



April 12, 2024

City of Lee's Summit  
220 SE Green Street  
Lee's Summit, MO 64063

**RE: *Stormwater Analysis Memorandum – Summit Fair, Lot 10F***

Kimley-Horn is pleased to submit this Stormwater Analysis Memo for the future development of Summit Fair, Lot 10F. This lot, currently part of Summit Fair Lot 10C, was analyzed as part of the previously approved "Summit Orchards West" Stormwater Analysis Report prepared by SitePoint and dated August 2022, as well as the report titled "Summit Fair, Lot 10D-10F... Stormwater Analysis Report" prepared by Phelps Engineering Implementation (PEI) and dated April 2024, both of which are attached for reference.

Future Lot 10F, which is planned to be developed with a 1,000 SF drive thru restaurant per the attached plan, is proposed with 19,260 SF of impervious area and a total area of 32,325 SF. The PEI report indicates an impervious coverage allocation of 22,642 SF for Lot 10F, which includes a safety factor of roughly 30%.

	Impervious Area	Pervious Area
	Area (SF)	Area (SF)
Proposed Conditions	19,260	13,065
PEI Report	22,642	9667
Change	-3,382	3,398

As the PEI report outlines, the future development of Lot 10F is within the overall development plan, which introduces approximately 21,536 SF of additional impervious area compared to the previously approved Stormwater Analysis Report. However, due to the size of the overall development, this increase in impervious area is deemed insignificant and has no negative impact on the proposed Curve Number (CN) value. Consequently, the proposed plan for Lot 10F is found to be in substantial compliance with the associated Stormwater Analysis Reports attached herein.

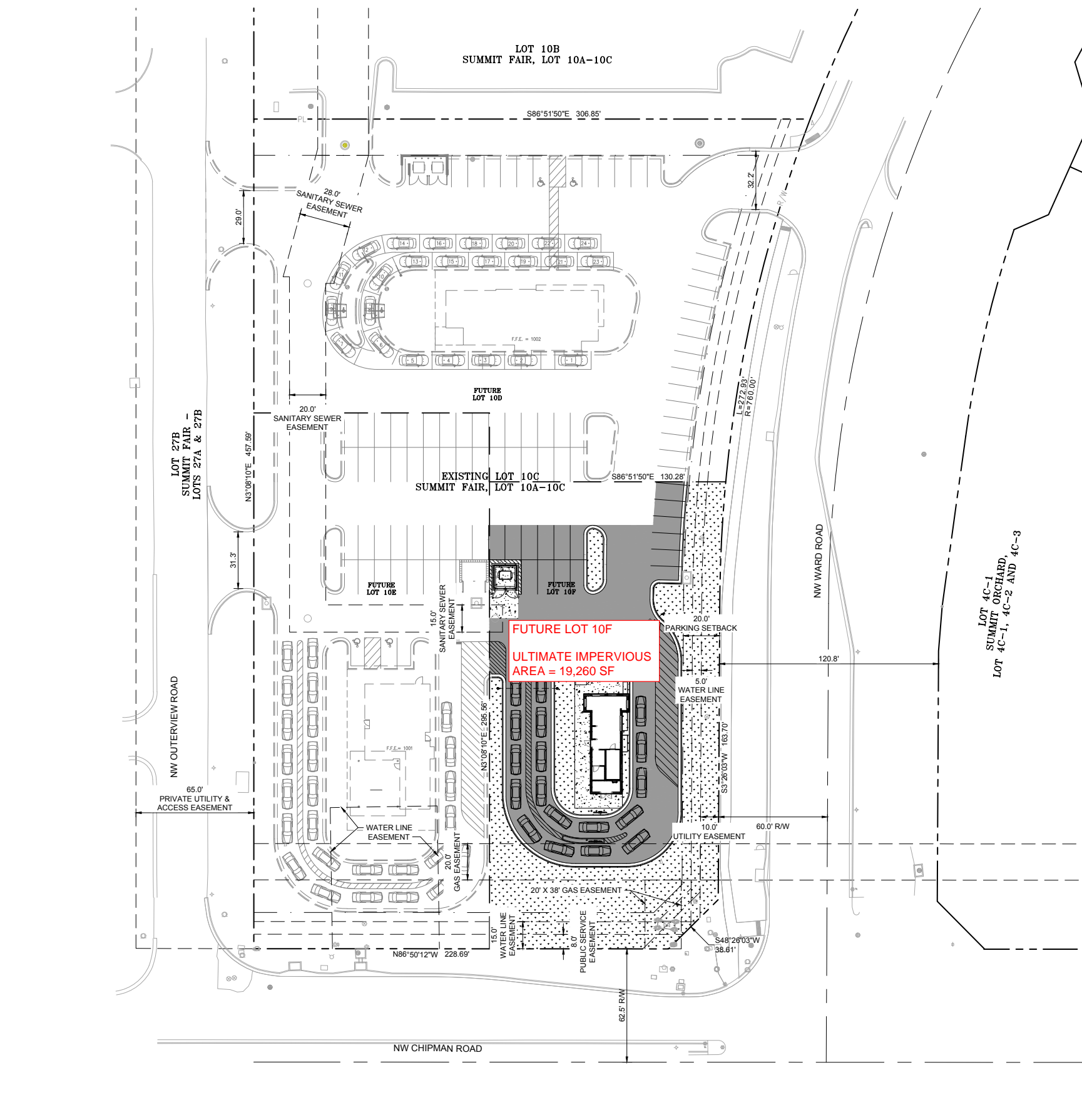
Please do not hesitate to contact Kimley-Horn at (816) 652-2333 if you require additional information or have further inquiries regarding this matter.

Sincerely,



Andrew Gribble, PE





## LEGEND

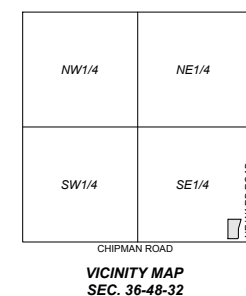
PROPERTY LINE

LOT LINE

STREET CENTER LINE

EASEMENT LINE

PARKING SETBACK LINE



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**Kimley»Horn**  
© 2024 KIMLEY-HORN AND ASSOCIATES, INC.  
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816-652-0350  
WWW.KIMLEY-HORN.COM

[illegible]

CHECKED BY: AG

DRAWN BY: AD

Owner: **AND GO CONCEPTS, LLC.**  
5555 E. VAN BUREN ST, SUITE 215  
PHOENIX, AZ 85008



Project:

SALAD AND GO  
2001 LEE'S SUMMIT

Building Address:

**700 N.W. WARD ROAD, LEE'S  
SUMMIT, MO 64086**

DRAWING:

Scale: AS NOTED

Date: \_\_\_\_\_

Project No. 195516018

Drawing No.



April 10, 2024

City of Lee's Summit  
220 SE Green St  
Lee's Summit, MO 64063

Re: Summit Fair, Lot 10D-10F (currently Summit Fair Lot 10C)  
Stormwater Analysis Report  
PEI #240017

Phelps Engineering, Inc. is pleased to submit this Stormwater Analysis Report for the future developments of Summit Fair, Lots 10D-10F (currently Summit Fair Lot 10C). Summit Fair Lot 10C was previously analyzed as part of the previously approved "Summit Orchards West" Stormwater Analysis Report which was prepared by SitePoint and dated August 2022.

As part of the previous report, the development of Lots 10A, 10B, and 10C were not to exceed a CN of 92. The proposed impervious areas for Lots 10A, 10B, and 10C were previously calculated as shown below.

Previously Approved Report		
Lot No.	Total Area	Impervious Coverage
<b>Lot 10A</b>	10.08 AC. (439,085 S.F.)	309,264 S.F. (70%)
<b>Lot 10B</b>	11.83 AC. (515,315 S.F.)	330,446 S.F. (64%)
<b>Lot 10C</b>	2.79 AC. (121,532 S.F.)	70,773 S.F. (58%)
<b>Total</b>	<b>24.70 AC.</b> <b>(1,075,932 S.F.)</b>	<b>710,483 S.F.</b> <b>(66%)</b>

Previously Approved CN  
 $(98 \times 710,483 + 80 \times 365,449) / 1,075,932 = 91.9 \rightarrow 92$

**PHELPS ENGINEERING, INC.**

1270 N. Winchester - Olathe, Kansas 66061 - (913) 393-1155 - Fax (913) 393-1166 - [www.phelpsengineering.com](http://www.phelpsengineering.com)



The proposed plan will subdivide Lot 10C into 3 separate lots, creating Lots 10D, 10E, and 10F. Each lot is anticipated to be developed with a restaurant. See the attached preliminary plan for reference. The proposed impervious areas for Lots 10A, 10B, 10D, 10E, and 10F are shown below.

<b>Proposed Conditions</b>		
<b>Lot No.</b>	<b>Total Area</b>	<b>Impervious Coverage</b>
<b>Lot 10A</b>	10.08 AC. (439,085 S.F.)	309,264 S.F. (70%)
<b>Lot 10B</b>	11.83 AC. (515,315 S.F.)	330,446 S.F. (64%)
<b>Lot 10D</b>	1.28 AC. (55,798 S.F.)	44,439 S.F. (80%)
<b>Lot 10E</b>	0.77 AC. (33,475 S.F.)	25,228 S.F. (75%)
<b>Lot 10F</b>	0.74 AC. (32,309 S.F.)	22,642 S.F. (70%)
<b>Total</b>	<b>24.70 AC.</b> <b>(1,075,932 S.F.)</b>	<b>732,019 S.F.</b> <b>(68%)</b>

Proposed CN

$$(98 \times 732,019 + 80 \times 343,913) / 1,075,932 = 92.2 \rightarrow 92$$

The proposed plan results in an increase in impervious area of 21,536 SF when compared to the previously approved Stormwater Analysis Report. However, given the size of the overall development, the increase in impervious area does not result in an increase in the proposed CN. Therefore, the increase in impervious area is deemed insignificant, and the proposed plan is found to be in substantial compliance with the previously approved Stormwater Analysis Report.

Please feel free to contact PEI at (913) 393-1155 if you require additional information.

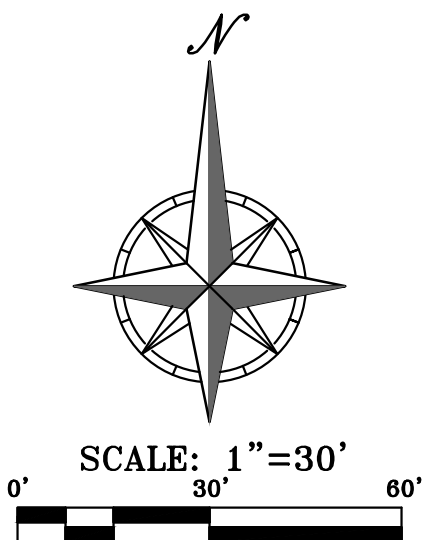
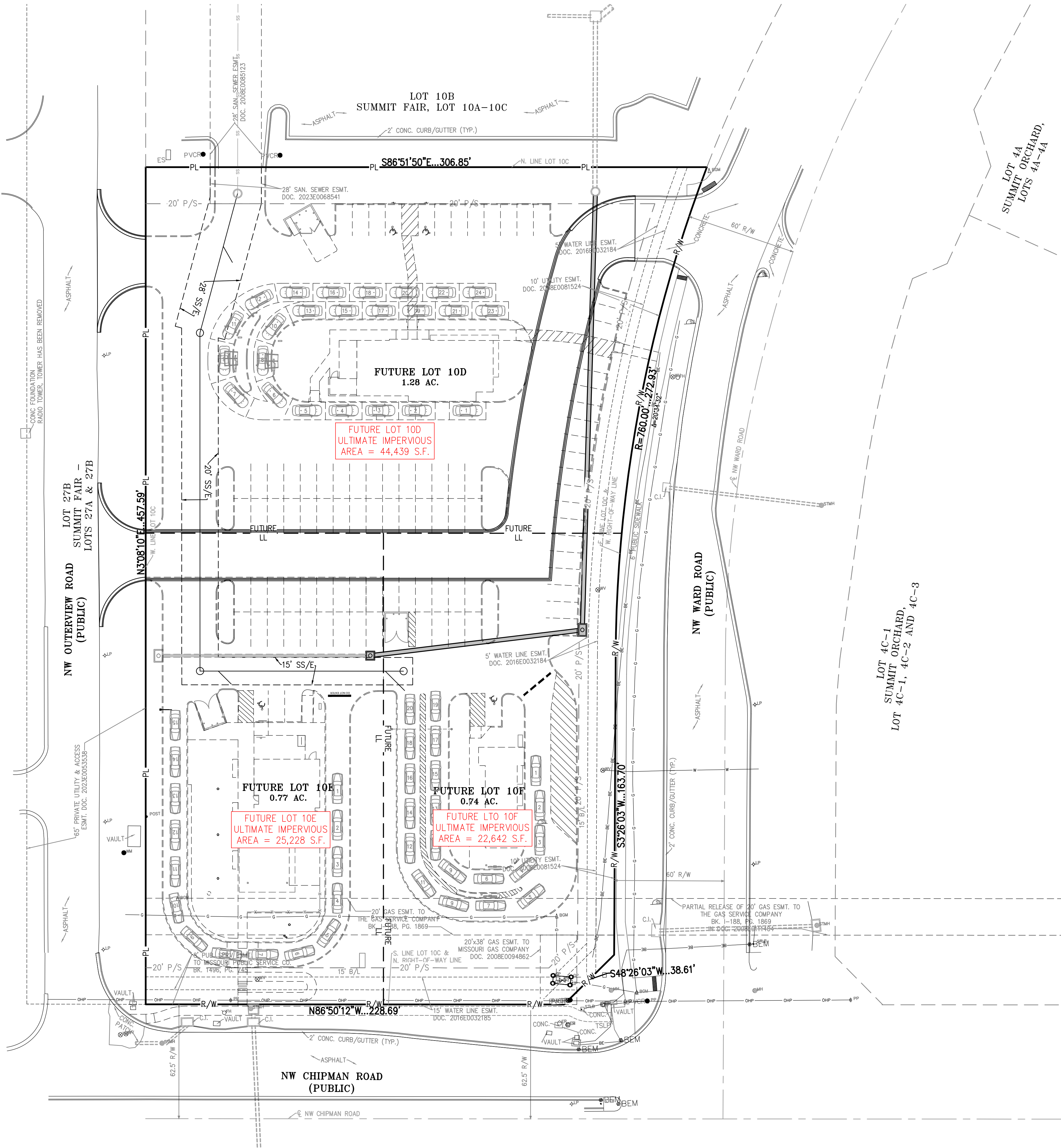
Sincerely,

**PHELPS ENGINEERING, INC.**

Judd Claussen, P.E.



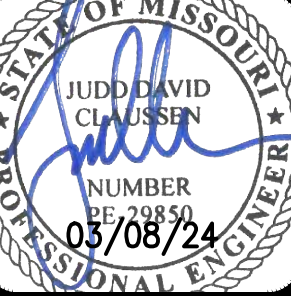
\\PHILIPS-SERVER\Projects\Projects\144017\Draw\Permit Plans\Overall Site - PAD SITE EXHIBIT IMPERVIOUS.dwg Layout1 Apr 10, 2024 - 12:03pm Daniel Finn



PROJECT NO.	240017	No.	Date	Revisions:	By	App.
DATE	03-08-2024	DRAWN/AB				
CHECKED	DAF	APPROVED	DAF			
CORROBORATE	DATE OF AUTHORIZATION					
LAND SURVEYING	- LS-82					
ENGINEERING	- E-361					
CERTIFICATE OF AUTHORIZATION						
LAND SURVEYING	2007001028					
ENGINEERING	2007000209					

SHEET

1



PHILIPS ENGINEERING, INC.  
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PLANNING  
ENGINEERING  
IMPLEMENTATION



OVERALL SITE PLAN - IMPERVIOUS AREA

SUMMIT FAIR, LOT 10-C  
700 NW WARD ROAD  
LEE'S SUMMIT, MISSOURI

# SUMMIT ORCHARDS WEST

LEE'S SUMMIT, MO

## Stormwater Analysis Report

Prepared For:



3315 N Oak Trafficway  
Kansas City, MO 64116

Prepared By:



3315 N Oak Trafficway  
Kansas City, MO 64116  
816.888.7380  
[sitepoint@northpointkc.com](mailto:sitepoint@northpointkc.com)

August 2022



Melissa G. DeConia 08/26/2022

## Table of Contents

1	Site Description	3
	Floodplain Summary	3
	Soil Conditions	3
2	Methodology	3
3	Existing Conditions	4
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## Attachments

Exhibit 1: PDP Site Plan

Exhibit 2: PDP Storm Sewer General Layout

Appendix A: THH Inc. Stormwater Drainage Report for Ward Road- Summit Technology Campus (Sep 2006)

Appendix B:

- Red Development Lee's Summit Fair Stormwater Drainage Study (Olsson Associates, Dec 2006)
- Regional Detention Basin Stormwater Flows Analysis (THH, Inc., July 2009)
- Detention Basin Contributing Areas Exhibit (THH, Inc., Sep 2009)
- Summit Innovation Center Stormwater Drainage Report (THH Inc., March 2015)
- Summit Orchard Lot 7A Stormwater Report (April 2016)



# 1 Site Description

Summit Orchards West is a proposed 24.70-acre mixed-use development consisting of three (3) individual parcels located southeast of the interchange of Interstate-470 and US Highway 50. The project is bounded on the north and east by Ward Road, on the south by NW Chipman Rd, and on the west by Outerview Road. The proposed development is directly east of the existing Summit Technology Campus. This study will focus on the entire development, which will contain a proposed 2.79-acre commercial lot, an 11.83-acre multifamily residential lot, and a 10.08-acre industrial lot. The Preliminary Development Plan (PDP) Site Plan is attached as Exhibit 1. The entirety of the proposed development is within the drainage area for a regional detention basin that was previously completed and approved for the Summit Technology Campus and surrounding area.

## Floodplain Summary

FEMA Flood Boundary Map 29095C0417G does not designate any floodplain on the property. The entire property is unshaded Zone X.

## Soil Conditions

Soil data was obtained from the NRCS Web Soil Survey. Soils within the watershed are a mixture of Hydrologic Soil Groups C and D. For this study, all Curve Numbers are based on HSG D for proposed conditions. The soils found in the watershed are summarized in the table below.

Table 1 Soil Data

Name	Slopes	HSG
Arisburg-Urban land complex	1-5%	C
Snead-Rock outcrop complex	5-14%	D
Udarents-Urban land-Sampsel complex	5-9%,	C
Urban land, upland	5-9%	C/D

# 2 Methodology

Analysis of the proposed Summit Orchards West improvements will be compared the findings found in the “Stormwater Drainage Report for Ward Road- Summit Technology Campus (September 2006)” created by THH Inc. This report serves as the Stormwater Master Plan for the area that was approved by the City of Lee’s Summit in 2007, and is attached as Appendix A. The objective of this report is to demonstrate compliance with the anticipated site conditions shown in the approved master plan, ensuring that the downstream regional detention basin will have the necessary capacity to continue functioning as it was originally designed. Since the proposed development is a small portion of the total drainage area contributing to the regional detention basin, the proposed Curve Number (CN) of the development will be compared to the designed CN for the project parcel in the THH Inc. report.

Additionally, the Summit Orchards West property and watershed have been included as a part of numerous stormwater studies created for the Summit Technology Campus and surrounding area. The following studies were provided to Sitepoint at the time of design, and are included in this report for reference in Appendix B:

- Red Development Lee's Summit Fair Stormwater Drainage Study (Olsson Associates, Dec 2006)
- Regional Detention Basin Stormwater Flows Analysis (THH, Inc., July 2009)
- Detention Basin Contributing Areas Exhibit (THH, Inc., Sep 2009)
- Summit Innovation Center Stormwater Drainage Report (THH Inc., March 2015)
- Summit Orchard Lot 7A Stormwater Report (April 2016)

### 3 Existing Conditions

The Summit Orchards West project property is currently an undeveloped portion of a large mixed-use development, which features a regional detention facility to control stormwater runoff flow rates to downstream systems. The study for this basin was submitted and approved in 2007 (Appendix A). In this study, the basin's entire drainage area is divided into sub-basins. The Summit Orchards West development is in sub-basin 1, 3 and 4, as shown in Exhibit 1 of the attached report. Included in the study are the existing, proposed, and future conditions for the sub-basins. The existing conditions for these sub-basins are as follows:

Existing Conditions (Per THH Inc. Report)				
Sub-Basin	Area (sq. miles)	Area (acres)	CN	Lag Time (hr.)
1	0.0844	54	76	0.65
3	0.0938	60	78	0.80
4	0.0938	60	81	0.62

The "Proposed Conditions" section of the study does not show any changes to the sub-basins, as there were no improvements in the immediate future planned in these areas at the time. These conditions will be considered the existing site conditions in this report.

### 4 Proposed Conditions

The THH Inc. report lists the "Future Conditions" of Sub-Basins 1, 3, and 4 as follows:

Future Conditions (Per THH Inc. Report)				
Sub-Basin	Area (sq. miles)	Area (acres)	CN	Lag Time (hr.)
1	0.0844	54	92	0.49
3	0.0938	60	94	0.60
4	0.0938	60	94	0.47

These conditions show a change in CN from 76 to 92 for sub-basin 1, 78 to 94 for sub-basin 3, and a change from 81 to 94 for Sub Basin 4. The 1% design storm event was analyzed under these conditions to ensure proper function of the basin. Per the PDP, the proposed conditions of the Summit Orchards West development shall be as follows:

Proposed Conditions (Per PDP)		
Surface	Area (acres)	CN
Pervious	8.02	80
Impervious	16.68	98

Composite CN	92
--------------	----

The proposed CN for the development is at or below the planned CN for sub-basins 1, 3, and 4. All runoff from the site will drain to the regional detention basin, which has been modeled to accommodate such an increase in runoff.

To match the existing drainage patterns, all runoff from the proposed development, along with all upstream runoff coming on site, will be routed north towards the existing 5'x5' RCB culvert on the northern end of the project property. Existing and proposed stormwater conveyance systems will be utilized on site to properly drain runoff to the 5'x5' RCB culvert. The preliminary drainage design is attached as Exhibit 2.

## 5 Summary

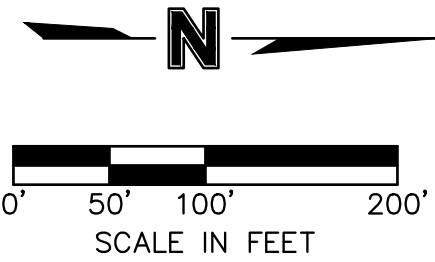
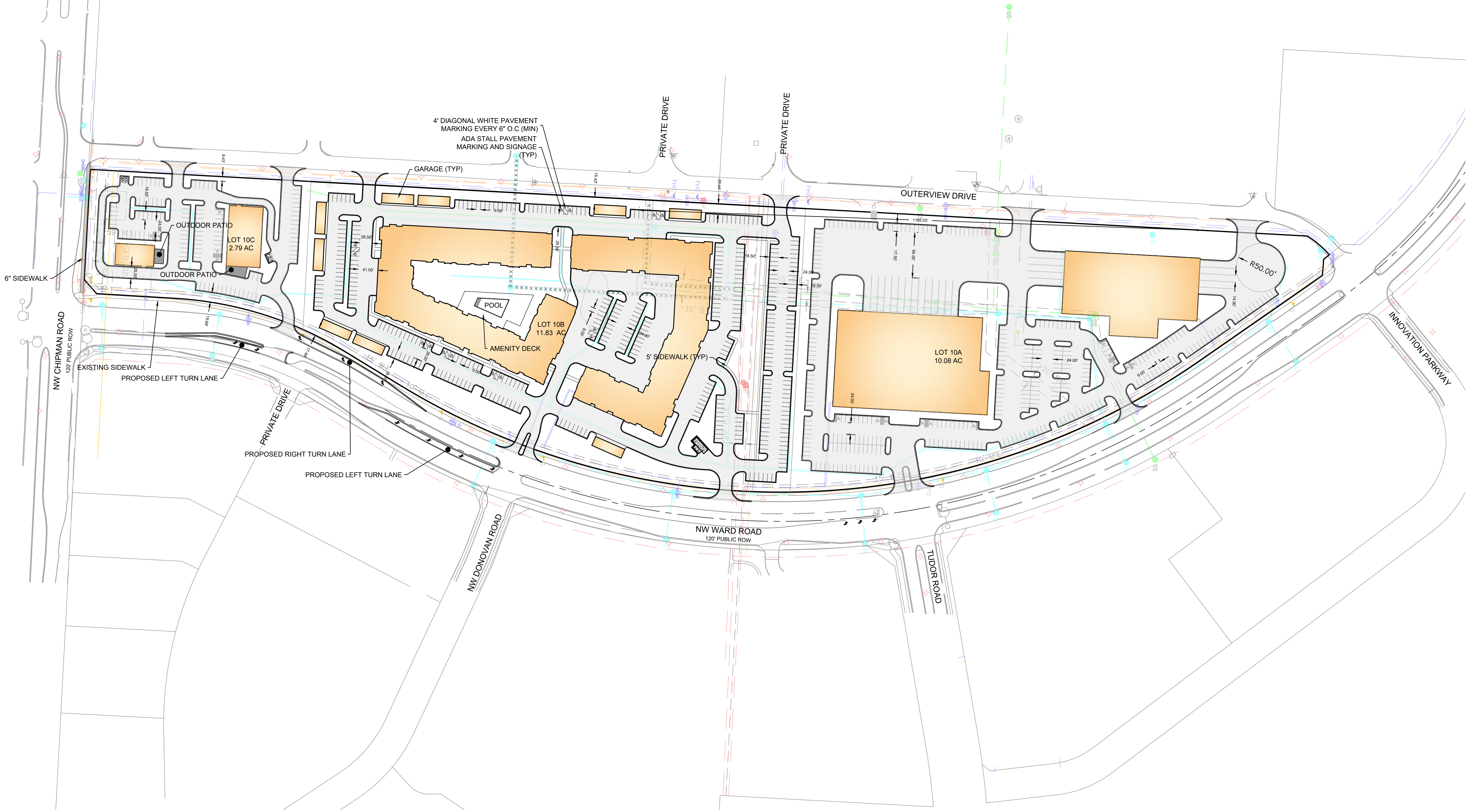
The proposed Summit Orchards West commercial, industrial, and multi-family residential development has been designed to match future condition assumption of the area, as specified in the approved basin design and master plan for the Summit Technology Campus by THH, Inc. All stormwater runoff on site will be conveyed to the existing 5'x5' culvert on the northern end of the lot. As seen in the comparison of existing and proposed curve numbers, the proposed improvements are within the design assumptions made in the THH Inc. stormwater master plan, and will not adversely affect the downstream regional detention basin's performance.

## Exhibit 1



S:\01 PROJECTS\MULTI-FAMILY\424 SUMMIT SQUARE 3\UTILITIES\PLANS\PRELIMINARY DEVELOPMENT PLAN-C-0200 SITE PLANNING

SITE DATA									
Lot No.	Total Area	Impervious Coverage	Maximum Building Height	Building Area (All stories)	Floor Area Ratio (FAR)	Proposed Building Use	Parking		
							Requirement		Proposed
10A	10.08 AC. (439,085 S.F.)	309,264 S.F. (70%)	60', 2 stories	123,000 S.F. (Building 1, 51,000 S.F. Building 2, 72,000 S.F.)	0.28	Office/Warehouse	4 per 1,000 S.F. of Office plus 1 per 1,000 S.F. of warehouse	243	326
10B	11.83 AC. (515,315 S.F.)	330,466 S.F. (64%)	60', 4 stories	470,000 S.F. (Building 1, 215,000 S.F. Building 2, 255,000 S.F.)	0.91	Multifamily Residential	1.7 per DU	549	562
10C	2.79 AC. (121,532 S.F.)	70,773 S.F. (58%)	45'	12,300 S.F. (Building 1, 8,800 S.F. Building 2, 3,500 S.F.)	0.10	Retail/ Drive-Through Restaurant	5 per 1,000 S.F. of Retail and 14 per 1,000 S.F. of Restaurant	93	114



LEGEND	
	STANDARD DUTY ASPHALT PAVEMENT
	CG-1 CURB & GUTTER
	STANDARD DUTY CONCRETE PAVEMENT

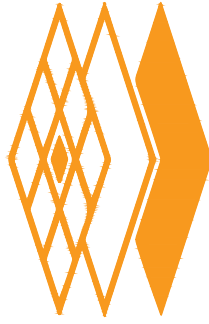
SITE PLAN

SUMMIT ORCHARDS WEST  
PRELIMINARY DEVELOPMENT PLAN  
LEE'S SUMMIT, JACKSON COUNTY, MO

Certificate of Authority #MO 2020018354  
SHEET #:

C-0200

REVIEWED BY:	DATE:	NO.	REVISIONS/APPROVALS:
M.C.D.	2022.08.26		INITIAL CITY SUBMITAL
DESIGNED BY:			
DRAFTED BY:			
SP PROJECT #:			
MELISSA G. DEGENIA, P.E.			
2011000992			



**SITEPOINT**  
A Division of NorthPoint Development  
3315 N Oak Trafficway  
Kansas City, MO 64116  
816.888.7380  
sitepoint@northpointkc.com



## Exhibit 2







## Appendix A

# *Stormwater Drainage Report*

for

## **Ward Road - Summit Technology Campus**

September 2006

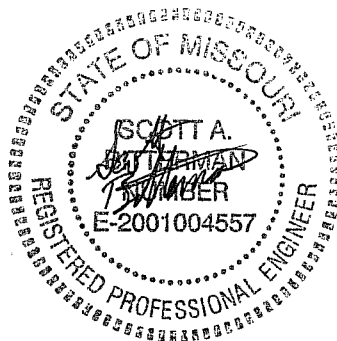
### ***Developer:***

Mr. Richard L. Muller  
Townsend Capital LLC  
777 NW Blue Parkway 3  
Lee's Summit, MO 64086

Project No. 063279

Prepared by:

**Trabue, Hansen & Hinshaw Inc.**  
1901 Pennsylvania Drive  
Columbia, MO 65202  
(573) 814-1568



9-28-06



..... *about the possibilities*

## TABLE OF CONTENTS

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#### APPENDICES

- Appendix A, Exhibits
- Appendix B, Existing Sub-Basin Curve Numbers
- Appendix C, Existing Sub-Basin Time of Concentration
- Appendix D, HEC-HMS 3.0.1 Printouts for Existing Conditions
- Appendix E, Proposed Sub-Basin Curve Numbers
- Appendix F, HEC-HMS 3.0.1 Printouts for Proposed Conditions
- Appendix G, Future Sub-Basin Curve Numbers
- Appendix H, HEC-HMS 3.0.1 Printouts for Future Conditions

# Stormwater Drainage Report For Ward Road - Summit Technology Campus

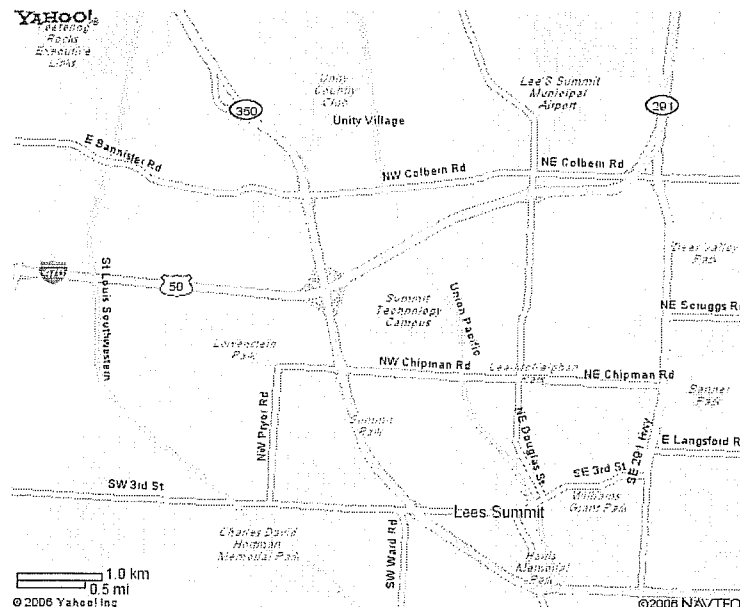
## Introduction

This storm drainage study is for the Townsend Development, which is part of the Preliminary Plan for the mixed-use development at Summit Technology Campus. The Campus is located in Lee's Summit, Missouri, and is owned by Townsend Capital LLC. This drainage report follows Section 5600 of the Standard Specifications and Design Criteria of the Kansas City Metropolitan Chapter of the American Public Works Association (APWA) and the Lee's Summit, Missouri, design supplement to these specifications. HEC-HMS 3.0.1 watershed modeling software was used to generate the drainage values in this report. This drainage report presents estimates of the flow to the proposed regional detention pond generated by the onsite drainage of the entire Technology Campus for the 1-year, 10-year, and 100-year storm events. This study incorporates a Stormwater Drainage Study, prepared by Olsson Engineering for RED Development, as the proposed condition sends a portion of the Red Development drainage through the Townsend Development.

This storm drainage study for the proposed developments evaluates existing and proposed hydraulic conditions to ensure runoff from the developments will not have an adverse impact on downstream tracts.

## Project Location

Summit Technology campus is located just southeast of the Interstate 470 / State Highway 50 interchange. The Campus is bound in the south by Chipman Road and in the east by Union Pacific Railroad. The Red Development encompasses the westerly portion of the site and is included by reference only. The Ward Road Development takes up the eastern part of the Campus. The location can be viewed in the below figure.



## **Project Description**

The Townsend Development site measures a total of 259 acres. The proposed development includes the extension of Northwest Ward Road to the Northwest Missouri Road / Northwest Blue Parkway intersection. The proposed development also includes the additional parking spaces; however an obsolete building and wastewater treatment plant will be removed resulting in a net increase of 0.7 acres of impervious surface. The adjacent Red Development measures 79 acres and will be fully developed at this time. The drainage from both developments will be collected in the same regional detention pond. This pond is located at the northeastern corner of the Campus, just southwest of the railroad crossing of Interstate 740. Exhibit 2, located in Appendix A, shows the proposed improvements. Exhibit 2 also shows development around Ward Road that will be constructed in the future, but not with this proposed development.

## **Drainage Area Description**

The current drainage area contributing to the regional detention pond measures 1.13 square miles. 111 acres of drainage area serving Red Development will also be diverted to the regional detention pond. The Red Development drainage has been evaluated by Olsson Engineering in their Stormwater Drainage Study, OA Project No. 2-2005-0451, which is referenced in this report. The Ward Development has been divided into sub-basin areas as illustrated in Exhibit 1, Located in Appendix A.

## **Methodology**

HEC-HMS 3.0.1 watershed modeling software was used to estimate the existing and proposed runoff quantities for the entire watershed contributing to the detention pond for the 1-year, 10-year, and 100-year storm events. The drainage contribution from the RED development was calculated by Olsson Engineering and is included in the total runoff.

City of Lee's Summit, Missouri Bogg's Hollow, Little Cedar Creek Stormwater Master Plan was referenced to determine drainage areas and existing site conditions.

## **Existing Site Conditions**

A 9' X 10' reinforced concrete box (RCB) culvert releases drainage from the site under Interstate 470. Most of the Red Development site is heavily vegetated with brush and trees. The Townsend Site has established vegetation in most areas and also includes parking and portions of the main STC buildings.



### **Existing Drainage Conditions**

The existing Townsend Site was divided into 8 sub-basins. TR-55 Curve Numbers were calculated for each sub-basin assuming Soil Type C. The Curve Number calculations can be viewed in Appendix B. The Lag Time for each basin was calculated using TR-55 recommended equations as shown in Appendix C.

Table 1 below shows the hydrologic properties for each sub-basin.

Table 1 – Existing Sub-Basin Conditions				
Sub-Basin	Area (sq. miles)	Area (acres)	CN	Lag Time (hr)
1	.0844	54	76	.65
2	.1188	76	80	.97
3	.0938	60	78	.80
4	.0938	60	81	.62
5	.0438	28	76	.40
6	.2922	187	86	.83
7	.2406	154	84	.62
8	.1672	107	87	.52

The values for these sub-basins were input into HEC-HMS 3.0.1 to produce the existing hydrographs. SCS Type II 24-hr design storms were used as shown in Table 2 below.

Table 2 – Existing Peak Flows										
Recurrence Interval	Precip Depth (in)	Peak Flow (cfs) per hydraulic element								
		Sub-Basin 1	Sub-Basin 2	Sub-Basin 3	Sub-Basin 4	Sub-Basin 5	Sub-Basin 6	Sub-Basin 7	Sub-Basin 8	9X10 RCB
100%	3.0	40	54	43	62	29	202	187	165	475
10%	5.3	117	140	119	157	82	456	439	360	1008
1%	7.7	206	237	205	262	144	724	709	565	1380

The 9'X10' RCB serves as existing detention for all storms as the box is not large enough to pass the water under I-470. During the 100 yr storm, the RCB would detain enough water to raise the head from 909 ft, to 925 ft. causing a small amount water to go under the I-470 & Railroad grade separated bridge.

Detailed existing conditions can be found in the summary output from HEC-HMS 3.0.1 files, located in Appendix D.

### Proposed Drainage Conditions

The proposed Townsend drainage was divided into 10 sub-basins; the 8 existing sub-basins plus 2 sub-basins diverted from Red Development. The Curve Numbers for the impacted sub-basins are shown in Appendix E. The Curve Number and time of concentration discussion for the drainage areas serving Red Development can be found in the aforementioned Olsson Study.

Table 3 below shows the hydrologic properties for each sub-basin for the proposed condition:

Table 3 – Proposed Sub-Basin Conditions				
Sub-Basin	Area (sq. miles)	Area (acres)	CN	Lag Time (hr)
1	.0844	54	76	.65
2	.1188	76	80	.97
3	.0938	60	78	.80
4	.0938	60	81	.62
5	.0438	28	77	.40
6	.2922	187	86	.83
7	.2406	154	84	.62
8	.1672	107	87	.52
1. Prop Site (Red Development)	.123	74	97	.13
2. Ex. Tech. Build. (Red Development)	.049	37	97	.08

The values for these sub-basins were input into HEC-HMS 3.0.1 to produce the proposed hydrographs. SCS Type II 24-hr design storms were used as shown in Table 4 below. For this condition, a regional detention basin was modeled to handle the increase in flow. The basin would need two 8.5 ft Corrugated Metal Pipes, or similar discharge culvert, to release the flow and the basin would need 131 AC-ft. of Storage to hold the 100 yr storm event. The basin would operate as a dry cell.

Table 4 – Proposed Peak Flows												
Recurrence Interval	Precip Depth (in)	Peak Flow (cfs) per hydraulic element										
		Sub-Basin 1	Sub-Basin 2	Sub-Basin 3	Sub-Basin 4	Sub-Basin 5	Sub-Basin 6	Sub-Basin 7	Sub-Basin 8	1 Prop Site	2. Ex. Tech	Regional Detent.
100%	3.0	40	54	43	62	31	202	187	165	243	137	432
10%	5.3	117	140	119	157	85	456	439	360	438	246	864
1%	7.7	206	237	204	262	147	724	709	565	639	359	1300

The regional detention pond would be able to reduce the discharge north of I-470 from 1380 cfs to 1300 cfs during the 1% event. Detailed proposed conditions can be found in the summary output from HEC-HMS files, located in Appendix F.

## Future Drainage Conditions

An additional drainage scenario was looked at to determine the size of the regional detention pond if the Townsend Development replaced the unutilized land with urban uses. This analysis was only conducted for the 100 yr storm. The Curve Numbers for the future condition would be different as the amount of impervious areas would increase substantially. The Curve Numbers for the impacted sub-basins are shown in detail in Appendix G. It was assumed that the lag time for the impacted Townsend Development sub-basins would be reduced by 25%.

Table 5 below shows the hydrologic properties for each sub-basin for the proposed condition:

Table 5 – Future Sub-Basin Conditions				
Sub-Basin	Area (sq. miles)	Area (acres)	CN	Lag Time (hr)
1	.0844	54	92	.49
2	.1188	76	93	.73
3	.0938	60	94	.60
4	.0938	60	94	.47
5	.0438	28	94	.30
6	.2922	187	86	.83
7	.2406	154	84	.62
8	.1672	107	87	.52
1. Prop Site (Red Development)	.123	74	97	.13
2. Ex. Tech. Build. (Red Development)	.049	37	97	.08

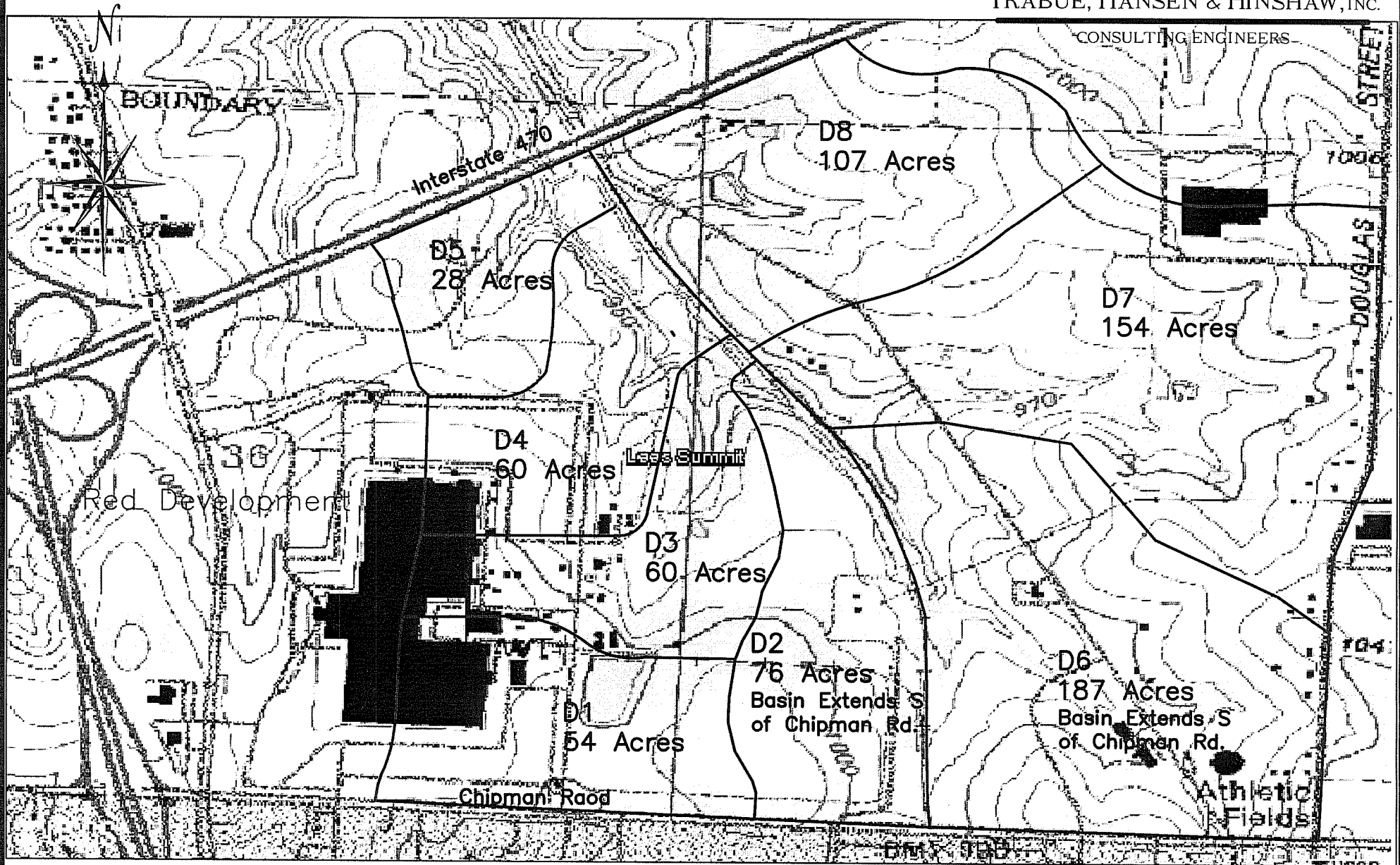
The values for these sub-basins were input into HEC-HMS 3.0.1 to produce the future hydrographs. SCS Type II 24-hr design storms were used as shown in Table 6 below. The detention pond would need two 8.5 ft Corrugated Metal Pipes, or similar discharge culvert, to release the flow and the basin would need 146 AC-ft. of Storage to hold the 100 yr storm event. The basin would operate as a dry cell.

Table 6 – Proposed Peak Flows												
Recurrence Interval	Precip Depth (in)	Peak Flow (cfs) per hydraulic element										
		Sub-Basin 1	Sub-Basin 2	Sub-Basin 3	Sub-Basin 4	Sub-Basin 5	Sub-Basin 6	Sub-Basin 7	Sub-Basin 8	1 Prop Site	2. Ex. Tech	Regional Detent.
1%	7.7	323	353	313	365	211	724	709	565	639	359	1389

The regional detention pond would be able to maintain the pre-development discharge north of I-470 for the 1% event. The calculations show a 9 cfs increase at the 9'X10' RCB; however, no additional storage is recommended as the Olsson Study showed substantial decreases in drainage for the 5'X5' RCB under I-470. Detailed future conditions can be found in the summary output from HEC-HMS file, located in Appendix H.

# APPENDIX A

## EXHIBITS



THHinc.

Townsend Capital LLC  
Summit Technology Campus

Drainage Sub-Basins

SCALE: 1"=1000'

Exhibit 1



# APPENDIX B

EXISTING SUB-BASIN CURVE NUMBERS

Project #: 3279

Project: Townsend Drainage Report

Subject: TR-55 Drainage Calculations, Existing Conditions

Location: Lee's Summit, MO

By: Scott Bitterman

**Existing Conditions**

<b>Sub-Basin 1. Runoff curve number</b>				
Hydrolic Soil Group	Land Use	CN Table 5602.3.B	Area	Product of CN and Area
C	Industrial, Heavy Areas	93	11%	10.23
C	Undeveloped Areas	74	89%	65.86

Use CN = **76**

<b>Sub-Basin 2. Runoff curve number</b>				
Hydrolic Soil Group	Land Use	CN Table 5602.3.B	Area	Product of CN and Area
C	Industrial, Heavy Areas	93	8%	7.44
C	Residential, 1/8 acre or less	92	24%	22.08
C	Undeveloped Areas	74	68%	50.32

Use CN = **80**



Project #: 3279

Project: Townsend Drainage Report

Subject: TR-55 Drainage Calculations, Existing Conditions

Location: Lee's Summit, MO

By: Scott Bitterman

**Existing Conditions**

<b>Sub-Basin 3. Runoff curve number</b>				
Hydrolic Soil Group	Land Use	CN Table 5602.3.B	Area	Product of CN and Area
C	Industrial, Heavy Areas	93	20%	18.6
C	Undeveloped Areas	74	80%	59.2

Use CN = **78**

<b>Sub-Basin 4. Runoff curve number</b>				
Hydrolic Soil Group	Land Use	CN Table 5602.3.B	Area	Product of CN and Area
C	Industrial, Heavy Areas	93	38%	35.34
C	Undeveloped Areas	74	62%	45.88

Use CN = **81**

Project #: 3279

Project: Townsend Drainage Report

Subject: TR-55 Drainage Calculations, Existing Conditions

Location: Lee's Summit, MO

By: Scott Bitterman

**Existing Conditions****Sub-Basin 5. Runoff curve number**

Hydrolic Soil Group	Land Use	CN Table 5602.3.B	Area	Product of CN and Area
C	Industrial, Heavy Areas	93	12%	11.16
C	Undeveloped Areas	74	88%	65.12

Use CN = **76****Sub-Basin 6. Runoff curve number**

Hydrolic Soil Group	Land Use	CN Table 5602.3.B	Area	Product of CN and Area
C	Industrial, Heavy Areas	93	36%	33.48
C	Residential, 1/8 acre or less	92	28%	25.76
C	Undeveloped Areas	74	36%	26.64

Use CN = **86**

Project #: 3279

Project: Townsend Drainage Report

Subject: TR-55 Drainage Calculations, Existing Conditions

Location: Lee's Summit, MO

By: Scott Bitterman

**Existing Conditions**

<b>Sub-Basin 7. Runoff curve number</b>				
Hydrolic Soil Group	Land Use	CN Table 5602.3.B	Area	Product of CN and Area
C	Industrial, Heavy Areas	93	53%	49.29
C	Undeveloped Areas	74	47%	34.78

Use CN = **84**

<b>Sub-Basin 8. Runoff curve number</b>				
Hydrolic Soil Group	Land Use	CN Table 5602.3.B	Area	Product of CN and Area
C	Industrial, Light Areas	88	90%	79.2
C	Undeveloped Areas	74	10%	7.4

Use CN = **87**

# APPENDIX C

EXISTING SUB-BASIN TIME OF CONCENTRATION



# TRABUE, HANSEN & HINSHAW, Inc.

1901 Pennsylvania Drive  
Columbia, MO 65205

Project #: 3279

Project: Townsend Drainage Report

Subject: TR-55 Drainage Calculations, Existing Conditions

Location: Lee's Summit, MO

By: Scott Bitterman

Sub-Basin 1

## E-3. Sheet Flow

Surface description (table3-1).....	Range	
Manning's Roughness Coefficient, n (TR-55 Table 3-1).....	0.13	
Flow Length, L.....ft	300	
Two-year 24-hour rainfall, P <sub>2</sub> .....in	3.5	
Land slope.....ft/ft	0.01	
T <sub>t</sub> .....hr	0.44	0.44

$$T_t = \frac{0.007 (nL)^{0.8}}{P_2^{0.5} S^{0.4}}$$

## E-4. Shallow Surface Flow

Surface description .....	Unpaved	
Flow Length, L.....ft	1200	
Watercourse slope.....ft/ft	0.01	
Average Velocity, V.....ft/s	1.6	
T <sub>t</sub> .....hr	0.21	0.21

$$T_t = \frac{L}{3600 V}$$

T<sub>c</sub> = 0.65 hr

Project #: 3279

Project: Townsend Drainage Report

Subject: TR-55 Drainage Calculations, Existing Conditions

Location: Lee's Summit, MO

By: Scott Bitterman

Sub-Basin 2

**E-3. Sheet Flow**

Surface description (table3-1).....	Range	
Manning's Roughness Coefficient, n (TR-55 Table 3-1).....	0.13	
Flow Length, L.....ft	300	
Two-year 24-hour rainfall, P <sub>2</sub> .....in	3.5	
Land slope.....ft/ft	0.02	
T <sub>t</sub> .....hr	0.34	0.34

$$T_t = \frac{0.007 (nL)^{0.8}}{P_2^{0.5} S^{0.4}}$$

**E-4. Shallow Surface Flow**

Surface description .....	Unpaved	
Flow Length, L.....ft	4600	
Watercourse slope.....ft/ft	0.015	
Average Velocity, V.....ft/s	2	
T <sub>t</sub> .....hr	0.64	0.64

$$T_t = \frac{L}{3600 V}$$

**Tc = 0.97 hr**



1901 Pennsylvania Drive  
Columbia, MO 65205

# TRABUE, HANSEN & HINSHAW, Inc.

Project #: 3279

Project: Townsend Drainage Report

Subject: TR-55 Drainage Calculations, Existing Conditions

Location: Lee's Summit, MO

By: Scott Bitterman

Sub-Basin 3

E-3. Sheet Flow		
Surface description (table3-1).....	Range	
Manning's Roughness Coefficient, n (TR-55 Table 3-1).....	0.13	
Flow Length, L.....ft	300	
Two-year 24-hour rainfall, P <sub>2</sub> .....in	3.5	
Land slope.....ft/ft	0.01	
T <sub>t</sub> .....hr	0.44	0.44

$$T_t = \frac{0.007 (nL)^{0.8}}{P_2^{0.5} S^{0.4}}$$

E-4. Shallow Surface Flow		
Surface description .....	Unpaved	
Flow Length, L.....ft	3300	
Watercourse slope.....ft/ft	0.025	
Average Velocity, V.....ft/s	2.6	
T <sub>t</sub> .....hr	0.35	0.35

$$T_t = \frac{L}{3600 V}$$

Tc = 0.80 hr

Project #: 3279

Project: Townsend Drainage Report

Subject: TR-55 Drainage Calculations, Existing Conditions

Location: Lee's Summit, MO

By: Scott Bitterman

Sub-Basin 4

**E-3. Sheet Flow**

Surface description (table3-1).....	Range	
Manning's Roughness Coefficient, n (TR-55 Table 3-1).....	0.13	
Flow Length, L.....ft	300	
Two-year 24-hour rainfall, P <sub>2</sub> .....in	3.5	
Land slope.....ft/ft	0.01	
T <sub>t</sub> .....hr	0.44	0.44

$$T_t = \frac{0.007 (nL)^{0.8}}{P_2^{0.5} S^{0.4}}$$

**E-4. Shallow Surface Flow**

Surface description .....	Unpaved	
Flow Length, L.....ft	2200	
Watercourse slope.....ft/ft	0.048	
Average Velocity, V.....ft/s	3.4	
T <sub>t</sub> .....hr	0.18	0.18

$$T_t = \frac{L}{3600 V}$$

**Tc = 0.62 hr**





1901 Pennsylvania Drive  
Columbia, MO 65205

# TRABUE, HANSEN & HINSHAW, Inc.

Project #: 3279  
Project: Townsend Drainage Report  
Subject: TR-55 Drainage Calculations, Existing Conditions  
Location: Lee's Summit, MO  
By: Scott Bitterman

## Sub-Basin 5

### E-3. Sheet Flow

Surface description (table3-1).....	Range	
Manning's Roughness Coefficient, n (TR-55 Table 3-1).....	0.13	
Flow Length, L.....ft	300	
Two-year 24-hour rainfall, P <sub>2</sub> .....in	3.5	
Land slope.....ft/ft	0.044	
T <sub>t</sub> .....hr	0.24	0.24

$$T_t = \frac{0.007 (nL)^{0.8}}{P_2^{0.5} S^{0.4}}$$

### E-4. Shallow Surface Flow

Surface description .....	Unpaved	
Flow Length, L.....ft	1700	
Watercourse slope.....ft/ft	0.037	
Average Velocity, V.....ft/s	3.1	
T <sub>t</sub> .....hr	0.15	0.15

$$T_t = \frac{L}{3600 V}$$

T<sub>c</sub> = 0.40 hr



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# TRABUE, HANSEN & HINSHAW, Inc.

Project #: 3279

Project: Townsend Drainage Report

Subject: TR-55 Drainage Calculations, Existing Conditions

Location: Lee's Summit, MO

By: Scott Bitterman

Sub-Basin 6

## E-3. Sheet Flow

Surface description (table3-1).....	Range	
Manning's Roughness Coefficient, n (TR-55 Table 3-1).....	0.13	
Flow Length, L.....ft	300	
Two-year 24-hour rainfall, P <sub>2</sub> .....in	3.5	
Land slope.....ft/ft	0.027	
T <sub>t</sub> .....hr	0.30	0.30

$$T_t = \frac{0.007 (nL)^{0.8}}{P_2^{0.5} s^{0.4}}$$

## E-4. Shallow Surface Flow

Surface description .....	Unpaved	
Flow Length, L.....ft	3800	
Watercourse slope.....ft/ft	0.015	
Average Velocity, V.....ft/s	2	
T <sub>t</sub> .....hr	0.53	0.53

$$T_t = \frac{L}{3600 V}$$

Tc = 0.83 hr



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Columbia, MO 65205

# TRABUE, HANSEN & HINSHAW, Inc.

Project #: 3279  
Project: Townsend Drainage Report  
Subject: TR-55 Drainage Calculations, Existing Conditions  
Location: Lee's Summit, MO  
By: Scott Bitterman

Sub-Basin 7

E-3. Sheet Flow		
Surface description (table3-1).....	Range	
Manning's Roughness Coefficient, n (TR-55 Table 3-1).....	0.13	
Flow Length, L.....ft	300	
Two-year 24-hour rainfall, P <sub>2</sub> .....in	3.5	
Land slope.....ft/ft	0.053	
T <sub>t</sub> .....hr	0.23	0.23

$$T_t = \frac{0.007 (nL)^{0.8}}{P_2^{0.5} S^{0.4}}$$

E-4. Shallow Surface Flow		
Surface description .....	Unpaved	
Flow Length, L.....ft	3100	
Watercourse slope.....ft/ft	0.02	
Average Velocity, V.....ft/s	2.2	
T <sub>t</sub> .....hr	0.39	0.39

$$T_t = \frac{L}{3600 V}$$

T<sub>c</sub> = 0.62 hr



1901 Pennsylvania Drive  
Columbia, MO 65205

# TRABUE, HANSEN & HINSHAW, Inc.

Project #: 3279  
Project: Townsend Drainage Report  
Subject: TR-55 Drainage Calculations, Existing Conditions  
Location: Lee's Summit, MO  
By: Scott Bitterman

Sub-Basin 8

E-3. Sheet Flow		
Surface description (table3-1).....	Range	
Manning's Roughness Coefficient, n (TR-55 Table 3-1).....	0.13	
Flow Length, L.....ft	300	
Two-year 24-hour rainfall, P <sub>2</sub> .....in	3.5	
Land slope.....ft/ft	0.043	
T <sub>t</sub> .....hr	0.25	0.25

$$T_t = \frac{0.007 (nL)^{0.8}}{P_2^{0.5} s^{0.4}}$$

E-4. Shallow Surface Flow		
Surface description .....	Unpaved	
Flow Length, L.....ft	2500	
Watercourse slope.....ft/ft	0.025	
Average Velocity, V.....ft/s	2.5	
T <sub>t</sub> .....hr	0.28	0.28

$$T_t = \frac{L}{3600 V}$$

T<sub>c</sub> = **0.52 hr**

# APPENDIX D

HEC-HMS 3.0.1 PRINTOUTS FOR  
EXISTING CONDITIONS

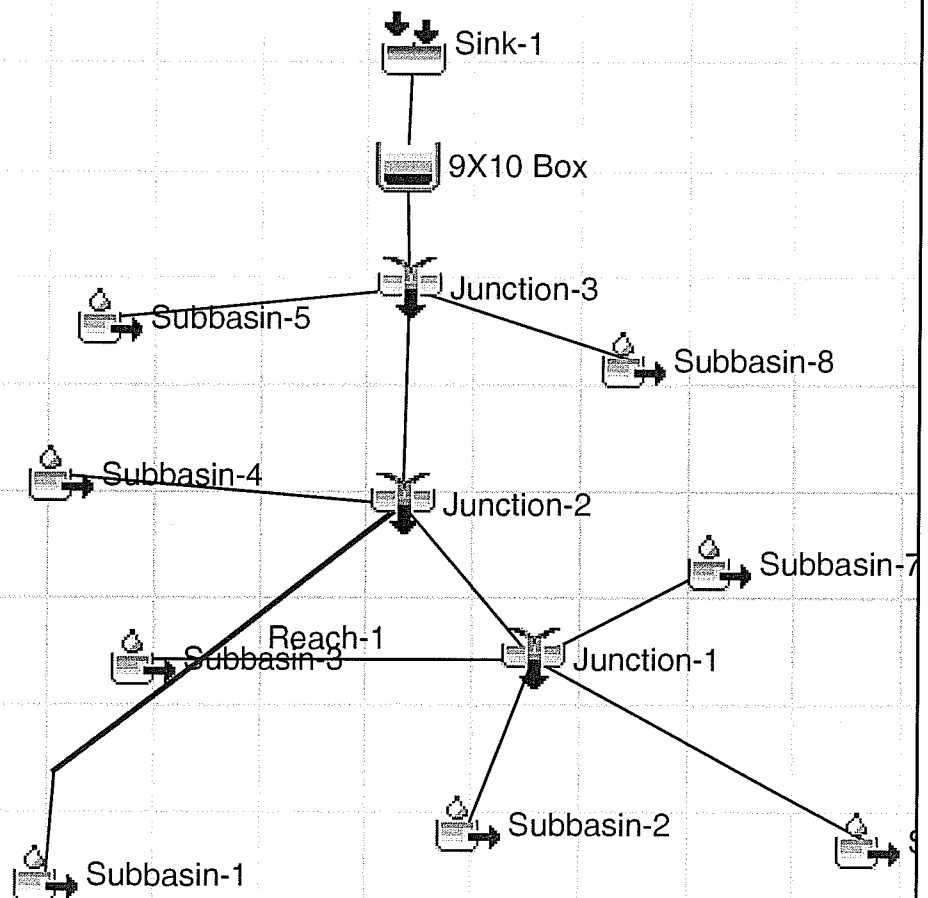


HEC-HMS

## Project : Townsend Drainage Study

Basin Model : Townsend Exist

Sep 28 13:48:01 CDT 2006



Project: Townsend Drainage Study    Simulation Run: Townsend Existing 100 yr

Start of Run: 18Jul2005, 00:00    Basin Model: Townsend Exist  
End of Run: 19Jul2005, 01:00    Meteorologic Model: 100 Year storm  
Compute Time: 28Sep2006, 08:28:04    Control Specifications: 24 Hour Storm

Volume Units: AC-FT

Hydrologic Element	Drainage Area (MI <sup>2</sup> )	Peak Discharge (CFS)	Time of Peak	Volume (AC-FT)
9X10 Box	1.1344	1380.04	18Jul2005, 12:42	343.51
Junction-1	0.7453	1803.11	18Jul2005, 12:19	227.98
Junction-2	0.9234	2260.44	18Jul2005, 12:18	277.25
Junction-3	1.1344	2869.58	18Jul2005, 12:15	343.56
Reach-1	0.0844	206.21	18Jul2005, 12:17	21.98
Sink-1	1.1344	1380.04	18Jul2005, 12:42	343.51
Subbasin-1	0.0844	206.36	18Jul2005, 12:15	21.98
Subbasin-2	0.1188	237.22	18Jul2005, 12:27	33.81
Subbasin-3	0.0938	204.97	18Jul2005, 12:21	25.56
Subbasin-4	0.0938	261.94	18Jul2005, 12:14	27.30
Subbasin-5	0.0438	144.20	18Jul2005, 12:07	11.40
Subbasin-6	0.2922	723.59	18Jul2005, 12:22	94.09
Subbasin-7	0.2406	709.15	18Jul2005, 12:14	74.52
Subbasin-8	0.1672	564.98	18Jul2005, 12:11	54.91

Project: Townsend Drainage Study    Simulation Run: Townsend Existing 10 yr

Start of Run: 18Jul2005, 00:00      Basin Model: Townsend Exist  
End of Run: 19Jul2005, 01:00      Meteorologic Model: 10 Year Storm  
Compute Time: 28Sep2006, 10:30:06    Control Specifications: 24 Hour Storm

Volume Units: AC-FT

Hydrologic Element	Drainage Area (MI <sup>2</sup> )	Peak Discharge (CFS)	Time of Peak	Volume (AC-FT)
9X10 Box	1.1344	1007.81	18Jul2005, 12:38	208.25
Junction-1	0.7453	1108.71	18Jul2005, 12:19	138.67
Junction-2	0.9234	1376.49	18Jul2005, 12:18	167.45
Junction-3	1.1344	1756.77	18Jul2005, 12:16	208.28
Reach-1	0.0844	117.03	18Jul2005, 12:17	12.53
Sink-1	1.1344	1007.81	18Jul2005, 12:38	208.25
Subbasin-1	0.0844	117.13	18Jul2005, 12:16	12.53
Subbasin-2	0.1188	140.43	18Jul2005, 12:28	19.96
Subbasin-3	0.0938	118.79	18Jul2005, 12:22	14.83
Subbasin-4	0.0938	157.18	18Jul2005, 12:14	16.26
Subbasin-5	0.0438	82.41	18Jul2005, 12:07	6.50
Subbasin-6	0.2922	455.50	18Jul2005, 12:22	58.37
Subbasin-7	0.2406	438.74	18Jul2005, 12:14	45.50
Subbasin-8	0.1672	359.90	18Jul2005, 12:11	34.33



Project: Townsend Drainage Study    Simulation Run: Townsend Existing 1 yr

Start of Run: 18Jul2005, 00:00    Basin Model: Townsend Exist  
End of Run: 19Jul2005, 01:00    Meteorologic Model: 1 Year Storm  
Compute Time: 28Sep2006, 10:27:09    Control Specifications: 24 Hour Storm

Volume Units: AC-FT

Hydrologic Element	Drainage Area (MI <sup>2</sup> )	Peak Discharge (CFS)	Time of Peak	Volume (AC-FT)
9X10 Box	1.1344	475.53	18Jul2005, 12:36	87.87
Junction-1	0.7453	466.24	18Jul2005, 12:20	58.89
Junction-2	0.9234	566.12	18Jul2005, 12:19	70.02
Junction-3	1.1344	732.43	18Jul2005, 12:16	87.90
Reach-1	0.0844	40.08	18Jul2005, 12:19	4.57
Sink-1	1.1344	475.53	18Jul2005, 12:36	87.87
Subbasin-1	0.0844	40.10	18Jul2005, 12:17	4.57
Subbasin-2	0.1188	53.71	18Jul2005, 12:29	7.90
Subbasin-3	0.0938	43.04	18Jul2005, 12:23	5.64
Subbasin-4	0.0938	62.17	18Jul2005, 12:15	6.57
Subbasin-5	0.0438	28.68	18Jul2005, 12:08	2.37
Subbasin-6	0.2922	202.41	18Jul2005, 12:23	25.89
Subbasin-7	0.2406	186.87	18Jul2005, 12:15	19.46
Subbasin-8	0.1672	164.54	18Jul2005, 12:12	15.51

# APPENDIX E

PROPOSED SUB-BASIN CURVE NUMBERS



Project #: 3279

Project: Townsend Drainage Report

Subject: TR-55 Drainage Calculations, Existing Conditions

Location: Lee's Summit, MO

By: Scott Bitterman

**Proposed Conditions****Sub-Basin 1. Runoff curve number**

Hydrolic Soil Group	Land Use	CN Table 5602.3.B	Area	Product of CN and Area
C	Industrial, Heavy Areas	93	10%	9.3
C	Pavement/ Parking	98	2%	1.96
C	Undeveloped Areas	74	88%	65.12

Use CN = **76****Sub-Basin 2. Runoff curve number**

Hydrolic Soil Group	Land Use	CN Table 5602.3.B	Area	Product of CN and Area
C	Industrial, Heavy Areas	93	8%	7.44
C	Residential, 1/8 acre or less	92	24%	22.08
C	Undeveloped Areas	74	68%	50.32

Use CN = **80**

Project #: 3279

Project: Townsend Drainage Report

Subject: TR-55 Drainage Calculations, Existing Conditions

Location: Lee's Summit, MO

By: Scott Bitterman

**Proposed Conditions**

<b>Sub-Basin 3. Runoff curve number</b>				
Hydrolic Soil Group	Land Use	CN Table 5602.3.B	Area	Product of CN and Area
C	Industrial, Heavy Areas	93	20%	18.6
C	Pavement	98	1%	0.98
C	Undeveloped Areas	74	79%	58.46

Use CN = **78**

<b>Sub-Basin 4. Runoff curve number</b>				
Hydrolic Soil Group	Land Use	CN Table 5602.3.B	Area	Product of CN and Area
C	Industrial, Heavy Areas	93	38%	35.34
C	Pavement	98	1%	0.98
C	Undeveloped Areas	74	61%	45.14

Use CN = **81**

Project #: 3279

Project: Townsend Drainage Report

Subject: TR-55 Drainage Calculations, Existing Conditions

Location: Lee's Summit, MO

By: Scott Bitterman

**Proposed Conditions****Sub-Basin 5. Runoff curve number**

Hydrolic Soil Group	Land Use	CN Table 5602.3.B	Area	Product of CN and Area
C	Industrial, Heavy Areas	93	12%	11.16
C	Pavement	98	1%	0.98
C	Undeveloped Areas	74	87%	64.38

Use CN = **77****Sub-Basin 6. Runoff curve number**

Hydrolic Soil Group	Land Use	CN Table 5602.3.B	Area	Product of CN and Area
C	Industrial, Heavy Areas	93	36%	33.48
C	Residential, 1/8 acre or less	92	28%	25.76
C	Undeveloped Areas	74	36%	26.64

Use CN = **86**

# APPENDIX F

HEC-HMS 3.0.1 PRINTOUTS FOR  
PROPOSED CONDITIONS

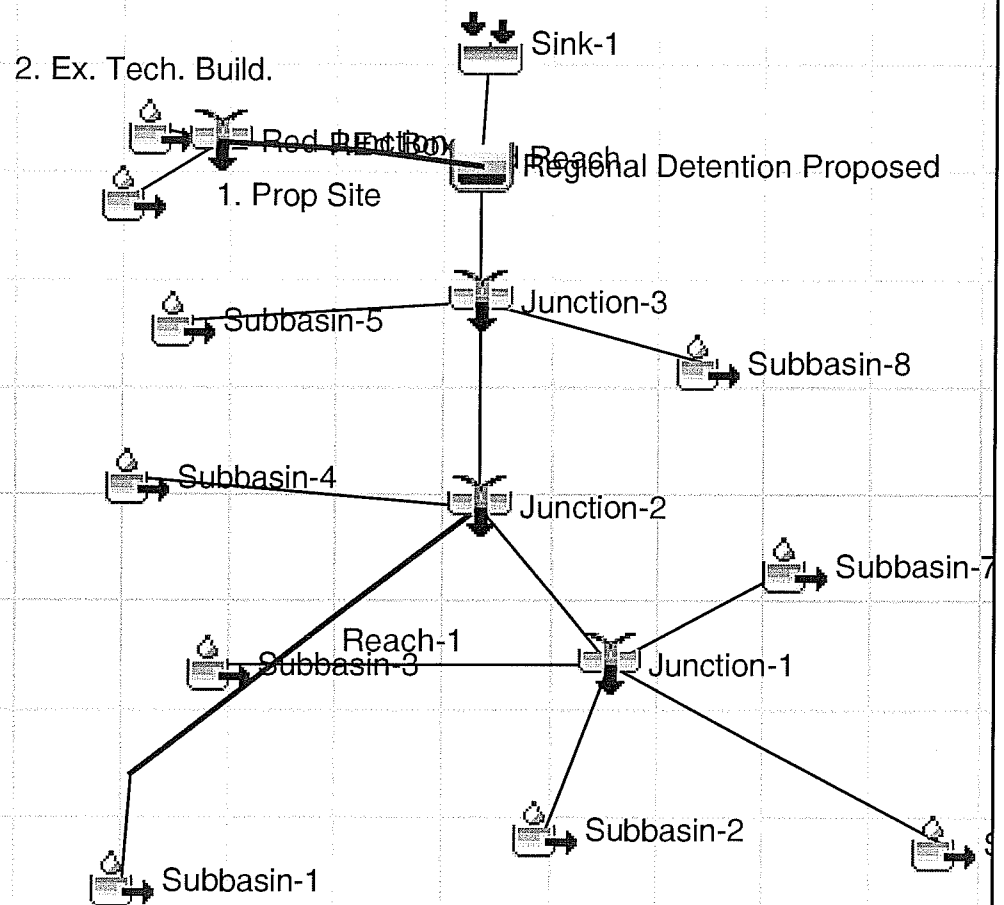


HEC-HMS

## Project : Townsend Drainage Study

Basin Model : Townsend Proposed

Sep 28 13:45:55 CDT 2006



Project: Townsend Drainage Study    Simulation Run: Townsend Proposed 100 yr

Start of Run: 18Jul2005, 00:00    Basin Model: Townsend Proposed  
 End of Run: 19Jul2005, 01:00    Meteorologic Model: 100 Year storm  
 Compute Time: 28Sep2006, 10:18:45    Control Specifications: 24 Hour Storm

Volume Units: AC-FT

Hydrologic Element	Drainage Area (MI <sup>2</sup> )	Peak Discharge (CFS)	Time of Peak	Volume (AC-FT)
1. Prop Site	0.1151	639.35	18Jul2005, 12:01	45.06
2. Ex. Tech. Build	0.0581	359.48	18Jul2005, 11:58	22.75
Junction-1	0.7453	1803.11	18Jul2005, 12:19	227.98
Junction-2	0.9234	2260.44	18Jul2005, 12:18	277.25
Junction-3	1.1344	2871.61	18Jul2005, 12:15	343.82
REd Box	0.1732	979.42	18Jul2005, 12:00	67.81
Reach-1	0.0844	206.21	18Jul2005, 12:17	21.98
Red Junction	0.1732	979.85	18Jul2005, 11:59	67.81
Red Reach	0.1732	977.30	18Jul2005, 12:01	67.81
Regional Detention Pond	1.3076	1299.71	18Jul2005, 12:46	410.66
Sink-1	1.3076	1299.71	18Jul2005, 12:46	410.66
Subbasin-1	0.0844	206.36	18Jul2005, 12:15	21.98
Subbasin-2	0.1188	237.22	18Jul2005, 12:27	33.81
Subbasin-3	0.0938	204.97	18Jul2005, 12:21	25.56
Subbasin-4	0.0938	261.94	18Jul2005, 12:14	27.30
Subbasin-5	0.0438	147.33	18Jul2005, 12:07	11.67
Subbasin-6	0.2922	723.59	18Jul2005, 12:22	94.09
Subbasin-7	0.2406	709.15	18Jul2005, 12:14	74.52
Subbasin-8	0.1672	564.98	18Jul2005, 12:11	54.91



Project: Townsend Drainage Study    Simulation Run: Townsend Proposed 10 yr

Start of Run: 18Jul2005, 00:00    Basin Model: Townsend Proposed  
 End of Run: 19Jul2005, 01:00    Meteorologic Model: 10 Year Storm  
 Compute Time: 28Sep2006, 10:36:09    Control Specifications: 24 Hour Storm

Volume Units: AC-FT

Hydrologic Element	Drainage Area (MI <sup>2</sup> )	Peak Discharge (CFS)	Time of Peak	Volume (AC-FT)
1. Prop Site	0.1151	437.54	18Jul2005, 12:01	30.36
2. Ex. Tech. Build	0.0581	246.05	18Jul2005, 11:58	15.33
Junction-1	0.7453	1108.71	18Jul2005, 12:19	138.67
Junction-2	0.9234	1376.49	18Jul2005, 12:18	167.45
Junction-3	1.1344	1758.47	18Jul2005, 12:16	208.50
REd Box	0.1732	670.22	18Jul2005, 12:00	45.69
Reach-1	0.0844	117.03	18Jul2005, 12:17	12.53
Red Junction	0.1732	670.43	18Jul2005, 11:59	45.69
Red Reach	0.1732	668.66	18Jul2005, 12:01	45.69
Regional Detention Pond	1.3076	863.78	18Jul2005, 12:44	253.65
Sink-1	1.3076	863.78	18Jul2005, 12:44	253.65
Subbasin-1	0.0844	117.13	18Jul2005, 12:16	12.53
Subbasin-2	0.1188	140.43	18Jul2005, 12:28	19.96
Subbasin-3	0.0938	118.79	18Jul2005, 12:22	14.83
Subbasin-4	0.0938	157.18	18Jul2005, 12:14	16.26
Subbasin-5	0.0438	85.17	18Jul2005, 12:07	6.71
Subbasin-6	0.2922	455.50	18Jul2005, 12:22	58.37
Subbasin-7	0.2406	438.74	18Jul2005, 12:14	45.50
Subbasin-8	0.1672	359.90	18Jul2005, 12:11	34.33

Project: Townsend Drainage Study Simulation Run: Townsend Proposed 1 yr

Start of Run: 18Jul2005, 00:00 Basin Model: Townsend Proposed  
 End of Run: 19Jul2005, 01:00 Meteorologic Model: 1 Year Storm  
 Compute Time: 28Sep2006, 10:33:58 Control Specifications: 24 Hour Storm

Volume Units: AC-FT

Hydrologic Element	Drainage Area (MI <sup>2</sup> )	Peak Discharge (CFS)	Time of Peak	Volume (AC-FT)
1. Prop Site	0.1151	242.68	18Jul2005, 12:01	16.32
2. Ex. Tech. Build	0.0581	136.54	18Jul2005, 11:58	8.24
Junction-1	0.7453	466.24	18Jul2005, 12:20	58.89
Junction-2	0.9234	566.12	18Jul2005, 12:19	70.02
Junction-3	1.1344	733.64	18Jul2005, 12:16	88.03
REd Box	0.1732	371.76	18Jul2005, 12:00	24.56
Reach-1	0.0844	40.08	18Jul2005, 12:19	4.57
Red Junction	0.1732	371.74	18Jul2005, 12:00	24.56
Red Reach	0.1732	371.11	18Jul2005, 12:01	24.56
Regional Detention Pond	1.3076	432.44	18Jul2005, 12:41	112.38
Sink-1	1.3076	432.44	18Jul2005, 12:41	112.38
Subbasin-1	0.0844	40.10	18Jul2005, 12:17	4.57
Subbasin-2	0.1188	53.71	18Jul2005, 12:29	7.90
Subbasin-3	0.0938	43.04	18Jul2005, 12:23	5.64
Subbasin-4	0.0938	62.17	18Jul2005, 12:15	6.57
Subbasin-5	0.0438	30.54	18Jul2005, 12:08	2.50
Subbasin-6	0.2922	202.41	18Jul2005, 12:23	25.89
Subbasin-7	0.2406	186.87	18Jul2005, 12:15	19.46
Subbasin-8	0.1672	164.54	18Jul2005, 12:12	15.51

# APPENDIX G

FUTURE SUB-BASIN CURVE NUMBERS

Project #: 3279

Project: Townsend Drainage Report

Subject: TR-55 Drainage Calculations, Existing Conditions

Location: Lee's Summit, MO

By: Scott Bitterman

**Future Conditions****Sub-Basin 1. Runoff curve number**

Hydrolic Soil Group	Land Use	CN Table 5602.3.B	Area	Product of CN and Area
C	Industrial, Heavy Areas	93	10%	9.3
C	Undeveloped Areas	94	88%	82.72

Use CN = **92****Sub-Basin 2. Runoff curve number**

Hydrolic Soil Group	Land Use	CN Table 5602.3.B	Area	Product of CN and Area
C	Industrial, Heavy Areas	93	8%	7.44
C	Residential, 1/8 acre or less	92	24%	22.08
C	Undeveloped Areas	94	68%	63.92

Use CN = **93**

Project #: 3279

Project: Townsend Drainage Report

Subject: TR-55 Drainage Calculations, Existing Conditions

Location: Lee's Summit, MO

By: Scott Bitterman

**Future Conditions**

<b>Sub-Basin 3. Runoff curve number</b>				
Hydrolic Soil Group	Land Use	CN Table 5602.3.B	Area	Product of CN and Area
C	Industrial, Heavy Areas	93	20%	18.6
C	Undeveloped Areas	94	80%	75.2

Use CN = **94**

<b>Sub-Basin 4. Runoff curve number</b>				
Hydrolic Soil Group	Land Use	CN Table 5602.3.B	Area	Product of CN and Area
C	Industrial, Heavy Areas	93	38%	35.34
C	Undeveloped Areas	94	62%	58.28

Use CN = **94**

Project #: 3279

Project: Townsend Drainage Report

Subject: TR-55 Drainage Calculations, Existing Conditions

Location: Lee's Summit, MO

By: Scott Bitterman

**Future Conditions****Sub-Basin 5. Runoff curve number**

Hydrolic Soil Group	Land Use	CN Table 5602.3.B	Area	Product of CN and Area
C	Industrial, Heavy Areas	93	12%	11.16
C	Undeveloped Areas	94	88%	82.72

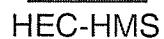
Use CN = **94****Sub-Basin 6. Runoff curve number**

Hydrolic Soil Group	Land Use	CN Table 5602.3.B	Area	Product of CN and Area
C	Industrial, Heavy Areas	93	36%	33.48
C	Residential, 1/8 acre or less	92	28%	25.76
C	Undeveloped Areas	74	36%	26.64

Use CN = **86**

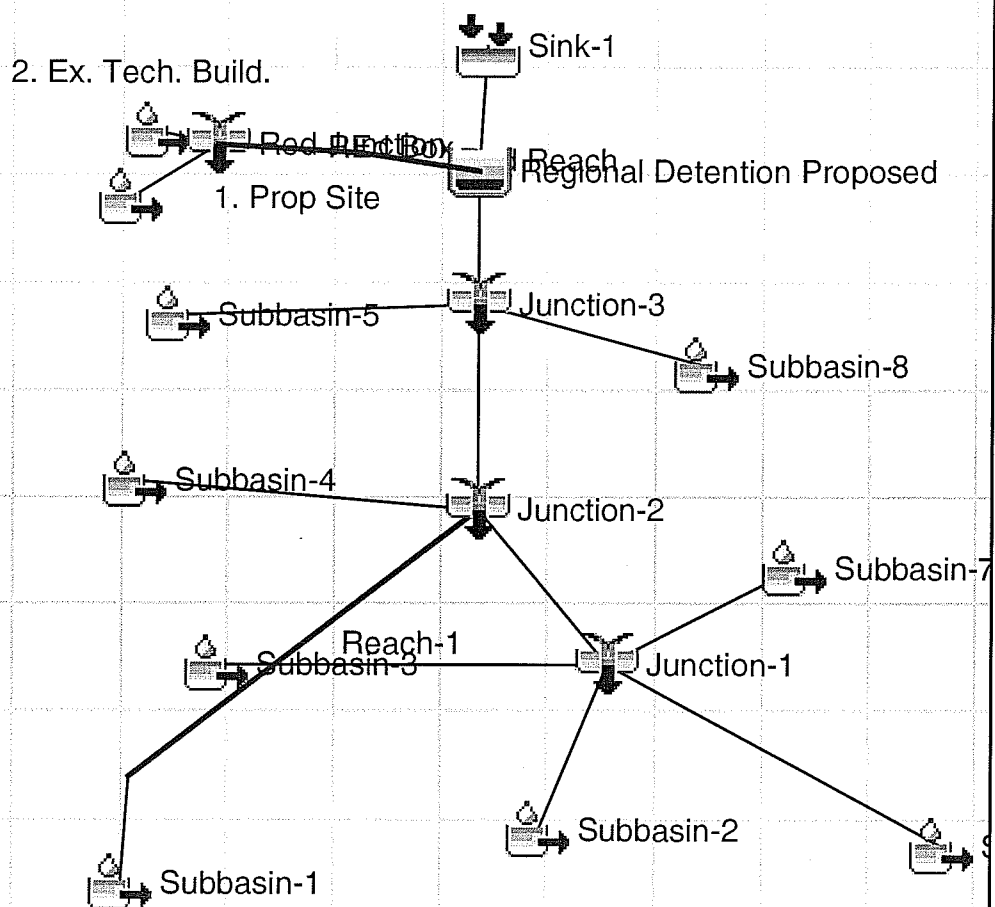
# APPENDIX H

HEC-HMS 3.0.1 PRINTOUTS FOR  
FUTURE CONDITIONS



### Basin Model : Townsend Future

Sep 28 13:43:28 CDT 2006





Project: Townsend Drainage Study Simulation Run: Townsend Future 100 yr

Start of Run: 18Jul2005, 00:00 Basin Model: Townsend Future  
 End of Run: 19Jul2005, 01:00 Meteorologic Model: 100 Year storm  
 Compute Time: 28Sep2006, 09:59:20 Control Specifications: 24 Hour Storm

Volume Units: AC-FT

Hydrologic Element	Drainage Area (MI <sup>2</sup> )	Peak Discharge (CFS)	Time of Peak	Volume (AC-FT)
1. Prop Site	0.1151	639.35	18Jul2005, 12:01	45.06
2. Ex. Tech. Build	0.0581	359.48	18Jul2005, 11:58	22.75
Junction-1	0.7453	2047.69	18Jul2005, 12:17	246.99
Junction-2	0.9234	2661.44	18Jul2005, 12:14	312.26
Junction-3	1.1344	3332.06	18Jul2005, 12:13	383.46
REd Box	0.1732	979.42	18Jul2005, 12:00	67.81
Reach-1	0.0844	322.28	18Jul2005, 12:11	30.36
Red Junction	0.1732	979.85	18Jul2005, 11:59	67.81
Red Reach	0.1732	977.30	18Jul2005, 12:01	67.81
Regional Detention Proposed	1.3076	1389.34	18Jul2005, 12:42	450.36
Sink-1	1.3076	1389.34	18Jul2005, 12:42	450.36
Subbasin-1	0.0844	323.03	18Jul2005, 12:09	30.36
Subbasin-2	0.1188	353.40	18Jul2005, 12:17	43.47
Subbasin-3	0.0938	313.12	18Jul2005, 12:14	34.91
Subbasin-4	0.0938	365.22	18Jul2005, 12:09	34.92
Subbasin-5	0.0438	211.24	18Jul2005, 12:04	16.30
Subbasin-6	0.2922	723.59	18Jul2005, 12:22	94.09
Subbasin-7	0.2406	709.15	18Jul2005, 12:14	74.52
Subbasin-8	0.1672	564.98	18Jul2005, 12:11	54.91

## Appendix B

# **STORMWATER DRAINAGE STUDY**

**LEE'S SUMMIT FAIR**

---

**LEE'S SUMMIT, MISSOURI**

***Prepared For:  
Red Development***

***PREPARED BY:*  
OLSSON ASSOCIATES  
7301 WEST 133<sup>RD</sup> STREET, SUITE 200  
OVERLAND PARK, KS 66213**

**December 1, 2006**

**Olsson No. 2-2005-0451**

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**FIGURES**

**Figure 1 – Project Location**

**Figure 2 – Soils Map**

**Figure 3 – Existing Conditions**

**Figure 4 – Proposed Conditions**

**APPENDICES**

**Appendix A: TR55 data**

**Appendix B: Existing HEC-HMS Results**

**Appendix C: Proposed HEC-HMS Results**

## **GENERAL INFORMATION**

### **Project Location and Description**

The proposed development of Lee's Summit Fair is located South of I-470 and east of Highway 50 in Lee's Summit (see Figure 1), Jackson County, Missouri. The proposed development lies within Section 36, Township 48 North, Range 32 West. The proposed development includes approximately 59 acres of retail commercial property.

Per previous discussion with city staff, two critical points downstream of the project are subject to flooding and were evaluated to determine the site's impact: 1) 8'x6' reinforced concrete box (RCB) culvert beneath NW Technology Dr. and 2) 5'x5' reinforced concrete box culvert beneath I-470 (see Figure 3). These two crossings were analyzed to determine if overtopping exists or will occur after development. No habitable buildings downstream of the project are impacted by existing or proposed 1% flood levels.

The existing Central Summit Center building and parking lot runoff was split down an existing ridgeline with 13.3 acres directly draining to the proposed site and the remaining draining to a 5'x5' RCB under I-470 (referenced City of Lee's Summit, Missouri Bogg's Hollow, Little Cedar Creek Stormwater Master Plan, Panel 4). The existing undeveloped site topography has a sloping terrain generally directing runoff to the east and is heavily vegetated with trees. See Figure 3 for existing drainage conditions.

### **Study Purpose**

The purpose of this study is to evaluate post development stormwater runoff and to establish feasible management practices to control the quantity and quality of stormwater runoff from the project site. The evaluation of post development impacts includes a review of the 1, 10, and 100-year peak discharge rates and runoff volumes associated with the project site watershed catchment area. Based on the results from the evaluation, this study identifies the most applicable Best Management Practices to alleviate increases in stormwater discharge from the Lee's Summit Fair development in accordance with Section 5600 of the *Standard Specifications and Design Criteria* of the Kansas City Metropolitan Chapter of the American Public Works Association (APWA) and Lee's Summit, Missouri's design supplement to APWA Section 5600. In particular, post development peak stormwater discharges from the site must be equal to or less than existing peak discharges from the 1, 10, and 100-year storm events.

### **Soils Descriptions and Curve Numbers**

The watershed soils are predominately of the Sharpsburg silt loam (6B), which is classified in Hydrological Soil Group (HSG) B, Sampsel silty clay loam (13B), which is classified in HSG D, Oska silty clay loam (22C2), which is classified in HSG C, Snead-Rock outcrop complex, which is classified in HSG D, and Urban Land, upland, which does not have a HSG classification but it was assumed a classification of HSG C (see Figure 2). The Curve Numbers used for existing conditions can be found in Appendix A. For proposed development the Curve Number used for hydraulic calculations is 97 for commercial development. Existing areas that will not be disturbed will retain the same Curve Number.

## **METHODOLOGY**

### **General Criteria and References**

The analytical and design criteria used in the study conform to those of “*Section 5600 – Storm Drainage Systems and Facilities*” of the Kansas City Chapter of the American Public Works Association’s “*Standard Specifications and Design Criteria*” dated February 2006. Based on these criteria the allowable discharge from the development will be based on limiting 100-year (1%), 10-yr (10%), and 1-yr (100%) post development discharges to no more than existing discharges from the site for each respective storm, with an allowance for passing through stormwater from off-site areas.

Stormwater discharges from the site for existing, proposed and detained conditions were evaluated using the U. S. Army Corps of Engineers “*Hydrological Modeling System – HEC-HMS*” version 3.0.1. HEC-HMS 3.0.1, has the capability to model storage on the upstream side of culverts and was used to analyze the culverts beneath I-470 and NW Technology Drive. Initial sub-basin losses were determined using the NRCS Curve Number method and direct runoff was determined using the SCS Unit Hydrograph (Type II Storm) method. Pre and post development times of concentration (TC) for NRCS lag time calculations ( $0.6 \times TC$ ) were determined using the NRCS TR 55 method (see TR55 output Appendix A).



## **HYDROLOGIC/HYDRAULICS ANALYSES**

### **Existing Conditions Hydrology**

Figure 3 illustrates the existing drainage sub-basin delineation for the proposed project and additional downstream watershed. The entire watershed modeled was split into six sub-basins; Existing Central Summit Center, Existing Site 1, Existing Commercial Federal Bank, Existing Site 2, Existing Site 3, and NW Technology Drive to account for the different CN values. Reaches were then added between each sub-basin and connected to a junction to determine peak flows (see Appendix B). Table 1 below displays the hydrologic properties for each sub-basin shown on the existing drainage area map. The “Existing Conditions” Basin Model Schematic and the associated Sub-basin parameters and flood routing results for the 1, 10, and 100-year storm events are provided in Appendix B and are summarized in Table 1 below.

**Table 1: Existing Conditions Basin Site Hydrologic Summary**

Sub-basin	Area	CN	Tc	Lag	1-Year	10-Year	100-Year
					Q	Q	Q
	(acre)		(min)	(min)	(cfs)	(cfs)	(cfs)
1. Ex. Central Summit Center	48.87	94	13.7	8.2	129.8	245.7	364.7
2. Ex. Site 1	28.84	77	17.4	10.4	32.0	87.7	150.4
3. Ex. Commercial Federal Bank	2.55	92	6.0	3.6	7.3	14.5	21.8
4. Ex. Site 2	21.21	64	21.0	12.6	6.7	35.8	74.6
5. Ex. Site 3	26.34	75	18.2	10.9	25.5	74.5	131.0
<b>Sink-1</b>	127.9	NA	NA	NA	183.5	424.8	696.1
6. NW Technology Drive	35.57	90	11.2	6.7	87.7	178.2	271.4
<b>Sink-2</b>	163.5	NA	NA	NA	228.6	459.8	580.4

The results of the existing conditions evaluation establish the maximum allowable discharge rate for the proposed development. On-site management practices

should mitigate for the changes in the hydrologic conditions resulting from post-development activities.

The existing 5'x5' and 8'x6' RCB culverts were modeled with HEC-HMS to determine if overtopping occurs at each location. The 8'x6' RCB was assumed to have minimal storage capacity. Results show no overtopping at both culvert locations in the 1% storm event. Table 2 shows results for each culvert crossing.

**Table 2: Existing Culvert Crossings Conditions**

Culvert	1%Storm Peak Flow (cfs)	Roadway Elev.	Water Surface Elev.	Overtopping (ft)
Existing 5'x5' RCB	696.1	958.00	955.2	0.00
Existing 8'x6' RCB	597.0	945.90	945.39	0.00

### **Proposed Conditions Hydrology**

The proposed development of the site includes commercial buildings, associated roadways, parking, utilities, and landscaping. The proposed grading will drain to curb inlets located throughout the development.

Runoff from the site will be collected in an on-site collection and conveyance system and routed to a public storm sewer system along Blue Parkway. The storm sewer system will be designed to convey the 10% chance storm runoff through a series of curb inlets, area inlets, and junction boxes. Approximately 38 acres of the proposed development plus approximately 31 acres of future development will flow north directly to the existing 5'x5' RCB culvert at I-470. The remaining 75 acres

from the proposed site and Summit Center Site will be routed via an 8'x6' reinforced concrete box (RCB) along Ward Road to a Regional Detention Basin located off-site to the northeast (See Figure 4) and constructed with the Summit Center development preceding this project. Runoff directed from this project to this regional detention basin is calculated and presented in Table 5.

The SCS CN value for the proposed site increases to 97 for business, downtown area. The lag time for the proposed development used is based on the proposed storm routing. Table 3 shows updated values for the sub-basins. The "Proposed Conditions" Basin Model Schematic and its sub-basin parameters and flood routing results for the 1, 10 and 100-year storm events investigated are contained in Appendix C and are summarized in Table 3 below.

**Table 3: Proposed Conditions Hydrologic Summary**

Sub-basin	Area	CN	Tc	Lag	1-Year	10-Year	100-Year
					Q	Q	Q
	(acre)		(min)	(min)	(cfs)	(cfs)	(cfs)
1. Ex. Central Summit Center	75.00	97	12.0	7.2	225.1	406.2	593.6
<b>To Regional Basin</b>	75.00	NA	NA	NA	225.1	406.2	593.6
2. Prop. Site 1	37.63	97	12.0	7.2	112.9	203.8	297.8
3. Prop. Site 2	31.36	87	10.0	6.0	70.3	151.1	235.4
<b>Sink-1</b>	69.00	NA	NA	NA	183.2	354.9	533.3
4. NW Technology Drive	35.57	90	11.2	6.7	87.7	178.2	271.4
<b>Sink-2</b>	104.57	NA	NA	NA	240.9	515.6	776.7

Table 4 displays the hydraulic results for both culverts under proposed conditions. The proposed peak run-off values at each culvert were computed for comparison with the existing conditions peak run-off values to ensure that future development will not cause overtopping conditions. Full development of this drainage basin tributary to "Sink 2" is complete, including MoDOT's improvements to I-470, will cause overtopping at the existing 8'x6' culvert. The reason for the increased water

surface elevation is the future off/on ramp will eliminate current detention volume behind the existing 5'x5' culvert. The construction of the off/on ramp will cause negative effects on the downstream 8'x6' culvert. When improvements are constructed local mitigation should be included with the improvements. The depth of overtopping is subjective and further detailed analysis shall be performed when Sub-basin "Prop. Site 2" is developed by MoDOT.

Note the proposed Regional Detention Basin and outflow must be designed by the Summit Center developer's engineer to control flows such that no net increase in peak discharge rates are caused downstream in the 1, 10, 100-year storm events.

**Table 4: Proposed Culvert Crossings Conditions**

Culvert	1%Storm Peak Flow (cfs)	Roadway Elev.	Water Surface Elev.	Overtopping (ft)
Existing 5'x5' RCB	533.3	958.00	957.03	0.00
Existing 8'x6' RCB	794.7	945.90	947.2	1.30

**Existing and Proposed Condition Comparison**

Existing and Proposed condition site peak discharges were derived from the Sink-1 and Sink-2 composite runoff hydrographs synthesized by the HEC-HMS program for the three storm events investigated (see Appendices B & C). The Watershed "Sink-1" and "Sink-2" basin elements in the two models represents the theoretical locus of runoff from the entire watershed modeled. For proposed conditions another sink was added ("Regional Basin") to show the peak runoff to the regional

detention basin. The existing or allowable peak discharges and their corresponding total values for the three storms at Watershed "Sink-1", "Sink-2", and "Regional Basin" are compared with the proposed condition results in Table 5 below:

**Table 5: Existing and Proposed Condition Runoff Comparison**

Summit Fair Subshed	Storm Event	Exist. Conditions	Prop. Conditions	Prop. - Exist.
		Q (cfs)	Q (cfs)	Q (cfs)
To Regional Basin	1 Year	0	225.1	225.1
To Regional Basin	10 Year	0	406.2	406.2
To Regional Basin	100 Year	0	593.6	593.6
Sink-1	1 Year	183.5	183.2	-0.3
Sink-1	10 Year	424.8	354.9	-69.9
Sink-1	100 Year	696.1	533.3	-162.8
Sink-2	1 Year	228.6	240.9	12.3
Sink-2	10 Year	459.8	515.6	55.8
Sink-2	100 Year	580.4	776.7	196.3

Note flows indicated as "To Regional Detention Basin" do not represent total flow to the regional basin, but rather only that runoff originally discharging to Sink 1 that is being redirected by this development to the Regional Detention Basin. This increase in runoff will be mitigated by the Regional Detention Facility. Existing flows were matched or decreased at Sink 1 by redirecting 75 acres to the Regional Detention Facility. While the existing flows were matched or decreased at Sink 1, flows at Sink 2 increase due to existing detention upstream of the existing 5'x5' culvert underneath I-470 being eliminated by MoDOT ramp construction (previously described in "Proposed Conditions").

### **CONCLUSIONS AND RECOMMENDATIONS**

Any revisions to the proposed site plan or drainage patterns caused by adjacent development will necessitate additional analysis to assess impact and revise management methods if needed. The proposed improvements shall be constructed in accordance with the City of Lee's Summit's Municipal Code. Due to downstream flooding conditions, detention or downstream improvements must be implemented with the project. The proposed regional stormwater detention facility planned on the Summit Center development shall be designed and constructed to accommodate the increased runoff from the Summit Fair site and will maintain or decrease the peak rate of runoff.

.



# FIGURE 1 - LOCATION MAP

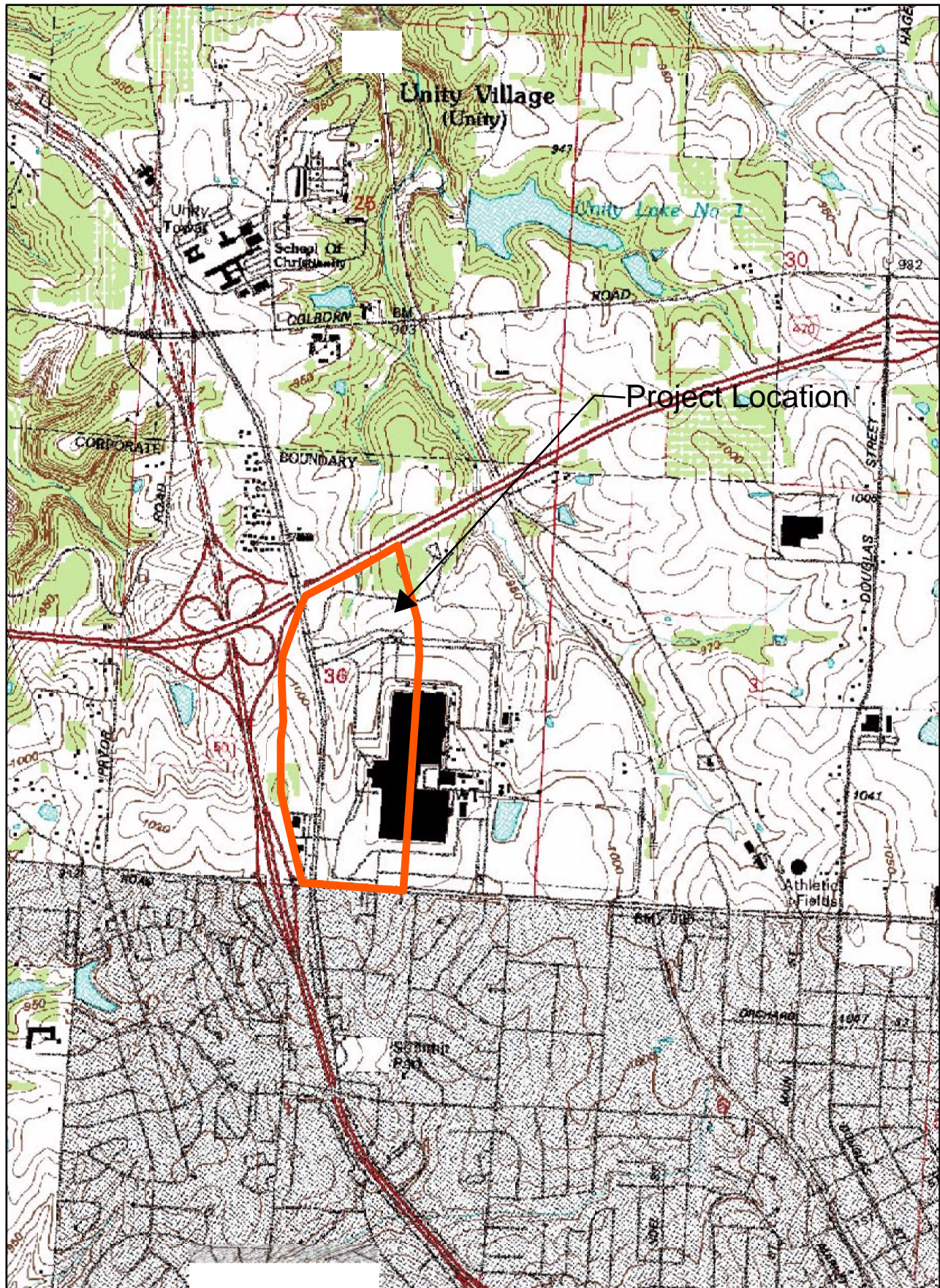
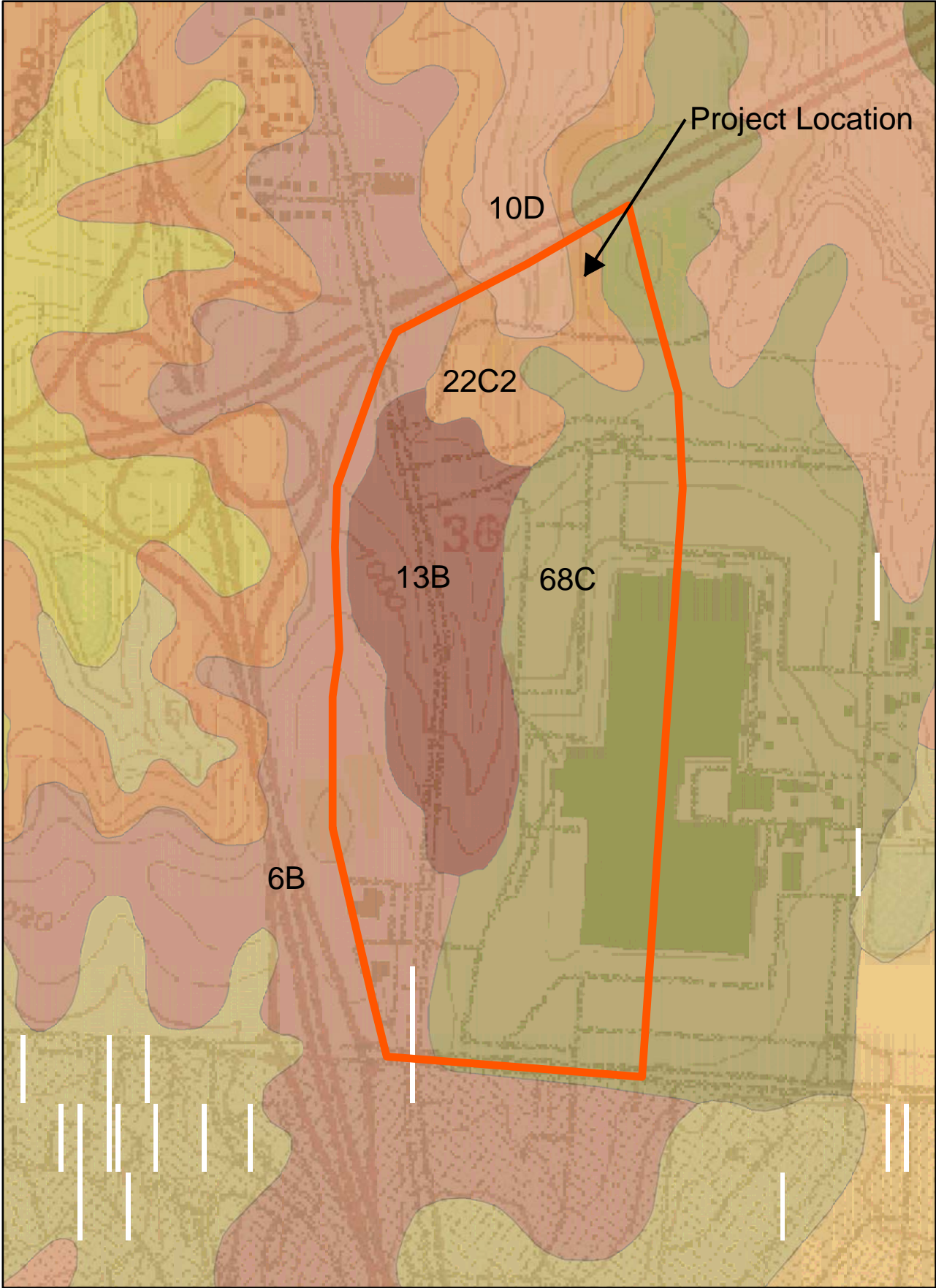




FIGURE 2 - SOILS MAP





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DATE: Nov 30, 2006 5:28pm XREFS: 50451\_PUB.DWG 50451\_PUB.DWG  
50451-base-public 2878 Design-Road-Active 50451\_PUBASE

**3. EXISTING COMMERCIAL  
FEDERAL BANK  
2.55 ACRES**

HIGHWAY 50

EXISTING 5'X5' RCB

**4. EXISTING SITE 2  
21.21 ACRES**

BLUE PARKWAY

**2. EXISTING SITE 1  
28.84 ACRES**

**1. EX. CENTRAL SUMMIT CENTER  
48.87 ACRES**

PRIMARY RIDGE LINE

**5. EXISTING SITE 3  
26.34 ACRES**

**6. NW TECH. DR.  
35.57 ACRES**

SINK 1

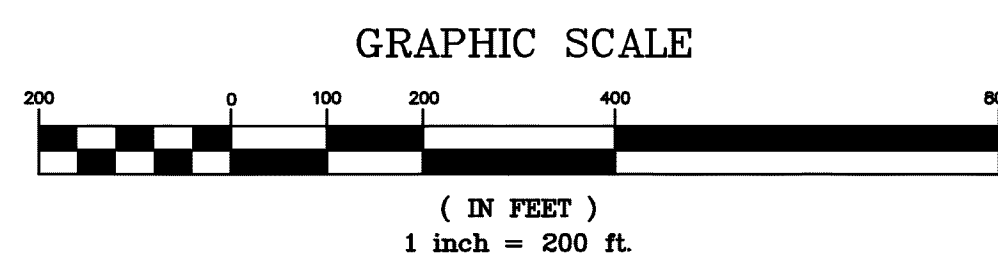
SINK 2

PRIMARY RIDGE LINE

**EXISTING 8'X6' RCB  
APPROXIMATE LOCATION  
(LIMITS OF DOWNSTREAM  
SYSTEM ANALYSIS)**

**LEGEND**

- Property Line/ROW
- Existing Property Line/ROW
- 1002 ----- Finished Grade Contours
- Drainage Areas



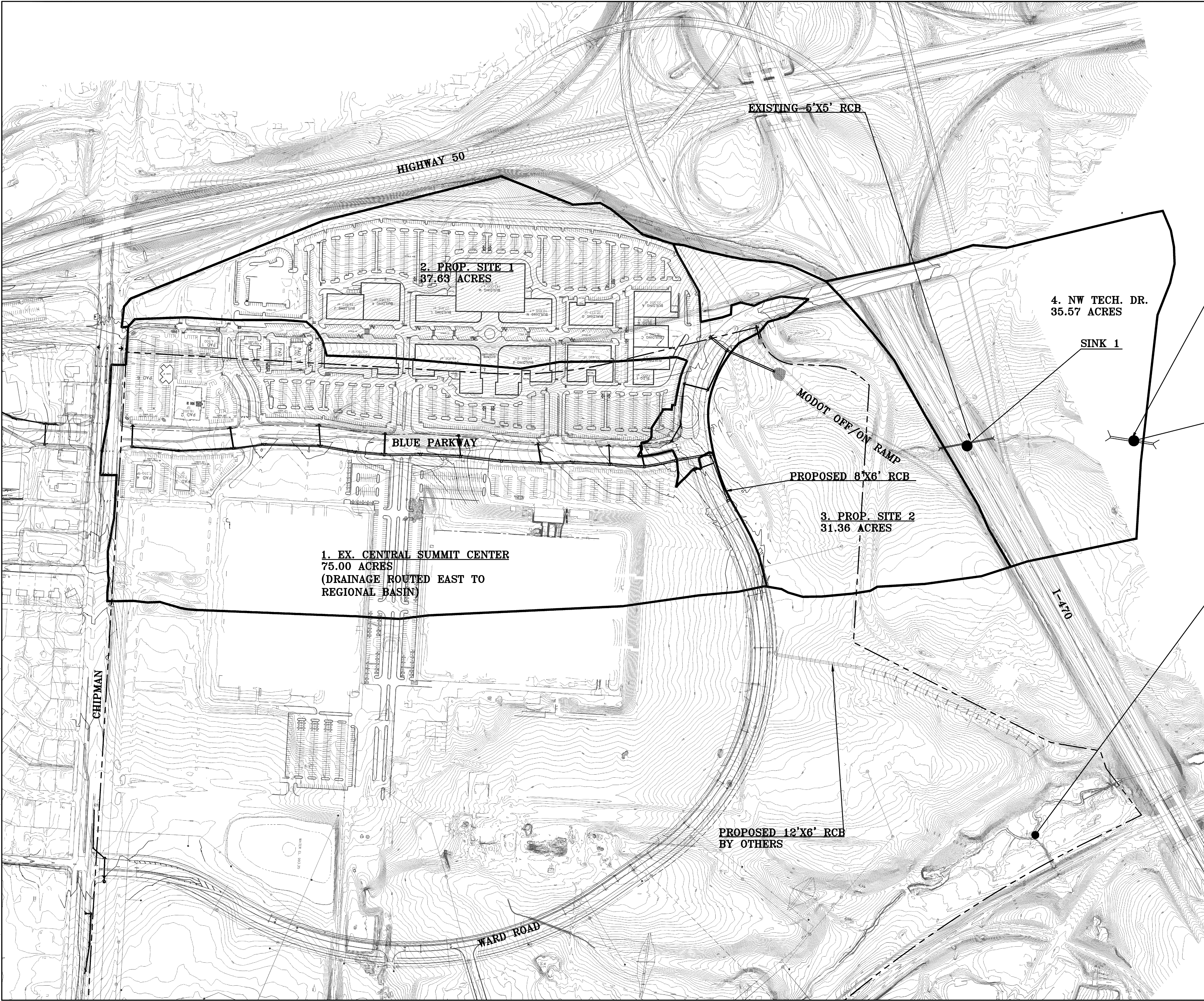
**FIGURE 3**  
**EXISTING  
CONDITIONS**

**MOLSSON**  
ASSOCIATES

7301 West 133rd Street, Suite 200  
Overland Park, KS 66213-4750  
TEL 913.381.1170  
FAX 913.381.1174  
www.molssonassociates.com



DWG: F:\PROJECTS\20090451\000\Storm Study\Find Drainage Study\Figures.dwg USER: jrk  
DATE: Nov 30, 2006 5:23pm APPS: 50451\_TMDL\_CON\_COLOR 50451\_PUBLIC\_DWG 50451\_PUBLIC\_DWG 50451\_PUBLIC\_DWG 50451\_PUBLIC\_DWG

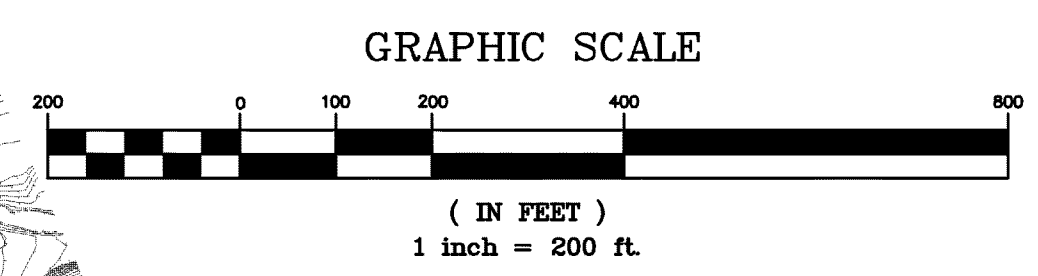


**LEGEND**

- Existing Property Line/ROW
- Property Line/ROW
- Existing Contours
- 1002 Finished Grade Contours
- Drainage Areas

**EXISTING 8'X6' RCB  
APPROXIMATE LOCATION  
(LIMITS OF DOWNSTREAM  
SYSTEM ANALYSIS)**

**REGIONAL DETENTION BASIN  
BY OTHERS WITH PROPOSED  
DEVELOPMENT.  
APPROXIMATE LOCATION**



**FIGURE 4**  
**PROPOSED  
CONDITIONS**

**OLSSON**  
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# *Appendix A*

# WinTR-55 Current Data Description

## --- Identification Data ---

User: Josh Birk Date: 11/27/2006  
 Project: Lee Summit Fair Units: English  
 SubTitle: Existing Conditions Areal Units: Acres  
 State: Missouri  
 County: Jackson  
 Filename: C:\Lee Summit Fair\Existing Conditions.w55

## --- Sub-Area Data ---

Name	Description	Reach	Area(ac)	RCN	Tc
1.	Ex. Central Summit	CenterOutlet	48.87	94	.228
2.	Existing Site 1	Outlet	28.84	77	.29
3.	Ex. Com Fed Bank	Outlet	2.55	92	0.100
4.	Existing Site 2	Outlet	21.21	64	.35
5.	Existing Site 3	Outlet	26.34	75	.304
6.	NW Tech Dr.	Outlet	35.57	90	.187

Total area: 163.38 (ac)

## --- Storm Data --

### Rainfall Depth by Rainfall Return Period

2-Yr (in)	5-Yr (in)	10-Yr (in)	25-Yr (in)	50-Yr (in)	100-Yr (in)	1-Yr (in)
3.5	4.6	5.3	6.2	6.9	7.7	3.0

Storm Data Source: Jackson County, MO (NRCS)  
 Rainfall Distribution Type: Type II  
 Dimensionless Unit Hydrograph: <standard>

Josh Birk

Lee Summit Fair  
Existing Conditions  
Jackson County, Missouri

Storm Data

Rainfall Depth by Rainfall Return Period

2-Yr (in)	5-Yr (in)	10-Yr (in)	25-Yr (in)	50-Yr (in)	100-Yr (in)	1-Yr (in)
3.5	4.6	5.3	6.2	6.9	7.7	3.0

Storm Data Source: Jackson County, MO (NRCS)  
Rainfall Distribution Type: Type II  
Dimensionless Unit Hydrograph: <standard>

Josh Birk

Lee Summit Fair  
Existing Conditions  
Jackson County, Missouri

Watershed Peak Table

Sub-Area or Reach Identifier	Peak Flow by Rainfall Return Period		
	10-Yr (cfs)	100-Yr (cfs)	1-Yr (cfs)

SUBAREAS

1.	264.77	392.46	140.58
2.	97.15	167.61	35.26
3.	16.16	24.27	8.28
4.	38.92	80.50	7.80
5.	81.46	143.62	27.78
6.	190.85	290.65	94.04

REACHES

OUTLET	664.33	1061.45	301.47
--------	--------	---------	--------

Josh Birk

Lee Summit Fair  
Existing Conditions  
Jackson County, Missouri

Hydrograph Peak/Peak Time Table

Sub-Area or Reach Identifier	Peak Flow 10-Yr (cfs) (hr)	Peak Flow 100-Yr (cfs) (hr)	Peak Time (hr) by Rainfall Return Period 1-Yr (cfs) (hr)
------------------------------------	-------------------------------------	--------------------------------------	-------------------------------------------------------------------

SUBAREAS

1.	264.77 12.02	392.46 12.02	140.58 12.01
2.	97.15 12.06	167.61 12.06	35.26 12.07
3.	16.16 11.93	24.27 11.93	8.28 11.93
4.	38.92 12.11	80.50 12.11	7.80 12.15
5.	81.46 12.07	143.62 12.08	27.78 12.10
6.	190.85 11.99	290.65 11.98	94.04 11.99

REACHES

OUTLET	664.33	1061.45	301.47
--------	--------	---------	--------

Josh Birk

Lee Summit Fair  
Existing Conditions  
Jackson County, Missouri

Sub-Area Summary Table

Sub-Area Identifier	Drainage Area (ac)	Time of Concentration (hr)	Curve Number	Receiving Reach	Sub-Area Description
1.	48.87	0.228	94	Outlet	Ex. Central Summit Center
2.	28.84	0.290	77	Outlet	Existing Site 1
3.	2.55	0.100	92	Outlet	Ex. Com Fed Bank
4.	21.21	0.350	64	Outlet	Existing Site 2
5.	26.34	0.304	75	Outlet	Existing Site 3
6.	35.57	0.187	90	Outlet	NW Tech Dr.

Total Area: 163.38 (ac)



Josh Birk

Lee Summit Fair  
Existing Conditions  
Jackson County, Missouri

Sub-Area Time of Concentration Details

Sub-Area Identifier/	Flow Length (ft)	Slope (ft/ft)	Mannings's n	End Area (sq ft)	Wetted Perimeter (ft)	Velocity (ft/sec)	Travel Time (hr)
-----							
1.							
SHEET	100	0.0200	0.150				0.156
CHANNEL	2574					10.000	0.072
						Time of Concentration	.228
							=====
2.							
SHEET	100	0.0200	0.240				0.227
CHANNEL	2254					10.000	0.063
						Time of Concentration	.29
							=====
3.							
User-provided							0.100
						Time of Concentration	0.100
							=====
4.							
SHEET	100	0.0310	0.400				0.287
CHANNEL	2250					10.000	0.063
						Time of Concentration	.35
							=====
5.							
SHEET	100	0.0390	0.410				0.267
CHANNEL	1315					10.000	0.037
						Time of Concentration	.304
							=====
6.							
SHEET	100	0.0200	0.150				0.156
CHANNEL	1132					10.000	0.031
						Time of Concentration	.187
							=====

Josh Birk

Lee Summit Fair  
Existing Conditions  
Jackson County, Missouri

Sub-Area Land Use and Curve Number Details

Sub-Area Identifier	Land Use	Hydrologic Soil Group	Sub-Area Area (ac)	Curve Number
1.	Commercial & business	C	48.87	94
	Total Area / Weighted Curve Number		48.87 =====	94 ==
2.	Open space; grass cover > 75%	(good) C	15.38	74
	Open space; grass cover > 75%	(good) D	13.46	80
	Total Area / Weighted Curve Number		28.84 =====	77 ==
3.	Commercial & business	B	2.55	92
	Total Area / Weighted Curve Number		2.55 =====	92 ==
4.	Woods	(fair) B	13.96	60
	Woods	(fair) C	7.25	73
	Total Area / Weighted Curve Number		21.21 =====	64 ==
5.	Woods - grass combination	(fair) B	4.44	65
	Woods - grass combination	(fair) C	17.68	76
	Woods - grass combination	(fair) D	4.22	82
	Total Area / Weighted Curve Number		26.34 =====	75 ==
6.	Industrial	B	18.86	88
	Industrial	C	9.65	91
	Industrial	D	7.06	93
	Total Area / Weighted Curve Number		35.57 =====	90 ==

## *Appendix B*

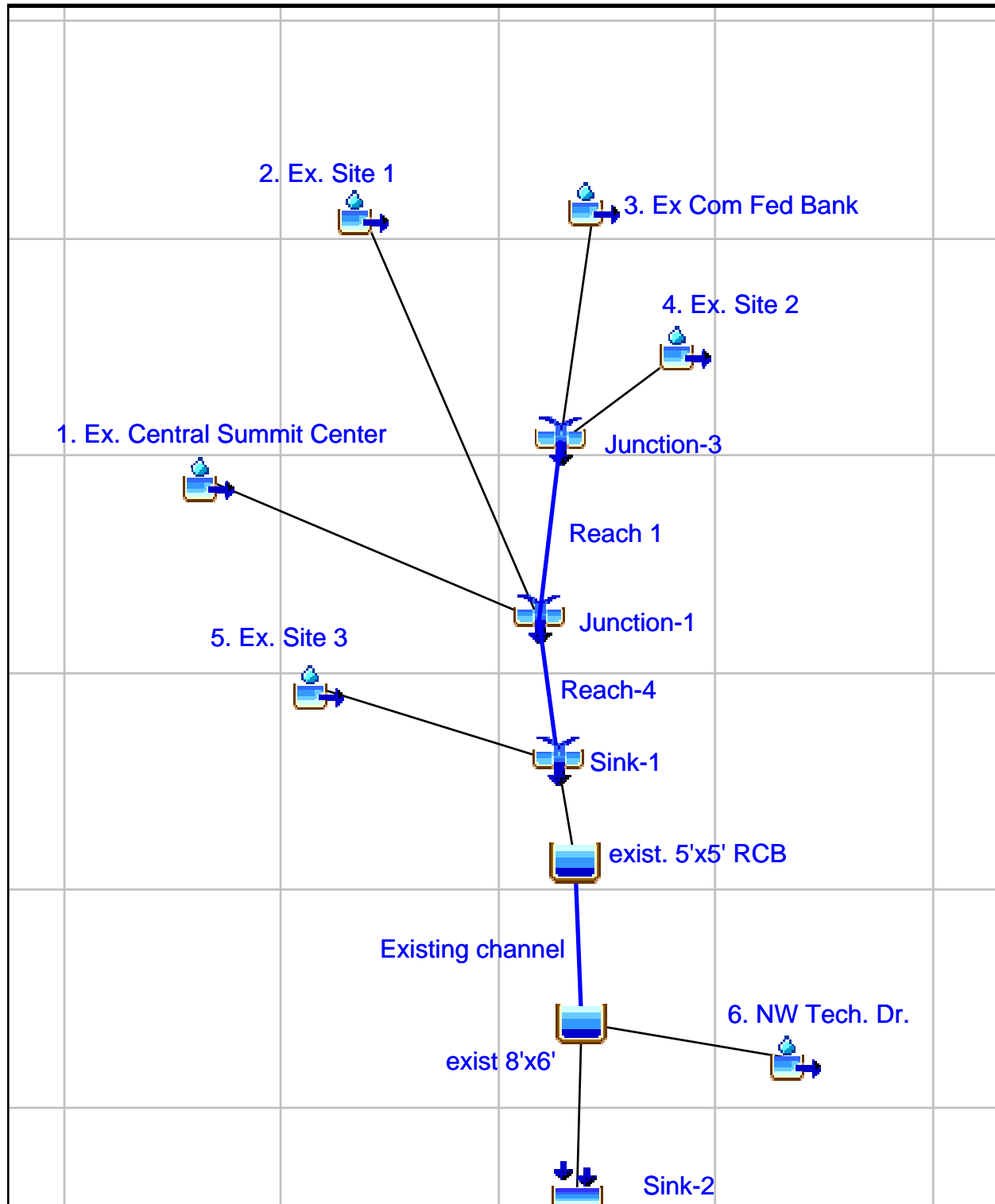


HEC-HMS

## Project : Lee Summit Fair

Basin Model : Existing

Nov 26 23:38:22 CST 2006



Project: Lee Summit Fair Simulation Run: Ex 1yr

Start of Run: 18Jul2005, 00:00 Basin Model: Existing  
End of Run: 19Jul2005, 01:00 Meteorologic Model: 1 Year Storm  
Compute Time: 27Nov2006, 00:17:11 Control Specifications: 24 Hour Storm

Volume Units: AC-FT

Hydrologic Element	Drainage Area (MI <sup>2</sup> )	Peak Discharge (CFS)	Time of Peak	Volume (AC-FT)
1. Ex. Central Summit Inter	0.0764	129.79	18Jul2005, 12:00	9.58
2. Ex. Site 1	0.0451	31.99	18Jul2005, 12:06	2.58
3. Ex Com Fed Bank	0.0040	7.34	18Jul2005, 11:54	0.46
4. Ex. Site 2	0.0331	6.72	18Jul2005, 12:06	0.83
5. Ex. Site 3	0.0412	25.47	18Jul2005, 12:06	2.11
6. NW Tech. Dr.	0.0556	87.74	18Jul2005, 12:00	5.88
Existing channel	0.1998	164.10	18Jul2005, 12:06	15.63
Junction-1	0.1586	168.98	18Jul2005, 12:00	13.44
Junction-3	0.0371	11.04	18Jul2005, 12:00	1.29
Reach 1	0.0371	10.56	18Jul2005, 12:00	1.29
Reach-4	0.1586	161.75	18Jul2005, 12:00	13.46
Sink-1	0.1998	183.45	18Jul2005, 12:00	15.57
Sink-2	0.2554	228.56	18Jul2005, 12:06	23.82
exist 8'x6'	0.2554	228.56	18Jul2005, 12:06	23.82
exist. 5'x5' RCB	0.1998	167.85	18Jul2005, 12:06	15.61

Project : Lee Summit Fair Simulation Run : Ex 1yr Reservoir: exist. 5'x5' RCB

Start of Run : 18Jul2005, 00:00 Basin Model : Existing

End of Run : 19Jul2005, 01:00 Meteorologic Model : 1 Year Storm

Compute Time : 27Nov2006, 00:17:11 Control Specifications : 24 Hour Storm

Volume Units : AC-FT

---

Computed Results

Peak Inflow : 183.45 (CFS) Date/Time of Peak Inflow : 18Jul2005, 12:00

Peak Outflow : 167.85 (CFS) Date/Time of Peak Outflow : 18Jul2005, 12:06

Total Inflow : 15.57 (AC-FT) Peak Storage : 0.83 (AC-FT)

Total Outflow : 15.61 (AC-FT) Peak Elevation : 946.52 (FT)

---

Project : Lee Summit Fair Simulation Run : Ex 1yr Reservoir: exist 8'x6'

Start of Run :	18Jul2005, 00:00	Basin Model :	Existing
End of Run :	19Jul2005, 01:00	Meteorologic Model :	1 Year Storm
Compute Time :	27Nov2006, 00:17:11	Control Specifications :	24 Hour Storm

Volume Units : AC-FT

#### Computed Results

Peak Inflow :	229.21 (CFS)	Date/Time of Peak Inflow :	18Jul2005, 12:06
Peak Outflow :	228.56 (CFS)	Date/Time of Peak Outflow :	18Jul2005, 12:06
Total Inflow :	21.51 (AC-FT)	Peak Storage :	0.55 (AC-FT)
Total Outflow :	23.82 (AC-FT)	Peak Elevation :	940.58 (FT)

Hydrologic Lee Summit Drainage Area Simulation	Peak Discharge	Time of Peak	Volume
Element	(MI2)	(CFS)	(AC-FT)
Start of Run:	18Jul2005, 00:00	Basin Model:	Existing
End of Run:	19Jul2005, 01:00	Meteorologic Model:	10 Year Storm
Compute Time:	26Nov2006, 23:34:58	Control Specifications:	24 Hour Storm
Volume Units: AC-FT			

1. Ex. Central Summit	0.0764	245.66	18Jul2005, 12:00	18.76
2. Ex. Site 1	0.0451	87.65	18Jul2005, 12:06	6.92
3. Ex Com Fed Bank	0.0040	14.47	18Jul2005, 11:54	0.93
4. Ex. Site 2	0.0331	35.81	18Jul2005, 12:06	3.14
5. Ex. Site 3	0.0412	74.51	18Jul2005, 12:06	5.92
6. NW Tech. Dr.	0.0556	178.16	18Jul2005, 12:00	12.35
Existing channel	0.1998	309.87	18Jul2005, 12:12	35.74
Junction-1	0.1586	368.84	18Jul2005, 12:00	29.76
Junction-3	0.0371	41.82	18Jul2005, 12:06	4.07
Reach 1	0.0371	41.79	18Jul2005, 12:06	4.08
Reach-4	0.1586	356.58	18Jul2005, 12:00	29.79
Sink-1	0.1998	424.76	18Jul2005, 12:00	35.72
Sink-2	0.2554	459.79	18Jul2005, 12:00	52.13
exist 8'x6'	0.2554	459.79	18Jul2005, 12:00	52.13
exist. 5'x5' RCB	0.1998	310.89	18Jul2005, 12:12	35.71



Project : Lee Summit Fair Simulation Run : Ex 10yr Reservoir: exist. 5'x5' RCB

Start of Run :	18Jul2005, 00:00	Basin Model :	Existing
End of Run :	19Jul2005, 01:00	Meteorologic Model :	10 Year Storm
Compute Time :	26Nov2006, 23:34:58	Control Specifications :	24 Hour Storm

Volume Units : AC-FT

---

#### Computed Results

Peak Inflow :	424.76 (CFS)	Date/Time of Peak Inflow :	18Jul2005, 12:00
Peak Outflow :	310.89 (CFS)	Date/Time of Peak Outflow :	18Jul2005, 12:12
Total Inflow :	35.72 (AC-FT)	Peak Storage :	3.44 (AC-FT)
Total Outflow :	35.71 (AC-FT)	Peak Elevation :	951.03 (FT)

---

Project : Lee Summit Fair Simulation Run : Ex 10yr Reservoir: exist 8'x6'

Start of Run :	18Jul2005, 00:00	Basin Model :	Existing
End of Run :	19Jul2005, 01:00	Meteorologic Model :	10 Year Storm
Compute Time :	26Nov2006, 23:34:58	Control Specifications :	24 Hour Storm

Volume Units : AC-FT

---

#### Computed Results

Peak Inflow :	450.36 (CFS)	Date/Time of Peak Inflow :	18Jul2005, 12:00
Peak Outflow :	459.79 (CFS)	Date/Time of Peak Outflow :	18Jul2005, 12:00
Total Inflow :	48.10 (AC-FT)	Peak Storage :	0.86 (AC-FT)
Total Outflow :	52.13 (AC-FT)	Peak Elevation :	943.89 (FT)

---

Project: Lee Summit Fair Simulation Run: Ex 100yr

Start of Run: 18Jul2005, 00:00 Basin Model: Existing  
 End of Run: 19Jul2005, 01:00 Meteorologic Model: 100 Year storm  
 Compute Time: 26Nov2006, 23:27:27 Control Specifications: 24 Hour Storm

Volume Units: AC-FT

Hydrologic Element	Drainage Area (MI <sup>2</sup> )	Peak Discharge (CFS)	Time of Peak	Volume (AC-FT)
1. Ex. Central Summit Inter	0.0764	364.73	18Jul2005, 12:00	28.46
2. Ex. Site 1	0.0451	150.42	18Jul2005, 12:06	12.03
3. Ex Com Fed Bank	0.0040	21.79	18Jul2005, 11:54	1.44
4. Ex. Site 2	0.0331	74.61	18Jul2005, 12:06	6.26
5. Ex. Site 3	0.0412	131.02	18Jul2005, 12:06	10.49
6. NW Tech. Dr.	0.0556	271.41	18Jul2005, 12:00	19.31
Existing channel	0.1998	385.87	18Jul2005, 12:18	58.76
Junction-1	0.1586	589.96	18Jul2005, 12:00	48.18
Junction-3	0.0371	83.56	18Jul2005, 12:06	7.69
Reach 1	0.0371	83.39	18Jul2005, 12:06	7.70
Reach-4	0.1586	573.14	18Jul2005, 12:00	48.24
Sink-1	0.1998	696.07	18Jul2005, 12:00	58.73
Sink-2	0.2554	580.35	18Jul2005, 12:06	88.06
exist 8'x6'	0.2554	580.35	18Jul2005, 12:06	88.06
exist. 5'x5' RCB	0.1998	385.94	18Jul2005, 12:18	58.72

Project : Lee Summit Fair Simulation Run : Ex 100yr Reservoir: exist. 5'x5' RCB

Start of Run : 18Jul2005, 00:00 Basin Model : Existing  
End of Run : 19Jul2005, 01:00 Meteorologic Model : 100 Year storm  
Compute Time : 26Nov2006, 23:27:27 Control Specifications : 24 Hour Storm

Volume Units : AC-FT

---

Computed Results

Peak Inflow :	696.07 (CFS)	Date/Time of Peak Inflow :	18Jul2005, 12:00
Peak Outflow :	385.94 (CFS)	Date/Time of Peak Outflow :	18Jul2005, 12:18
Total Inflow :	58.73 (AC-FT)	Peak Storage :	8.85 (AC-FT)
Total Outflow :	58.72 (AC-FT)	Peak Elevation :	955.17 (FT)

---

Project : Lee Summit Fair Simulation Run : Ex 100yr Reservoir: exist 8'x6'

Start of Run : 18Jul2005, 00:00 Basin Model : Existing  
End of Run : 19Jul2005, 01:00 Meteorologic Model : 100 Year storm  
Compute Time : 26Nov2006, 23:27:27 Control Specifications : 24 Hour Storm

Volume Units : AC-FT

---

Computed Results

Peak Inflow :	597.03 (CFS)	Date/Time of Peak Inflow :	18Jul2005, 12:00
Peak Outflow :	580.35 (CFS)	Date/Time of Peak Outflow :	18Jul2005, 12:06
Total Inflow :	78.06 (AC-FT)	Peak Storage :	1.05 (AC-FT)
Total Outflow :	88.06 (AC-FT)	Peak Elevation :	945.39 (FT)

---

# *Appendix C*

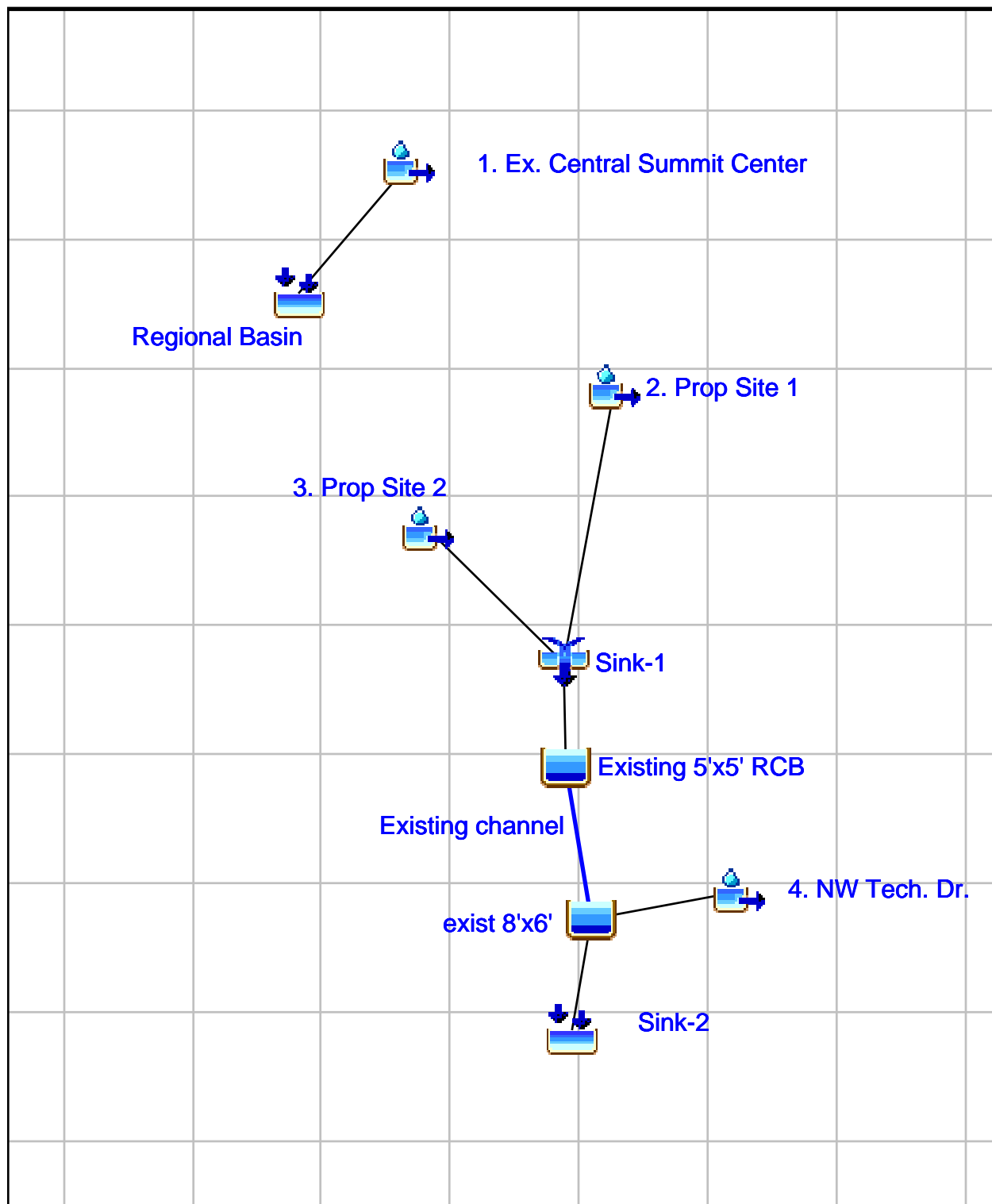


HEC-HMS

## Project : Lee Summit Fair

Basin Model : Proposed

Nov 27 00:10:19 CST 2006



Project: Lee Summit Fair Simulation Run: Prop 1yr				
Start of Run: 18Jul2005, 00:00		Basin Model: Proposed		
End of Run: 19Jul2005, 01:00		Meteorologic Model: 1 Year Storm		
Compute Time: 27Nov2006, 00:34:36		Control Specifications: 24 Hour Storm		
Hydrologic Volume Units: Element	Drainage Area (MI <sup>2</sup> ) AC-FT	Peak Discharge (CFS)	Time of Peak	Volume (AC-FT)

1. Ex. Central Summit Center	0.1072	225.07	18Jul2005, 12:00	16.62
2. Prop Site 1	0.0588	112.92	18Jul2005, 12:00	8.34
3. Prop Site 2	0.0490	70.28	18Jul2005, 12:00	4.54
4. NW Tech. Dr.	0.0556	87.74	18Jul2005, 12:00	5.88
Existing 5'x5' RCB	0.1078	184.44	18Jul2005, 12:00	12.88
Existing channel	0.1078	178.94	18Jul2005, 12:00	12.91
Regional Basin	0.1172	225.07	18Jul2005, 12:00	16.62
Sink-1	0.1078	183.20	18Jul2005, 12:00	12.88
Sink-2	0.1634	240.86	18Jul2005, 12:00	19.17
exist 8'x6'	0.1634	240.86	18Jul2005, 12:00	19.17



Project : Lee Summit Fair Simulation Run : Prop 1yr Reservoir: Existing 5'x5' RCB

Start of Run :	18Jul2005, 00:00	Basin Model :	Proposed
End of Run :	19Jul2005, 01:00	Meteorologic Model :	1 Year Storm
Compute Time :	27Nov2006, 00:34:36	Control Specifications :	24 Hour Storm

Volume Units : AC-FT

---

Computed Results

Peak Inflow :	183.20 (CFS)	Date/Time of Peak Inflow :	18Jul2005, 12:00
Peak Outflow :	184.44 (CFS)	Date/Time of Peak Outflow :	18Jul2005, 12:00
Total Inflow :	12.88 (AC-FT)	Peak Storage :	0.05 (AC-FT)
Total Outflow :	12.88 (AC-FT)	Peak Elevation :	946.57 (FT)

---

Project : Lee Summit Fair Simulation Run : Prop 1yr Reservoir: exist 8'x6'

Start of Run :	18Jul2005, 00:00	Basin Model :	Proposed
End of Run :	19Jul2005, 01:00	Meteorologic Model :	1 Year Storm
Compute Time :	27Nov2006, 00:34:36	Control Specifications :	24 Hour Storm

Volume Units : AC-FT

#### Computed Results

Peak Inflow :	266.68 (CFS)	Date/Time of Peak Inflow :	18Jul2005, 12:00
Peak Outflow :	240.86 (CFS)	Date/Time of Peak Outflow :	18Jul2005, 12:00
Total Inflow :	18.79 (AC-FT)	Peak Storage :	0.59 (AC-FT)
Total Outflow :	19.17 (AC-FT)	Peak Elevation :	940.78 (FT)

Project: Lee Summit Fair Simulation Run: Prop 10yr

Start of Run: 18Jul2005, 00:00 Basin Model: Proposed  
 End of Run: 19Jul2005, 01:00 Meteorologic Model: 10 Year Storm  
 Compute Time: 27Nov2006, 00:33:00 Control Specifications: 24 Hour Storm

Volume Units: AC-FT

Hydrologic Element	Drainage Area (MI <sup>2</sup> )	Peak Discharge (CFS)	Time of Peak	Volume (AC-FT)
1. Ex. Central Summit Center	0.1072	406.15	18Jul2005, 12:00	30.92
2. Prop Site 1	0.0588	203.77	18Jul2005, 12:00	15.51
3. Prop Site 2	0.0490	151.13	18Jul2005, 12:00	10.06
4. NW Tech. Dr.	0.0556	178.16	18Jul2005, 12:00	12.35
Existing 5'x5' RCB	0.1078	355.02	18Jul2005, 12:00	25.57
Existing channel	0.1078	347.46	18Jul2005, 12:00	25.62
Regional Basin	0.1172	406.15	18Jul2005, 12:00	30.92
Sink-1	0.1078	354.89	18Jul2005, 12:00	25.57
Sink-2	0.1634	515.62	18Jul2005, 12:00	42.40
exist 8'x6'	0.1634	515.62	18Jul2005, 12:00	42.40

Project : Lee Summit Fair Simulation Run : Prop 10yr Reservoir: Existing 5'x5' RCB

Start of Run :	18Jul2005, 00:00	Basin Model :	Proposed
End of Run :	19Jul2005, 01:00	Meteorologic Model :	10 Year Storm
Compute Time :	27Nov2006, 00:33:00	Control Specifications :	24 Hour Storm

Volume Units : AC-FT

#### Computed Results

Peak Inflow :	354.89 (CFS)	Date/Time of Peak Inflow :	18Jul2005, 12:00
Peak Outflow :	355.02 (CFS)	Date/Time of Peak Outflow :	18Jul2005, 12:00
Total Inflow :	25.57 (AC-FT)	Peak Storage :	0.05 (AC-FT)
Total Outflow :	25.57 (AC-FT)	Peak Elevation :	952.73 (FT)

Project : Lee Summit Fair Simulation Run : Prop 10yr Reservoir: exist 8'x6'

Start of Run :	18Jul2005, 00:00	Basin Model :	Proposed
End of Run :	19Jul2005, 01:00	Meteorologic Model :	10 Year Storm
Compute Time :	27Nov2006, 00:33:00	Control Specifications :	24 Hour Storm

Volume Units : AC-FT

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#### Computed Results

Peak Inflow :	525.63 (CFS)	Date/Time of Peak Inflow :	18Jul2005, 12:00
Peak Outflow :	515.62 (CFS)	Date/Time of Peak Outflow :	18Jul2005, 12:00
Total Inflow :	37.97 (AC-FT)	Peak Storage :	0.95 (AC-FT)
Total Outflow :	42.40 (AC-FT)	Peak Elevation :	944.60 (FT)

---

Project: Lee Summit Fair Simulation Run: Prop 100yr				
Start of Run: 18Jul2005, 00:00		Basin Model: Proposed		
End of Run: 19Jul2005, 01:00		Meteorologic Model: 100 Year storm		
Compute Time: 27Nov2006, 00:27:54		Control Specifications: 24 Hour Storm		
Hydrologic Volume Units: Element	Drainage Area (MI <sup>2</sup> ) AC-FT	Peak Discharge (CFS)	Time of Peak	Volume (AC-FT)

1. Ex. Central Summit Center	0.1072	593.64	18Jul2005, 12:00	45.89
2. Prop Site 1	0.0588	297.83	18Jul2005, 12:00	23.02
3. Prop Site 2	0.0490	235.43	18Jul2005, 12:00	16.09
4. NW Tech. Dr.	0.0556	271.41	18Jul2005, 12:00	19.31
Existing 5'x5' RCB	0.1078	532.90	18Jul2005, 12:00	39.44
Existing channel	0.1078	523.29	18Jul2005, 12:00	39.54
Regional Basin	0.1172	593.64	18Jul2005, 12:00	45.89
Sink-1	0.1078	533.26	18Jul2005, 12:00	39.11
Sink-2	0.1634	776.66	18Jul2005, 12:00	66.77
exist 8'x6'	0.1634	776.66	18Jul2005, 12:00	66.77

Project : Lee Summit Fair Simulation Run : Prop 100yr Reservoir: Existing 5'x5' RCB

Start of Run :	18Jul2005, 00:00	Basin Model :	Proposed
End of Run :	19Jul2005, 01:00	Meteorologic Model :	100 Year storm
Compute Time :	27Nov2006, 00:27:54	Control Specifications :	24 Hour Storm

Volume Units : AC-FT

---

Computed Results

Peak Inflow :	533.26 (CFS)	Date/Time of Peak Inflow :	18Jul2005, 12:00
Peak Outflow :	532.90 (CFS)	Date/Time of Peak Outflow :	18Jul2005, 12:00
Total Inflow :	39.11 (AC-FT)	Peak Storage :	0.05 (AC-FT)
Total Outflow :	39.44 (AC-FT)	Peak Elevation :	957.03 (FT)

---

Project : Lee Summit Fair Simulation Run : Prop 100yr Reservoir: exist 8'x6'

Start of Run : 18Jul2005, 00:00 Basin Model : Proposed  
End of Run : 19Jul2005, 01:00 Meteorologic Model : 100 Year storm  
Compute Time : 27Nov2006, 00:27:54 Control Specifications : 24 Hour Storm

Volume Units : AC-FT

---

Computed Results

Peak Inflow :	794.69 (CFS)	Date/Time of Peak Inflow :	18Jul2005, 12:00
Peak Outflow :	776.66 (CFS)	Date/Time of Peak Outflow :	18Jul2005, 12:00
Total Inflow :	58.85 (AC-FT)	Peak Storage :	1.30 (AC-FT)
Total Outflow :	66.77 (AC-FT)	Peak Elevation :	947.20 (FT)

---



July 22, 2009

Mr. Steven W. Rich  
Townsend Capital, LLC  
11311 McCormick Road, Ste. 470  
Hunt Valley, MD 21031

Re: Stormwater Regional Detention Basin Association

Dear Steve,

As requested, Trabue, Hansen & Hinshaw Inc. (**THHinc**) completed a review of the regional detention basin stormwater flows analysis for the Summit Technology Campus, located in Lee's Summit, Missouri. The review determined the individual contributions of the flow currently going to the basin.

There are three properties contributing flow to the basin: the original Summit Technology Campus, the Red Development Site, and the remaining undeveloped portion of the site. The attached Figure 1 depicts the drainage areas. **THHinc** previously determined the flows in the "Stormwater Drainage Report for Ward Road-Summit Technology Campus" dated May 16, 2007 approved by the City.

The City approved a 1-year storm design for the detention basin because the entire area floods under storms of higher frequency. The Highway 470 culvert controls and provides detention for higher frequency storms. Flows and contribution percentages for higher frequency storms are slightly different. When area C or other area develops with on-site detention, the contributing areas, flows, and percentages will change

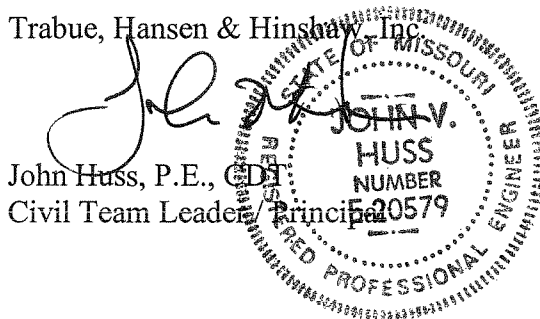
**Table 1: Current Flow to Regional Detention Basin in July, 2009**

	Area (acres)	1yr Flow (cfs)	% of Total 100 yr Flow
Original Summit Technology Campus	97.1	241.9	40.4%
Red Development Site	33.0	122.4	20.4%
Residual Townsend Capital Property	186.5	235.0	39.2%

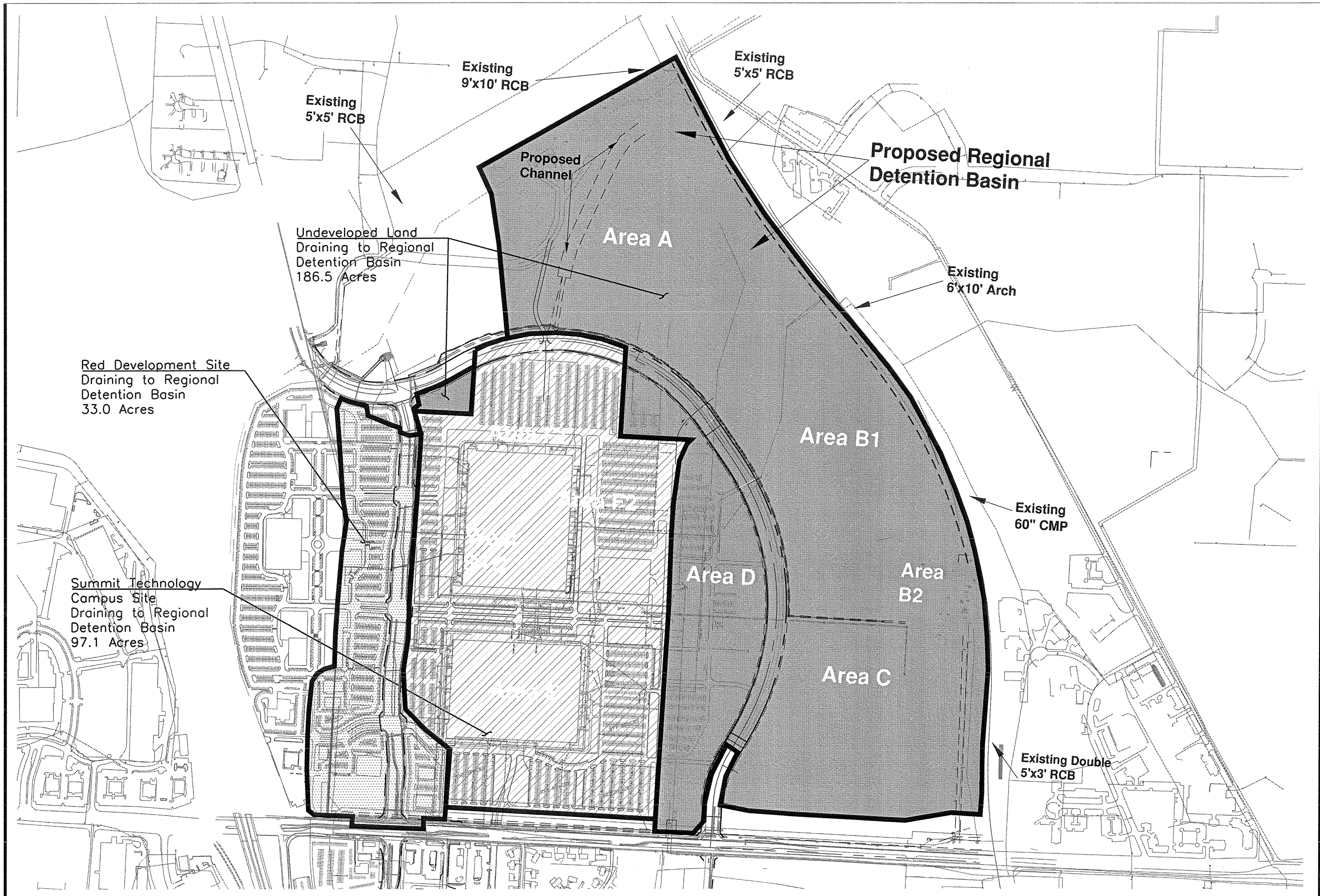
Please call if you have any questions.

Trabue, Hansen & Hinshaw, Inc.

John Huss, P.E., CDE  
Civil Team Leader/Principal



7/22/2009

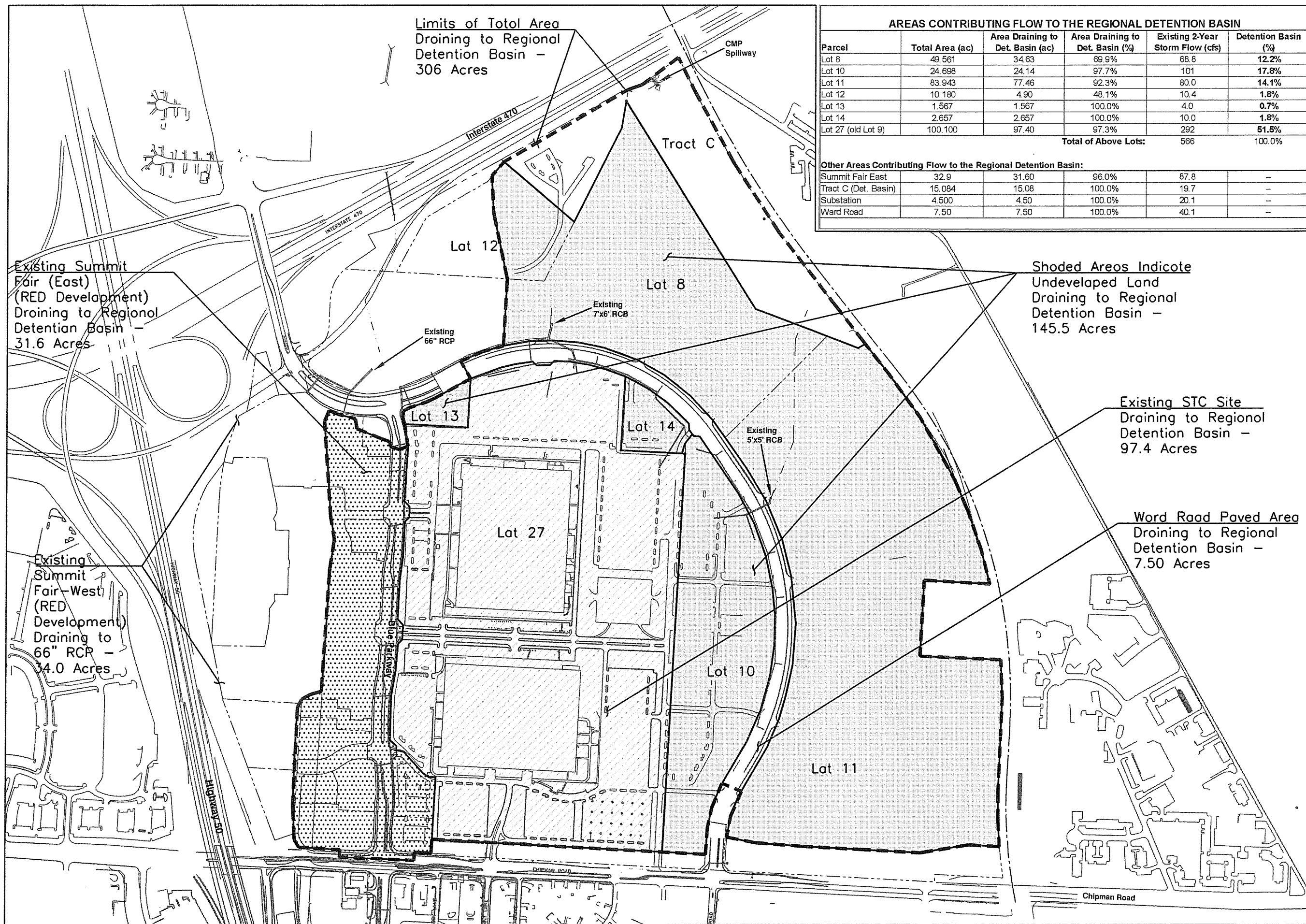


Revisions	No.	Date	Description	Initials

**THHinc**  
 Consulting Engineers  
 TRABUE, HANSEN &  
 HINSHAW, INC.  
 1901 Pennsylvania Dr.  
 Columbia, MO 65202  
 Phone (573) 814-1568  
 Fax (573) 814-1128  
 Corp. No. MO E-1454-D

Townsend Capital, LLC  
**Summit Technology Campus**  
 Lee's Summit, MO  
 Detention Basin Contributing Areas

Client Proj #  
 THHinc Proj # 4907  
 Engineer: JVH  
 Designer: TBB  
 Drafter:  
 Plotted: 07/22/2009



AREAS CONTRIBUTING FLOW TO THE REGIONAL DETENTION BASIN					
Parcel	Total Area (ac)	Area Draining to Det. Basin (ac)	Area Draining to Det. Basin (%)	Existing 2-Year Storm Flow (cfs)	Detention Basin (%)
Lot 8	49.561	34.63	69.9%	68.8	12.2%
Lot 10	24.698	24.14	97.7%	101	17.8%
Lot 11	83.943	77.46	92.3%	80.0	14.1%
Lot 12	10.180	4.90	48.1%	10.4	1.8%
Lot 13	1.567	1.567	100.0%	4.0	0.7%
Lot 14	2.657	2.657	100.0%	10.0	1.8%
Lot 27 (old Lot 9)	100.100	97.40	97.3%	292	51.5%
Total of Above Lots:				566	100.0%
Other Areas Contributing Flow to the Regional Detention Basin:					
Summit Fair East	32.9	31.60	96.0%	87.8	-
Tract C (Det. Basin)	15.084	15.08	100.0%	19.7	-
Substation	4.500	4.50	100.0%	20.1	-
Ward Road	7.50	7.50	100.0%	40.1	-

Revisions	Initials	
	No.	Description

**THHinc**  
 Consulting Engineers  
 TRABUE, HANSEN &  
 HINSHAW, INC.  
 1901 Pennsylvania Dr.  
 Columbia, MO 65202  
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 Corp. No. MO E-1454-D

Townsend Capital, LLC  
 Summit Technology Campus  
 Lee's Summit, MO  
 Detention Basin Contributing Areas

Client Proj # \_\_\_\_\_  
 THHinc Proj # 4907  
 Engineer: CMF  
 Designer: TBB  
 Drafter: \_\_\_\_\_  
 Plotted: 09/21/2009





# STORMWATER REPORT

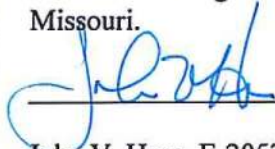
**City of Lee's Summit**

**Jackson County, Missouri**

**Summit Technology Campus  
Summit Innovation Center**

March, 2015

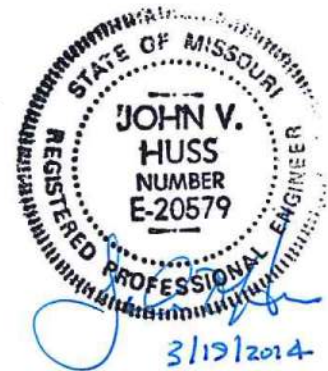
I certify that this report was prepared by me or under my direct supervision, and that I am a duly registered Professional Engineer under the law of the State of Missouri.



John V. Huss, E-20579  
Expiration 12.31.2015

3/19/2015

Date



Prepared by:

**Trabue, Hansen & Hinshaw Inc.**  
1901 Pennsylvania Avenue  
Columbia, MO 65202  
MO Engineering Corporation #001454  
Expiration 12.31.2016  
(573) 814-1568  
Fax: (573) 814-1128

**THHinc**

..... *about the possibilities*

## **Introduction**

This report details the preliminary design of the storm sewer system supporting the Summit Innovation Center Preliminary Development Plan (PDP), a mixed-use development, at the Summit Technology Campus (STC) located in Lee's Summit, Missouri. See Figure 1 for a site location map.

## **Project Description**

The Summit Technology Campus is located southeast of the Interstate-470/State Highway 50 interchange. The entire development covers approximately 367 acres, and is bordered to the south by Chipman Road, to the north by I-470, to the west by Blue Parkway, and to the east by the Union Pacific Railroad. The Summit Technology Campus is split by Ward Road which was opened to traffic in October 2008.

Townsend Capital LLC proposes improvements to the existing Summit Technology Campus, including the addition of a variety of mixed business commercial and residential uses along Ward Road. In this report, the site for these improvements will be referred to as the "35 Acre Tract." The current proposed building layout, grading plan, and storm sewer system drawings for the 35 Acre Tract can be found in the PDP.

## **Existing System**

When Ward Road was constructed the drainage for the roadway and from the western side of the road was collected and discharged from a 5' x 5' concrete box culvert in the middle portion of the site. The stormwater silt basin was left in place. A Stormwater Master Plan and model was prepared for the overall development in 2007 and approved by the City.

The Master plan established a regional detention facility on Tract C at the northeast corner of the development. The improvements were constructed in 2008 and the facility has been in operation since that time.

## **Proposed Improvements:**

This project develops a portion of the site that was modeled for the regional detention facility. The 2007 study assumed this portion of the site would be developed with up to 71% impervious area. The proposed development limits the impervious area to 68%. Therefore, the proposed development is within the parameters of the original study and we do not propose a revision to the hydraulic study for the regional detention basin.

Within the site we will extend the box culvert to the regional detention basin and provide site storm sewers and piping to collect the surface flow and transport it to the detention basin. The layout and drainage areas are depicted on the stormwater masterplan drawing. The peak flows generated by this site are:

	Pre-Development Q (cfs)	Post Development Q (cfs)
1-yr storm	22.6	127.2
10-yr storm	67.7	226.1
100-yr storm	144.4	367.4

Hydrographs for the storm flows are in appendix at the end of this report.

**Design and Methodology:**

The hydrographs and peak flows were calculated using Hydroflow Hydrograph Extension to AutoCAD Civil 3D 2015. Basin storm calculations and preliminary system sizing was prepared using the Rational Formula and entrance conditions with a maximum of 1.5 HW/D.

**Results of Analysis:**

The preliminary layout of system and system sizing is depicted on the Stormwater masterplan drawing.

**APPENDIX**

	<u>Pages</u>
Hydrographs	6

# Hydrograph Report

Hydraflow Hydrographs Extension for AutoCAD® Civil 3D® 2015 by Autodesk, Inc. v10.4

Thursday, 03 / 19 / 2015

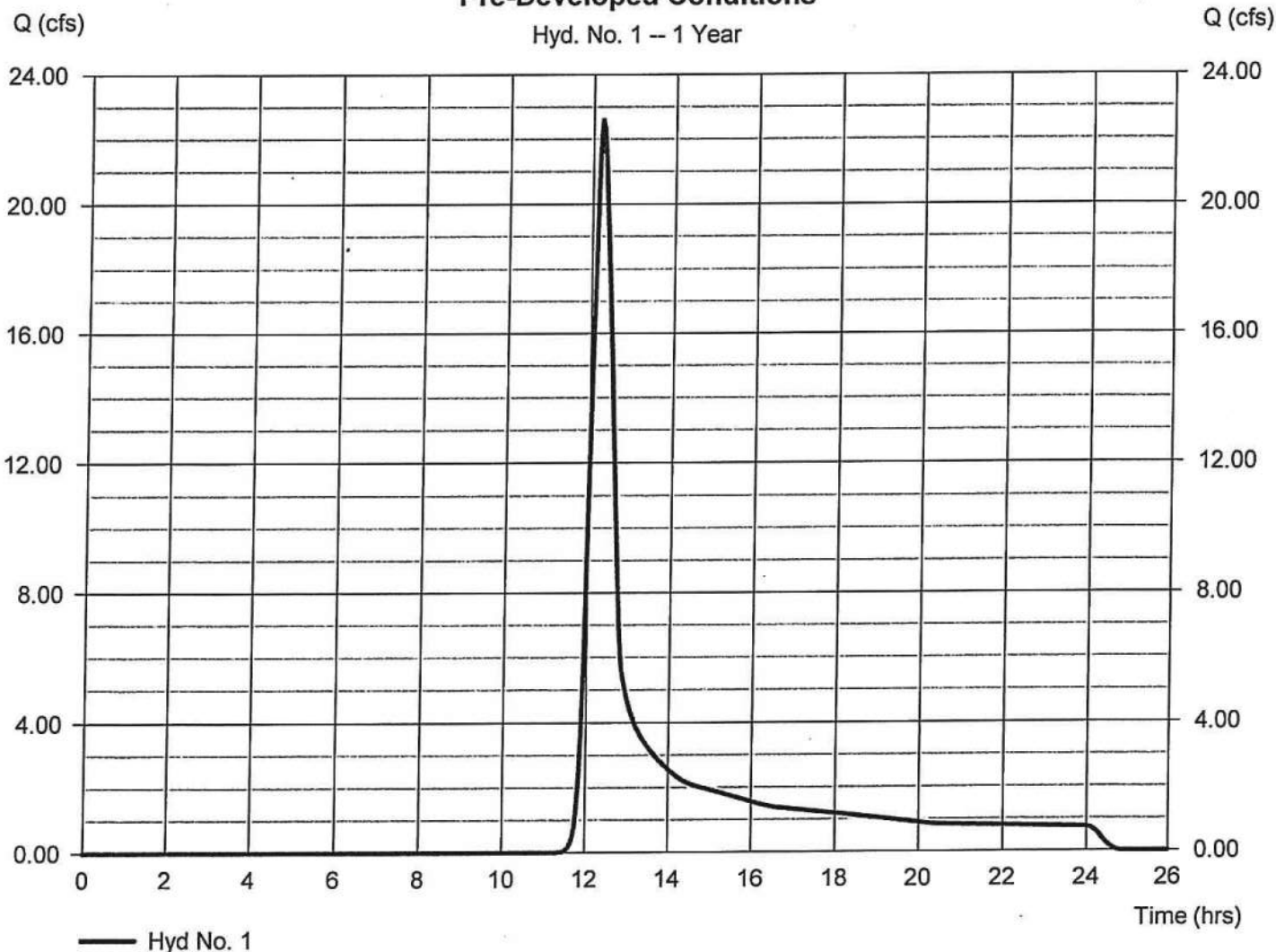
## Hyd. No. 1

### Pre-Developed Conditions

Hydrograph type	=	SCS Runoff	Peak discharge	=	22.58 cfs
Storm frequency	=	1 yrs	Time to peak	=	12.23 hrs
Time interval	=	2 min	Hyd. volume	=	109,519 cuft
Drainage area	=	37.410 ac	Curve number	=	73
Basin Slope	=	0.0 %	Hydraulic length	=	0 ft
Tc method	=	TR55	Time of conc. (Tc)	=	30.50 min
Total precip.	=	2.90 in	Distribution	=	Type II
Storm duration	=	24 hrs	Shape factor	=	484

### Pre-Developed Conditions

Hyd. No. 1 -- 1 Year





# Hydrograph Report

Hydraflow Hydrographs Extension for AutoCAD® Civil 3D® 2015 by Autodesk, Inc. v10.4

Thursday, 03 / 19 / 2015

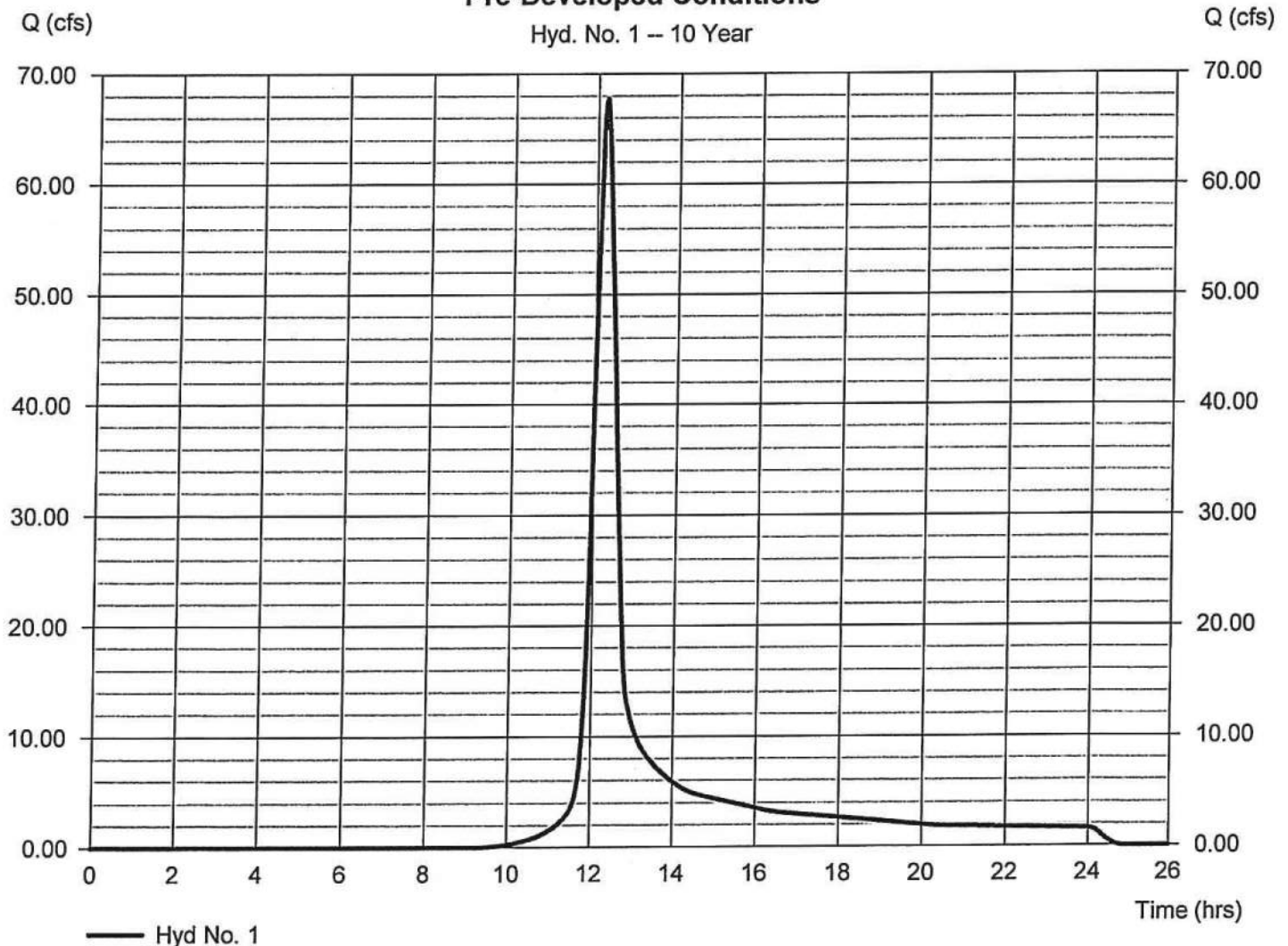
## Hyd. No. 1

### Pre-Developed Conditions

Hydrograph type	=	SCS Runoff	Peak discharge	=	67.73 cfs
Storm frequency	=	10 yrs	Time to peak	=	12.23 hrs
Time interval	=	2 min	Hyd. volume	=	297,468 cuft
Drainage area	=	37.410 ac	Curve number	=	73
Basin Slope	=	0.0 %	Hydraulic length	=	0 ft
Tc method	=	TR55	Time of conc. (Tc)	=	30.50 min
Total precip.	=	4.85 in	Distribution	=	Type II
Storm duration	=	24 hrs	Shape factor	=	484

### Pre-Developed Conditions

Hyd. No. 1 -- 10 Year



# Hydrograph Report

Hydraflow Hydrographs Extension for AutoCAD® Civil 3D® 2015 by Autodesk, Inc. v10.4

Thursday, 03 / 19 / 2015

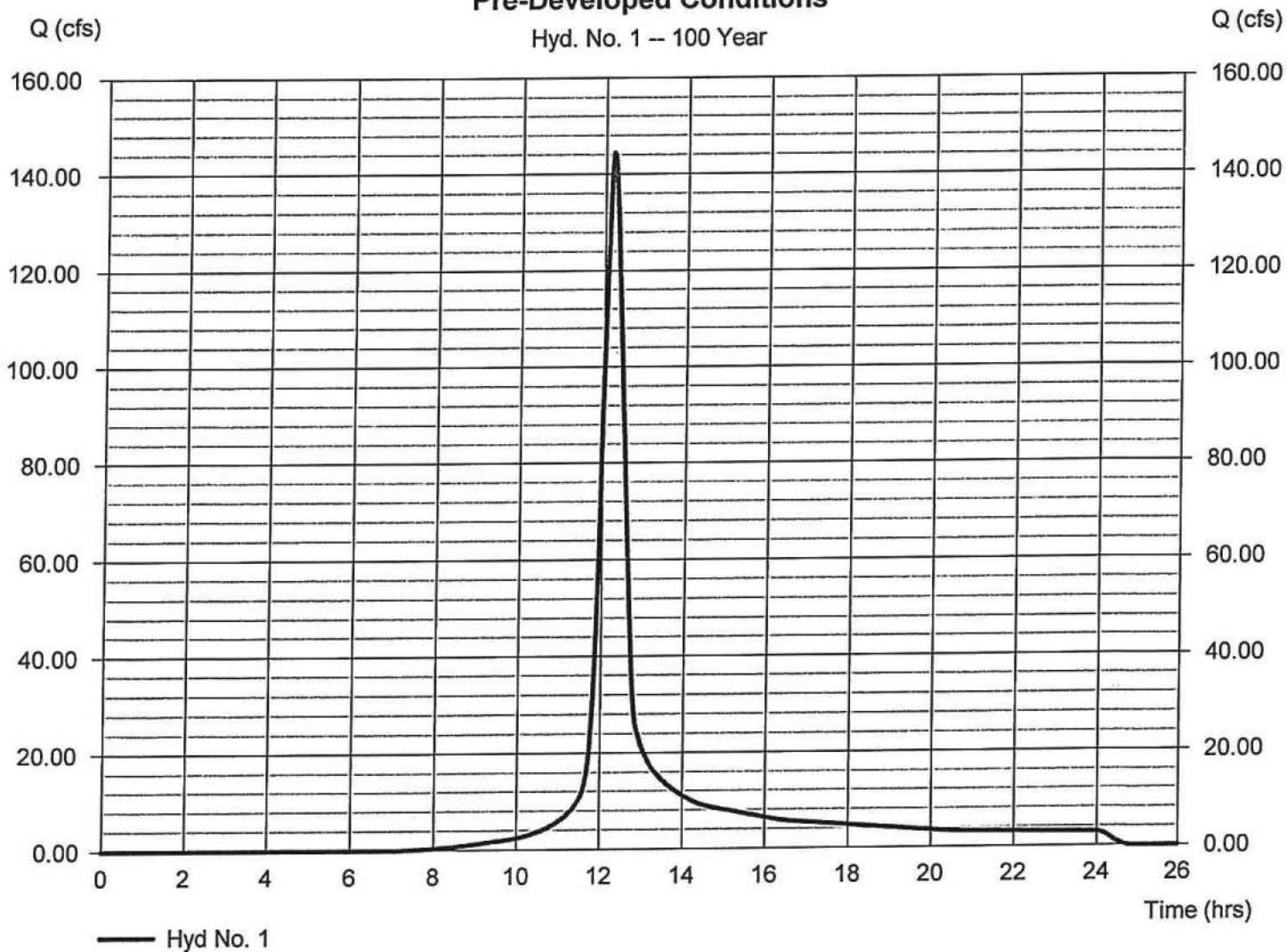
## Hyd. No. 1

### Pre-Developed Conditions

Hydrograph type	=	SCS Runoff	Peak discharge	=	144.36 cfs
Storm frequency	=	100 yrs	Time to peak	=	12.20 hrs
Time interval	=	2 min	Hyd. volume	=	623,718 cuft
Drainage area	=	37.410 ac	Curve number	=	73
Basin Slope	=	0.0 %	Hydraulic length	=	0 ft
Tc method	=	TR55	Time of conc. (Tc)	=	30.50 min
Total precip.	=	7.69 in	Distribution	=	Type II
Storm duration	=	24 hrs	Shape factor	=	484

### Pre-Developed Conditions

Hyd. No. 1 -- 100 Year



# Hydrograph Report

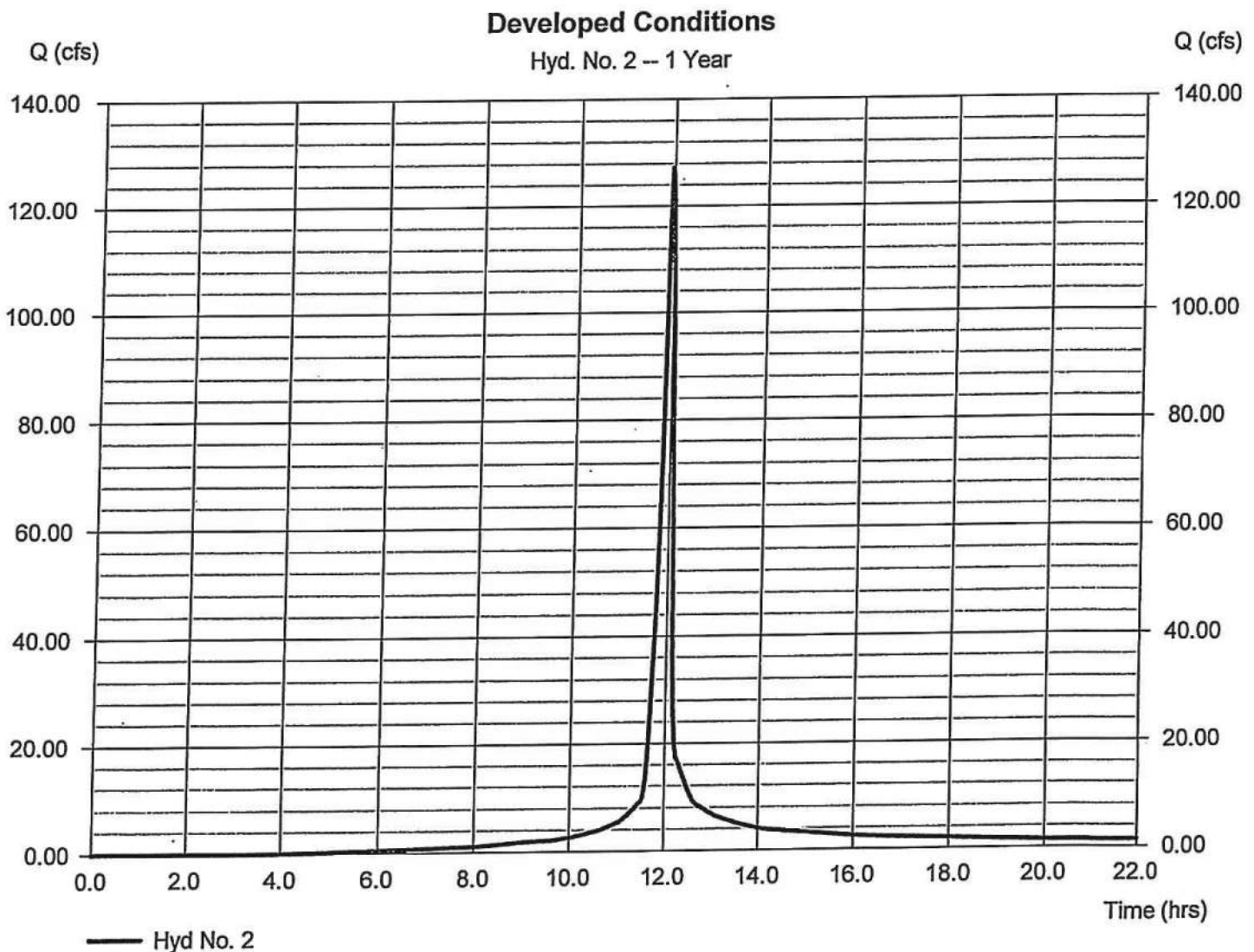
Hydraflow Hydrographs Extension for AutoCAD® Civil 3D® 2015 by Autodesk, Inc. v10.4

Thursday, 03 / 19 / 2015

## Hyd. No. 2

### Developed Conditions

Hydrograph type	= SCS Runoff	Peak discharge	= 127.15 cfs
Storm frequency	= 1 yrs	Time to peak	= 11.97 hrs
Time interval	= 2 min	Hyd. volume	= 306,021 cuft
Drainage area	= 37.410 ac	Curve number	= 94
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= TR55	Time of conc. (Tc)	= 8.80 min
Total precip.	= 2.90 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484



# Hydrograph Report

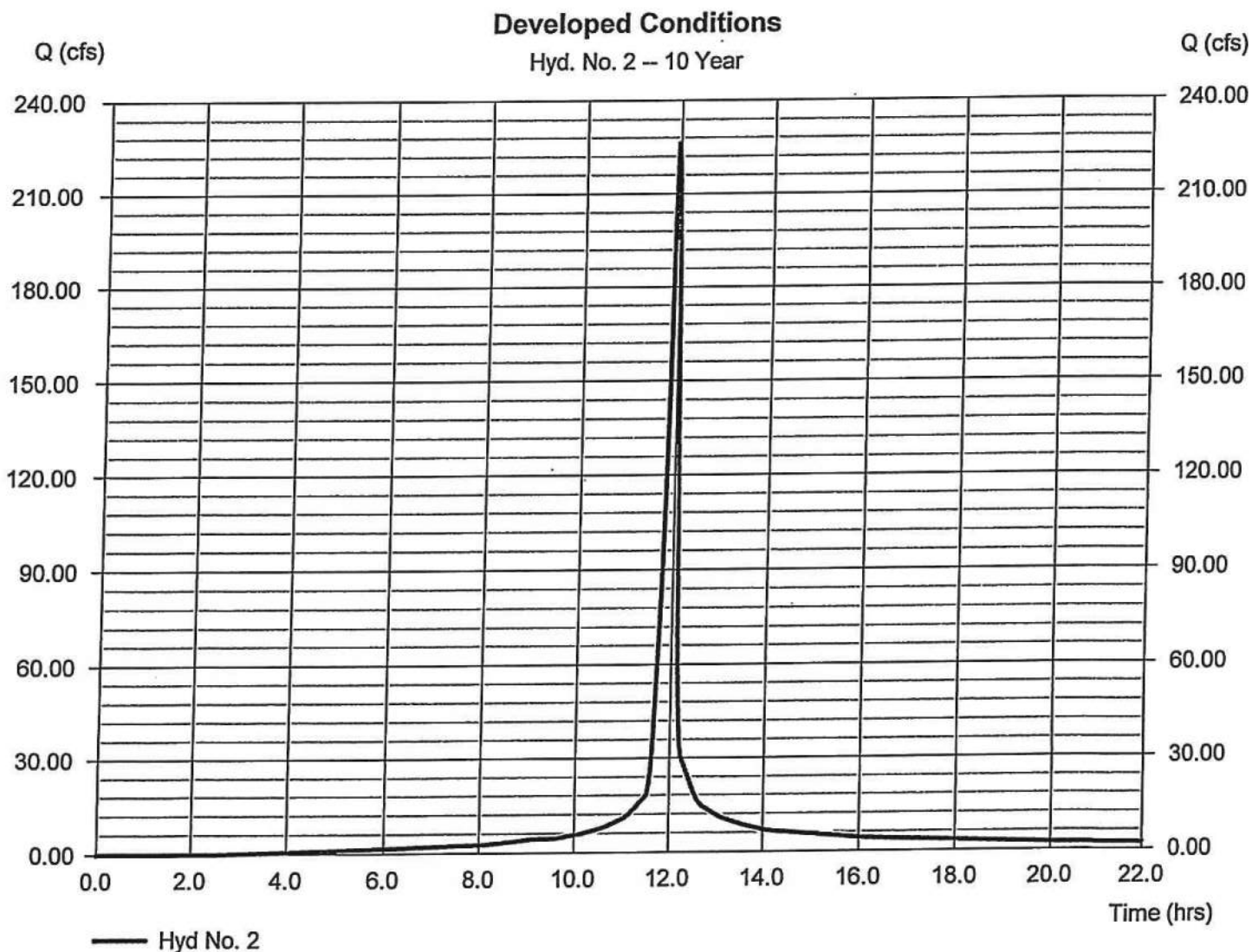
Hydraflow Hydrographs Extension for AutoCAD® Civil 3D® 2015 by Autodesk, Inc. v10.4

Thursday, 03 / 19 / 2015

## Hyd. No. 2

### Developed Conditions

Hydrograph type	= SCS Runoff	Peak discharge	= 226.12 cfs
Storm frequency	= 10 yrs	Time to peak	= 11.97 hrs
Time interval	= 2 min	Hyd. volume	= 564,927 cuft
Drainage area	= 37.410 ac	Curve number	= 94
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= TR55	Time of conc. (Tc)	= 8.80 min
Total precip.	= 4.85 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484



# Hydrograph Report

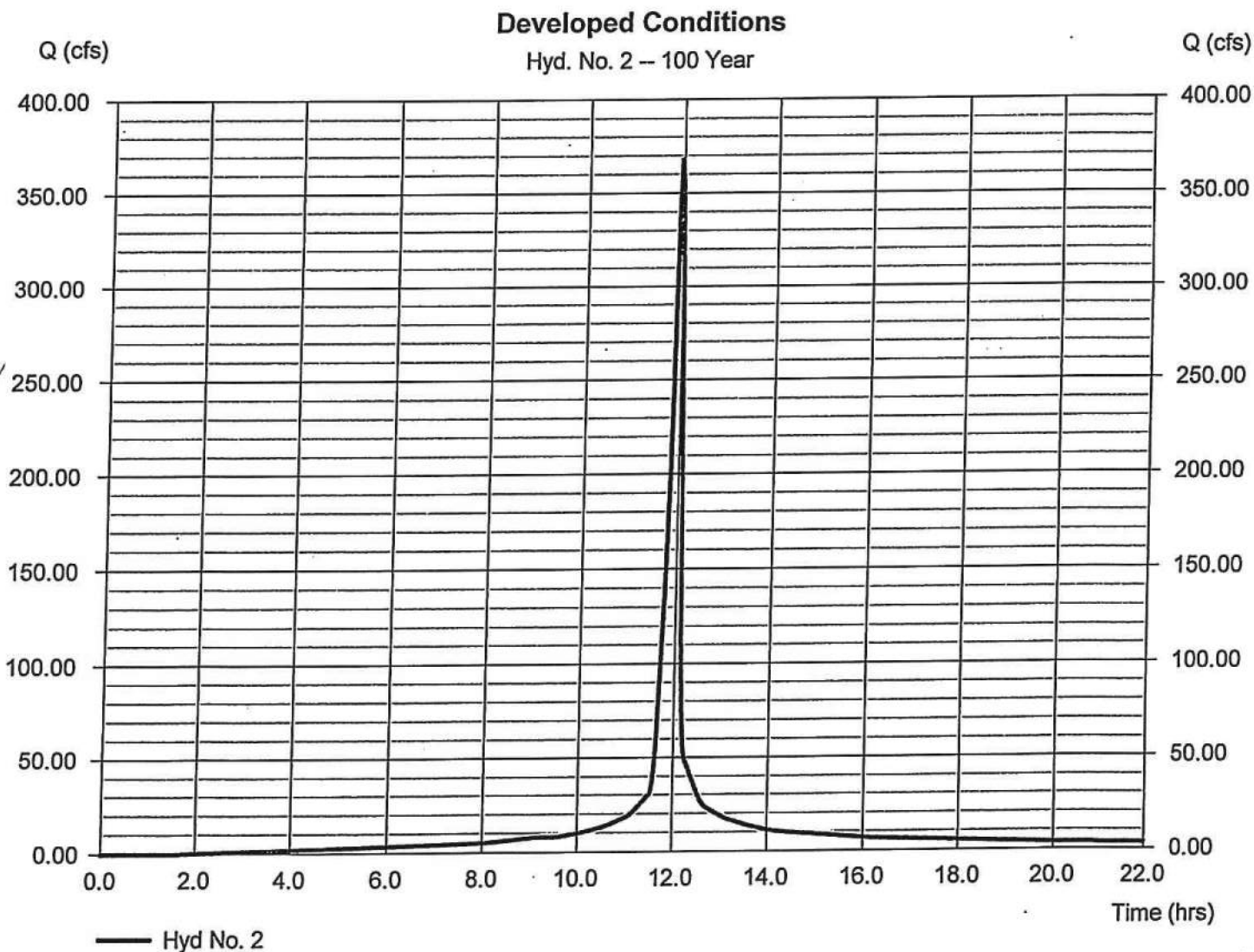
Hydraflow Hydrographs Extension for AutoCAD® Civil 3D® 2015 by Autodesk, Inc. v10.4

Thursday, 03 / 19 / 2015

## Hyd. No. 2

### Developed Conditions

Hydrograph type	= SCS Runoff	Peak discharge	= 367.91 cfs
Storm frequency	= 100 yrs	Time to peak	= 11.97 hrs
Time interval	= 2 min	Hyd. volume	= 947,020 cuft
Drainage area	= 37.410 ac	Curve number	= 94
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= TR55	Time of conc. (Tc)	= 8.80 min
Total precip.	= 7.69 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484





# STORMWATER REPORT

for

**Townsend Capital, LLC**

**Summit Orchard  
Lee's Summit, MO**

April, 2016

I hereby certify this engineering document was prepared by me or under my direct personal supervision and that I am a duly licensed Professional Engineer under the laws of the State of Missouri.

Ryan Fuller, P.E.

License No. PE-2016001250

My renewal date is December 31, 2016

Date: 4/4/2016



*Ryan Fuller*  
4/4/2016

PREPARED BY



**THHinc M<sup>C</sup>CLURE<sup>TM</sup>**  
ENGINEERING CO.

## **Introduction**

This report details the preliminary design of the storm sewer system supporting the Summit Orchard Preliminary Development Plan (PDP), a mixed-use development, at the Summit Technology Campus (STC) located in Lee's Summit, Missouri. See Figure 1 for a site location map

## **Project Description**

The Summit Technology Campus is located southeast of the Interstate-470/State Highway 50 interchange. The entire development covers approximately 367 acres, and is bordered to the south by Chipman Road, to the north by I-470, to the west by Blue Parkway, and to the east by the Union Pacific Railroad. The Summit Technology Campus is split by Ward Road which was opened to traffic in October 2008.

Townsend Capital, LLC proposes improvements to the existing Summit Technology Campus, including the addition of a variety of mixed business commercial and residential uses to the lot northeast of the intersection of Ward Road and Chipman Road. In this report, the site for these improvements is referred to as Lot 7A. The current proposed building and lot layout for Summit Orchard can be found in the PDP.

## **Existing Drainage Overview**

The majority of Lot 7A has been disturbed during borrow activities for the development of the Summit Innovation Center directly North of Lot 7A. A portion of Lot 7A sheet flows stormwater to the storm sewers installed along Ward Rd. This water flows south where it discharges into a ditch along the southern portion of Lot 7A. This water channel flows east to a natural drainage way west of the Union Pacific Railroad. This water flows to the regional detention basin constructed in 2008. Additional information on the regional detention basin can be found in the stormwater master plan prepared for the Summit Technology Campus in 2007.

The remainder of the site sheet flows stormwater east across the site to the natural drainage way west of the Union Pacific Railroad. Stormwater is then routed North to the regional detention basin.

A Stormwater Master Plan and model was prepared for the entire Summit Technology Campus development in 2007 and approved by the City. The Master Plan established a regional detention facility on Tract C at the northeast corner of the development. The improvements were constructed in 2008 and the facility has been in operation since that time.

## **Proposed Improvements**

This project develops Lot 7A from an existing pasture to a mixed use commercial and residential development called Summit Orchard. The 2007 study assumed



this portion of the site would be developed with up to 71% impervious area. The proposed development limits the impervious area to 63%. Therefore, the proposed development is within the parameters of the original study and we do not propose a revision to the hydraulic study for the regional detention basin.

While onsite detention is not necessary based on the 2007 study, we are proposing a detention basin along the Eastern property line west of the Union Pacific Railroad. This will be a shallow basin with a large footprint to minimize the ponding depth. Multiple outlets and overflows will be provided to reduce runoff rates from Summit Orchards.

Within the site we will install storm sewers to convey stormwater west towards Ward Rd and East toward the existing drainage way west of the Union Pacific Railroad. The layout and drainage areas are depicted on the stormwater masterplan drawing. The peak flows generated by this site are:

Storm Return Period	Pre-Development Q (cfs)	Post Development Q (cfs) West to Ward Rd	Post Development Q (cfs) East to Drainage way along Railroad
1 Year	40.5	13.1	92.6
10 Year	115.1	27.7	197.7
100 Year	198.2	42.5	305.5

Hydrographs for the storms listed above were generated using Hydraflow Hydrograph Extension to AutoCAD Civil 3D 2015 and are included in the appendix at the end of this report.

### **Results of Analysis**

The preliminary layout of the system and system sizing is depicted on the Stormwater masterplan drawing included in the PDP.



## **Appendix**

Hydraflow Hydrographs Extension for AutoCAD Civil 3D 2015 Report

**1 - Year**

<b>Hydrograph Reports.....</b>	<b>1</b>
Hydrograph No. 1, SCS Runoff, Pre-Developed Conditions.....	1
Hydrograph No. 2, SCS Runoff, Post Development East to RR.....	2
Hydrograph No. 3, SCS Runoff, Post Development West to Ward.....	3

**10 - Year**

<b>Hydrograph Reports.....</b>	<b>4</b>
Hydrograph No. 1, SCS Runoff, Pre-Developed Conditions.....	4
Hydrograph No. 2, SCS Runoff, Post Development East to RR.....	5
Hydrograph No. 3, SCS Runoff, Post Development West to Ward.....	6

**100 - Year**

<b>Hydrograph Reports.....</b>	<b>7</b>
Hydrograph No. 1, SCS Runoff, Pre-Developed Conditions.....	7
Hydrograph No. 2, SCS Runoff, Post Development East to RR.....	8
Hydrograph No. 3, SCS Runoff, Post Development West to Ward.....	9

# Hydrograph Report

Hydraflow Hydrographs Extension for AutoCAD® Civil 3D® 2015 by Autodesk, Inc. v10.4

Monday, 03 / 14 / 2016

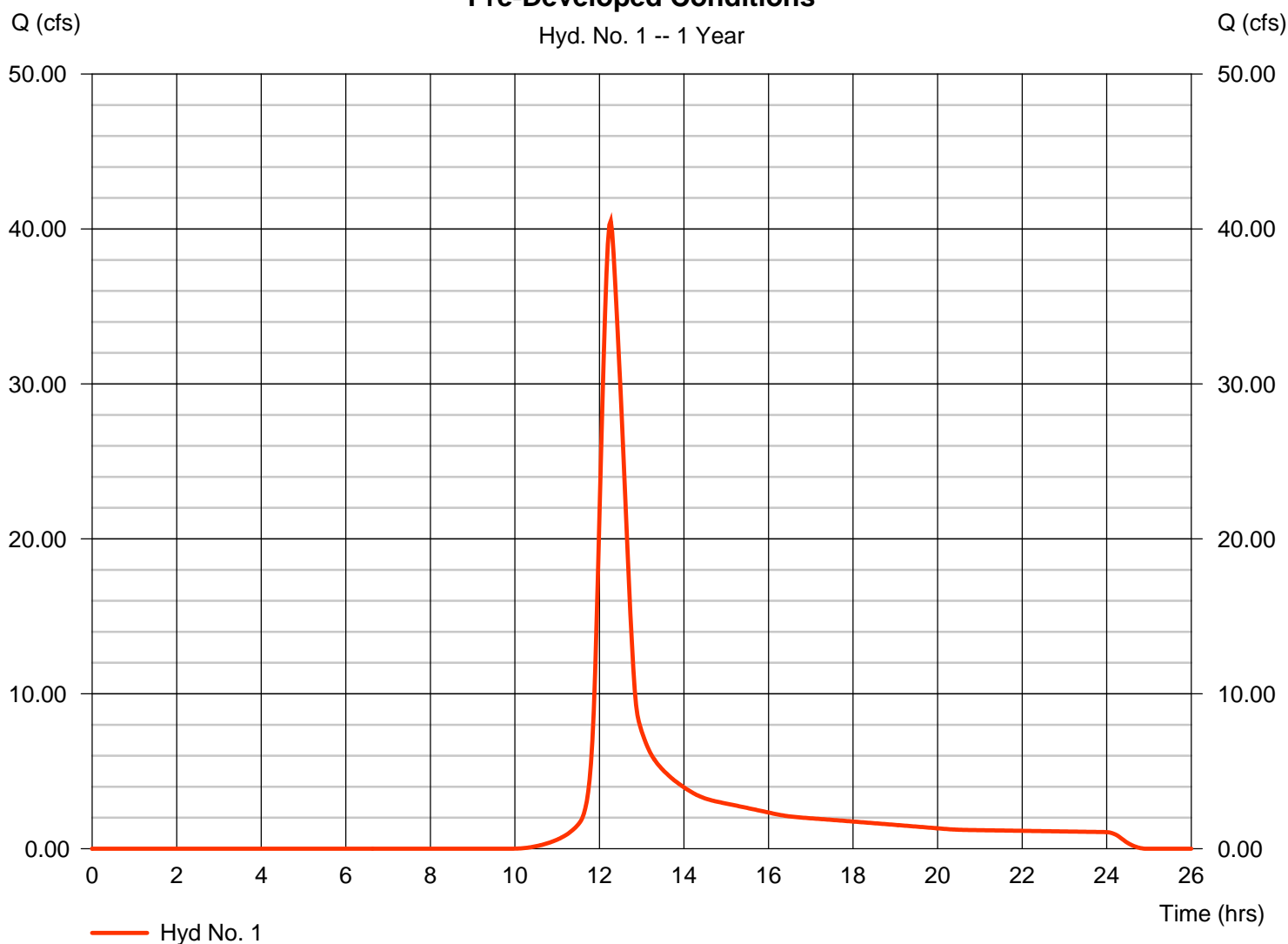
## Hyd. No. 1

### Pre-Developed Conditions

Hydrograph type	= SCS Runoff	Peak discharge	= 40.51 cfs
Storm frequency	= 1 yrs	Time to peak	= 12.27 hrs
Time interval	= 2 min	Hyd. volume	= 188,909 cuft
Drainage area	= 44.780 ac	Curve number	= 80
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= TR55	Time of conc. (Tc)	= 34.10 min
Total precip.	= 2.90 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484

### Pre-Developed Conditions

Hyd. No. 1 -- 1 Year



# Hydrograph Report

Hydraflow Hydrographs Extension for AutoCAD® Civil 3D® 2015 by Autodesk, Inc. v10.4

Monday, 03 / 14 / 2016

## Hyd. No. 2

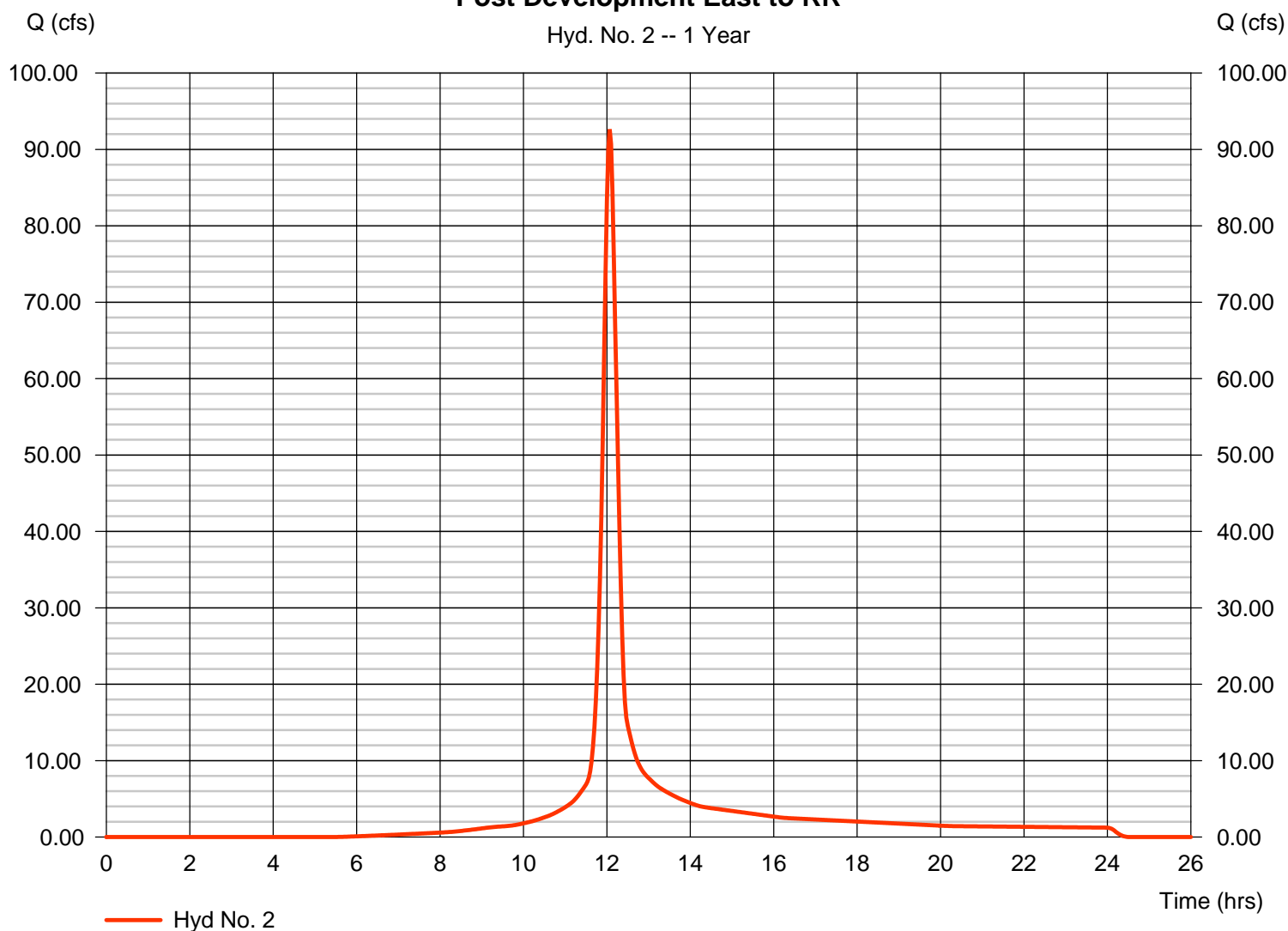
Post Development East to RR

Hydrograph type	= SCS Runoff	Peak discharge	= 92.62 cfs
Storm frequency	= 1 yrs	Time to peak	= 12.07 hrs
Time interval	= 2 min	Hyd. volume	= 292,474 cuft
Drainage area	= 40.730 ac	Curve number	= 91*
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= TR55	Time of conc. (Tc)	= 19.60 min
Total precip.	= 2.90 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484

\* Composite (Area/CN) =  $[(25.660 \times 98) + (15.070 \times 80)] / 40.730$

### Post Development East to RR

Hyd. No. 2 -- 1 Year



# Hydrograph Report

Hydraflow Hydrographs Extension for AutoCAD® Civil 3D® 2015 by Autodesk, Inc. v10.4

Monday, 03 / 14 / 2016

## Hyd. No. 3

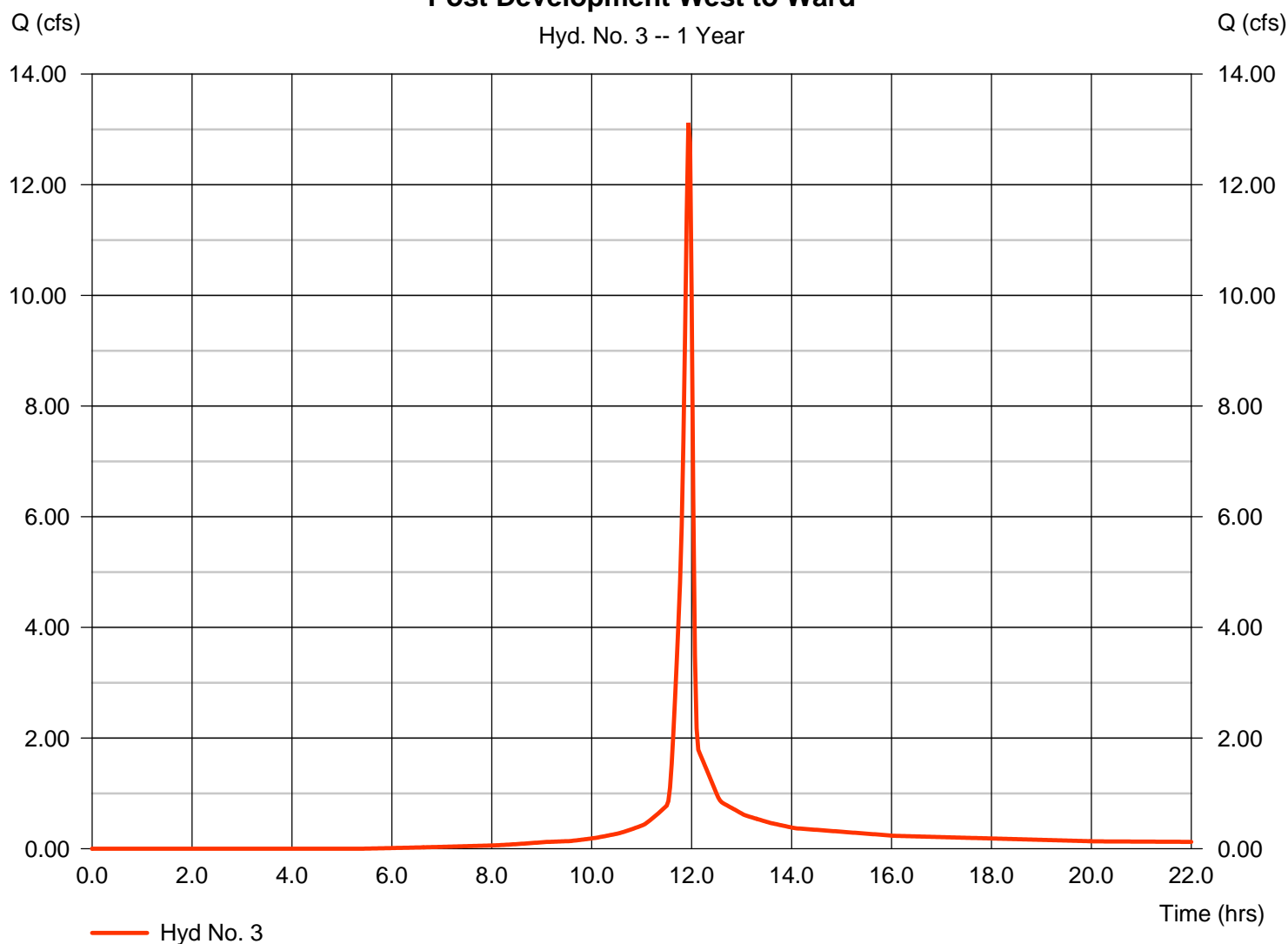
Post Development West to Ward

Hydrograph type	= SCS Runoff	Peak discharge	= 13.12 cfs
Storm frequency	= 1 yrs	Time to peak	= 11.93 hrs
Time interval	= 2 min	Hyd. volume	= 27,265 cuft
Drainage area	= 4.050 ac	Curve number	= 91*
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= User	Time of conc. (Tc)	= 5.00 min
Total precip.	= 2.90 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484

\* Composite (Area/CN) =  $[(2.550 \times 98) + (1.500 \times 80)] / 4.050$ 

### Post Development West to Ward

Hyd. No. 3 -- 1 Year



# Hydrograph Report

Hydraflow Hydrographs Extension for AutoCAD® Civil 3D® 2015 by Autodesk, Inc. v10.4

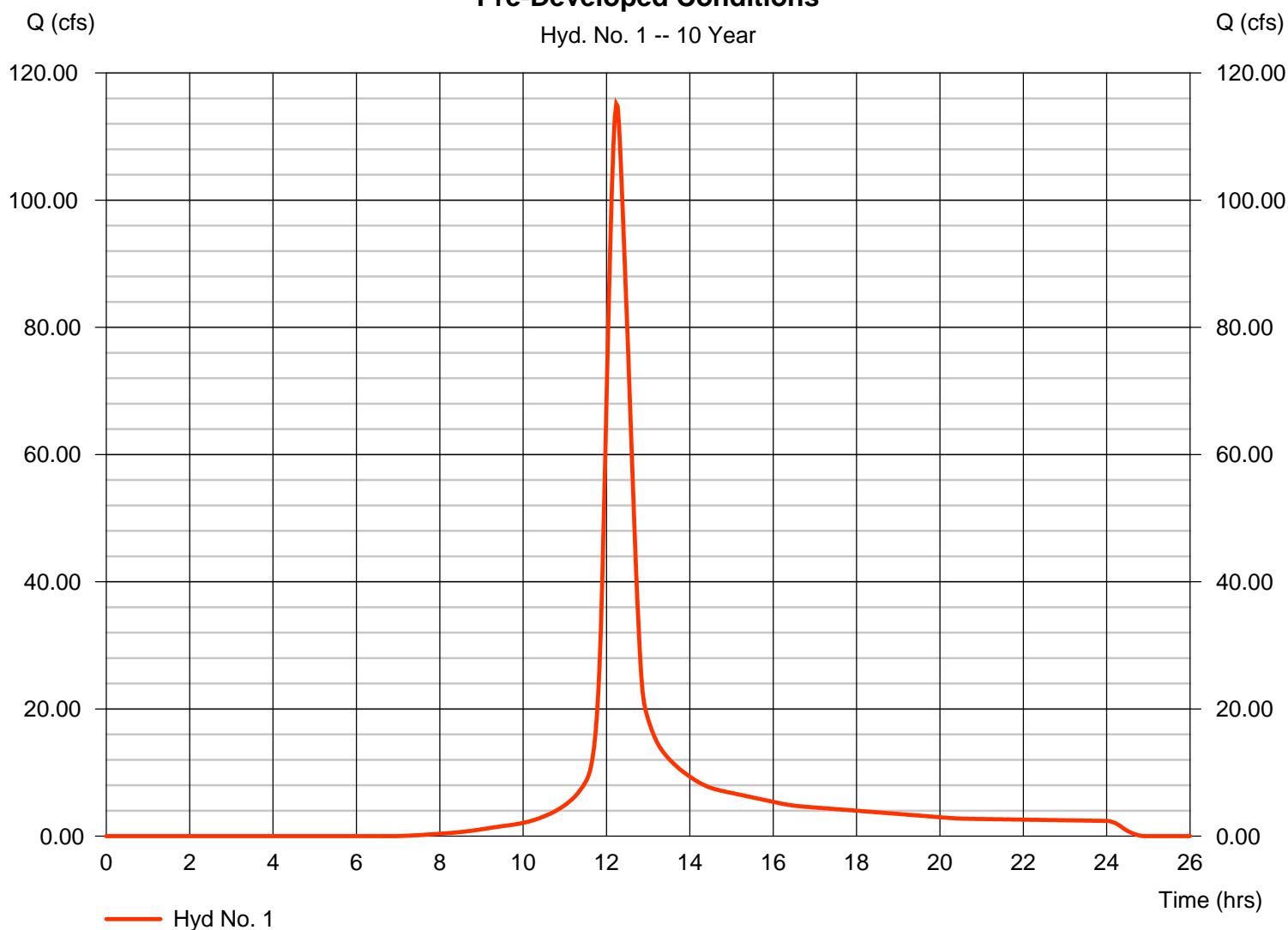
Monday, 03 / 14 / 2016

## Hyd. No. 1

### Pre-Developed Conditions

Hydrograph type	=	SCS Runoff	Peak discharge	=	115.13 cfs
Storm frequency	=	10 yrs	Time to peak	=	12.23 hrs
Time interval	=	2 min	Hyd. volume	=	521,420 cuft
Drainage area	=	44.780 ac	Curve number	=	80
Basin Slope	=	0.0 %	Hydraulic length	=	0 ft
Tc method	=	TR55	Time of conc. (Tc)	=	34.10 min
Total precip.	=	5.40 in	Distribution	=	Type II
Storm duration	=	24 hrs	Shape factor	=	484

### Pre-Developed Conditions



# Hydrograph Report

Hydraflow Hydrographs Extension for AutoCAD® Civil 3D® 2015 by Autodesk, Inc. v10.4

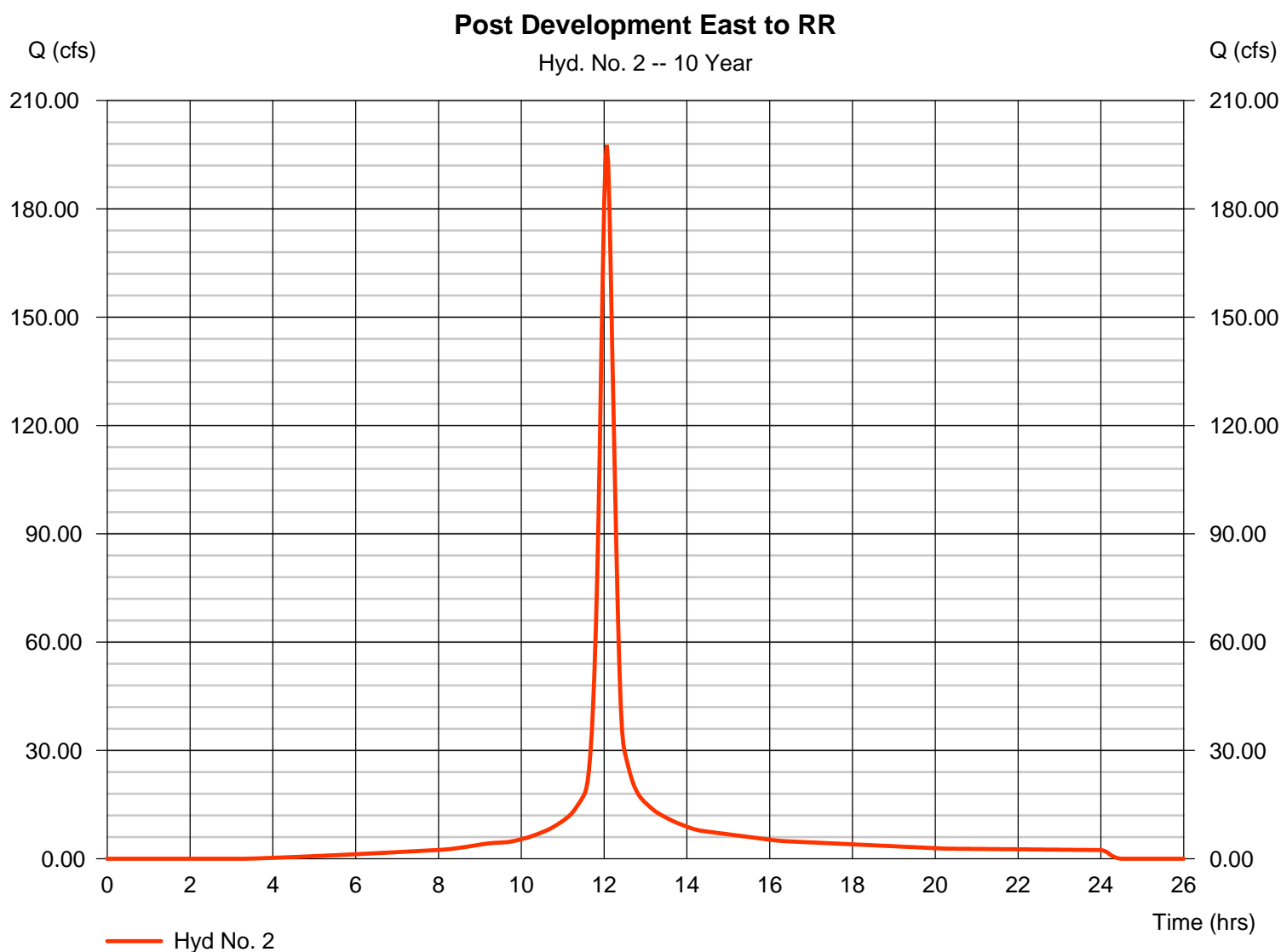
Monday, 03 / 14 / 2016

## Hyd. No. 2

Post Development East to RR

Hydrograph type	= SCS Runoff	Peak discharge	= 197.74 cfs
Storm frequency	= 10 yrs	Time to peak	= 12.07 hrs
Time interval	= 2 min	Hyd. volume	= 646,278 cuft
Drainage area	= 40.730 ac	Curve number	= 91*
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= TR55	Time of conc. (Tc)	= 19.60 min
Total precip.	= 5.40 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484

\* Composite (Area/CN) =  $[(25.660 \times 98) + (15.070 \times 80)] / 40.730$



# Hydrograph Report

Hydraflow Hydrographs Extension for AutoCAD® Civil 3D® 2015 by Autodesk, Inc. v10.4

Monday, 03 / 14 / 2016

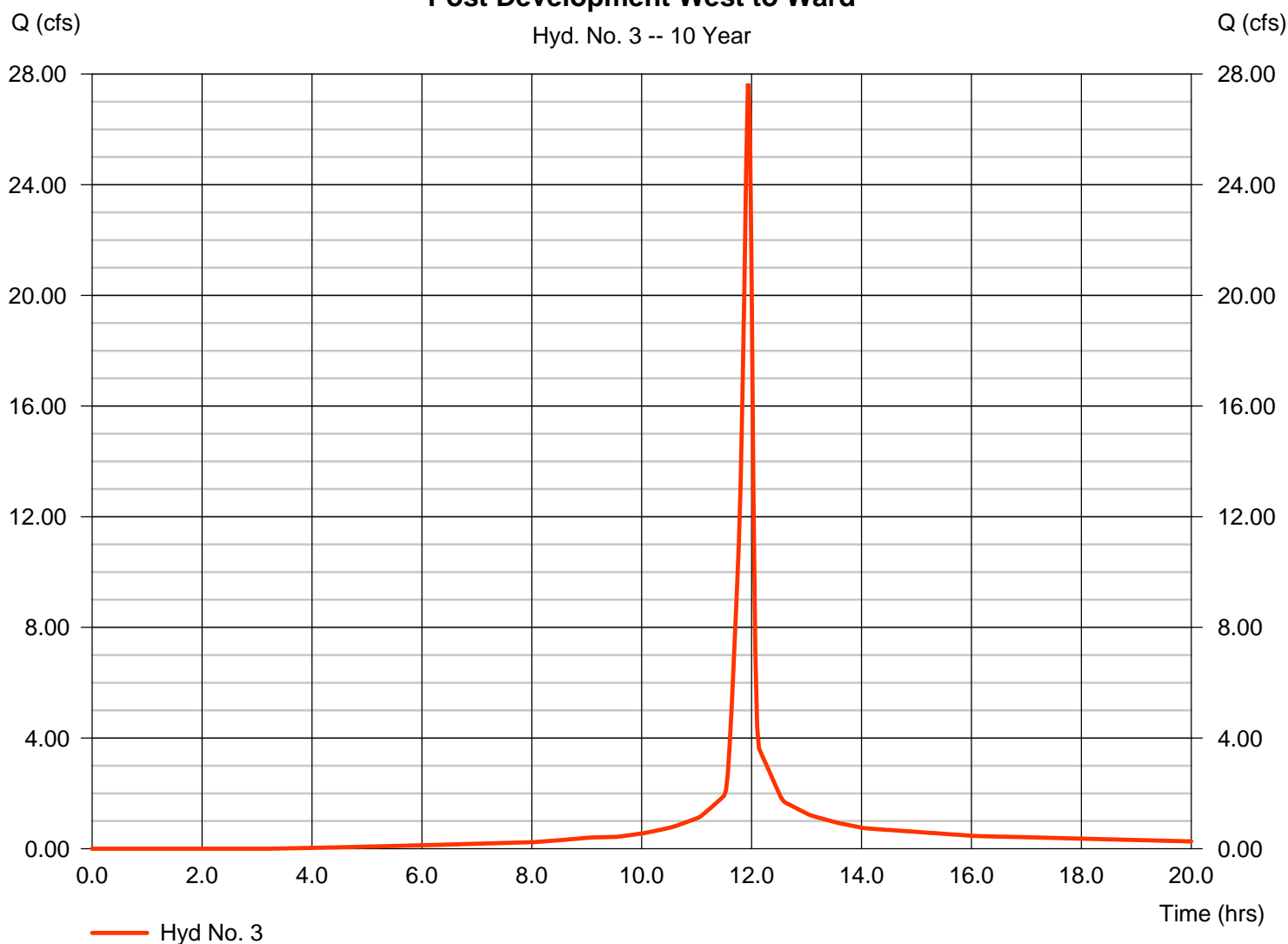
## Hyd. No. 3

Post Development West to Ward

Hydrograph type	= SCS Runoff	Peak discharge	= 27.66 cfs
Storm frequency	= 10 yrs	Time to peak	= 11.93 hrs
Time interval	= 2 min	Hyd. volume	= 60,246 cuft
Drainage area	= 4.050 ac	Curve number	= 91*
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= User	Time of conc. (Tc)	= 5.00 min
Total precip.	= 5.40 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484

\* Composite (Area/CN) = [(2.550 x 98) + (1.500 x 80)] / 4.050

### Post Development West to Ward





# Hydrograph Report

Hydraflow Hydrographs Extension for AutoCAD® Civil 3D® 2015 by Autodesk, Inc. v10.4

Monday, 03 / 14 / 2016

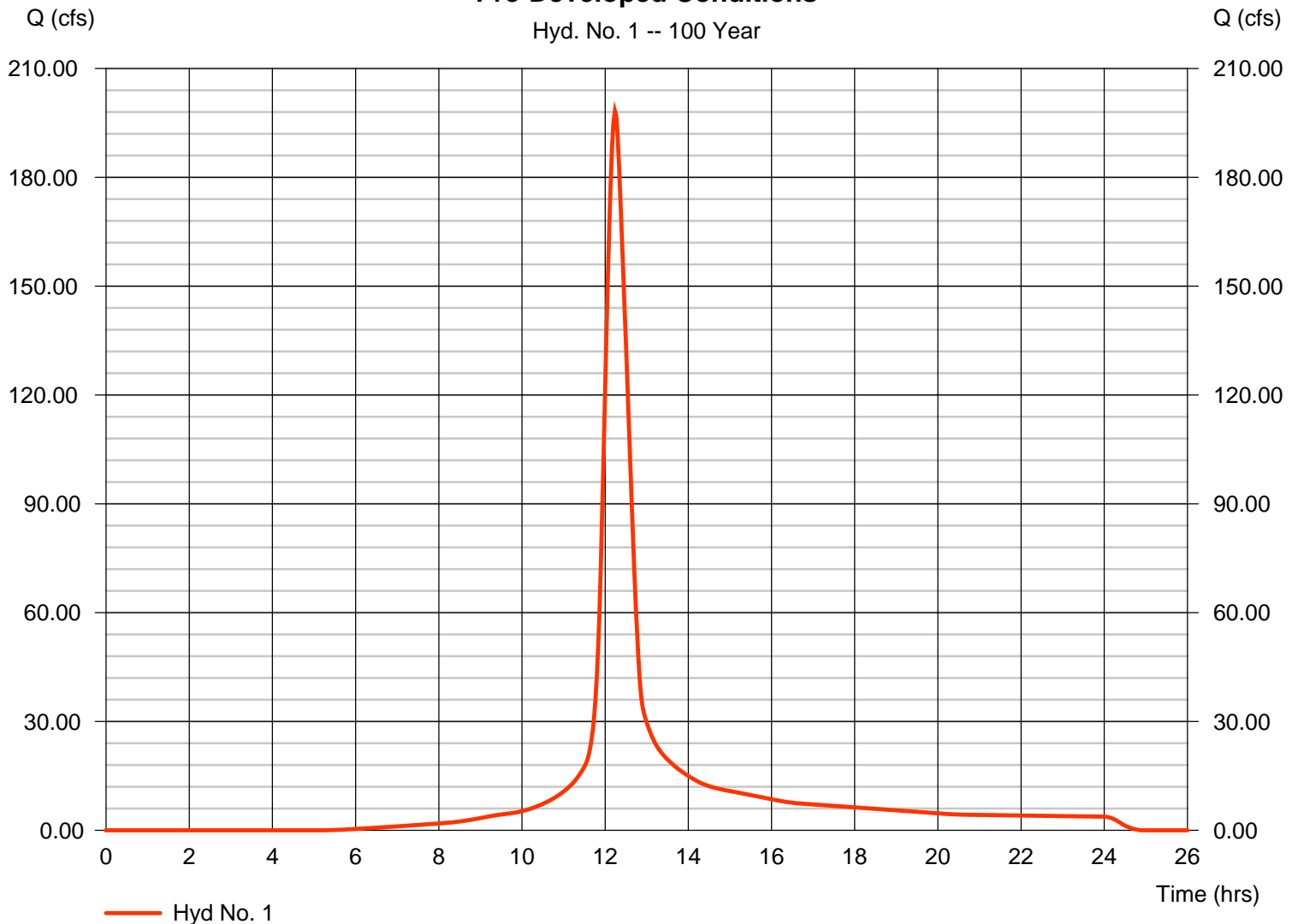
## Hyd. No. 1

### Pre-Developed Conditions

Hydrograph type = SCS Runoff  
 Storm frequency = 100 yrs  
 Time interval = 2 min  
 Drainage area = 44.780 ac  
 Basin Slope = 0.0 %  
 Tc method = TR55  
 Total precip. = 8.00 in  
 Storm duration = 24 hrs

Peak discharge = 198.22 cfs  
 Time to peak = 12.23 hrs  
 Hyd. volume = 903,962 cuft  
 Curve number = 80  
 Hydraulic length = 0 ft  
 Time of conc. (Tc) = 34.10 min  
 Distribution = Type II  
 Shape factor = 484

### Pre-Developed Conditions



# Hydrograph Report

Hydraflow Hydrographs Extension for AutoCAD® Civil 3D® 2015 by Autodesk, Inc. v10.4

Monday, 03 / 14 / 2016

## Hyd. No. 2

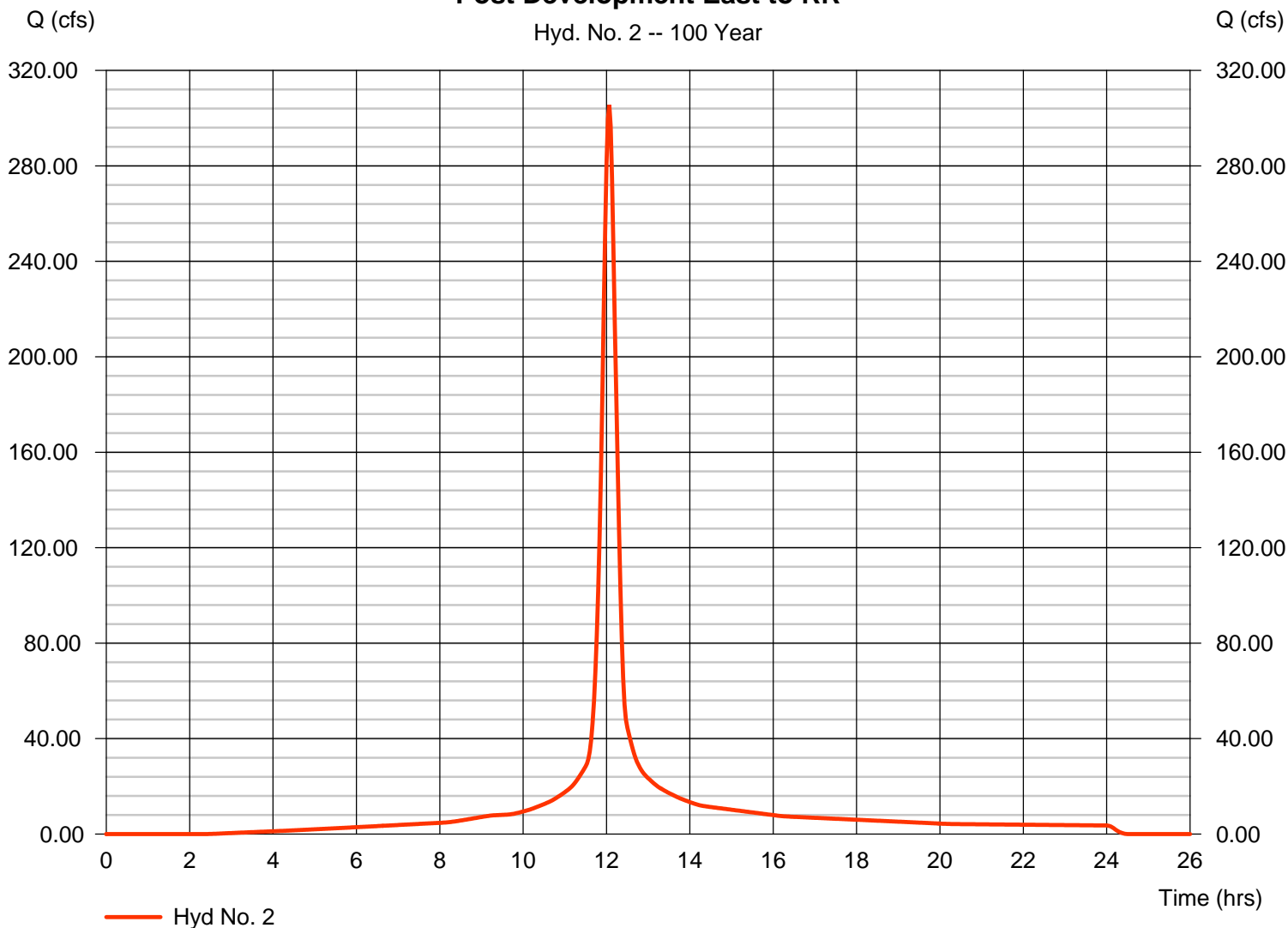
Post Development East to RR

Hydrograph type	= SCS Runoff	Peak discharge	= 305.49 cfs
Storm frequency	= 100 yrs	Time to peak	= 12.07 hrs
Time interval	= 2 min	Hyd. volume	= 1,023,779 cuft
Drainage area	= 40.730 ac	Curve number	= 91*
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= TR55	Time of conc. (Tc)	= 19.60 min
Total precip.	= 8.00 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484

\* Composite (Area/CN) =  $[(25.660 \times 98) + (15.070 \times 80)] / 40.730$

### Post Development East to RR

Hyd. No. 2 -- 100 Year



# Hydrograph Report

Hydraflow Hydrographs Extension for AutoCAD® Civil 3D® 2015 by Autodesk, Inc. v10.4

Monday, 03 / 14 / 2016

## Hyd. No. 3

Post Development West to Ward

Hydrograph type	= SCS Runoff	Peak discharge	= 42.53 cfs
Storm frequency	= 100 yrs	Time to peak	= 11.93 hrs
Time interval	= 2 min	Hyd. volume	= 95,437 cuft
Drainage area	= 4.050 ac	Curve number	= 91*
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= User	Time of conc. (Tc)	= 5.00 min
Total precip.	= 8.00 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484

\* Composite (Area/CN) = [(2.550 x 98) + (1.500 x 80)] / 4.050

