to improve water quality and increase times of concentration.

### Specific Details

As mentioned above there is an existing regional retention pond located west of the project site. When the First National Bank Subdivision, including E. Idaho Place right-of-way, was first designed in 1981 full retention as opposed to detention was required per City of Aurora criteria. The areas tributary to the regional pond are First National Bank of Aurora Subdivision Filings No. 1 and 2, which consist of approximately 3.54 acres of commercial land. The retention pond was designed to accommodate a composite imperviousness of 80% for the two lots.

The City of Aurora indicated early in the process that the existing regional retention pond does not meet current standards. As such, the developer tried several options to provide detention and water quality that met all current standards. These options and reasons they were not viable are outlined in the table below.

<b>Option</b>	<b>Reason not Viable</b>
Provide on-site detention (surface)	There is not enough fall on the site to provide a surface outfall from a surface detention pond. The only existing storm infrastructure within a reasonable distance of the site lies within S. Havana Street. This storm line ultimately outfalls to the High Line Canal and the City of Aurora indicated that no additional runoff may be contributed to this canal.
Provide on-site detention (underground)	The only existing storm infrastructure within a reasonable distance of the site lies within S. Havana Street. This storm line ultimately outfalls to the High Line Canal and the City of Aurora indicated that no additional runoff may be contributed to this canal.
Bring ex. regional pond up to current code	The existing regional retention pond is located offsite and there are no existing easements granting access for maintenance or improvements. The developer was unable to obtain property owner permission to access the pond for topographic

	survey and water percolation testing. Both of these are needed to verify the existing capacity and drain rate of the pond.
Parking lot detention	Parking lot detention would create grades that exceed that allowed by code within the exiting fire lane easement in the shared access drive on the west side of the site.

Based on the results of these analysis options, the City of Aurora provided direction during a video call on June 2, 2021 to utilize the existing regional retention pond. The proposed site must be designed to match or reduce the composite imperviousness from the existing condition and some form of surface water quality or LID must be implemented if practical. A series of grass swales have been designed on the site to provide water quality and increase the times of concentration for on-site drainage basins (refer to Appendix B for swale sizing calculations).

## V. Conclusions

### Compliance with Standards

The proposed storm drainage design has been performed in accordance with applicable sections of the City of Aurora *Storm Drainage Design & Technical Manual*, the Mile High Flood District *Urban Storm Drainage Criteria Manual*, and sound engineering principles. The design shows that the proposed site improvements will be safely conveyed, treated, detained, and discharged to the receiving watershed with no adverse effects. Detailed calculations provided in this report show the design will be adequate for the proposed development.

### Variances

Multiple variances are requested with this project. Section 3.60 of the TCM states the following:

*On-site detention is required for all new development, expansion and redevelopment.*

Based on the constraints outlined in Section IV of this report a variance is requested to utilize the existing regional retention pond to meet this requirement. The proposed composite imperviousness is less than the existing composite imperviousness for the site and a series of grass swales is proposed to provide some additional water quality and increase times of concentration. The proposed site will therefore improve the drainage conditions of the area and will not cause any adverse impacts to the existing pond or surrounding developments.

Section 3.70 of the TCM states the following:

*Provide minimum water quality capture volume (WQCV) as described in Volume 3 of the USDCM. The WQCV shall be increased by 20% to account for sedimentation.*

Based on the constraints outlined in Section IV of this report a variance is requested to implement LID practices that provide a WQCV runoff reduction in lieu of a traditional water quality treatment device. The LID practices include design of three grass swales, which will improve the quality of stormwater through biological uptake.



## **VI. References**

1. Storm Drainage Design & Technical Criteria Manual, City of Aurora, September 2010 (with current revisions).
2. Urban Storm Drainage Criteria Manual, Mile High Flood District, January 2021 (with current revisions).
3. Flood Insurance Rate Map – Arapahoe County, Colorado and Incorporated Areas Community Panel No. 08005C0178K, Effective December 12, 2010.
4. Soil Map – Arapahoe County Area, Colorado as available through the Natural Resources Conservation Service National Cooperative Soil Survey web site via Web Soil Survey 2.0.

## **VII. Appendices**

## **APPENDIX A – Hydrologic Calculations**

Composite Percent Impervious Calculations

Composite Runoff Coefficient Calculations

Standard Form 2 – Time of Concentration Calculations

Standard Form 3 – Minor Storm Runoff Calculations

Standard Form 3 – Major Storm Runoff Calculations

## Pro

**Location:** CO, Aurora

Project No.: KSF30.20

Checked By: \_\_\_\_\_

Date: 7/16/21

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[illegible]

## COMPOSITE % IMPERVIOUS CALCULATIONS

Subdivision: Havana & Idaho  
Location: CO, Aurora

Project Name: King Soopers Fuel #30  
Project No.: KSF30.20  
Calculated By: Jessica Greenough, PE  
Checked By: Troy Kelts, PE  
Date: 7/16/21

Basin ID	Total Area (ac)	Asphalt Pavement			Concrete Walks and Drives			Lawns			Roofs			Basins Total Weighted % Imp.
		% Imp.	Area (ac)	Weighted % Imp.	% Imp.	Area (ac)	Weighted % Imp.	% Imp.	Area (ac)	Weighted % Imp.	% Imp.	Area (ac)	Weighted % Imp.	
102	0.12	100	0.05	43.0	96	0.01	8.7	2	0.06	1.0	90	0.00	0.00	52.8
104	0.33	100	0.08	24.2	96	0.03	7.6	2	0.18	1.1	90	0.05	12.60	45.5
106	0.18	100	0.07	36.4	96	0.01	5.6	2	0.05	0.5	90	0.06	29.70	72.3
202	0.32	100	0.20	63.2	96	0.05	14.6	2	0.02	0.1	90	0.05	14.60	92.5
302	0.05	100	0.05	100.0	96	0.00	0.0	2	0.00	0.0	90	0.00	0.00	100.0
<b>Total to Pond</b>	<b>0.99</b>	<b>100</b>	<b>0.45</b>	<b>45.0</b>	<b>96</b>	<b>0.10</b>	<b>9.3</b>	<b>2</b>	<b>0.29</b>	<b>0.6</b>	<b>90</b>	<b>0.16</b>	<b>14.30</b>	<b>69.2</b>
402	0.03	100	0.00	0.0	96	0.01	31.5	2	0.02	1.3	90	0.00	0.00	32.8
404	0.03	100	0.00	5.3	96	0.01	21.0	2	0.02	1.5	90	0.00	0.00	27.8
<b>Total Site</b>	<b>1.01</b>	<b>100</b>	<b>0.40</b>	<b>39.7</b>	<b>96</b>	<b>0.11</b>	<b>10.8</b>	<b>2</b>	<b>0.34</b>	<b>0.7</b>	<b>90</b>	<b>0.16</b>	<b>14.10</b>	<b>65.2</b>

# COMPOSITE RUNOFF COEFFICIENT CALCULATIONS

Subdivision: Havana & Idaho  
Location: CO, Aurora

Project Name: King Soopers Fuel #30  
Project No.: KSF30.20  
Calculated By: Jessica Greenough, PE  
Checked By: Troy Kelts, PE  
Date: 7/16/21

Basin ID	Total Area (ac)	Asphalt Pavement			Concrete Walks and Drives			Lawns (A & B Soils), 2% Slope			Lawns (A & B Soils), 2-7% Slope			Lawns (A & B Soils), > 7% Slope			Roofs			Basins Total Weighted C <sub>2</sub>
		C <sub>2</sub>	Area (ac)	Weighted C	C <sub>2</sub>	Area (ac)	Weighted C	C <sub>2</sub>	Area (ac)	Weighted C	C <sub>2</sub>	Area (ac)	Weighted C	C <sub>2</sub>	Area (ac)	Weighted C	C <sub>2</sub>	Area (ac)	Weighted C	
102	0.12	0.87	0.08	0.58	0.87	0.01	0.08	0.13	0.03	0.00	0.18	0.00	0.00	0.25	0.03	0.10	0.80	0.00	0.00	0.76
104	0.33	0.87	0.24	0.65	0.87	0.03	0.07	0.13	0.08	0.00	0.18	0.08	0.00	0.25	0.01	0.00	0.80	0.05	0.10	0.82
106	0.18	0.87	0.08	0.39	0.87	0.01	0.05	5.00	0.00	0.00	0.18	0.02	0.00	0.25	0.03	0.00	0.80	0.06	0.30	0.74
202	0.32	0.87	0.22	0.60	0.87	0.05	0.13	5.00	0.02	0.30	0.18	0.00	0.00	0.25	0.00	0.00	0.80	0.05	0.10	0.83
302	0.05	0.87	0.05	0.87	0.87	0.00	0.00	5.00	0.00	0.00	0.18	0.00	0.00	0.25	0.00	0.00	0.80	0.00	0.00	0.87
402	0.03	0.87	0.00	0.00	0.87	0.01	0.29	5.00	0.00	0.00	0.18	0.02	0.10	0.25	0.00	0.00	0.80	0.00	0.00	0.29
404	0.03	0.87	0.00	0.05	0.87	0.01	0.19	5.00	0.00	0.00	0.18	0.01	0.10	0.25	0.01	0.10	0.80	0.00	0.00	0.34

Basin ID	Total Area (ac)	Asphalt Pavement			Concrete Walks and Drives			Lawns (A & B Soils), 2% Slope			Lawns (A & B Soils), 2-7% Slope			Lawns (A & B Soils), > 7% Slope			Roofs			Basins Total Weighted C <sub>100</sub>
		C <sub>100</sub>	Area (ac)	Weighted C	C <sub>100</sub>	Area (ac)	Weighted C	C <sub>100</sub>	Area (ac)	Weighted C	C <sub>100</sub>	Area (ac)	Weighted C	C <sub>100</sub>	Area (ac)	Weighted C	C <sub>100</sub>	Area (ac)	Weighted C	
102	0.12	0.93	0.08	0.63	0.89	0.01	0.08	0.17	0.03	0.00	0.22	0.00	0.00	0.35	0.03	0.10	0.90	0.00	0.00	0.81
104	0.33	0.93	0.24	0.69	0.89	0.03	0.07	0.17	0.08	0.00	0.22	0.08	0.10	0.35	0.01	0.00	0.90	0.05	0.10	0.86
106	0.18	0.93	0.08	0.42	0.89	0.01	0.05	0.17	0.00	0.00	0.22	0.02	0.00	0.35	0.03	0.10	0.90	0.06	0.30	0.87
202	0.32	0.93	0.22	0.64	0.89	0.05	0.14	0.17	0.02	0.00	0.22	0.00	0.00	0.35	0.00	0.00	0.90	0.05	0.10	0.88
302	0.05	0.93	0.05	0.93	0.89	0.00	0.00	0.17	0.00	0.00	0.22	0.00	0.00	0.35	0.00	0.00	0.90	0.00	0.00	0.93
402	0.03	0.93	0.00	0.00	0.89	0.01	0.29	0.17	0.00	0.00	0.22	0.02	0.10	0.35	0.00	0.00	0.90	0.00	0.00	0.29
404	0.03	0.93	0.00	0.05	0.89	0.01	0.19	0.17	0.00	0.00	0.22	0.01	0.10	0.35	0.01	0.10	0.90	0.00	0.00	0.34

## STANDARD FORM SF-2 TIME OF CONCENTRATION

**Subdivision:** Havana & Idaho  
**Location:** CO, Aurora

**Project Name:** King Soopers Fuel #30  
**Project No.:** KSF30.20  
**Calculated By:** Jessica Greenough, PE  
**Checked By:** Troy Kelts, PE  
**Date:** 7/16/21

SUB-BASIN						INITIAL/OVERLAND			TRAVEL TIME					T <sub>c</sub> CHECK			FINAL
DATA						(T <sub>i</sub> )			(T <sub>t</sub> )					(URBANIZED BASINS)			
BASIN ID	D.A. (AC)	Hydrologic Soils Group	Impervious (%)	C <sub>100</sub>	C <sub>2</sub>	L (FT)	S (%)	T <sub>i</sub> (MIN)	L (FT)	S (%)	C <sub>v</sub>	VEL. (FPS)	T <sub>t</sub> (MIN)	COMP. T <sub>c</sub> (MIN)	TOTAL LENGTH (FT)	Urbanized T <sub>c</sub> (MIN)	
102	0.12	A	52.8	0.81	0.76	38	1.60	3.3	125	0.85	7.0	0.6	3.2	6.5	163.0	10.9	6.5
104	0.33	A	45.5	0.86	0.82	64	1.80	3.4	68	0.70	7.0	0.6	1.9	5.3	132.0	10.7	5.3
106	0.18	A	72.3	0.87	0.74	62	3.00	3.6	60	0.70	7.0	0.6	1.7	5.3	122.0	10.7	5.3
202	0.32	A	92.5	0.88	0.83	82	1.86	3.6	44	1.50	20.0	2.4	0.3	3.9	126.0	10.7	5.0
302	0.05	A	100.0	0.93	0.87	13	4.80	0.9	115	1.50	20.0	2.4	0.8	1.7	128.0	10.7	5.0
402	0.03	A	32.8	0.29	0.29	8.3	1.80	3.5	5	1.80	7.0	0.9	0.1	3.6	13.3	10.1	5.0
404	0.03	A	27.8	0.34	0.34	9.5	2.00	3.4	5	1.80	7.0	0.9	0.1	3.5	14.5	10.1	5.0

**NOTES:**

$T_i = (0.395 * (1.1 - C_5) * (L)^{0.5}) / ((S)^{0.33})$ , S in ft/ft

$T_t = L / 60V$  (Velocity From Fig. 501)

Velocity  $V = C_v * S^{0.5}$ , S in ft/ft

T<sub>c</sub> Check = 10+L/180

For Urbanized basins a minimum T<sub>c</sub> of 5.0 minutes is required.

For non-urbanized basins a minimum T<sub>c</sub> of 10.0 minutes is required

## STORM DRAINAGE SYSTEM DESIGN

(RATIONAL METHOD PROCEDURE)

Subdivision: Havana & Idaho  
Location: CO, Aurora  
Design Storm: 2-Year

Project Name: King Soopers Fuel #30  
Project No.: KSF30.20  
Calculated By: Jessica Greenough, PE  
Checked By: Troy Kelts, PE  
Date: 7/16/21

[illegible]

**STANDARD FORM SF-3**  
**STORM DRAINAGE SYSTEM DESIGN**  
(RATIONAL METHOD PROCEDURE)

**Subdivision:** Havana & Idaho  
**Location:** CO, Aurora  
**Design Storm:** 100-Year

Project Name: King Soopers Fuel #30  
Project No.: KSF30.20  
Calculated By: Jessica Greenough, PE  
Checked By: Troy Kelts, PE  
Date: 7/16/21

[illegible]



## **APPENDIX B – Hydraulic Calculations**

MHFD Design Procedure Form – Runoff Reduction

Grass Swale Capacity Calculations

Wier Calculation – Outflow Under Fence

# Design Procedure Form: Runoff Reduction

UD-BMP (Version 3.07, March 2018)

Sheet 1 of 1

**Designer:** Jessica Greenough, PE  
**Company:** Galloway & Company, Inc.  
**Date:** July 14, 2021  
**Project:** King Sloopers Fuel #30  
**Location:** 1369 S. Havana Street | Aurora, Colorado

## SITE INFORMATION (User Input in Blue Cells)

WQCV Rainfall Depth 0.60 inches  
Depth of Average Runoff Producing Storm,  $d_e$  = 0.43 inches (for Watersheds Outside of the Denver Region, Figure 3-1 in USDCM Vol. 3)

Area Type	UIA:RPA	UIA:RPA	UIA:RPA	DCIA	DCIA								
Area ID	Basin 102	Basin 104	Basin 106	Basin 202	Basin 302								
Downstream Design Point ID	1	2	2	3	3								
Downstream BMP Type	RP	RP	RP	RP	RP								
DCIA (ft <sup>2</sup> )	--	--	--	13,238	2,151								
UIA (ft <sup>2</sup> )	2,627	6,526	5,986	--	--								
RPA (ft <sup>2</sup> )	2,414	7,639	1,962	--	--								
SPA (ft <sup>2</sup> )	--	--	--	--	--								
HSG A (%)	100%	100%	100%	--	--								
HSG B (%)	0%	0%	0%	--	--								
HSG C/D (%)	0%	0%	0%	--	--								
Average Slope of RPA (ft/ft)	0.010	0.008	0.008	--	--								
UIA:RPA Interface Width (ft)	10.00	10.00	110.00	--	--								

## CALCULATED RUNOFF RESULTS

Area ID	Basin 102	Basin 104	Basin 106	Basin 202	Basin 302								
UIA:RPA Area (ft <sup>2</sup> )	5,041	14,165	7,948	--	--								
L / W Ratio	16.00	16.00	0.66	--	--								
UIA / Area	0.5211	0.4607	0.7531	--	--								
Runoff (in)	0.00	0.00	0.00	0.50	0.50								
Runoff (ft <sup>3</sup> )	0	0	0	552	90								
Runoff Reduction (ft <sup>3</sup> )	109	272	249	0	0								

## CALCULATED WQCV RESULTS

Area ID	Basin 102	Basin 104	Basin 106	Basin 202	Basin 302								
WQCV (ft <sup>3</sup> )	88	218	200	441	72								
WQCV Reduction (ft <sup>3</sup> )	109	272	249	0	0								
WQCV Reduction (%)	125%	125%	125%	0%	0%								
Untreated WQCV (ft <sup>3</sup> )	-22	-54	-50	441	72								

## CALCULATED DESIGN POINT RESULTS (sums results from all columns with the same Downstream Design Point ID)

Downstream Design Point ID	1	2	2	3	3								
DCIA (ft <sup>2</sup> )	0	0	0	15,389	15,389								
UIA (ft <sup>2</sup> )	2,627	12,512	12,512	0	0								
RPA (ft <sup>2</sup> )	2,414	9,601	9,601	0	0								
SPA (ft <sup>2</sup> )	0	0	0	0	0								
Total Area (ft <sup>2</sup> )	5,041	22,113	22,113	15,389	15,389								
Total Impervious Area (ft <sup>2</sup> )	2,627	12,512	12,512	15,389	15,389								
WQCV (ft <sup>3</sup> )	88	417	417	513	513								
WQCV Reduction (ft <sup>3</sup> )	109	521	521	0	0								
WQCV Reduction (%)	125%	125%	125%	0%	0%								
Untreated WQCV (ft <sup>3</sup> )	-22	-104	-104	513	513								

## CALCULATED SITE RESULTS (sums results from all columns in worksheet)

Total Area (ft <sup>2</sup> )	80,045
Total Impervious Area (ft <sup>2</sup> )	58,429
WQCV (ft <sup>3</sup> )	1,018
WQCV Reduction (ft <sup>3</sup> )	631
WQCV Reduction (%)	62%
Untreated WQCV (ft <sup>3</sup> )	387

## Grass Swale GS-1 | 2-Yr

### Project Description

Friction Method Manning Formula  
Solve For Normal Depth

### Input Data

Roughness Coefficient 0.035  
Channel Slope 0.00850 ft/ft  
Left Side Slope 4.00 ft/ft (H:V)  
Right Side Slope 4.00 ft/ft (H:V)  
Discharge 0.30 ft<sup>3</sup>/s

### Results

Normal Depth 0.27 ft  
Flow Area 0.30 ft<sup>2</sup>  
Wetted Perimeter 2.24 ft  
Hydraulic Radius 0.13 ft  
Top Width 2.18 ft  
Critical Depth 0.20 ft  
Critical Slope 0.03981 ft/ft  
Velocity 1.01 ft/s  
Velocity Head 0.02 ft  
Specific Energy 0.29 ft  
Froude Number 0.48  
Flow Type Subcritical

### GVF Input Data

Downstream Depth 0.00 ft  
Length 0.00 ft  
Number Of Steps 0

### GVF Output Data

Upstream Depth 0.00 ft  
Profile Description  
Profile Headloss 0.00 ft  
Downstream Velocity Infinity ft/s  
Upstream Velocity Infinity ft/s  
Normal Depth 0.27 ft  
Critical Depth 0.20 ft  
Channel Slope 0.00850 ft/ft  
Critical Slope 0.03981 ft/ft

## Grass Swale GS-1 | 100-Yr

### Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

### Input Data

Roughness Coefficient	0.035	
Channel Slope	0.00850	ft/ft
Left Side Slope	4.00	ft/ft (H:V)
Right Side Slope	4.00	ft/ft (H:V)
Discharge	0.70	ft <sup>3</sup> /s

### Results

Normal Depth	0.37	ft
Flow Area	0.56	ft <sup>2</sup>
Wetted Perimeter	3.08	ft
Hydraulic Radius	0.18	ft
Top Width	2.99	ft
Critical Depth	0.29	ft
Critical Slope	0.03556	ft/ft
Velocity	1.25	ft/s
Velocity Head	0.02	ft
Specific Energy	0.40	ft
Froude Number	0.51	
Flow Type	Subcritical	

### GVF Input Data

Downstream Depth	0.00	ft
Length	0.00	ft
Number Of Steps	0	

### GVF Output Data

Upstream Depth	0.00	ft
Profile Description		
Profile Headloss	0.00	ft
Downstream Velocity	Infinity	ft/s
Upstream Velocity	Infinity	ft/s
Normal Depth	0.37	ft
Critical Depth	0.29	ft
Channel Slope	0.00850	ft/ft
Critical Slope	0.03556	ft/ft

## Grass Swale GS-2 | 2-Yr

### Project Description

Friction Method Manning Formula  
Solve For Normal Depth

### Input Data

Channel Slope 0.00700 ft/ft  
Discharge 0.90 ft<sup>3</sup>/s  
Section Definitions

Station (ft)	Elevation (ft)
0+00	5494.14
0+04	5492.58
0+18	5493.85

### Roughness Segment Definitions

Start Station	Ending Station	Roughness Coefficient
(0+00, 5494.14)	(0+18, 5493.85)	0.035

### Options

Current Roughness weighted Method Pavlovskii's Method  
Open Channel Weighting Method Pavlovskii's Method  
Closed Channel Weighting Method Pavlovskii's Method

### Results

Normal Depth 0.35 ft  
Elevation Range 5492.58 to 5494.14 ft  
Flow Area 0.82 ft<sup>2</sup>  
Wetted Perimeter 4.74 ft  
Hydraulic Radius 0.17 ft  
Top Width 4.65 ft  
Normal Depth 0.35 ft  
Critical Depth 0.26 ft  
Critical Slope 0.03620 ft/ft  
Velocity 1.10 ft/s

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## Grass Swale GS-2 | 2-Yr

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### Results

Velocity Head	0.02	ft
Specific Energy	0.37	ft
Froude Number	0.46	
Flow Type	Subcritical	

### GVF Input Data

Downstream Depth	0.00	ft
Length	0.00	ft
Number Of Steps	0	

### GVF Output Data

Upstream Depth	0.00	ft
Profile Description		
Profile Headloss	0.00	ft
Downstream Velocity	Infinity	ft/s
Upstream Velocity	Infinity	ft/s
Normal Depth	0.35	ft
Critical Depth	0.26	ft
Channel Slope	0.00700	ft/ft
Critical Slope	0.03620	ft/ft

## Cross Section for Grass Swale GS-2 | 2-Yr

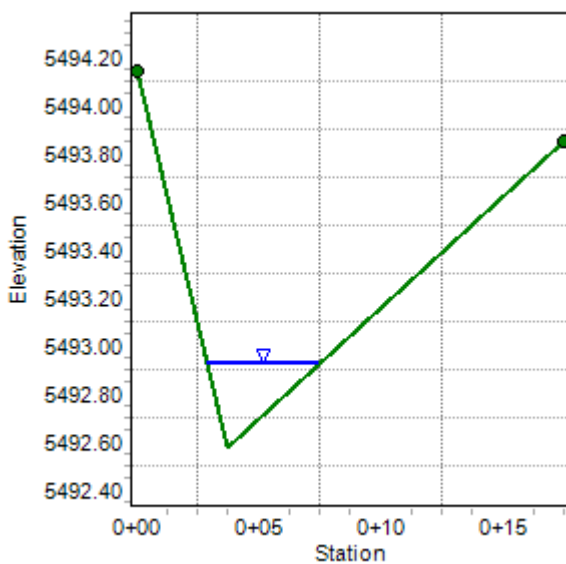
### Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

### Input Data

Channel Slope	0.00700	ft/ft
Normal Depth	0.35	ft
Discharge	0.90	ft <sup>3</sup> /s

### Cross Section Image



## Grass Swale GS-2 | 100-Yr

### Project Description

Friction Method Manning Formula  
Solve For Normal Depth

### Input Data

Channel Slope 0.00700 ft/ft  
Discharge 2.40 ft<sup>3</sup>/s  
Section Definitions

Station (ft)	Elevation (ft)
0+00	5494.14
0+04	5492.58
0+18	5493.85

### Roughness Segment Definitions

Start Station	Ending Station	Roughness Coefficient
(0+00, 5494.14)	(0+18, 5493.85)	0.035

### Options

Current Roughness weighted Method Pavlovskii's Method  
Open Channel Weighting Method Pavlovskii's Method  
Closed Channel Weighting Method Pavlovskii's Method

### Results

Normal Depth 0.51 ft  
Elevation Range 5492.58 to 5494.14 ft  
Flow Area 1.71 ft<sup>2</sup>  
Wetted Perimeter 6.85 ft  
Hydraulic Radius 0.25 ft  
Top Width 6.72 ft  
Normal Depth 0.51 ft  
Critical Depth 0.38 ft  
Critical Slope 0.03176 ft/ft  
Velocity 1.41 ft/s



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## Grass Swale GS-2 | 100-Yr

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### Results

Velocity Head	0.03	ft
Specific Energy	0.54	ft
Froude Number	0.49	
Flow Type	Subcritical	

### GVF Input Data

Downstream Depth	0.00	ft
Length	0.00	ft
Number Of Steps	0	

### GVF Output Data

Upstream Depth	0.00	ft
Profile Description		
Profile Headloss	0.00	ft
Downstream Velocity	Infinity	ft/s
Upstream Velocity	Infinity	ft/s
Normal Depth	0.51	ft
Critical Depth	0.38	ft
Channel Slope	0.00700	ft/ft
Critical Slope	0.03176	ft/ft

# Cross Section for Grass Swale GS-2 | 100-Yr

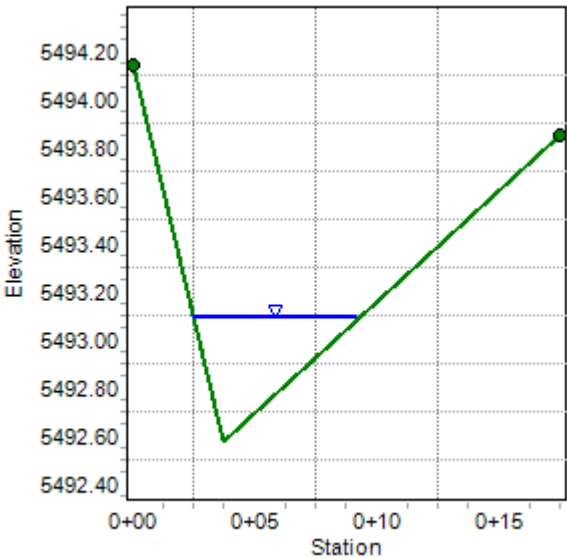
## Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

## Input Data

Channel Slope	0.00700	ft/ft
Normal Depth	0.51	ft
Discharge	2.40	ft³/s

## Cross Section Image



## Grass Swale GS-3 | 2-Yr

### Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

### Input Data

Channel Slope	0.00700	ft/ft
Discharge	1.40	ft <sup>3</sup> /s
Section Definitions		

Station (ft)	Elevation (ft)
0+00	5494.14
0+04	5492.58
0+18	5493.85

### Roughness Segment Definitions

Start Station	Ending Station	Roughness Coefficient
(0+00, 5494.14)	(0+18, 5493.85)	0.035

### Options

Current Roughness Weighted Method	Pavlovskii's Method
Open Channel Weighting Method	Pavlovskii's Method
Closed Channel Weighting Method	Pavlovskii's Method

### Results

Normal Depth	0.41	ft
Elevation Range	5492.58 to 5494.14 ft	
Flow Area	1.14	ft <sup>2</sup>
Wetted Perimeter	5.60	ft
Hydraulic Radius	0.20	ft
Top Width	5.49	ft
Normal Depth	0.41	ft
Critical Depth	0.31	ft
Critical Slope	0.03413	ft/ft
Velocity	1.23	ft/s

---

## Grass Swale GS-3 | 2-Yr

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### Results

Velocity Head	0.02	ft
Specific Energy	0.44	ft
Froude Number	0.48	
Flow Type	Subcritical	

### GVF Input Data

Downstream Depth	0.00	ft
Length	0.00	ft
Number Of Steps	0	

### GVF Output Data

Upstream Depth	0.00	ft
Profile Description		
Profile Headloss	0.00	ft
Downstream Velocity	Infinity	ft/s
Upstream Velocity	Infinity	ft/s
Normal Depth	0.41	ft
Critical Depth	0.31	ft
Channel Slope	0.00700	ft/ft
Critical Slope	0.03413	ft/ft

## Cross Section for Grass Swale GS-3 | 2-Yr

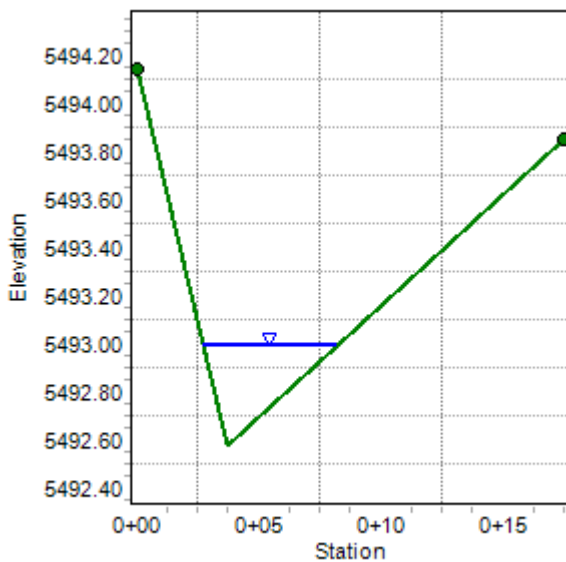
### Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

### Input Data

Channel Slope	0.00700	ft/ft
Normal Depth	0.41	ft
Discharge	1.40	ft <sup>3</sup> /s

### Cross Section Image



## Grass Swale GS-3 | 100-Yr

## Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

## Input Data

Channel Slope	0.00700	ft/ft
Discharge	3.80	ft³/s
Section Definitions		

Station (ft)	Elevation (ft)
0+00	5494.14
0+04	5492.58
0+18	5493.85

## Roughness Segment Definitions

Start Station	Ending Station	Roughness Coefficient
(0+00, 5494.14)	(0+18, 5493.85)	0.035

## Options

Current Roughness Weighted Method	Pavlovskii's Method
Open Channel Weighting Method	Pavlovskii's Method
Closed Channel Weighting Method	Pavlovskii's Method

## Results

Normal Depth		0.60	ft
Elevation Range	5492.58 to 5494.14 ft		
Flow Area		2.41	ft²
Wetted Perimeter		8.13	ft
Hydraulic Radius		0.30	ft
Top Width		7.98	ft
Normal Depth		0.60	ft
Critical Depth		0.46	ft
Critical Slope		0.02987	ft/ft
Velocity		1.58	ft/s

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## Grass Swale GS-3 | 100-Yr

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### Results

Velocity Head	0.04	ft
Specific Energy	0.64	ft
Froude Number	0.51	
Flow Type	Subcritical	

### GVF Input Data

Downstream Depth	0.00	ft
Length	0.00	ft
Number Of Steps	0	

### GVF Output Data

Upstream Depth	0.00	ft
Profile Description		
Profile Headloss	0.00	ft
Downstream Velocity	Infinity	ft/s
Upstream Velocity	Infinity	ft/s
Normal Depth	0.60	ft
Critical Depth	0.46	ft
Channel Slope	0.00700	ft/ft
Critical Slope	0.02987	ft/ft

# Cross Section for Grass Swale GS-3 | 100-Yr

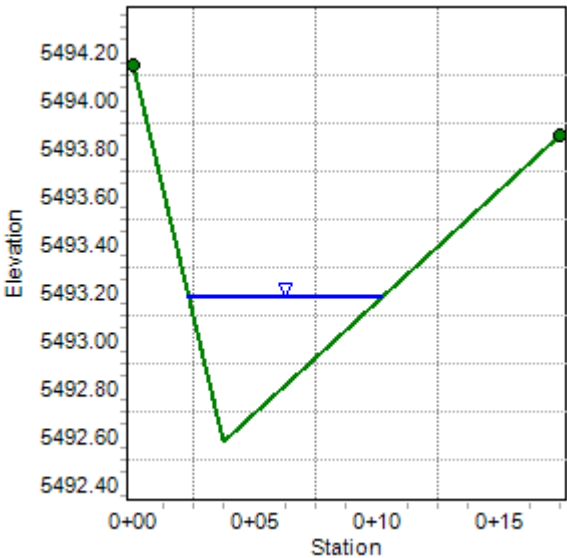
## Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

## Input Data

Channel Slope	0.00700	ft/ft
Normal Depth	0.60	ft
Discharge	3.80	ft³/s

## Cross Section Image





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## Weir Calculation - Ex. Fence | 100-Yr

---

### Project Description

Solve For Crest Elevation

### Input Data

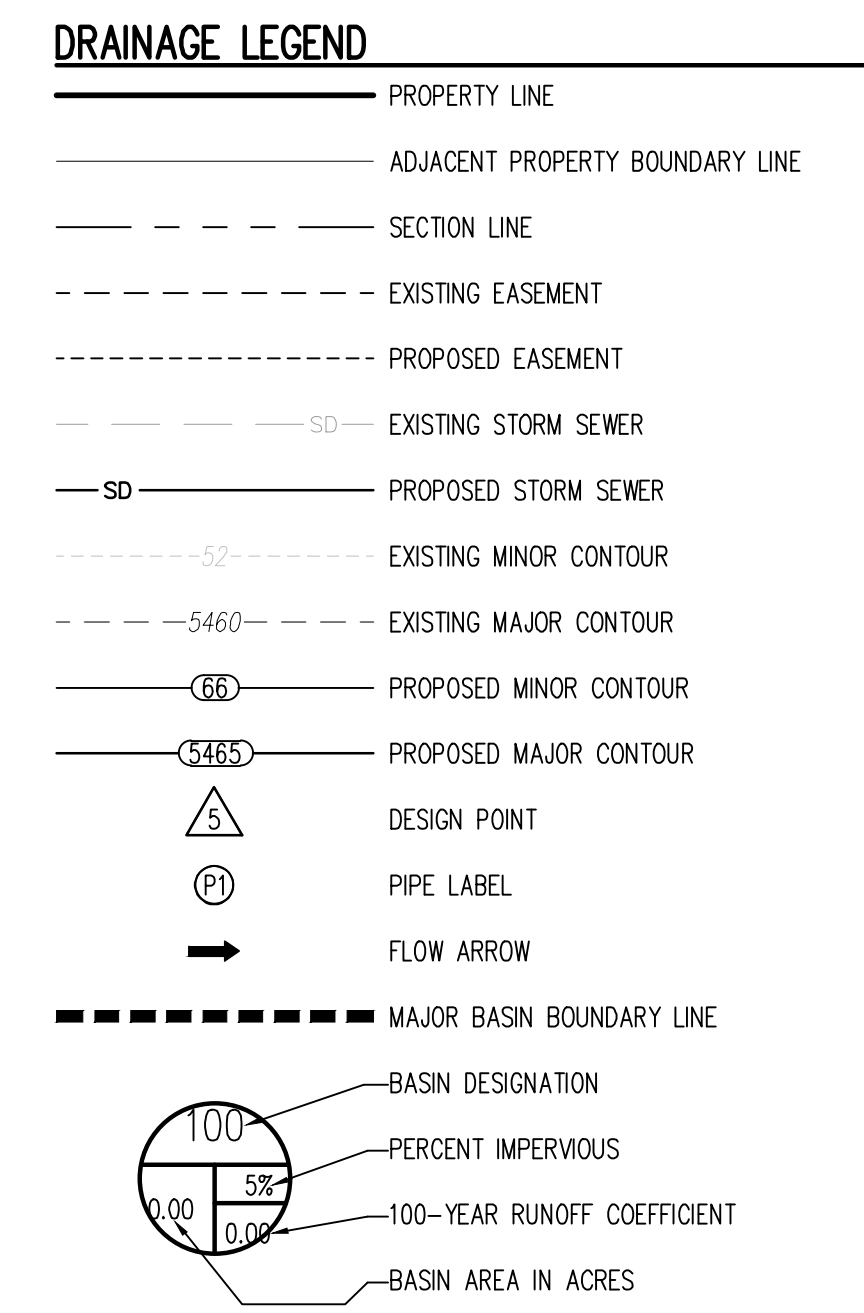
Discharge	7.00	ft <sup>3</sup> /s
Headwater Elevation	0.50	ft
Tailwater Elevation	0.00	ft
Weir Coefficient	3.00	US
Crest Length	24.00	ft
Number Of Contractions	0	

### Results

Crest Elevation	0.29	ft
Headwater Height Above Crest	0.21	ft
Tailwater Height Above Crest	-0.29	ft
Flow Area	5.07	ft <sup>2</sup>
Velocity	1.38	ft/s
Wetted Perimeter	24.42	ft
Top Width	24.00	ft

## **APPENDIX C – Drainage Map**

Proposed Drainage Map



- BENCHMARK**  
PUBLISHED BENCHMARK:  
CITY OF AURORA BENCHMARK 03-060A
- 3" DIAM. BRASS CAP (STAMPED C.O.A., 3-60A, M-10B, BM) ATOP THE S.E. CORNER OF A CURB OPENING INLET STRUCTURE BEING SOUTH OF THE S. POR @ THE S.E. COR. OF S. HAVANA ST. & MISS. AVE.
- ELEVATION = 5484.589'

Tributary Sub-basin	Area (acres)	C <sub>s</sub>	C <sub>100</sub>	t <sub>c</sub> (min)	Q <sub>5</sub>	Q <sub>100</sub> (cfs)	Design Point	5-Yr Routed Flow (cfs)	100-Yr Routed Flow (cfs)
102	0.12	0.76	0.81	6.5	0.3	0.7	1		
104	0.33	0.82	0.86	5.3	0.9	2.4	2		
106	0.18	0.74	0.87	5.3	0.0	0.0	3	1.4	3.8
202	0.32	0.83	0.88	5.0	0.5	1.4			
302	0.05	0.87	0.93	5.0	0.0	0.0			
							4	2.5	7.0
402	0.03	0.29	0.29	5.0	0.9	2.5	5		
404	0.03	0.34	0.34	5.0	0.0	0.0	6		

Approved For One Year From This Date	
City Engineer	Date
Water Department	Date

## **APPENDIX D – Reference Material**

FEMA FIRMette Map

NRCS Web Soil Survey

Excerpts from Approved Drainage Study



## NOTES TO USERS

This map is for use in administering the National Flood Insurance Program. It does not necessarily identify all areas subject to flooding, particularly from local drainage sources of small size. The **community map repository** should be consulted for possible updated or additional flood hazard information.

To obtain more detailed information in areas where **Base Flood Elevations** (BFEs) and/or **floodways** have been determined, users are encouraged to consult the Flood Profiles and Floodway Data and/or Summary of Stillwater Elevations tables contained within the Flood Insurance Study (FIS) report that accompanies this FIRM. Users should be aware that BFEs shown on the FIRM represent rounded whole-foot elevations. These BFEs are intended for flood insurance rating purposes only and should not be used as the sole source of flood elevation information. Accordingly, flood elevation data presented in the FIS report should be utilized in conjunction with the FIRM for purposes of construction and/or floodplain management.

**Coastal Base Flood Elevations** shown on this map apply only landward of 0.0' North American Vertical Datum of 1988 (NAVD 88). Users of this FIRM should be aware that coastal flood elevations are also provided in the Summary of Stillwater Elevations table in the Flood Insurance Study report for this jurisdiction. Elevations shown in the Summary of Stillwater Elevations table should be used for construction and/or floodplain management purposes when they are higher than the elevations shown on this FIRM.

Boundaries of the **floodways** were computed at cross sections and interpolated between cross sections. The floodways were based on hydraulic considerations with regard to requirements of the National Flood Insurance Program. Floodway widths and other pertinent floodway data are provided in the Flood Insurance Study report for this jurisdiction.

Certain areas not in Special Flood Hazard Areas may be protected by flood control structures. Refer to Section 2.4 "Flood Protection Measures" of the Flood Insurance Study report for information on flood control structures for this jurisdiction.

The **projection** used in the preparation of this map was Universal Transverse Mercator (UTM) zone 13. The **horizontal datum** was NAD83, GRS1980 spheroid. Differences in datum, spheroid, projection or UTM zones used in the production of FIRMs for adjacent jurisdictions may result in slight positional differences in map features across jurisdiction boundaries. These differences do not affect the accuracy of this FIRM.

Flood elevations on this map are referenced to the North American Vertical Datum of 1988. These flood elevations must be compared to structure and ground elevations referenced to the same vertical datum. For information regarding conversion between the National Geodetic Vertical Datum of 1929 and the North American Vertical Datum of 1988, visit the National Geodetic Survey website at <http://www.ngs.noaa.gov/> or contact the National Geodetic Survey at the following address:

NGS Information Services  
NOAA, NNGS12  
National Geodetic Survey  
SSWIC-3, #6202  
1315 East-West Highway  
Silver Spring, MD 20910-3282

To obtain current elevation, description, and/or location information for **bench marks** shown on this map, please contact the Information Services Branch of the National Geodetic Survey at (301) 713-3242, or visit its website at <http://www.ngs.noaa.gov/>.

**Base map** information shown on this FIRM was provided by the Arapahoe County and Cities of Aurora and Littleton GIS depts. The coordinate system used for production of the digital FIRM is Universal Transverse Mercator, Zone 13N, referenced to the North American Datum of 1983 and the GRS 80 spheroid, Western Hemisphere.

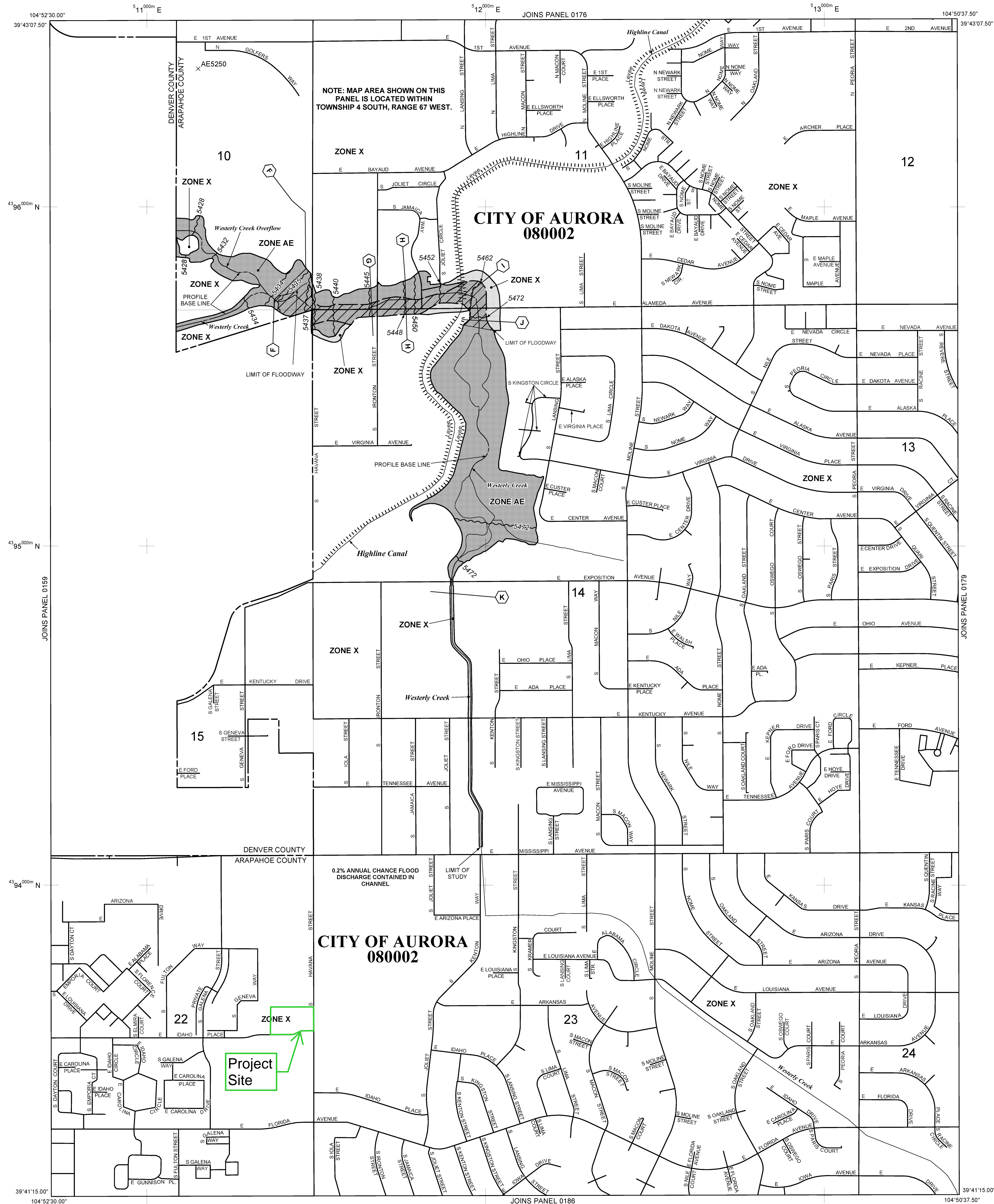
This map reflects more detailed and up-to-date **stream channel configurations** than those shown on the previous FIRM for this jurisdiction. The floodplains and floodways that were transferred from the previous FIRM may have been adjusted to conform to these new stream channel configurations. As a result, the Flood Profiles and Floodway Data tables in the *Flood Insurance Study report* (which contains authoritative hydraulic data) may reflect stream channel distances that differ from what is shown on this map.

**Corporate limits** shown on this map are based on the best data available at the time of publication. Because changes due to annexations or de-annexations may have occurred after this map was published, map users should contact appropriate community officials to verify current corporate limit locations.

Please refer to the separately printed **Map Index** for an overview map of the county showing the layout of map panels; community map repository addresses; and a Listing of Communities table containing National Flood Insurance Program dates for each community as well as a listing of the panels on which each community is located.

Contact the **FEMA Map Service Center** at 1-800-358-9616 for information on available products associated with this FIRM. Available products may include previously issued Letters of Map Change, a *Flood Insurance Study* report, and/or digital versions of this map. The FEMA Map Service Center may also be reached by Fax at 1-800-358-9620 and its website at <http://www.msc.fema.gov/>.

If you have **questions about this map** or questions concerning the National Flood Insurance Program in general, please call 1-877-FEMA MAP (1-877-336-2627) or visit the FEMA website at <http://www.fema.gov/>.



## LEGEND

**SPECIAL FLOOD HAZARD AREAS (SFHAs) SUBJECT TO INUNDATION BY THE 1% ANNUAL CHANCE FLOOD**

The 1% annual chance flood (100-year flood), also known as the base flood, is the flood that has a 1% chance of being equaled or exceeded in any given year. The Special Flood Hazard Area is the area subject to flooding by the 1% annual chance flood. Areas of Special Flood Hazard include Zones A, AE, AH, AO, AR, A99, V and VE. The Base Flood Elevation is the water-surface elevation of the 1% annual chance flood.

- ZONE A** No Base Flood Elevations determined.  
**ZONE AE** Base Flood Elevations determined.  
**ZONE AH** Flood depths of 1 to 3 feet (usually areas of ponding); Base Flood Elevations determined.  
**ZONE AO** Flood depths of 1 to 3 feet (usually sheet flow on sloping terrain); average depths determined. For areas of alluvial fan flooding, velocities also determined.  
**ZONE AR** Special Flood Hazard Area formerly protected from the 1% annual chance flood by a flood control system that was subsequently decertified. Zone AR indicates that the former flood control system is being restored to provide protection from the 1% annual chance or greater flood.  
**ZONE A99** Area to be protected from 1% annual chance flood by a Federal flood protection system under construction; no Base Flood Elevations determined.  
**ZONE V** Coastal flood zone with velocity hazard (wave action); no Base Flood Elevations determined.  
**ZONE VE** Coastal flood zone with velocity hazard (wave action); Base Flood Elevations determined.

**FLOODWAY AREAS IN ZONE AE**

The floodway is the channel of a stream plus any adjacent floodplain areas that must be kept free of encroachment so that the 1% annual chance flood can be carried without substantial increases in flood heights.

**OTHER FLOOD AREAS**

**ZONE X** Areas of 0.2% annual chance flood; areas of 1% annual chance flood with average depths of less than 1 foot or with drainage areas less than 1 square mile; and areas protected by levees from 1% annual chance flood.

**OTHER AREAS**

**ZONE X** Areas determined to be outside the 0.2% annual chance floodplain.

**ZONE D** Areas in which flood hazards are undetermined, but possible.

**COASTAL BARRIER RESOURCES SYSTEM (CBRS) AREAS**

**OTHERWISE PROTECTED AREAS (OPAs)**

CBRS areas and OPAs are normally located within or adjacent to Special Flood Hazard Areas.

- Floodplain boundary
- Floodway boundary
- Zone D boundary
- CBRS and OPA boundary
- Boundary dividing Special Flood Hazard Areas of different Base Flood Elevations, flood depths or flood velocities.
- Base Flood Elevation line and value; elevation in feet\*
- Base Flood Elevation value where uniform within zone; elevation in feet\*

\* Referenced to the North American Vertical Datum of 1988 (NAVD 88)

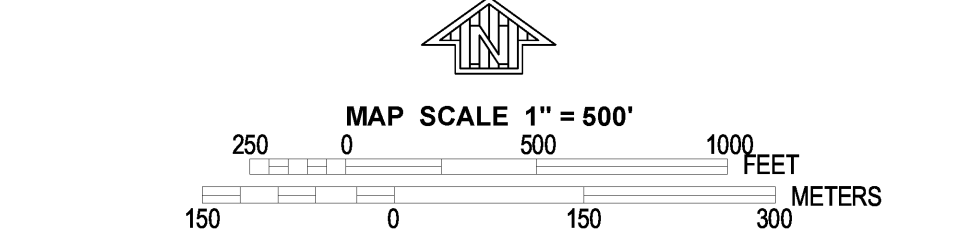
- Cross section line
- Transect line
- Geographic coordinates referenced to the North American Datum of 1983 (NAD 83)
- 1000-meter Universal Transverse Mercator grid ticks, zone 13
- 5000-foot grid ticks: New York State Plane coordinate system, east zone (FIPSZONE 3101), Transverse Mercator

- Bench mark (see explanation in Notes to Users section of this FIRM panel)
- River Mile
- MAP REPOSITORIES
- Refer to Map Repositories list on Map Index

EFFECTIVE DATE OF COUNTYWIDE FLOOD INSURANCE RATE MAP  
April 17, 1989  
EFFECTIVE DATE(S) OF REVISION(S) TO THIS PANEL  
December 3, 1993 - August 16, 1995  
December 17, 2010 - to update map format, to change Special Flood Hazard Areas, and to change Base Flood Elevations.

For community map revision history prior to countywide mapping, refer to the Community Map History table located in 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.



NFIP

PANEL 0178K

NATIONAL FLOOD INSURANCE PROGRAM

**FIRM**  
**FLOOD INSURANCE RATE MAP**  
**ARAPAHOE COUNTY,**  
**COLORADO**  
**AND INCORPORATED AREAS**

**PANEL 178 OF 725**  
(SEE MAP INDEX FOR FIRM PANEL LAYOUT)  
**CONTAINS:**  
**COMMUNITY** NUMBER PANEL SUFFIX  
AURORA, CITY OF 080002 0178 K

Notice to User: The Map Number shown below should be used when placing map orders. The Community Number shown above should be used on insurance applications for the subject community.



**MAP NUMBER**  
**08005C0178K**  
**MAP REVISED**  
**DECEMBER 17, 2010**

Federal Emergency Management Agency



# Hydrologic Soil Group—Arapahoe County, Colorado




**Natural Resources  
Conservation Service**

Web Soil Survey  
National Cooperative Soil Survey

3/30/2021  
Page 1 of 4

## 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 16, Jun 4, 2020

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
BmB	Bijou sandy loam, wet, 0 to 3 percent slopes	A	1.2	100.0%
<b>Totals for Area of Interest</b>			<b>1.2</b>	<b>100.0%</b>

### 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

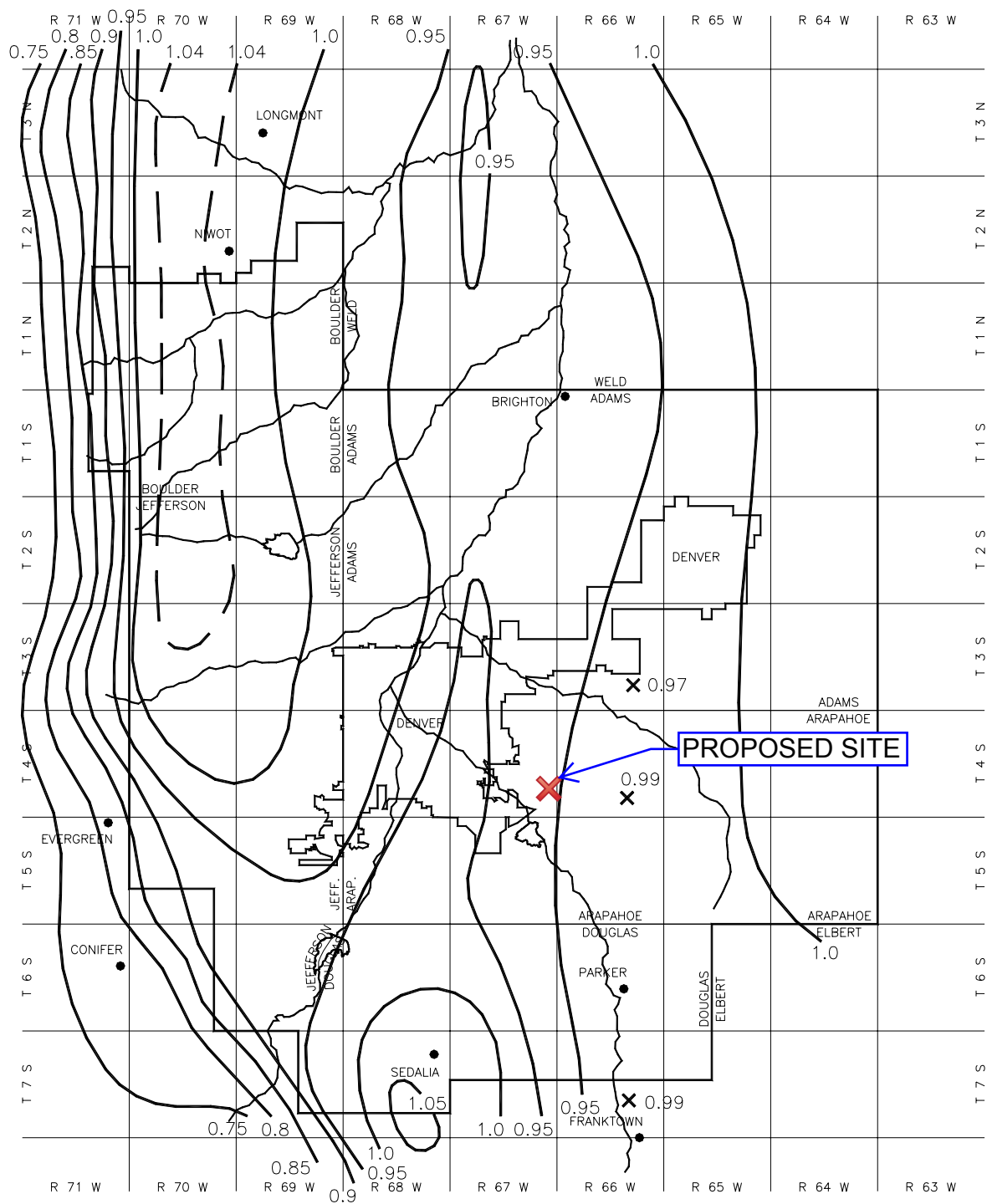
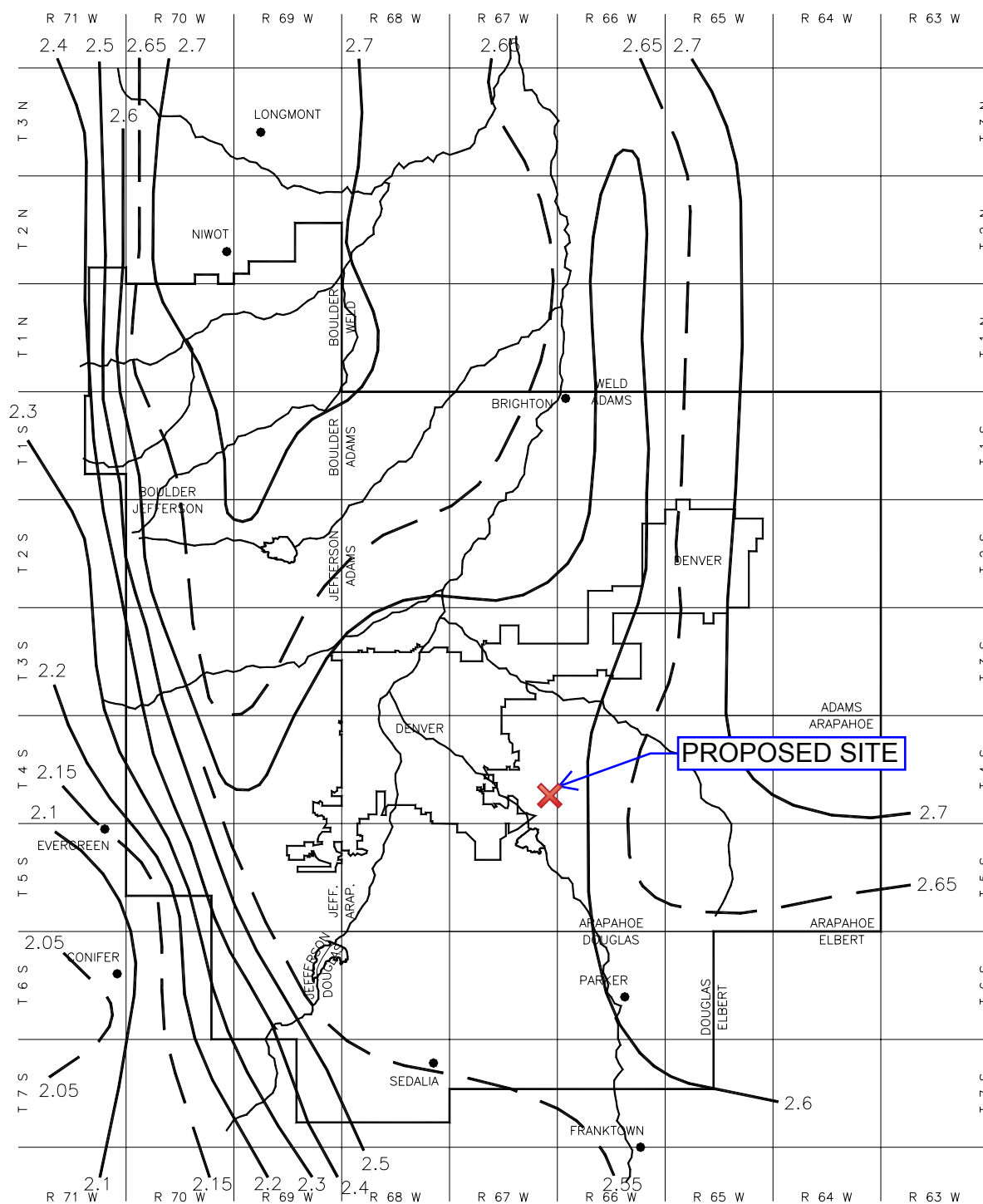


Figure RA-1—Rainfall Depth-Duration-Frequency: 2-Year, 1-Hour Rainfall



**Figure RA-6—Rainfall Depth-Duration-Frequency: 100-Year, 1-Hour Rainfall**

**Table 6-4. Runoff coefficient equations based on NRCS soil group and storm return period**

NRCS Soil Group	Storm Return Period						
	2-Year	5-Year	10-Year	25-Year	50-Year	100-Year	500-Year
A	$C_A =$ $0.84i^{1.302}$	$C_A =$ $0.86i^{1.276}$	$C_A =$ $0.87i^{1.232}$	$C_A =$ $0.88i^{1.124}$	$C_A =$ $0.85i+0.025$	$C_A =$ $0.78i+0.110$	$C_A =$ $0.65i+0.254$
B	$C_B =$ $0.84i^{1.169}$	$C_B =$ $0.86i^{1.088}$	$C_B =$ $0.81i+0.057$	$C_B =$ $0.63i+0.249$	$C_B =$ $0.56i+0.328$	$C_B =$ $0.47i+0.426$	$C_B =$ $0.37i+0.536$
C/D	$C_{C/D} =$ $0.83i^{1.122}$	$C_{C/D} =$ $0.82i+0.035$	$C_{C/D} =$ $0.74i+0.132$	$C_{C/D} =$ $0.56i+0.319$	$C_{C/D} =$ $0.49i+0.393$	$C_{C/D} =$ $0.41i+0.484$	$C_{C/D} =$ $0.32i+0.588$

Where:

$i$  = % imperviousness (expressed as a decimal)

$C_A$  = Runoff coefficient for Natural Resources Conservation Service (NRCS) HSG A soils

$C_B$  = Runoff coefficient for NRCS HSG B soils

$C_{C/D}$  = Runoff coefficient for NRCS HSG C and D soils.

The values for various catchment imperviousness and storm return periods are presented graphically in Figures 6-1 through 6-3, and are tabulated in Table 6-5. These coefficients were developed for the Denver region to work in conjunction with the time of concentration recommendations in Section 2.4. Use of these coefficients and this procedure outside of the semi-arid climate found in the Denver region may not be valid. The UD-Rational Excel workbook performs all the needed calculations to find the runoff coefficient given the soil type and imperviousness and the reader may want to take advantage of this macro-enabled Excel workbook that is available for download from the UDFCD's website [www.udfcd.org](http://www.udfcd.org).

See Examples 7.1 and 7.2 that illustrate the Rational Method.

FIRST NATIONAL BANK OF AURORA  
FILINGS ONE AND TWO

FINAL  
DRAINAGE STUDY

C6-2-669  
DECEMBER 1981

APPROVED FOR ONE YEAR FROM THIS DATE	
<u>2-3-82</u>	
<u>DRH 1-20-82</u> <u>H.C. Le Bonde</u> DIRECTOR OF PUBLIC WORKS	<u>1/20/82</u> DATE
<u>CKL</u> <u>Clonall</u> DIRECTOR OF UTILITIES	<u>1/20/82</u> DATE

STUDY PREPARED BY:

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Phone: 771-5370

FOR:

First National Bancorporation  
P.O. Box 5605  
Denver, Colorado 80217  
Phone: 893-2211

September 22, 1981

FIRST NATIONAL BANK OF AURORA

DRAINAGE STUDY

The proposed development consists of 4.15 acres in the NE $\frac{1}{4}$  of Section 22, T4S, R67W of the 6th P.M., City of Aurora, County of Arapahoe, State of Colorado.

Full retention as opposed to detention is the criteria set by the City of Aurora. With this in mind, exploring the drainage for the undeveloped site condition is not necessary and the efforts of this study have been concentrated on the developing conditions of this site and surrounding sites that affect or are affected by the subject parcel. As can be seen from the accompanying drawing, the bank site is bordered to the North by Suss Pontiac/GMC Dealership and Richard Boddicker's Auto Dealership, S. Havana St. to the East, proposed E. Idaho Pl. to the South, and proposed Willow Glen Subdivision Filing 2 to the West.

The existing slope of the land is to the North and West, thus eliminating the automobile dealerships and the Willow Glen Subdivision as tributaries to this site. S. Havana St. intercepts any drainage from the East and E. Idaho Pl. will intercept the drainage from the South. This includes the runoff from Federal Savings & Loan just South of E. Idaho Pl.. This runoff is controlled by a curb cut and a flume will be constructed to allow this discharge to enter E. Idaho Pl. This can be seen on the overall grading plan. With this overall concept, the project site North of E. Idaho Pl. can be considered a self-contained watershed.

The developed watershed within the 4.15 acre tract has been divided into three separate areas. Area one is approximately 0.61 acres, which is the area of E. Idaho Pl. that passes through the 4.15 acre tract. Area two is the First National Bank of Aurora Filing No. 1 less the area of E. Idaho Pl. that crosses Filing No. 1 and is 1.28 acres. Area three is known as the First National Bank of Aurora Filing No. 2 less the acreage of E. Idaho Pl. that passes through Filing No. 2 and comprises 2.26 acres.

Although the site is not affected by "outside" drainage, as mentioned before, the 0.61 acres of E. Idaho Place will contribute to the Willow Glen basin downstream. This drainage must be absorbed by the Willow Glen Subdivision.

This study is based on the Colorado Urban Hydrograph Procedure. From the Rainfall Depth-Duration-Frequency Map for the 100 year, 24 hour rainfall published by D.R.C.O.G., the isohyetal line crossing the area in question is 4.5 inches. Then, by using the Intensity-Duration-Frequency Curves for south of Alameda Ave. supplied in the Storm Drainage Design and Technical Criteria Manual from the City of Aurora, the total precipitation for 10 minute intervals was determined. Following the procedure outlined in the Urban Storm Drainage Manual the total average effective rainfall was calculated to be 3.98 inches. This can be seen in detail on the Effective Rainfall sheet included with this report.

Knowing what the Total Average Effective Rainfall for the area is, the total amount of retention volume for each area can be calculated as follows:

Entire Area:

Area = 4.15 acres

Total Average Effective Rainfall = 3.98 inches

$$4.15 \text{ acres} \times \frac{3.98 \text{ inches}}{12} = 1.38 \text{ ac. ft.} = \underline{59,957 \text{ c.f.}}$$

Area One (E. Idaho Pl.)

Area = 0.61 acres

$$0.61 \text{ acres} \times \frac{3.98 \text{ inches}}{12} = 0.20 \text{ ac. ft.} = 8,812.9 \text{ c.f.}$$

Use: 8,813 c.f.  
to be stored in Willow Glen Subdiv.

Area Two (Filing No. 1)

Area = 1.28 acres

$$1.28 \text{ acres} \times \frac{3.98 \text{ inches}}{12} = 0.43 \text{ ac. ft.} = 18,492.6 \text{ c.f.}$$

Use: 18,493 c.f.

Area Three (Filing No. 2)

Area = 2.26 acres

$$2.26 \text{ acres} \times \frac{3.98 \text{ inches}}{12} = 0.75 \text{ ac. ft.} = \underline{32,651 \text{ c.f.}}$$

Area Two + Area Three

Required Volume Area Two = 18,493 c.f.

Required Volume Area Three = 32,651 c.f.

Total Required Volume 51,144 c.f.

As can be seen from the accompanying grading plan, Area Two (Filing No. 1) surface drains across the site onto Area Three (Filing No. 2) and eventually discharges into a retention pond located in the N.E. corner of Filing No. 2. Area Three (Filing No. 2) also surface drains across the site and is retained in the same retention pond at the N.E. corner of Filing No. 2.

An additional boring in the center of the proposed pond revealed a stabilized ground water table 5.50 feet below the existing ground surface. This puts the water table at an elevation of 5480.00 USGS. These records are available on request.

Setting the maximum pond depth at 5480.00 USGS and creating a berm around the pond with its' maximum elevation set at 5486.00 yields a retention pond capacity of 52,364 c.f. which is ample enough to contain the 51,144 c.f. required from the 24 hour storm. The release into the retention pond is thru a 4 ft. curb cut as shown on the accompanying grading plan.

In addition to the runoff entering the site and carried overland across the project site, there is an existing 24 inch CMP that discharges just South of E. Idaho Pl.. The capacity of this pipe is 15 cfs.

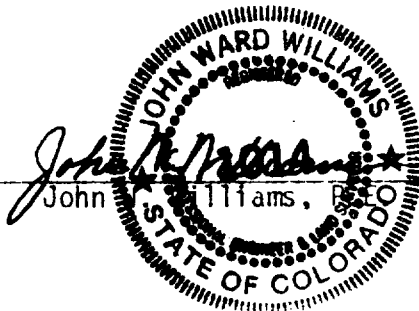
The 24 inch CMP shall be cut back to a point behind an existing inlet on S. Havana St. and a junction box built to accommodate flow entering the inlet. A proposed 24 inch RCP Cl. III will then be extended North approximately 195 feet where another junction box will join the proposed 24 inch RCP and the existing 24 inch CMP. A permit has been issued for this work by the State Highway Dept. of Colorado. A detail of this junction box can be found on the standard detail sheet provided.

Respectfully submitted,

J.W. Williams & Associates, Inc.

*Theodore Kupper*  
Theodore Kupper

Reviewed by:



For: First National Bancorporation  
Job. # 2415-12

Revised Dec. 23, 1981

Revised Jan. 19, 1982





