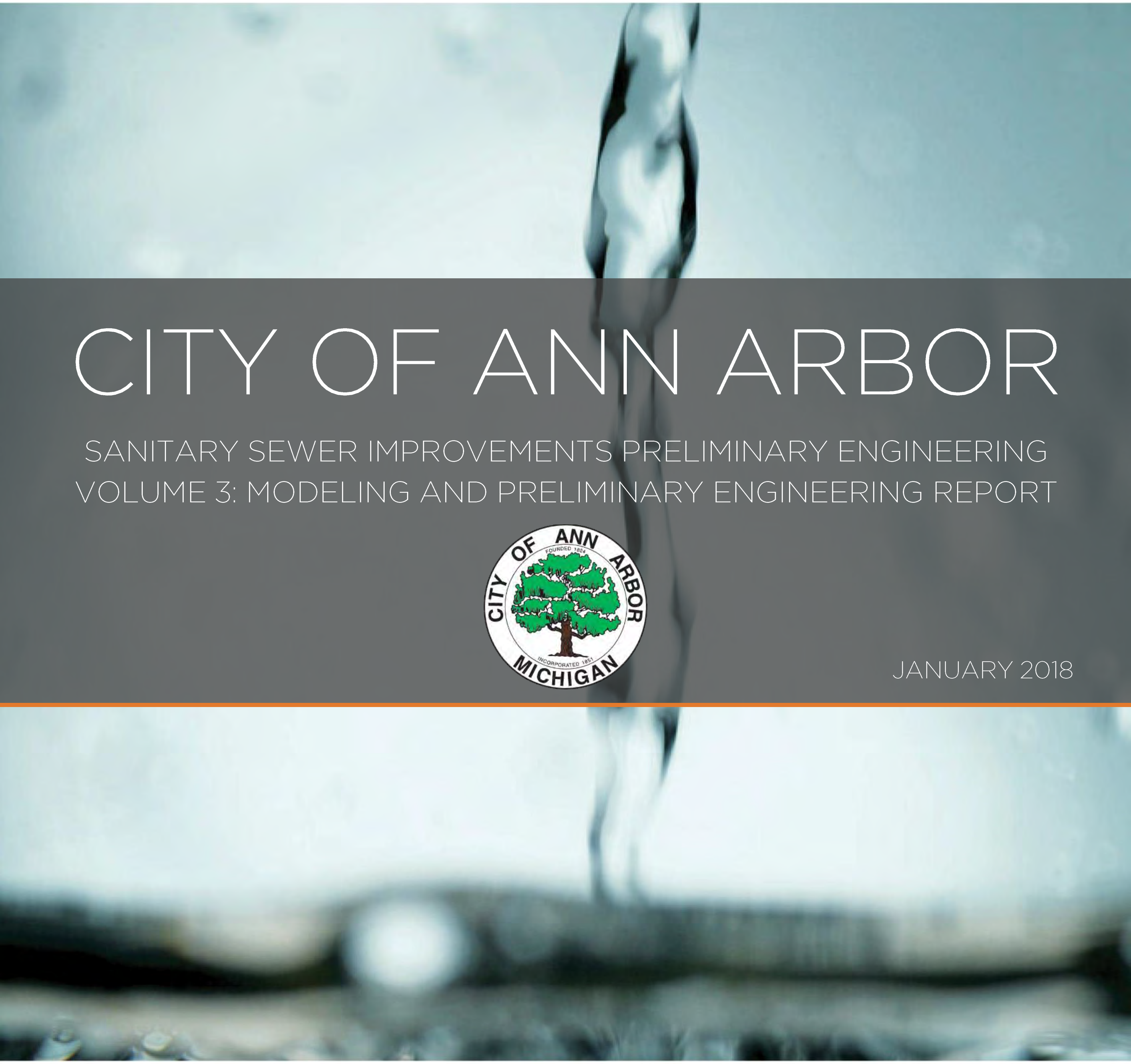


CITY OF ANN ARBOR

SANITARY SEWER IMPROVEMENTS PRELIMINARY ENGINEERING
VOLUME 3: MODELING AND PRELIMINARY ENGINEERING REPORT

JANUARY 2018

OHM
Advancing Communities®

Introduction

In 2013 and 2014, the City of Ann Arbor conducted a Sanitary Sewer Wet Weather Evaluation (SSWWE) to evaluate the effectiveness of the City's footing drain disconnection program. The SSWWE included evaluation of the entire City and found five areas with potential capacity issues during wet weather events. These areas were evaluated as part of the 2016-2017 Sanitary Sewer Improvements and Preliminary Engineering (SSIPE) project. An additional area, Area F, was added to this project as an operation and maintenance evaluation by the City.

The scope and details of the SSIPE project are described in Volumes 1 and 2 of the project report. The following report discusses the hydrologic and hydraulic analyses completed as part of the SSIPE project. The following recommendations include a preliminary engineering analysis where applicable. This following background information is based on the five original project sheets, which are located in Appendix A of the SSES Report.

Area A Objective

As part of the 2013 Sanitary Sewer Wet Weather Evaluation Project (SSWWEP), which evaluated the effectiveness of the Footing Drain Disconnect (FDD) Program, Project Area A, Huron/West Park was identified as an over loaded area with the 2013 hydraulic model. The model indicated that the sanitary pipe was over loaded in this region. The 2013 sanitary sewer model was calibrated to a downstream sanitary meter. The flow distribution upstream of this meter was estimated in the 2013 study. The model resulted in excessive surcharging in this area. The City had previously recognized this as a problem area and constructed a relief sewer downstream of the original metered location. There is no history of reported sewer backups in this area. The modeling team did not have high confidence in the surcharging identified in the hydraulic model based on the lack of citizen complaints.

For the current Sanitary Sewer Improvements and Preliminary Engineering (SSIPE) Project, Area A was subdivided with new meter locations upstream, and the flow distribution was updated in the hydraulic model based on the meter data. The Volume 1: Flow Monitoring Report discusses the details of the flow monitoring for Area A and the other identified Project Areas.

Area A Modeling Results

Existing Conditions

As discussed above, Area A was metered further for the current SSIPE study. The results of the metering were used to adjust the flow distribution in the upstream portion of Area A in the hydraulic model. The hydraulic model was run under Scenario B, which is the selected design. This event consists of a 25-year frequency event plus additional flow to account for growth planned by the City and growth expected in the Township. Scenario B also includes a 10% increase in peak flows within the City to account for climate change, an increase in the level of service from a 25- to a 50-year design event, or additional growth beyond that contained in the City's planned development list.

The existing conditions (2013 modeled physical pipe characteristics) were evaluated for modeling the Area A system. Similar to the results of the 2013 study, many pipes in Area A were overloaded during the design event model analysis. A profile of the overloaded pipes is shown in Figure 1.

For the section upstream of the ravine, it was determined through discussion with the City that an improvement was not necessary. Though the pipes surcharge, the HGL does not reach the measured basement elevations, as shown in Figures 1 and 2.

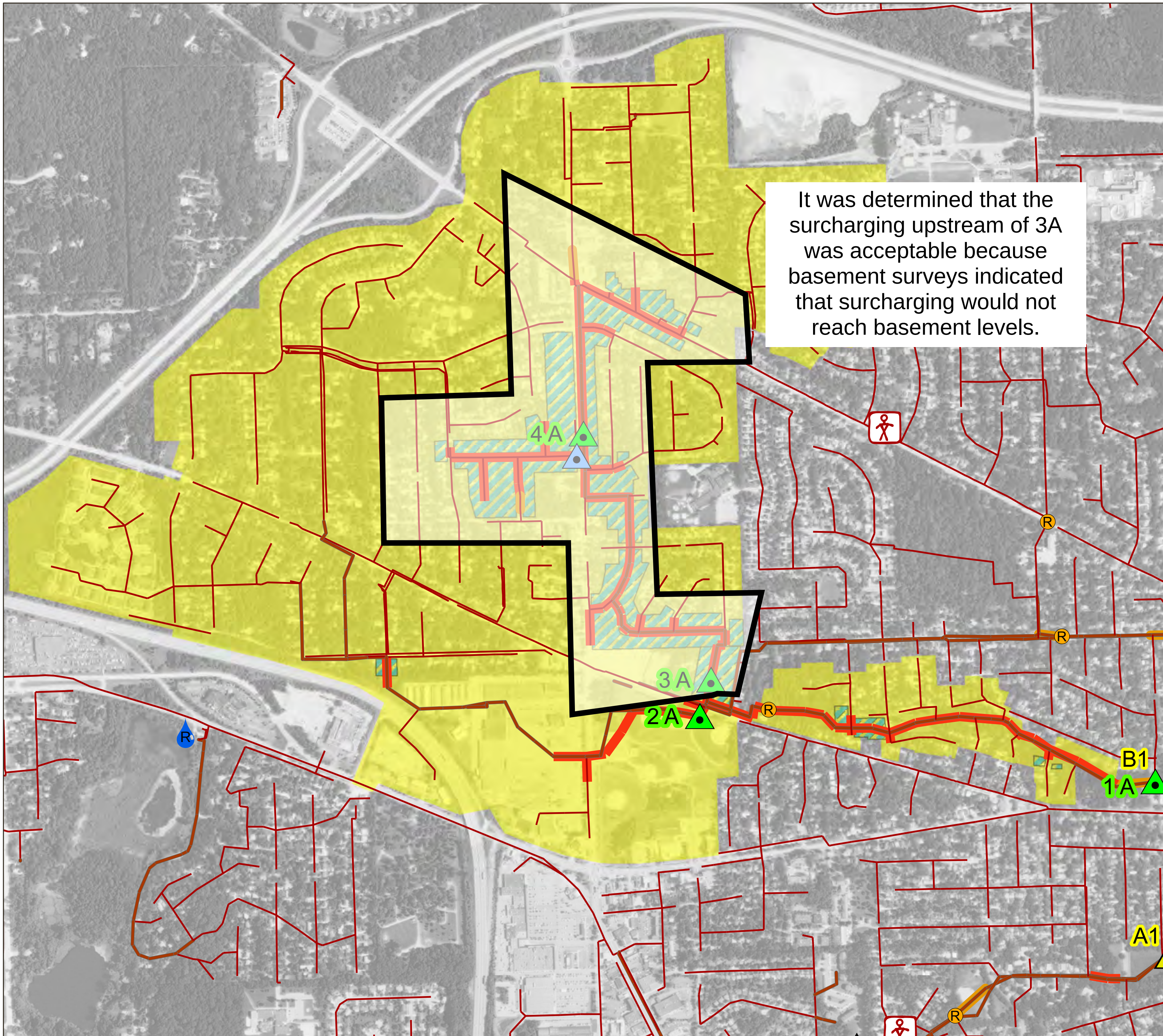
Alternative Solutions

The model was used to size and identify the extent of improvements needed. In an attempt to relieve the surcharging, several alternatives were explored, and two were chosen as viable options.

Alternative One – Doty to Arbana
Alternative Two – Dexter Ave to Arbana

Alternatives One and Two both resolve the issue of surcharging in Area A. Details of these alternatives are covered in the following preliminary engineering discussion. Figures 3-5 show the profile of the sewer through the ravine and further downstream in Area A for existing and proposed conditions.

In addition to Alternatives One and Two, another alternative was considered. Preliminary engineering analysis concluded that the third was not feasible. Details of these options are discussed in the following section.



Ann Arbor Sanitary Sewer Improvements

Project Area A Huron/West Park Trunkline

Figure 1

Legend

- Project Area
- Basement Survey Areas
- Proposed Meters
- Optional Meters
- 2013 Meter
- City Raingage
- 2013 PSR
- CAC Member

0 500 1,000 Feet

N W E S

Source: Data provided by the City of Ann Arbor. OHM Advisors does not warrant the accuracy of the data and/or the map. This document is intended to depict the approximate spatial location of the mapped features within the Community and all use is strictly at the user's own risk.

Coordinate System: NAD 1983 StatePlane Michigan South FIPS 2113 IntlFeet

Map Published: January 5, 2017

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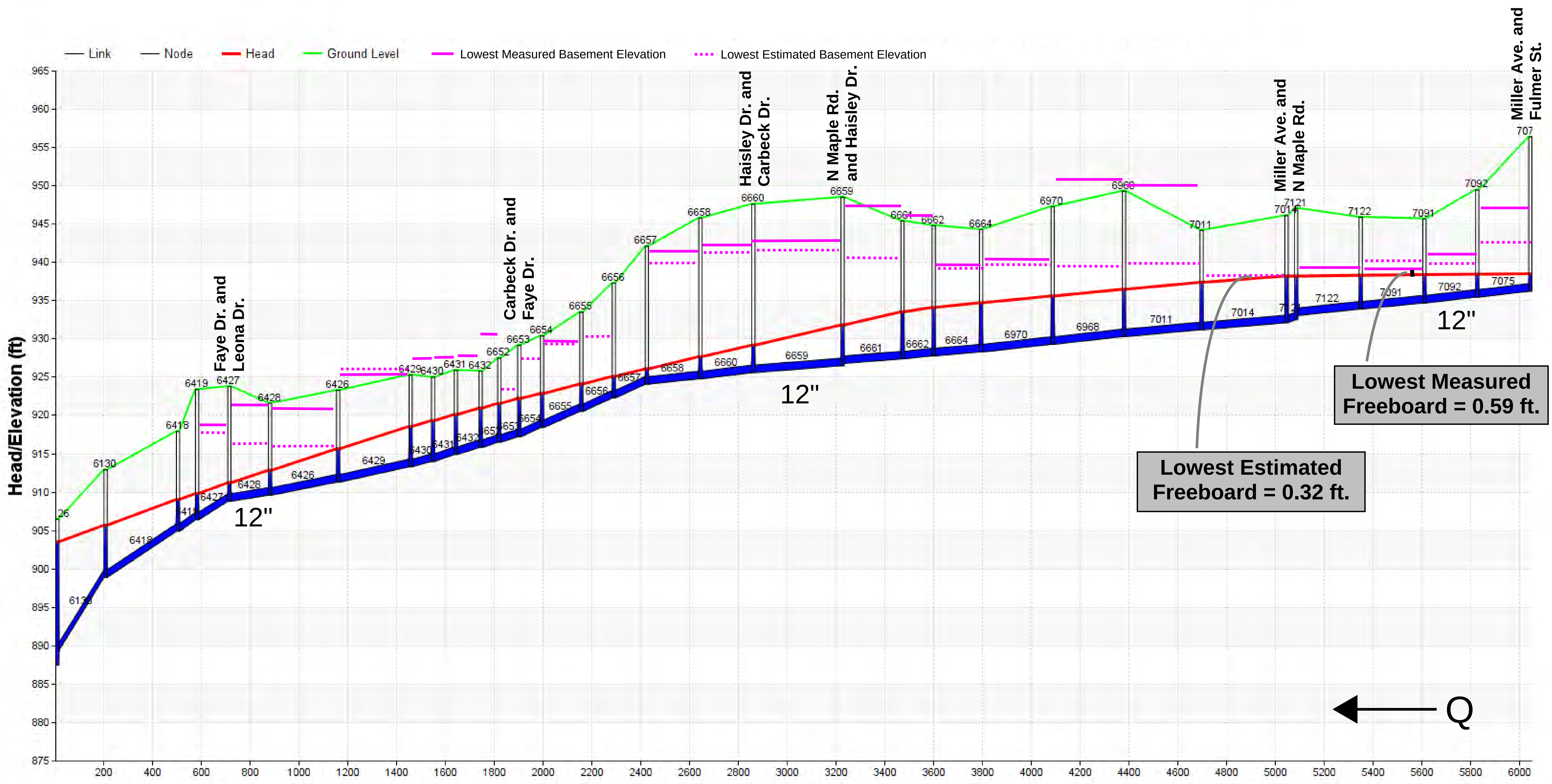
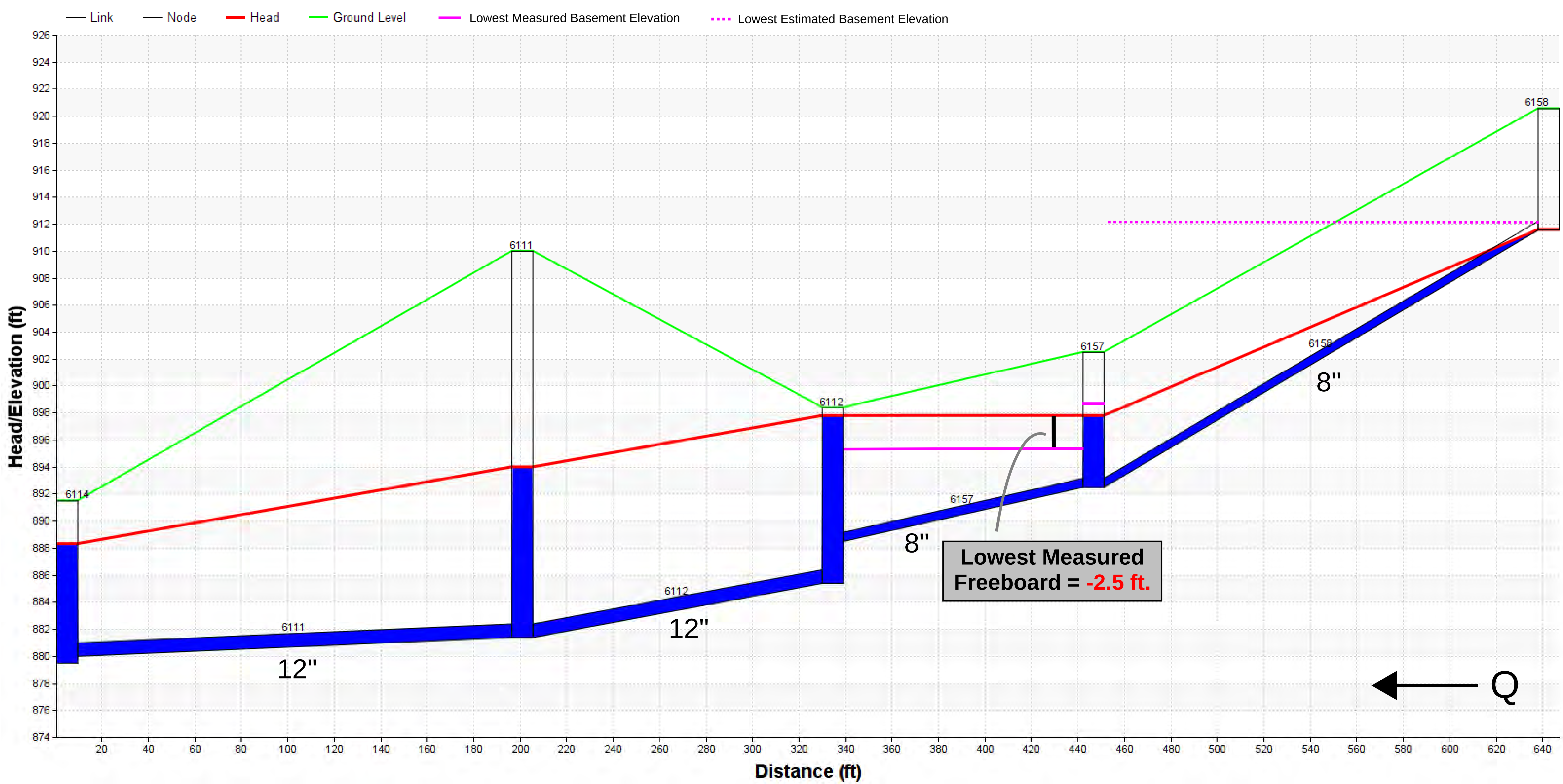
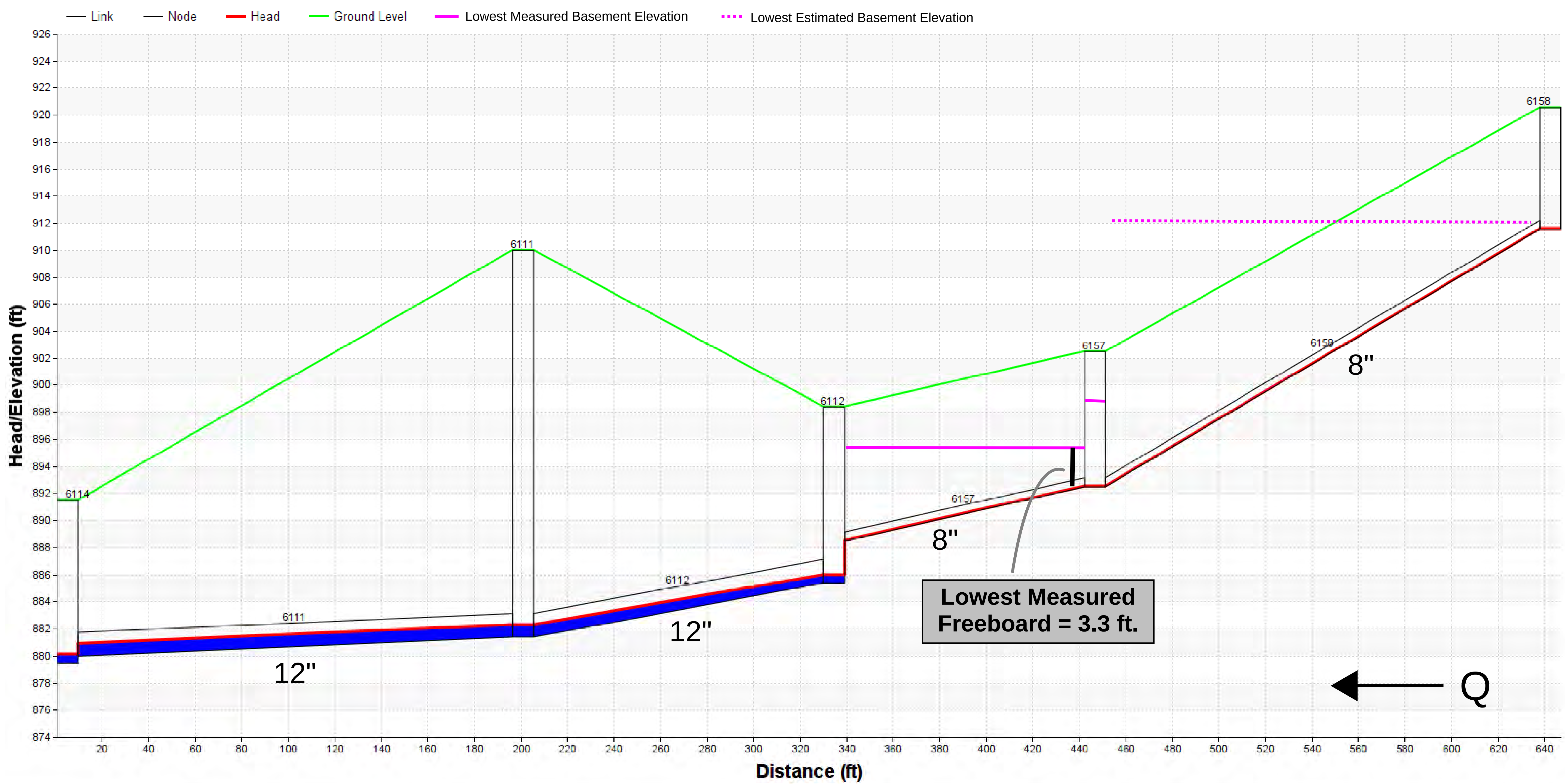


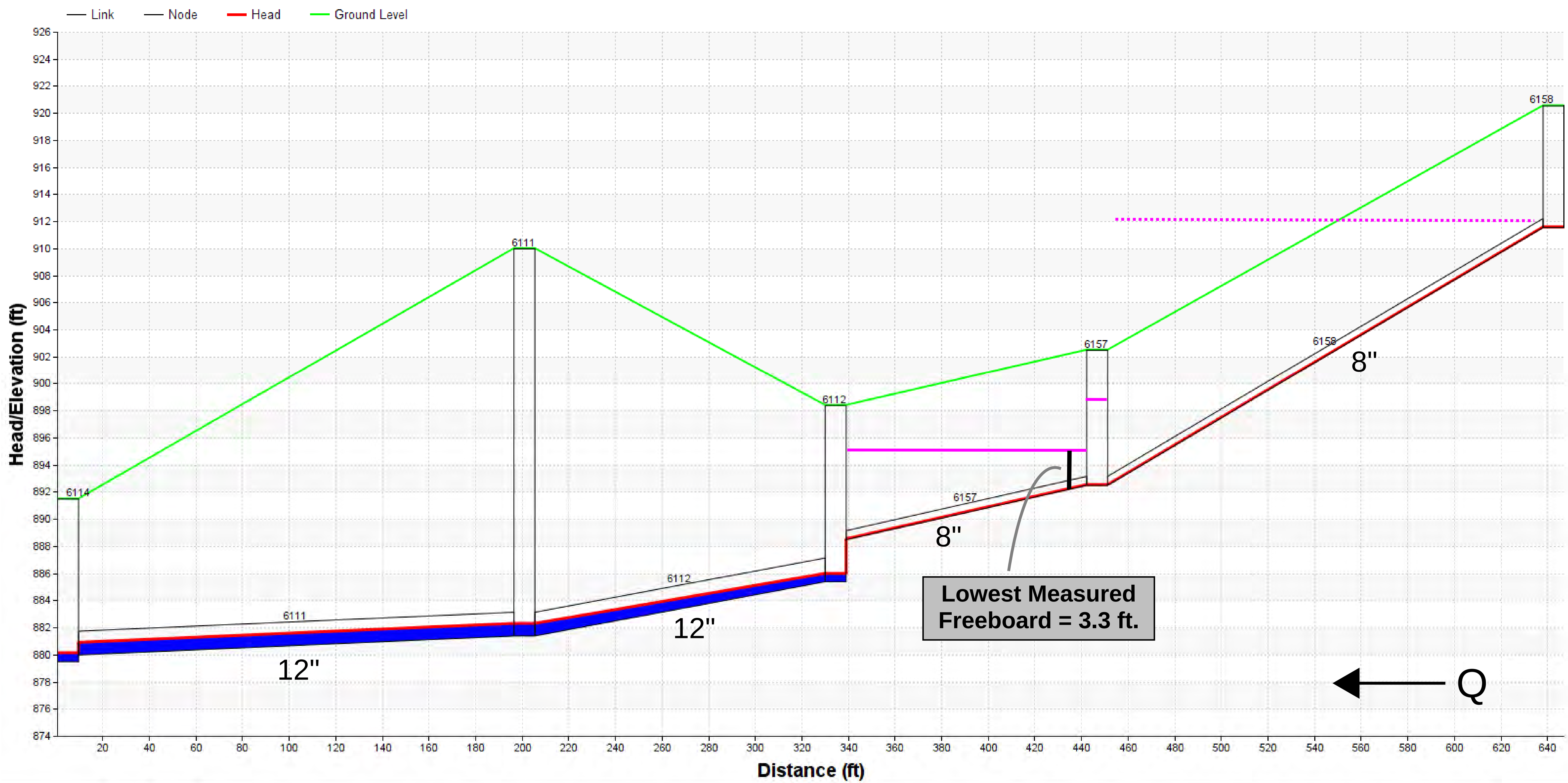
Area A - Upstream of Ravine - Existing Conditions



Area A - Doty Ave. - Existing Conditions



Area A - Doty Ave. - Entire Ravine Line Increased to 21"



Area A - Doty Ave. - Ravine Line Increased to 21" up to Doty

Preliminary Engineering

Sanitary sewers in the vicinity of Project Area A drain to the existing 12" and 18" diameter sewers in the ravine that runs between Linwood and Dexter Avenues. Existing sewage flows easterly in a 12" collector sewer from the vicinity of the Mapleridge apartments, through the ravine to Arbana Drive. This route is roughly parallel to Dexter Avenue. At Arbana Drive the flow continues into an existing 21" sewer just north of W. Huron St.

The objective of the project is to increase the size of the existing sewers to 21" in diameter to increase the sewer flow capacity for the project area. Another goal is to create a permanent path along the sewer that is navigable by sewer maintenance vehicles. Currently the existing sewer is not readily accessible. Photos of the areas are shown in Appendix A.

Alternative One – Doty to Arbana

Alternative One is to replace the existing 12" diameter sewers with a new 21" diameter sewer through the ravine from Doty Ave. to Arbana Drive. Figure 2 shows the profile along Doty Ave. with this improvement as compared to measured and estimated basement elevations.

Sewer Design

i. The proposed sanitary sewer would be 21" reinforced concrete pipe in accordance with the Ann Arbor Design Standards. Concrete corrosion inhibitors, such as Xypex, can be added to the concrete mix at the time of pipe production. This will be considered at the time of design engineering. The City could also consider products which can be applied to the interior of the concrete pipes for protection.
ii. The existing sewers have slopes of approximately 0.10% to 3.0%. The proposed sewer would have similar slopes.

Route Description

i. The proposed route is along a wooded ravine through a residential neighborhood. The route would parallel the existing sanitary sewer.
ii. Drains- The proposed sewer route follows the route of the "West Park – Fairgrounds" County Drain. (see attached map) There is also a local storm drainage system in the surface roads consisting of mostly 12" diameter sewers.
iii. Roads – Several residential streets would have to be crossed by the proposed sewer. The existing pavement in those streets is asphalt in average condition. The roads have concrete curb and gutter.
iv. The sewer passes through Maryfield Wildwood Park between Westwood and Revena.

Construction Methods

i. The anticipated construction method would be open cut installation of the sewers. Installation of new sewers by the pipe bursting method was considered. This method would not be plausible for this project because of the desired inside diameter of the proposed sewer. The existing sewer has a 12" inside diameter and the desired inside diameter of the proposed sewer is 21". A nominal size 24" plastic pipe (O.D. = 25.8") would be required to achieve an inside diameter of at least 21". This is because plastic pipe has thicker walls, and needs that thickness to withstand pull forces on the pipe during pipe bursting operations. It is not feasible to pipe burst a 12" clay pipe to a condition whereby a new 24" plastic pipe could be pulled through the void.

ii. Bypass pumping of the sewage flow would be required at times during the construction operations.

Potential Construction Challenges

i. This is a wooded corridor with a number of large trees. Numerous trees will need to be cleared in order to create an access route along the length of the proposed sewer.
ii. The ravine is up to 25 feet lower than adjacent roads. Access routes would have to be built for construction equipment to enter into the work zone.
iii. Two roads may have to be crossed by a jack and bore operation. These are Westwood Ave. and Revena Blvd. There is already a segment of 21" pipe under Wildwood, so that road will not need to be disturbed.
iv. Because the route of the sewer is along the "West Park – Fairgrounds" County Drain, weather and storm water will need to be considered and accommodated during construction operations. The proposed work will need to be coordinated with the Washtenaw County Water Resource Commissioner's office.
v. The operation of construction equipment and bypass pumping will produce heightened noise levels in a residential neighborhood that is not accustomed to it. Measures may need to be employed to mitigate noise from construction operations and bypass pumping.
vi. The Maryfield Wildwood Park (see attached map) is central to the project area. Park land could be a desirable location for some construction staging. Coordination with the Parks and Recreation Dept. will be necessary to determine how and when the park land could be used for construction purposes.
vii. Construction operations will have an impact on plants and wildlife along the ravine. Coordination will be required with any environmental agencies that have jurisdiction over this area. A sign near the sewer route on Revena indicates that the area is a "Certified Wildlife Habitat" by the National Wildlife Federation.

Traffic Control Considerations

i. It is anticipated that there would be temporary road blockages during construction. The local traffic in the neighborhood could be managed with traffic control devices. The existing road network in the neighborhood allows for alternate routes to enable residents to access their homes.
ii. There is an existing park in the middle of the neighborhood. Coordination would be required with the Parks and Recreation Dept. to manage pedestrian and other traffic coming and going from the park.
iii. Dexter Road is a heavily travelled road. Construction traffic would be travelling on the road and slowing down to turn into the subdivision. Although traffic control devices may not need to be set up in Dexter Ave., the typical flow of traffic could be slowed due to the movements of construction vehicles.
iv. Easement Needs: Both temporary and permanent easements will be needed along the route in order to build the proposed sewer. Research will be required by the City to determine locations of any existing easements. Also, coordination with the Washtenaw County Water Resources Commissioner's office will be needed to determine what easements they have in the project area.

v. Existing soil conditions: No investigations were performed under the scope of this study.
vi. Existing buried utilities: No investigations were performed under the scope of this study.

A summary of pipe lengths in the project under Alternative One are shown in the following table.

Table 1: Alternative One Sewer Lengths

Alternative One - Sewer Segments	**Existing Sewer Diameter**	**Proposed Sewer Diameter**	**Distance, feet**
Doty Ave. to Arbana Dr.	12”	21”	2,800
TOTAL			2,800

Alternative Two – Dexter Ave. to Arbana
Alternative Two is to replace the existing 12” and 18” diameter sewers with 21” diameter sewer through the ravine from a point in Dexter Ave. near the Mapleridge Apartments to Arbana Drive.

Sewer Design
i. The proposed sanitary sewer would be 21” reinforced concrete pipe in accordance with the Ann Arbor Design Standards. Concrete corrosion inhibitors, such as Xypex, can be added to the concrete mix at the time of pipe production. This will be considered at time of design engineering. The City could also consider products such as Sika Shield which can be applied to the interior of the concrete pipes for protection
ii. The existing sewers have slopes of approximately 0.10% to 3.0%. The proposed sewer would have similar slopes.

Route Description
i. The beginning of the route is in Dexter Ave. near the Mapleridge Apts. The remainder of the proposed route is along a wooded ravine through a residential neighborhood. The route would parallel the existing sanitary sewer.
ii. Drains-The proposed sewer route follows the route of the “West Park – Fairgrounds” County Drain. (see attached map) The drain is enclosed in a 72” storm sewer pipe that runs parallel to the sanitary sewer from Dexter Ave. to Doty Ave. There is also a local storm drainage system in the surface roads consisting of mostly 12” diameter sewers.
iii. Roads – Several residential streets would need to be crossed. The existing pavement in those streets is asphalt in average condition. The roads have concrete curb and gutter. Dexter is a 66 feet wide arterial road with 2 lanes of pavement. The pavement is 34 feet wide from back to back of curbs. Curb and gutter is 2 ft wide.
iv. The sewer passes through Maryfield Wildwood Park between Westwood and Revena.

Construction Methods

i. The anticipated construction method through the ravine would be open cut installation of the sewers. Installation of new sewers by the pipe bursting method was considered. This method would not be plausible for this project because of the desired inside diameter of the proposed sewer. The existing sewer has a 12" inside diameter and the desired inside diameter of the proposed sewer is 21". A nominal size 24" plastic pipe (O.D. = 25.8") would be required to achieve an inside diameter of at least 21". This is because plastic pipe has thicker walls, and needs that thickness to withstand pull forces on the pipe during pipe bursting operations. It is not feasible to pipe burst a 12" clay pipe to a condition whereby a new 24" plastic pipe could be pulled through the void.
ii. Open cut installation of the sewer in Dexter Ave. would not be possible without closing the road during construction. This is due to the sewer depth and presence of other utilities. In this case the entire paved surface in the sewer construction area would be removed and replaced. Alternately, the road could be partially closed and pits constructed to allow for jacking and boring sewer segments into place. The pros and cons of these options would need to be further evaluated at the time of engineering design. For the purposes of this preliminary study, installation by jack and bore has been assumed for the opinion of probable construction costs.
iii. Bypass pumping of the sewage flow would be required at times during the construction operations.

Potential Construction Challenges

i. This is a wooded corridor with a number of large trees. Numerous trees will need to be cleared in order to create an access route along the length of the proposed sewer.
ii. The ravine is up to 25 feet lower than adjacent roads. Access routes would have to be built for construction equipment to enter into the work zone.
iii. Work in Dexter Ave: Because of the sewer depth and existing utilities in Dexter Ave., it is anticipated that the segments of sewer in Dexter Ave. would be constructed by jacking and boring the pipe into place.
iv. Dexter Ave. is a heavily travelled road. Construction traffic would be travelling on the road and slowing down to turn into the subdivision. The typical flow of traffic could be slowed due to the movements of construction vehicles. The road will have to be partially or fully closed during the construction of the sewer segments in Dexter Ave.
v. Two roads within the neighborhood may have to be crossed by a jack and bore operation. These are Westwood Ave. and Revena Blvd. There is already a segment of 21" pipe under Wildwood, so that road will not need to be disturbed.
vi. Because the route of the sewer is along a ravine, weather and storm water will need to be considered and accommodated during construction operations. Coordination will be required with the Washtenaw County Water Resources Commissioner's office.
vii. The operation of construction equipment and bypass pumping will produce heightened noise levels in a residential neighborhood that is not accustomed to it. Measures may need to be employed to mitigate noise from construction operations and bypass pumping.
viii. The Maryfield Wildwood Park is central to the project area. Park land could be a desirable location for some construction staging. Coordination with the Parks and Recreation Dept. will be necessary to determine how and when the park land could be used for construction purposes.

ix. Construction operations will have an impact on plants and wildlife along the ravine. Coordination will be required with any environmental agencies that have jurisdiction over this area. A sign near the sewer route on Revena indicates that the area is a "Certified Wildlife Habitat" by the National Wildlife Federation.

Traffic Control Considerations

i. It is anticipated that there would be temporary road blockages during construction. The local traffic in the neighborhood could be managed with traffic control devices.
ii. There is an existing park in the middle of the neighborhood. Coordination would be required with the Parks and Recreation Dept. to manage pedestrian and other traffic coming and going from the park.
iii. Dexter Road is a heavily travelled road. Construction traffic would be travelling on the road and slowing down to turn into the subdivision. The typical flow of traffic could be slowed due to the movements of construction vehicles. The road would need to be partially or fully shut closed during construction of sewer in Dexter Ave.
iv. Easement Needs: Both temporary and permanent easements will be needed in order to build the project. Research will be required by the City to determine locations of any existing easements. Also, coordination with the Washtenaw County Water Resources Commissioner's office will be needed to determine what easements they have in the project area.
v. Existing soil conditions: No investigations were performed under the scope of this study.
vi. Existing buried utilities: No investigations were performed under the scope of this study.

A summary of pipe lengths in the project area under Alternative Two are shown in the following table.

Table 2: Alternative Two Sewer Lengths

Alternative Two - Street Segments	Existing Sewer Diameter	Proposed Sewer Diameter	Distance, feet
Mapleridge Apts to Doty Ave.	18"	21"	1,450
Doty Ave. to Arbana Dr.	12"	21"	2,800
TOTAL			4,250

Other Option Considered

Constructing a new 21" diameter sewer in Dexter Avenue from the vicinity of Mapleridge Apartments to Doty Ave. was considered. In this option, sewage would flow easterly on Dexter, then turn north on Doty, and be directed into new 21" sewer flowing east from Doty. This would avoid approximately 900 feet of sewer construction through the ravine.

With this option, sewer depths would reach up to 37 feet. Open cut construction would require the complete closure and reconstruction of Dexter Ave. in the project area. Sewers can be installed by horizontal directional drilling under certain circumstances, but it is not a viable option for this route.

The accuracy of the pilot hole drilling at these depths is typically within 1% of the pipe length installed. This accuracy level cannot be tolerated for the pipe slopes needed for this project, which are as low as 0.11%.

This route was not considered further because of the reasons stated above.

Opinions of Probable Construction Costs
The detailed opinions of probable construction costs are attached. The totals are:

i. Alternative One - $2,943,000
ii. Alternative Two - $4,988,000

Conceptual Plans
Preliminary conceptual plans for each option are attached.

Photos
Representative photos of the project area are attached in Appendix A.

Appendix A

Photos of Area with Recommended Improvements


STOP


2230
2250
Mapleridge
vacancy
res mgr 994-6085


VETERANS
MEMORIAL PARK
DEXTER AVE. PARKING
FIELDS 4, 5 - PLAY AREA
Parks & Recreation
SPEED LIMIT 30


SPEED
LIMIT
30


MARYFIELD
WILDWOOD
PARK
NO SMOKING


MARYFELD
WILDWOOD PARK
NO SMOKING
BY CITY ORDINANCE


NATIONAL WILDLIFE FEDERATION®
Certified
WILDLIFE
Habitat®
This property provides the four basic habitat elements needed for wildlife to thrive: food, water, cover, and places to raise young.
NATIONAL WILDLIFE FEDERATION®
nwf.org


NO
DUMPING
$100 FINE
HANNAH
PARK

Appendix B

Preliminary Cost Estimates

Project Summary
Engineer's Opinion of Probable Project Costs

Owner:	**City of Ann Arbor**	**Date:**	**3/8/2017**
Project:	**Sanitary Sewer Improvement Project**	**Project No.**	**0028-15-0051**
Work:	**AREA A - OPTION 1**	**Prepared By:**	**E.Gumpper**
	Upsize existing sewer from 12 inch to 21 inch	**Reviewed By:**	
	Route through ravine from Doty Ave. to Arbana Drive		

Item No.	Item Description	Est. Quantity	Unit	Unit Price	Total Cost
1	Mobilization (5%)	1	LS	$78,000	$78,000
2	Soil Erosion and Sediment Control (5%)	1	LS	$71,000	$71,000
3	Traffic Maintenance and Control (5%)	1	LS	$71,000	$71,000
4	Digital Video Route Survey	1	LS	$5,000	$5,000
5	Exploratory Excavations	10	EA	$2,000	$20,000
6	Earthwork for access ramps to ravine	1	LS	$50,000	$50,000
7	Sewer, 21 inch, Tr Det A (10'-20' Deep)	2500	FT	$210	$525,000
8	Sewer, 21 inch, Tr Det A (over 20' deep)	200	FT	$230	$46,000
9	Sewer, 21 inch, Bore & Jack in 36" Steel Casing (Revena)	100	FT	$600	$60,000
10	Sewer Reconnections	10	EA	$5,000	$50,000
11	Trench Under Cut and Back Fill (6A)	500	CYD	$50	$25,000
12	Dewatering Trench	500	FT	$50	$25,000
13	Bypass Pumping	1	LS	$50,000	$50,000
14	Sanitary Sewer Manhole, 4 ft diameter	8	EA	$12,000	$96,000
15	Sanitary Sewer Manhole, 5 ft diameter	8	EA	$16,000	$128,000
16	Storm Sewer, 12 inch	100	FT	$100	$10,000
17	Storm Drain Manhole, 4 ft diameter	4	EA	$10,000	$40,000
18	Abandon Existing sewer with Flowable Fill	100	CYD	$200	$20,000
19	Pavement Remove and Replacement	400	SYD	$50	$20,000
20	Curb and Gutter, Remove and Replace	200	FT	$25	$5,000
21	Sidewalk , Remove and Replace	2000	SFT	$5	$10,000
22	Subgrade Undercut and Refill	50	CYD	$100	$5,000
23	Permanent aggregate maintenance path	5200	SYD	$20	$104,000
24	Clearing & Tree Removal	1	LS	$50,000	$50,000
25	Green Belt Restoration	13700	SYD	$5	$68,500
26	Utility Relocation Allowance	1	LS	$25,000	$25,000
27	Easement Acqusition Allowance	1	LS	$80,000	$80,000
28	Permit Application Allowance	1	LS	$10,000	$10,000
29	General Conditions & Requirements	10	%		$175,000.00
	CONSTRUCTION SUBTOTAL				**$1,923,000.00**
	Engineering, Contract Admin, Constr Eng, Observation	25	%		**$481,000.00**
	Geotechnical Services	3	%		**$58,000.00**
	Contingencies	25	**%**		**$481,000.00**
	ENGINEER'S OPINION OF PROJECT COST				**$2,943,000.00**
	PROJECT ASSUMPTIONS				
	Residential Pavement thickness	3" asphalt	and	8" agg base	
	Easements needed in ravine area				
	Construction method open cut				
	Design flow is XX CFS. Proposed pipe is 21" diameter at 0.0 to 0.0% slope.				
	Pipe is 21" RCP with corrosion inhibitor added				
	Geotechnical investigations and existing utility research was out of the scope of this study.				
	Pavement work includes costs for removal and replacement of HMA, aggregate base, underdrain, and pavement markings.				

Project Summary
Engineer's Opinion of Probable Project Costs

Owner:	**City of Ann Arbor**	**Date:**	**3/8/2017**
Project:	**Sanitary Sewer Improvement Project**	**Project No.**	**0028-15-0051**
Work:	**AREA A - OPTION 2**	**Prepared By:**	**E.Gumpper**
	Upsize existing sewer from 12 inch and 18 inch to 21 inch diameter	**Reviewed By:**	
	Route from Dexter Ave. through ravine to Arbana Drive		

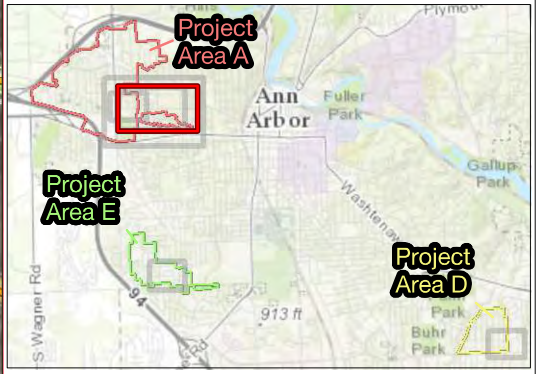
Item No.	Item Description	Est. Quantity	Unit	Unit Price	Total Cost
1	Mobilization (5%)	1	LS	$134,000	$134,000
2	Soil Erosion and Sediment Control (5%)	1	LS	$116,000	$116,000
3	Traffic Maintenance and Control (10%)	1	LS	$232,000	$232,000
4	Digital Video Route Survey	1	LS	$7,000	$7,000
5	Exploratory Excavations	20	EA	$2,000	$40,000
6	Earthwork for access ramps to ravine	1	LS	$100,000	$100,000
7	Sewer, 21 inch, Tr Det A (10'-20' Deep)	3400	FT	$210	$714,000
8	Sewer, 21 inch, Tr Det A (over 20' deep)	200	FT	$230	$46,000
9	Sewer, 21 inch, Bore & Jack in 36" Steel Casing	650	FT	$600	$390,000
10	Sewer Reconnections	10	EA	$5,000	$50,000
11	Trench Under Cut and Back Fill (6A)	700	CYD	$50	$35,000
12	Dewatering Trench	700	FT	$50	$35,000
13	Bypass Pumping	1	LS	$75,000	$75,000
14	Sanitary Sewer Manhole, 4 ft diameter	12	EA	$12,000	$144,000
15	Sanitary Sewer Manhole, 5 ft diameter	12	EA	$16,000	$192,000
16	Storm Sewer, 12 inch	150	FT	$100	$15,000
17	Storm Drain Manhole, 4 ft diameter	6	EA	$10,000	$60,000
18	Abandon Existing Sewer with Flowable Fill	200	CYD	$200	$40,000
19	Pavement Remove and Replacement, Residential	400	SYD	$50	$20,000
20	Pavement Remove and Replacement, Dexter Ave	400	SYD	$70	$28,000
21	Curb and Gutter, Remove and Replace	200	FT	$25	$5,000
22	Sidewalk , Remove and Replace	2000	SFT	$5	$10,000
23	Subgrade Undercut and Refill	50	CYD	$100	$5,000
24	Permanent aggregate maintenance path	6800	SYD	$20	$136,000
25	Clearing & Tree Removal	1	LS	$75,000	$75,000
26	Green Belt Restoration	20000	SYD	$5	$100,000
27	Utility Relocation Allowance	1	LS	$50,000	$50,000
28	Easement Acqusition Allowance	1	LS	$100,000	$100,000
29	Permit Application Allowance	1	LS	$10,000	$10,000
30	General Conditions & Requirements	10	%		$296,000.00
	CONSTRUCTION SUBTOTAL				**$3,260,000.00**
	Engineering, Contract Admin, Constr Eng, Observation	25	%		**$815,000.00**
	Geotechnical Services	3	%		**$98,000.00**
	Contingencies	25	%		**$815,000.00**
	ENGINEER'S OPINION OF PROJECT COST				**$4,988,000.00**
	PROJECT ASSUMPTIONS				
	Residential Pavement thickness	3" asphalt	and	8" agg base	
	Easements needed in ravine area				
	Construction method: open cut through ravine and pipe jacked in place in Dexter Ave.				
	Dexter Ave. will be limited to one lane of traffic or shut completely				
	Design flow is XX CFS. Proposed pipe is 21" diameter at 0.1 to 3.0% slope.				
	Pipe is 21" RCP with corrosion inhibitor added.				
	Geotechnical investigations and existing utility research was out of the scope of this study.				
	Pavement work includes costs for removal and replacement of HMA, aggregate base, underdrain, and pavement markings.				

Appendix C

Preliminary Conceptual Plans

Ann Arbor Sanitary Sewer Improvements

Area A - Option 1



Improvement Areas
- Area A
- Area D
- Area E

Proposed Sanitary Mains - Size
- 12"
- 18"
- 21"
- Sanitary Manhole

Sanitary Main - Type
- Collector
- Force Main
- Storm Manhole
- Storm Discharge Point
- Storm Catchbasin
- Storm Main

Project Areas
- Project Area A
- Project Area D
- Project Area E

0 400 800
Feet

1 " = 400 '

Source: Data provided by Washtenaw County and the City of Ann Arbor. OHM Advisors does not warrant the accuracy of the data and/or the map. This document is intended to depict the approximate spatial location of the mapped features within the Community and all use is strictly at the user's own risk.

Coordinate System: NAD 1983 StatePlane Michigan South FIPS 2113 Feet Intl

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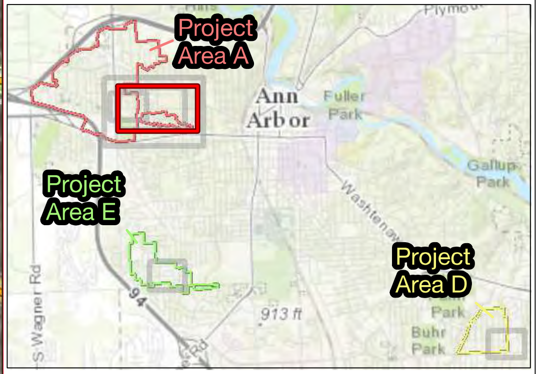
Ann Arbor Sanitary Sewer Improvements

Area A - Option 2



Improvement Areas
- Area A
- Area D
- Area E

Proposed Sanitary Mains - Size
- 12"
- 18"
- 21"
- Sanitary Manhole

Sanitary Main - Type
- Collector
- Force Main
- Storm Manhole
- Storm Discharge Point
- Storm Catchbasin
- Storm Main

Project Areas
- Project Area A
- Project Area D
- Project Area E

0 400 800
Feet

1 " = 400 '

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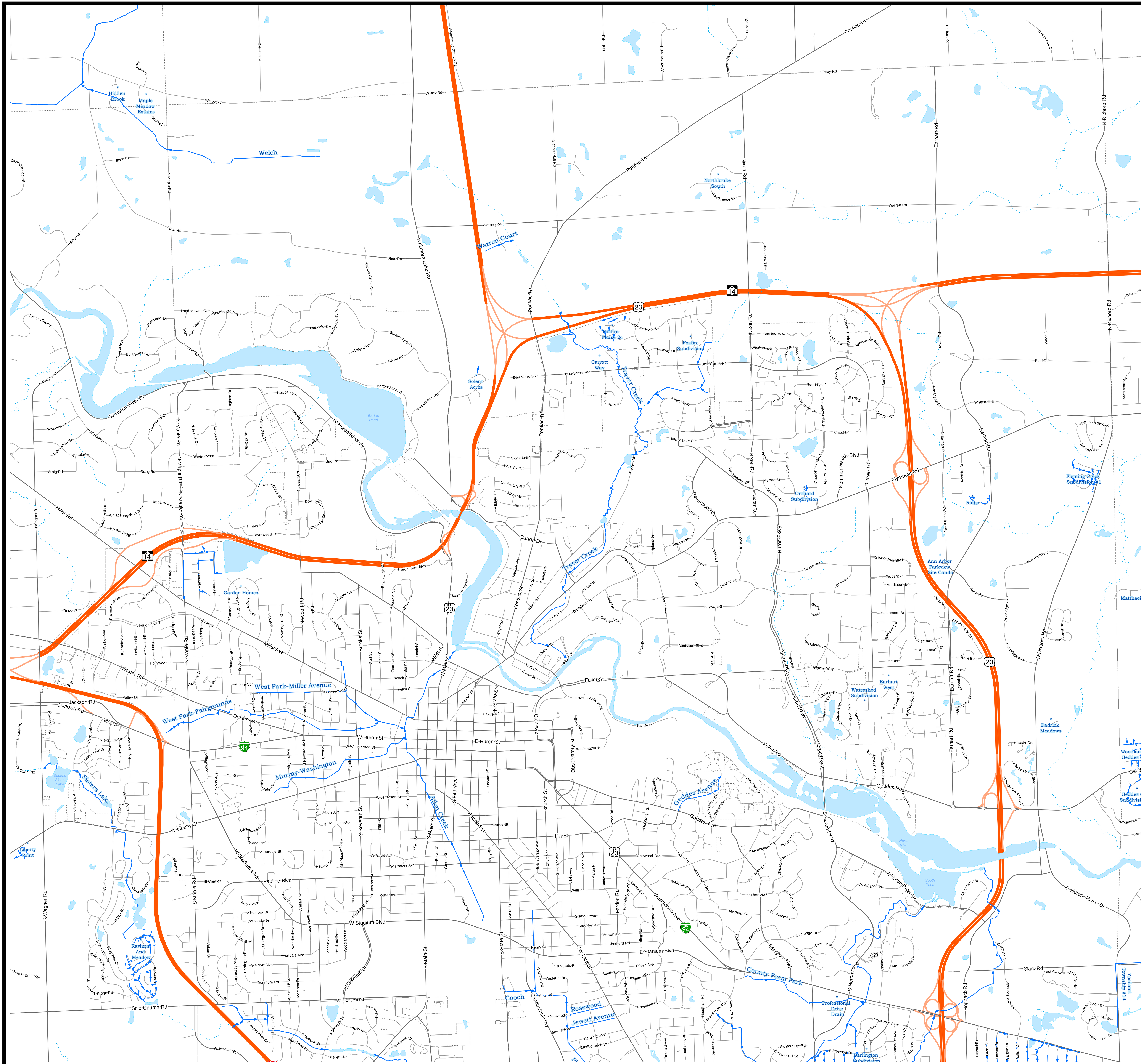
Ann Arbor Township County Drain Map

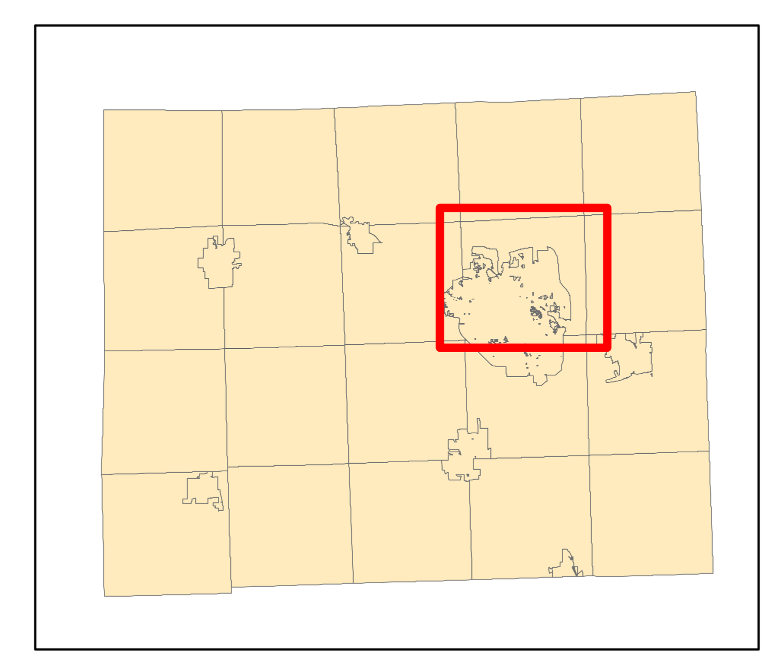


Evan N. Pratt P.E.
Washtenaw County
Water Resources
Commissioner

705 N. Zeeb Rd.
Ann Arbor, MI 48107
Ph: 734-222-6860
Fax: 734-222-6803
http://drain.ewashtenaw.org

Legend

- Lakes
- County Drain Systems
- Waters of the State



0 1,600 3,200
Feet

1:19,200

Map Published On : Date: 1/12/2016

Maryfield Wildwood Park

City of Ann Arbor
Community Services GIS
September 30, 2011

City of Ann Arbor Map Disclaimer

This map complies with National Map Accuracy Standards for mapping at 1 Inch = 100 Feet. The City of Ann Arbor and its mapping contractors assume no legal representation for the content and/or inappropriate use of information represented on this map.

Areas B & C Objectives

As part of the 2013 Sanitary Sewer Wet Weather Evaluation Project (SSWWEP), Areas B & C experienced surcharging up to eight feet above the sewer invert. High hydraulic losses were added to the hydraulic model for Area B (1st Street) and Area C (State & Hoover) in order to make the model results replicate that surcharging. The recommendation from the 2013 study was to investigate these areas thoroughly in the field to identify the cause of the hydraulic losses. This information is based on the five original project sheets, which are located in Appendix A of the SSES Report.

This extensive field investigation was conducted as part of the current SSIPE project, and included flow metering, pipeline inspections, large manhole junction inspections, wet weather observation, and basement elevation surveys. The flow metering results are detailed in Volume 1: Flow Metering Report, and the field data collection and SSES results are discussed in Volume 2 of this report.

Areas B & C Modeling Results

Existing Conditions

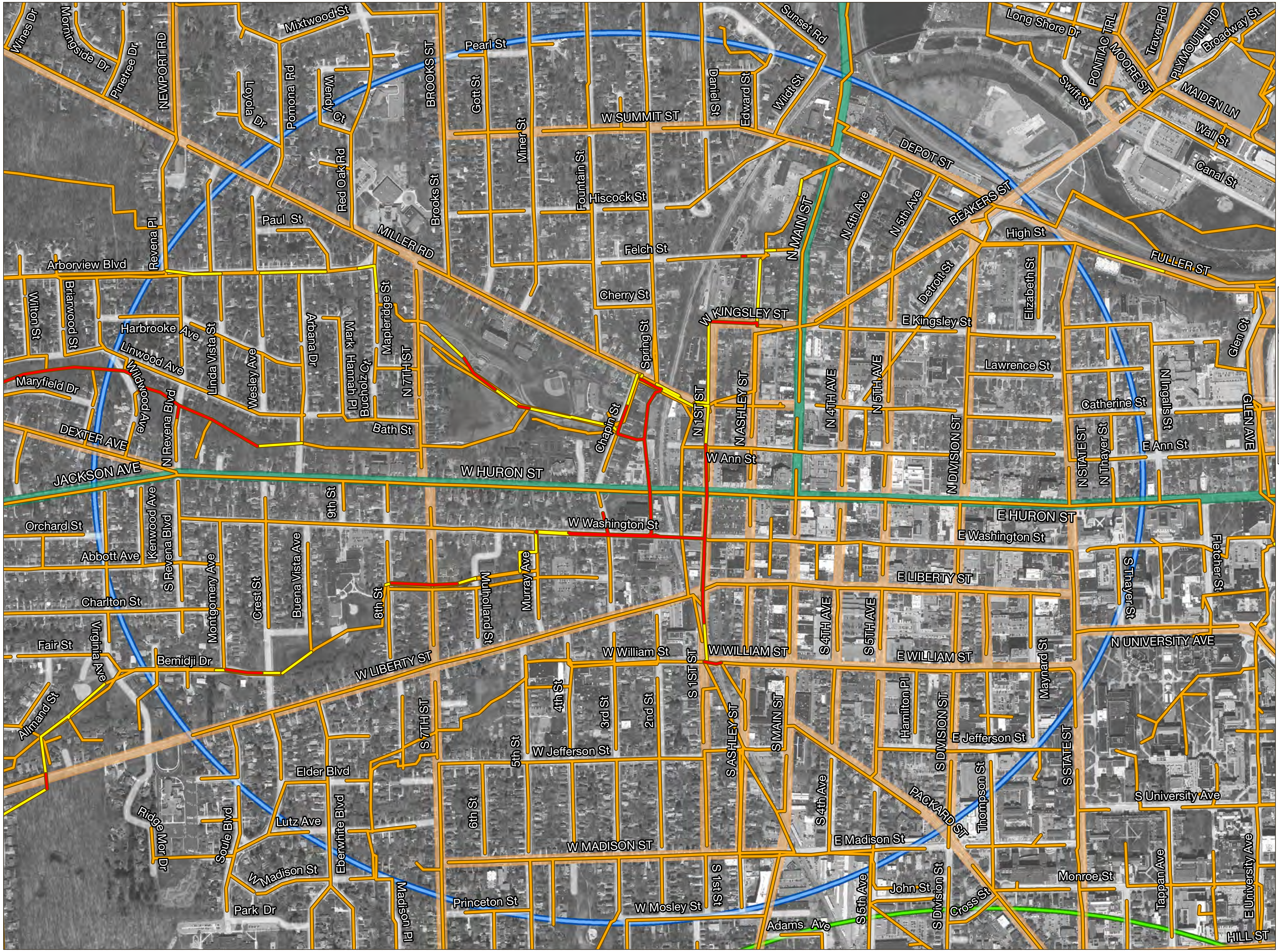
As discussed above, Areas B & C were metered further for the current SSIPE study. However, no large storm events triggered the amount of surcharging witnessed by the peak stage recorders as part of the 2013 study. The existing model, which utilizes the 2013 modeled pipe characteristics, shows that some pipes in both Areas B & C are overloaded. This is shown in Figures 1 and 2.

Alternative Solutions

Because the areas did not experience a storm event that caused the level of surcharging observed in 2013, preliminary engineering analysis was not completed for these areas. We recommend that the City perform long-term flow metering in these areas until a sufficient event is recorded in order to understand the hydraulic performance of the area. OHM is holding our budget allocated to preliminary engineering for this area until a sufficient event is recorded, and we will prepare an addendum to this report when that work is complete. Figure 3 shows a schematic of proposed meter locations for the long-term flow metering described above. Additionally, Appendix B of the SSES Report shows detailed schematics of our understanding of the two project areas.

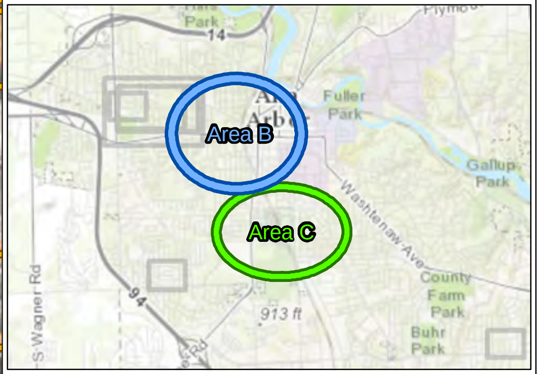
Preliminary modeling was completed to determine approximate locations of flow removal and/or diversion in order to prevent the system from overloading. The surcharging within the current hydraulic model is caused by artificial friction factors based on assumptions in order to mimic the observed 2013 surcharging. The locations in the model that are the cause of the surcharging may not be accurately identified. Once the long-term flow metering is completed, OHM will re-calibrate the hydraulic model with updated flow data. At that point, the cause of the surcharging will ideally be more evident. This will provide a better understanding of flow removal/diversion locations.

Once the hydraulic model is re-calibrated based on additional meter data, a peak flow removal number will be determined. It is expected that removing this peak flow, either through upstream source removal or by constructing a new sewer, will relieve existing surcharging. Alternatively, this flow could be diverted into a storage basin during the time that the existing pipes are overloaded. These concepts will be further evaluated during preliminary engineering when sufficient flow data is available.



Ann Arbor Sanitary Sewer Improvements

Figure 1
Area B Pipe Capacity
Scenario B



CAPACITY

- Less than 0.8
- 0.8 - 0.999
- Greater than 0.999

Area Name

- Area C
- Area B

0 700 1,400
Feet
1 " = 700 '

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Coordinate System: NAD 1983 StatePlane Michigan South FIPS 2113 Feet Intl

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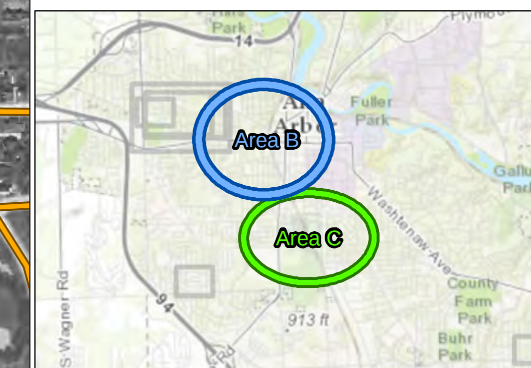
Ann Arbor Sanitary Sewer Improvements

Figure 2
Area C Pipe Capacity
Scenario B



CAPACTY

- Less than 0.8
- 0.8 - 0.999
- Greater than 0.999

Area Name

- Area C
- Area B

0 700 1,400
Feet
1 " = 700 '

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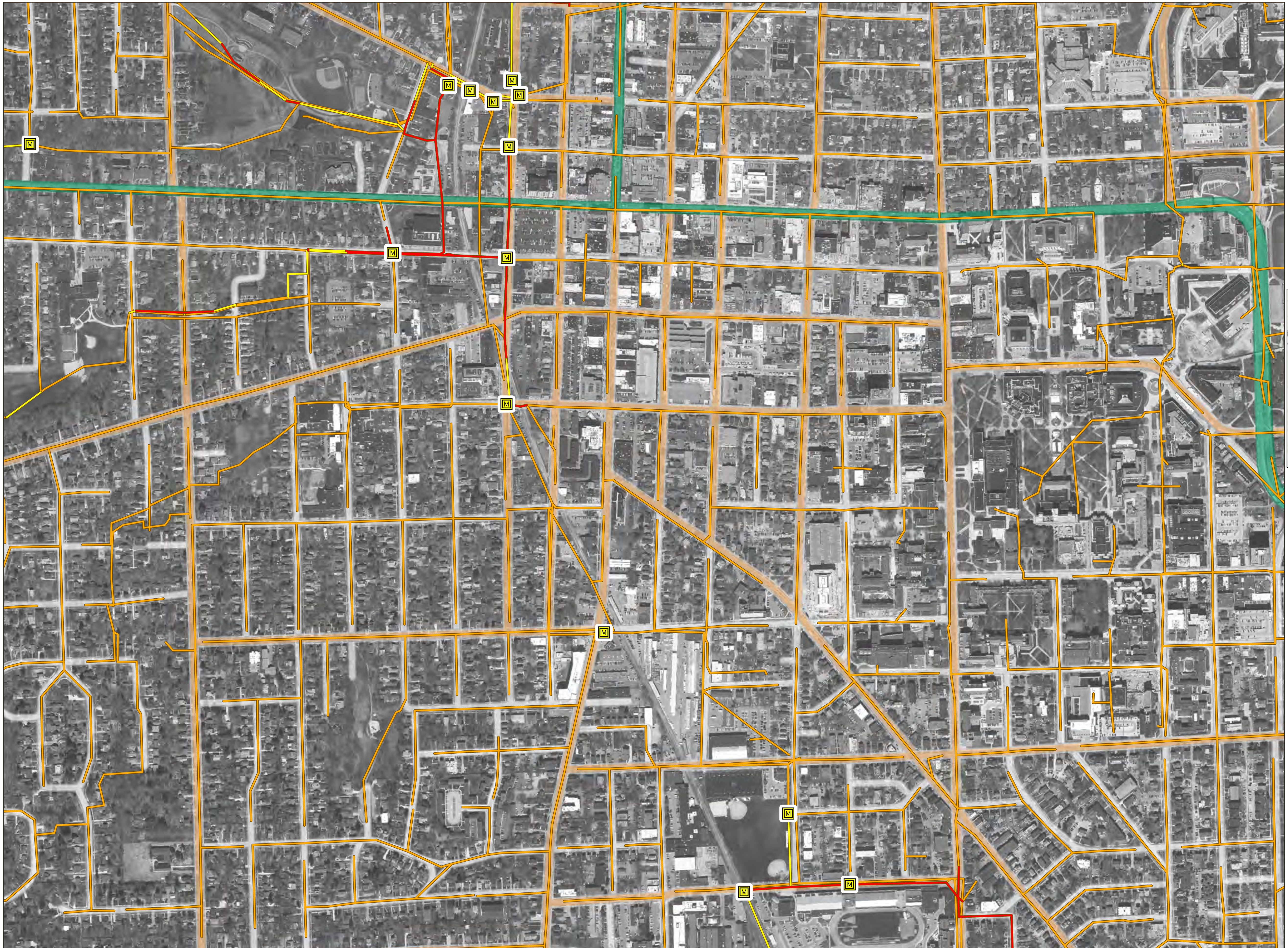
Ann Arbor Sanitary Sewer Improvements

Figure 3
Proposed Meter Locations



M Flow Meter

CAPACTY

Less than 0.8

0.8 - 0.999

Greater than 0.999

0 590 1,180
Feet

1 " = 594 '

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Coordinate System: NAD 1983 StatePlane Michigan South FIPS 2113 Feet Intl

Map Published: July 14, 2017

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Area D Objective

As part of the 2013 Sanitary Sewer Wet Weather Evaluation Project (SSWWEP), which examined the effectiveness of the Footing Drain Disconnect (FDD) Program, Project Area D, Pittsfield Valley was identified as a location where flows may exceed pipe capacities. It was an area expected to have high footing drain flows, but was not directly metered as part of the 2013 study. The action plan for this area was to perform flow metering and an SSES to quantify the inflow and infiltration entering the system. This information is based on the five original project sheets, which are located in Appendix A of the SSES Report.

For the current Sanitary Sewer Improvements and Preliminary Engineering (SSIPE) Project, Area D was metered, an SSES study was completed, a new hydrologic model was created, and the hydraulic model was updated. The Volume 1: Flow Monitoring Report discusses the details of the flow monitoring for Area D and the other identified Project Areas, and the Volume 2: SSES Report discusses the pipeline inspections, manhole inspections, and smoke testing done in this area.

Hydrologic Modeling

Flow metering data was collected to understand the flow response to rainfall in this area and to update the hydraulic model. The flow meter locations are shown in Figure 1. The flow monitoring results were tabulated in the Volume 1: Flow Monitoring Report. The Antecendent Moisture Model (AMM) was used to develop design peak flows for this area. The model allows for development of a continuous hydrologic model of the system accounting for the variation in antecedent moisture conditions. Recent rainfall and soil moisture conditions significantly affect the system response to wet weather events. The AMM accounts for these variations, and because it uses rain gauges in each priority district, the impacts of spatially varied rainfall is minimal. These characteristics of AMM give us high confidence in these results.

Accuracy of Fits and Validation

An accuracy of fit analysis, which includes an evaluation of model errors, quantifies model performance to determine if the model is calibrated sufficiently. The accuracy of fit compares the peak flows and volumes between actual observed values in the system to the model predictions for several large storm events. Net average error is the average of all the errors from several storms and allows positive and negative values to offset each other. The net average error is a measure of the model bias and should be as close to zero as possible. Total average error is the average of the absolute value of the errors from several storms and is a measure of the model's ability to predict volumes and flows for individual storm events. A model that accurately simulates wet weather flows generally produces an accuracy of fit with net errors of 0-2% (model bias) and total errors around 10-20% (predictive accuracy).

Table 1 summarizes the Accuracy of Fit (AOF) analysis for meter 20D. Only two storms were used for analysis because the metering period was limited. Three useful storms were observed during the metering period, but one of the storms had spatially varied rainfall so it was not included in the analysis. The results of the AOF indicates that the model is simulating the wet weather flows with a model bias percentage higher than what we normally like to see. However, this was accounted for with a safety factor on the design flows used to develop the recommendations.

Table 1: Accuracy of Fit for Meter 20D

Storm	Rain (in)	Observed Peak (cfs)	Model Peak (cfs)	Peak Flow Error (%)	Observed Vol (cf)	Model Vol (cf)	Volume Error (%)
7/30/2016	1.39	0.23926	0.23227	-3%	2.55949	2.65426	4%
8/15/2016	1.8	0.28083	0.25381	-10%	3.89374	3.6046	-7%
Net Average Error				**-6.27%**			**-1.86%**
Total Average Error				**6.27%**			**5.56%**

Once it was determined that the model was accurately simulating wet weather flows, it was deemed suitable for use in the flow removal evaluation, long term simulation, and to determine system frequency flows.

Design Peak Flows

The objective of a frequency analysis is to develop the design peak flows. A frequency analysis is performed by routing 60 years of historic rainfall through the calibrated AMMs. Because the process uses the continuous AMM and the historic rainfall to generate a long-term flow record, the resulting output provides information on the likelihood of various flows occurring. It also accounts for variations in the rainfall amounts, rainfall pattern and various wetness conditions. This results in 60 years of predicted flow that can be used in a statistical analysis of that flow to develop a plot of the peak flow rate versus the annual probability of that flow occurring.

The historic rainfall and temperature data were obtained from the NOAA's National Climatic Data Center (NCDC). The annual peak flow rates that occurred during the growth season (defined from April to October) were used to determine the recurrence interval for flows in that sewershed using a Log-Pearson Type III Distribution. The recurrence interval estimates the likeliness that a given flow rate will occur. The average recurrence interval can be related to frequency of occurrence. For example, over a long period of time, the 10-year flow can be expected to occur with an average interval of 10 years. This means there is a 10% probability of that flow being exceeded in a given year. This translates to yearly exceedance probabilities of 4% for 25-year, 2% for 50-year, and 1% for 100-year flows. Table 2 shows the recurrence intervals for each of the metered areas studied in this analysis.

Table 2: Frequency Analysis Recurrence Intervals

Meter ID	Frequency Analysis Total Flow Rate (cfs)			
	10 year	25 year	50 year	100 year
13D	0.83	1.02	1.16	1.3
14D	0.3	0.37	0.42	0.47
15D	0.59	0.72	0.83	0.93
19D	1.74	2.17	2.5	2.84
20D	1.04	1.35	1.59	1.84

Figures 4 through 8 in Appendix A show the frequency analysis plots for each of the five meters in Area D. The 10-year recurrence interval is identified on each plot. The 25-year recurrence interval flow values, which is Scenario B in the hydraulic model, were used for further analysis. To estimate the flow per footing drain, it was assumed that all wet weather flow calculated by the frequency analyses was footing drain flow. The 25-year flow for each meter district was divided by the number of footing drains in the district to determine the estimated peak flow per footing drain. Table 3 shows these breakdown of this calculation and the estimated flow per footing drain for each meter district.

Table 3: Frequency Analysis for Area D

Meter	**Frequency Analysis Flow in cfs (gpm)**	**Number of Footing Drains**	**Flow per FD in cfs (gpm)**
20 D	0.6 (269)	117	0.0051 (2.3)
15D	0.72 (323)	117	0.0062 (2.8)
13D	1.02 (458)	182	0.0056 (2.5)
19D	2.17 (974)	372	0.0058 (2.6)
14D	0.37 (166)	20	0.0185 (8.3)
TOTAL	4.88 (2190)	808	
Weighted Average Flow per Footing Drain			0.006 (2.7)

Estimated Number of Homes (FD + 10%)	969
Baseflow for 350 gpd/house	339,185
Total Baseflow, cfs (gpm)	0.525 (236)

Total Flow Input for Area D, cfs (gpm)	5.4 (2,426)

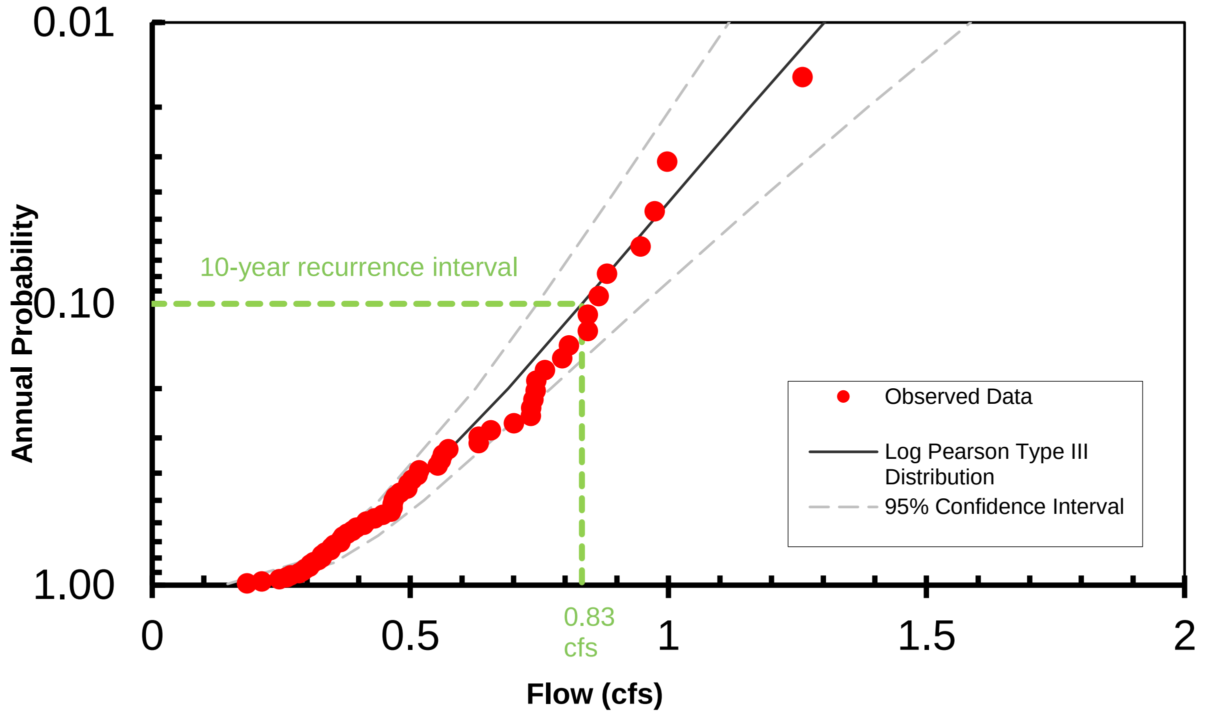


Figure 4: Meter 13D Frequency Analysis

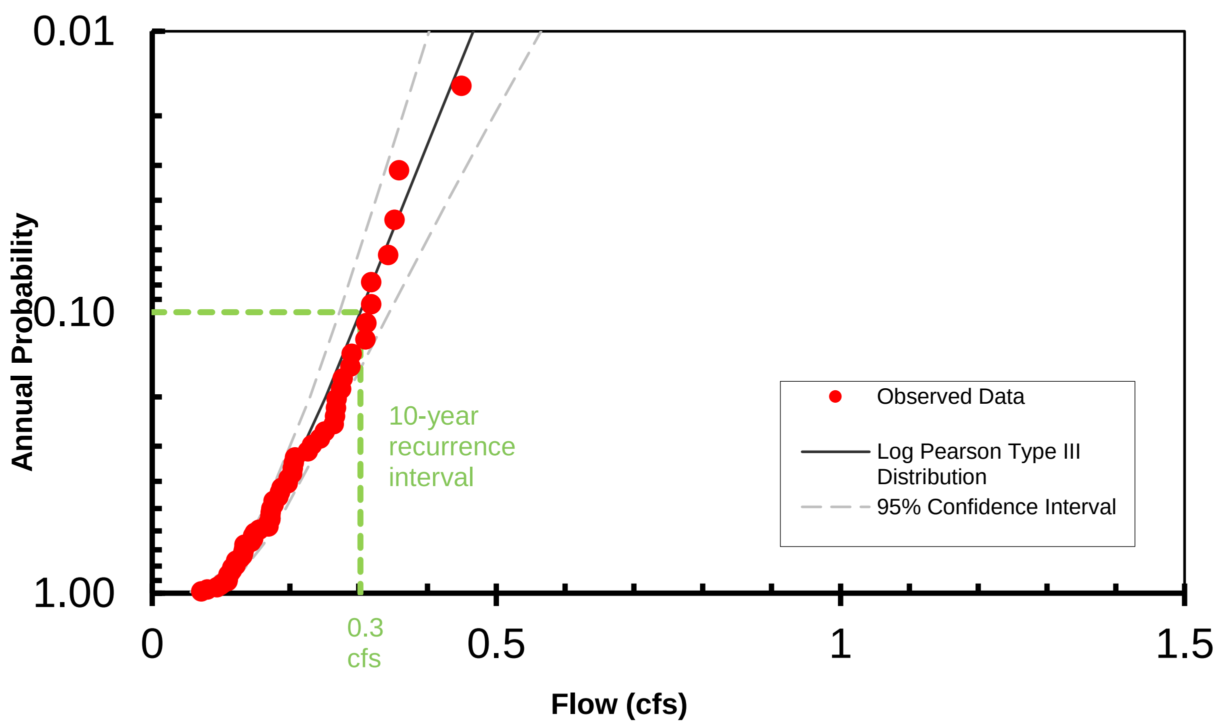


Figure 5: Meter 14D Frequency Analysis

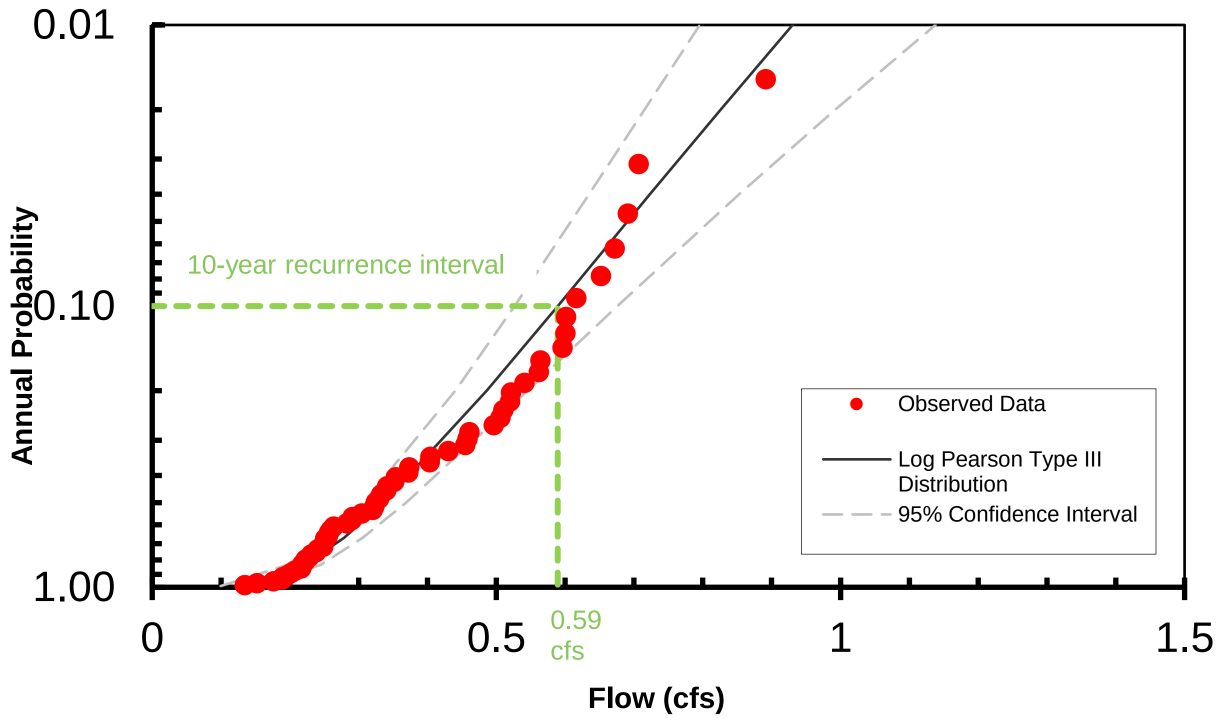


Figure 6: Meter 15D Frequency Analysis

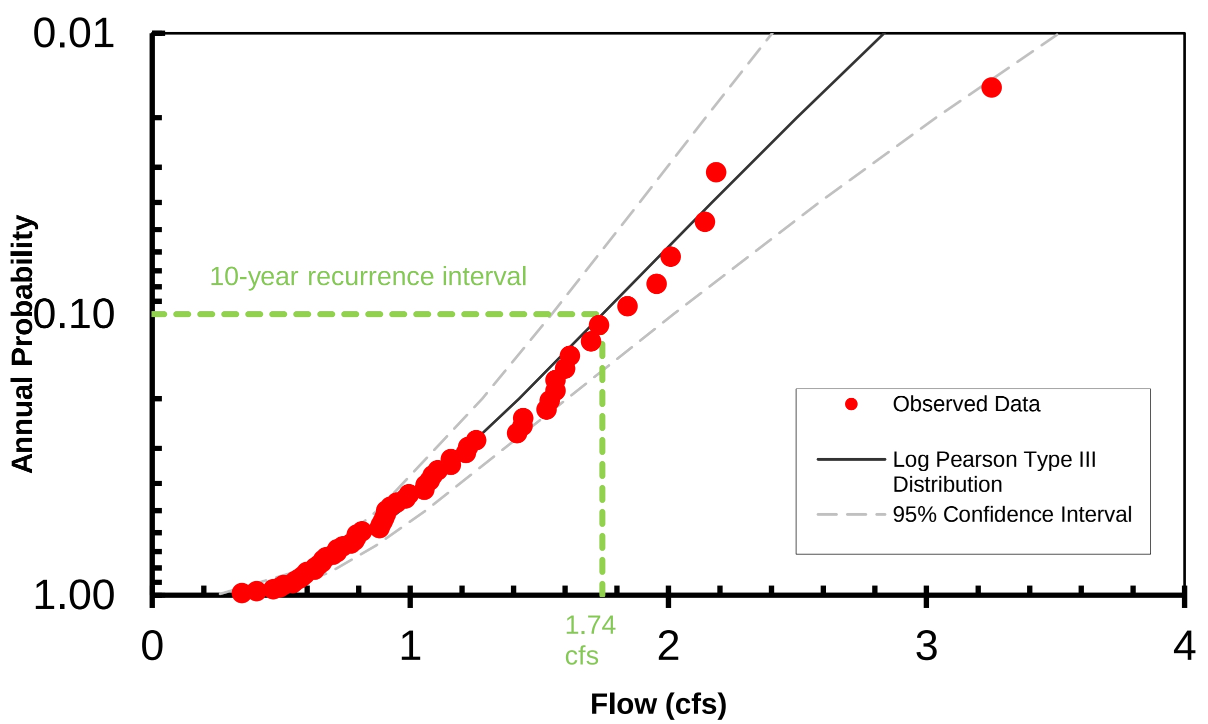


Figure 7: Meter 19D Frequency Analysis

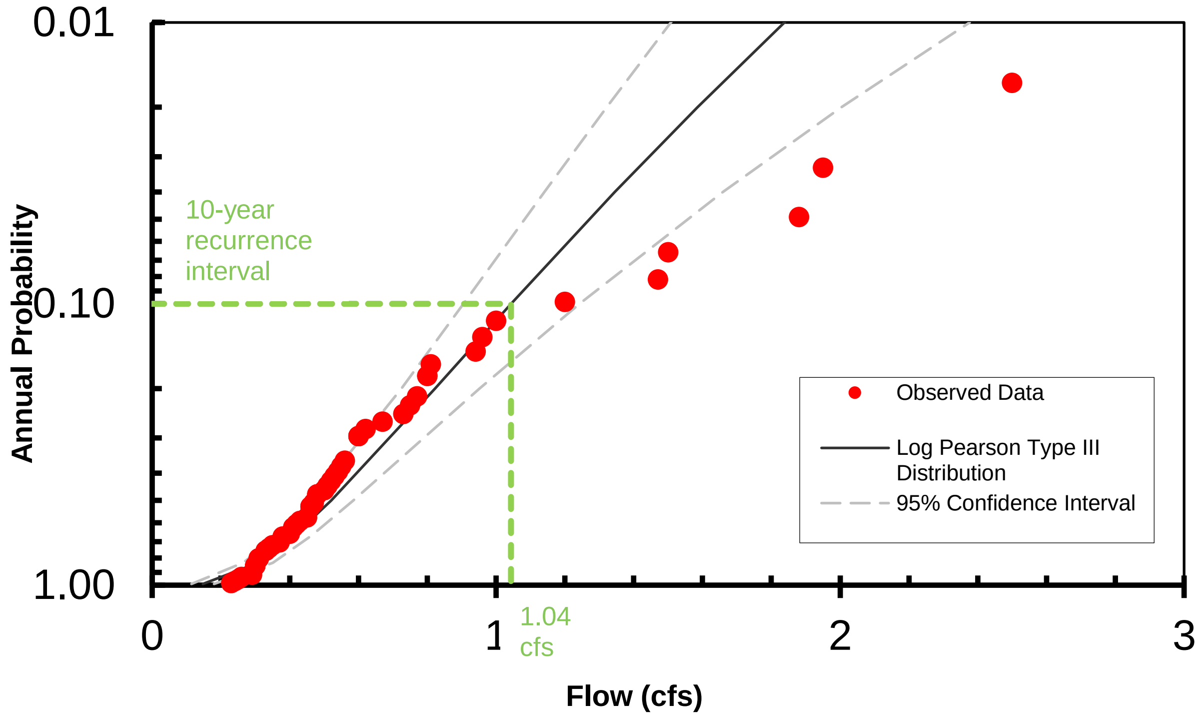


Figure 8: Meter 20D Frequency Analysis

Area D Modeling Results

Existing Conditions

In order to update the existing conditions model, several factors were taken into consideration as described below. The sewer lines in Area D underwent CCTV inspection. The results of that inspection showed a buildup of sediment in many of the lines. A PACP inspection process was also completed on the sewer lines in Area D. Many defects were found including root intrusions, joint offsets, fractures in the pipe, and grease deposits. The details of the CCTV and PACP inspections are described in the Volume 2: SSES Report. A final factor taken into consideration for the model update was the assumption that all wet weather flows were caused by footing drain connections. Therefore, with the City's approval, the system was modeled with the following assumptions:

- First, that the pipe roughness factor would be 0.016 to represent the pipe condition.
- Second, that one inch of sediment was added to the model to represent the CCTV findings showing sediment buildup.
- Finally, though the calculations shown in Table 3 show that most of the meter districts were estimated to have between 2 and 3 gpm per footing drain, the common range for similar systems is between 3 and 5 gpm per footing drain. To be conservative and include a safety factor on design flows, a value of 4 gpm per footing drain was used.

Figure 1 shows the modeled profile of the existing conditions.

Alternative Solutions

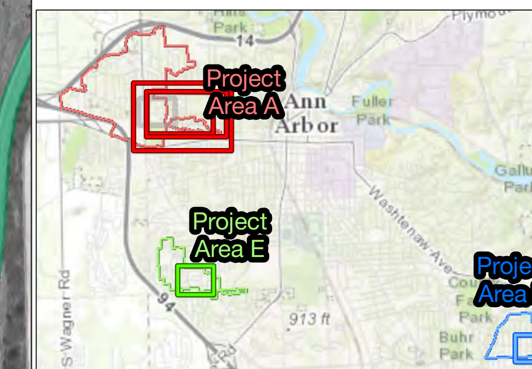
The model was updated with previously discussed modifications and run with the design event. In the modified scenario described above, several pipes were over-loaded. The model was used to size and identify the extent of the improvements needed. In an attempt to relieve the surcharging, two alternatives were considered:

- Alternative One – Norwood Replacement – Replace existing 8" with 12"
- Alternative Two – New Norwood Sewer – Install new 12" to the East

Alternatives one and two both resolve the issue of surcharging in the southeast section of Area D. Details of these alternatives are covered in the following preliminary engineering discussion. Figures 2 and 3 show the modeled profiles of the Alternatives. Plan views of the proposed Alternatives are shown in Appendix D.

Ann Arbor Sanitary Sewer Improvements

Meter Locations



- Rain Gage
- Flow Meter
- Collector
- Force Main
- Area D

0 500 1,000
Feet

1 " = 500 '

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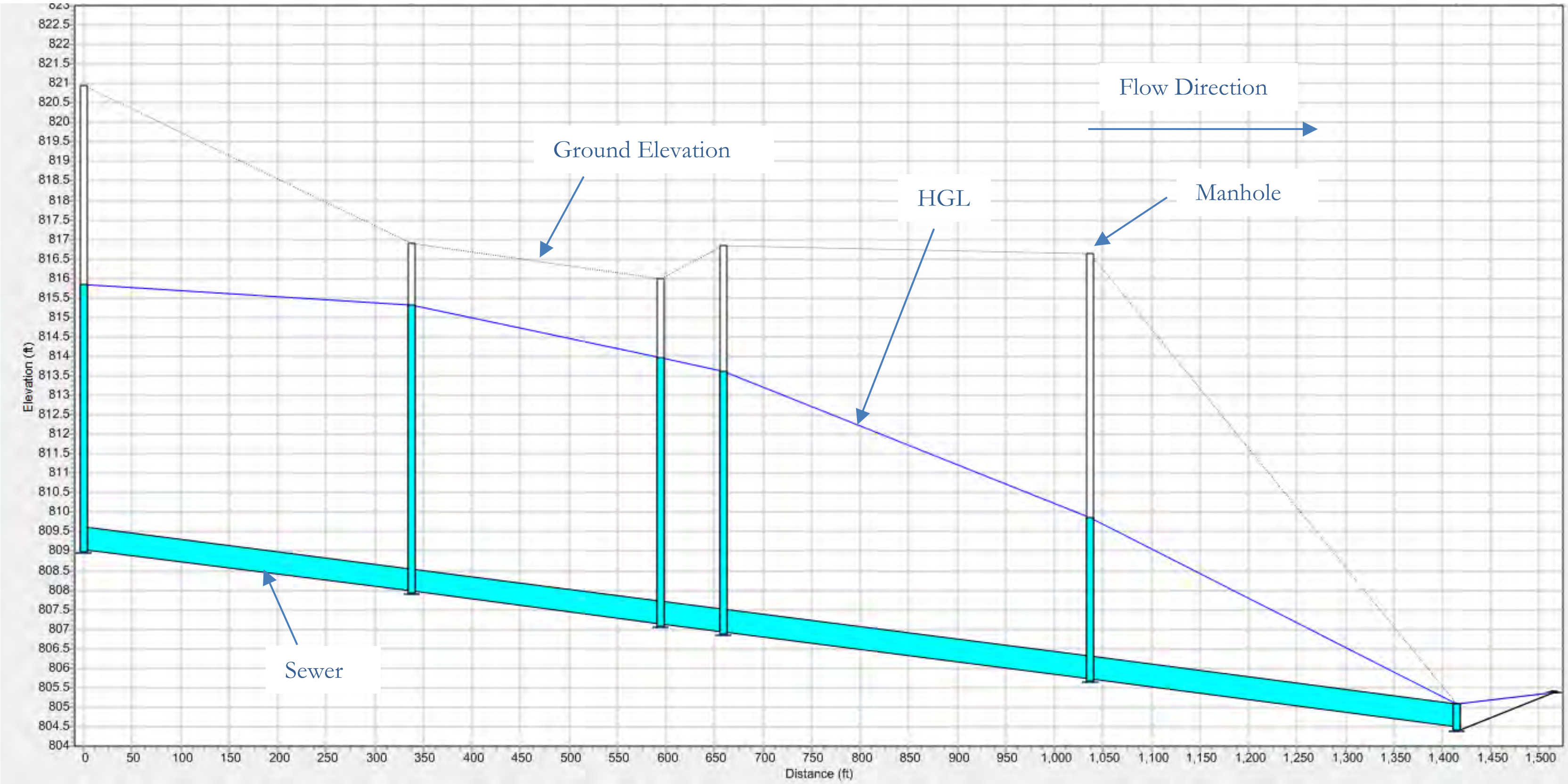


Figure 1: Profile view of modeled Area D trunk sewer – Modified Existing Conditions

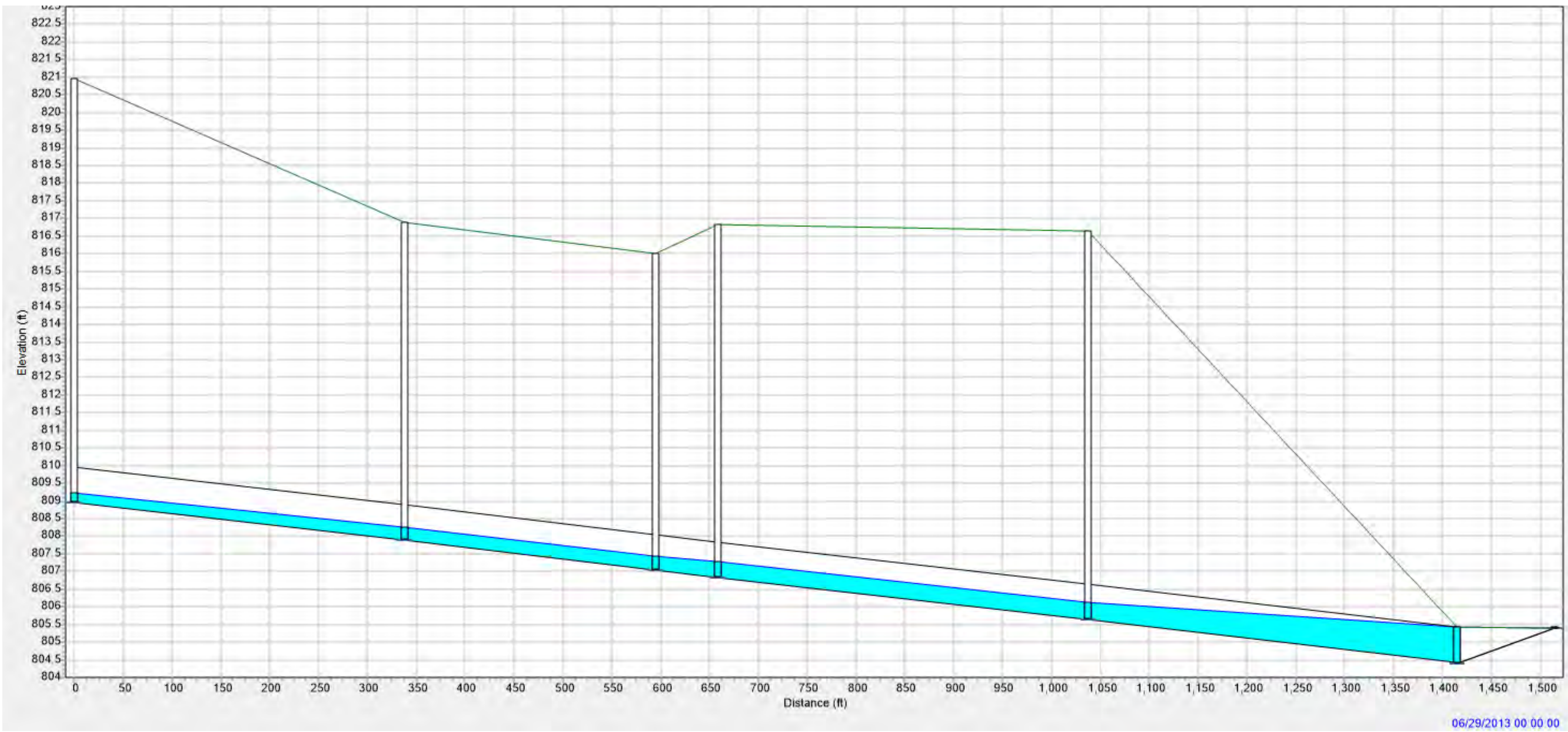


Figure 2: Profile view of modeled Area D trunk sewer – Alternative Option 1 – Norwood Replacement

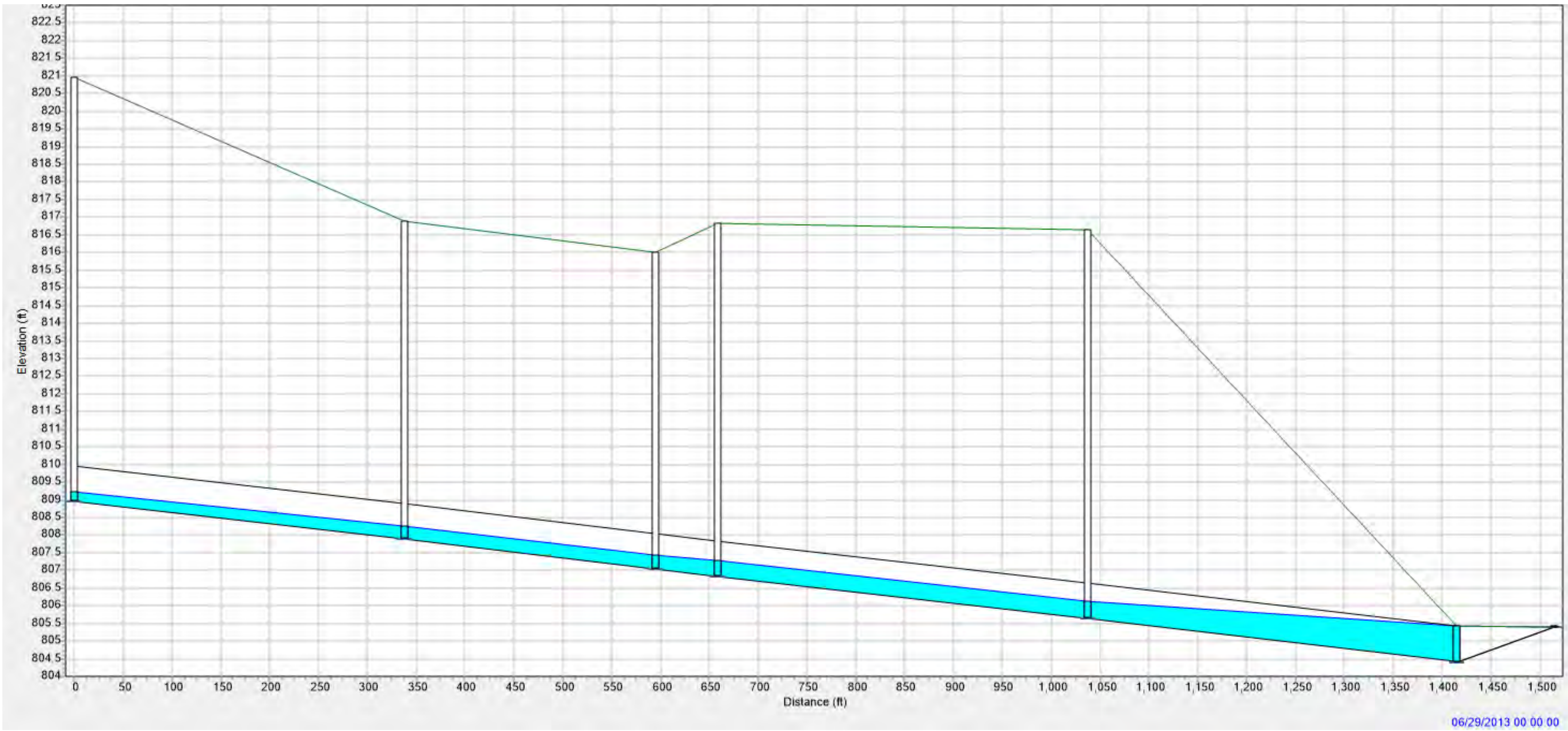


Figure 3: Profile view of modeled Area D trunk sewer – Alternative Option 2 – New Norwood Sewer

Preliminary Engineering

Currently, the sewers in the vicinity of Area D drain to the existing 12-inch sewer in Packard Road. Existing sewage flows easterly in an 8-inch collector sewer in Norwood, from Bellwood to Fernwood, and then flows south in an 8-inch sewer in Fernwood from Norwood to Packard. From there, it flows across Packard to an existing 12-inch sewer in the south side of Packard. Photos of the location are shown in Appendix B.

The following preliminary engineering analyses look into Alternative One and Alternative Two, described above.

Alternative One – Norwood Replacement

Alternative One is to replace the existing 8" sewer with 12" diameter sewer in Norwood between Bellwood and Fernwood, and to replace the existing 8" sewer in Fernwood with 12"diameter sewer between Norwood and Packard. Appendix C reviews preliminary cost estimates for this Alternative, and Figure 10 in Appendix D identifies the replacement sewer for this Alternative.

Sewer Design

i. The proposed sanitary sewer could be 12" PVC (polyvinyl chloride) or vitrified clay pipe in accordance with the Ann Arbor Design Standards.
ii. The existing sewers have slopes of approximately 0.3%. The proposed sewer would have similar slopes.

Route Description

i. Norwood and Fernwood are residential streets. Packard is an arterial road.
ii. Drains- there is a local storm drainage system in the roads consisting of mostly 12" diameter sewers. There are potentially storm sewers in Packard Road that would have to be crossed by the proposed sewer. These are not yet identified.
iii. Roads – the existing pavement in Norwood and Fernwood is asphalt in average condition. The roads have concrete curb and gutter. Norwood has 66 feet of right-of-way and Fernwood has 50 feet of right-of-way. Packard is a 120 feet wide arterial road with 5 lanes of pavement.

Construction Methods

i. The anticipated construction method would be open cut installation of the sewers. Installation of new sewers by the pipe bursting method was considered. This method would not be favorable for this project because of the proximity of existing utilities to the existing sanitary sewer. A large force is needed to burst an existing 8" diameter pipe to a condition where a new 12" pipe could be pulled through the void. This force could damage existing water main and storm sewers which in some areas are within 5' of the existing sanitary sewer. The age of the existing utilities makes them vulnerable to the pipe bursting forces. Pipe bursting would be feasible for one of the sewer segments, but it would not be economical to do so for such a short distance of sewer.
ii. Construction could be staged in a way that the new segments could be built while the existing sewer remains in operation. After successful testing of the new sewer, it would be connected into the existing system. After it is operational, the existing house laterals would be switched over to the new sewer, and the existing sewer would be abandoned in place. Bypass pumping

of the sewage flow would be required during some of the construction operations and connections.

iii. Because of the age, proximity and depth of the local water main and storm sewers, it is anticipated that all of the local water main and sewers in Fernwood and Norwood would be replaced.

Potential Construction Challenges

i. The Fernwood right-of-way width is 50 feet. This is a narrow corridor with a number of large trees close to the road. In order to replace the sewer using open cut methods, the road surface will need to be removed and replaced.

ii. Packard Road is a heavily travelled road. The crossing of the sewer from the north side to the south side of the road could best be accomplished by jacking and boring across the road. The sewer would be placed in a steel casing pipe that is jacked into place.

Traffic Control Considerations

i. The local traffic in Norwood and Fernwood could be managed with traffic control devices.

ii. The sewer crossing of Packard by jacking and boring would require staging areas for construction materials and equipment. Construction operations in Packard Road could require shutting down a traffic lane and temporarily modifying the traffic light at the intersection of Fernwood and Packard.

iii. There is an existing school at the corner of Norwood and Fernwood. Coordination would be required with the school district to manage school busses and other traffic coming and going from the school.

Easement Needs

i. It is not anticipated that any permanent easements would need to be acquired for the project as the work will be done in public streets. Temporary construction easements may be needed for construction operations.

A summary of street segments in the project under Alternative One are shown in the following table.

Table 4: Alternative One Sewer Lengths

Alternative One - Street Segments	Existing San	Existing Storm	Exist WM	Distance ft	Pipe Burst Feasible	Reason
Norwood – Bellwood to Parkwood	8”	12”	none	340	NO	Proximity to storm sewer
Norwood –Parkwood to Fernwood	8”	12”	none	320	YES	
Fernwood –Norwood to Packard	8”	12”	8”	760	NO	Proximity to storm and WM
Packard Road Crossing	8”			200	NO	Proximity to utilities
TOTAL				1,620		

Alternative Two – New Norwood Sewer

Alternative Two is to replace the existing 8-inch with 12-inch in Norwood from Bellwood to the existing 24-inch sewer just east of Whitewood and to the leave the existing 8-inch sewer in Fernwood intact.

The existing sewer in Fernwood would be disconnected from the manhole at the corner of Norwood and Fernwood, such that it would only carry the flow from the Fernwood St. homes. The new high end of the existing 8” sewer in Fernwood would be a new manhole in the south side of the Norwood/Fernwood intersection. The existing 8” in Fernwood would be lined with CIPP to improve its poor condition.

The route of new sewer would be in Norwood from Bellwood to east of Whitewood. At that point it would be connected to the existing 24” Swift Run Relief sewer. Because of the proximity of other utilities, pipe bursting would only be feasible for one pipe run. Therefore, the construction method for the new 12” would be open cut. A potential advantage of constructing Option 2 is that it may be feasible to build at a depth that it could receive flow from the neighborhood to the north.

Sewer Design

i. The proposed sanitary sewer could be 12” PVC (polyvinyl chloride) or vitrified clay pipe in accordance with the Ann Arbor Design Standards.
ii. The existing sewers have slopes around 0.3%. The proposed sewer would have similar slopes.

Route Description and Crossings

i. Norwood is a residential street with 66 ft wide right-of-way.
ii. Drains: there is a local storm drainage system in the roads consisting of mostly 12” to 15” storm sewers. There is a 42” diameter storm sewer adjacent to the 24” Swift Run Relief sewer that the proposed sanitary sewer will have to cross to connect to the existing sewer.

iii. Roads: the existing pavement in Norwood is asphalt in average condition. The roads have concrete curb and gutter. The sidewalk is immediately adjacent to the road east of Pittsfield.

Construction Methods

i. The anticipated construction method would be open cut installation of the sewers. Installation of new sewers by the pipe bursting method was considered. This method would not be favorable for this project because of the proximity of existing utilities to the existing sanitary sewer. A large force is needed to burst an existing 8" diameter pipe to a condition where a new 12" pipe could be pulled through the void. This force could damage existing water main and storm sewers which in some areas are within 5' of the existing sanitary sewer. The age of the existing utilities makes them more vulnerable to the pipe bursting forces. Pipe bursting would be feasible for one of the sewer segments, but it would not be economical to do so for such a short distance.

ii. Construction could be staged in a way that the new segments could be built while the existing sewer remains in operation. After successful testing of the new sewer, it would be connected into the existing system. After it is operational, the existing house laterals would be switched over to the new sewer, and the existing sewer would be abandoned in place. Bypass pumping of the sewage flow would be required during some of the construction operations and connections.

iii. Because of the age, proximity and depth of the local water main and sewers, it is anticipated that all of the local water main and sewers in Norwood would be replaced.

Potential Construction Challenges

i. Connection of the proposed 12" sewer to the existing 24" Swift Run Relief sewer will require the crossing of a 42" storm drain. This is a low area and controlling surface waters during construction may be a challenge.

Traffic Control Considerations

i. The local traffic in Norwood could be managed with traffic control devices.

ii. There is an existing school at the corner of Norwood and Fernwood. Coordination would be required with the school district to manage school busses and other traffic coming and going from the school.

Easement Needs

i. It is not anticipated that any permanent easements would need to be acquired for the project as the work will be done in public streets and easements. Temporary construction easements may be needed for construction operations.

Summary of street segments under Alternative Two are shown in the following table.

Table 5: Alternative Two Sewer Lengths

Alternative Two - Street Segments	**Existing San**	**Existing Storm**	**Exist WM**	**Distance, ft**	**Pipe Burst Feasible**	**Reason**
Norwood – Bellwood to Parkwood	8"	12"	none	340	NO	Proximity to storm sewer
Norwood –Parkwood to Fernwood	8"	12"	none	320	YES	
Norwood – Fernwood to Pittsfield	none	12"	none	355	NO	No exist sewer here
Norwood – Pittsfield to Whitewood	8"	15" to 18"	6"	680	NO	Proximity to WM
TOTAL				1,695		

Opinions on Probably Construction Costs
The detailed opinions on probably construction costs are attached. The totals are:

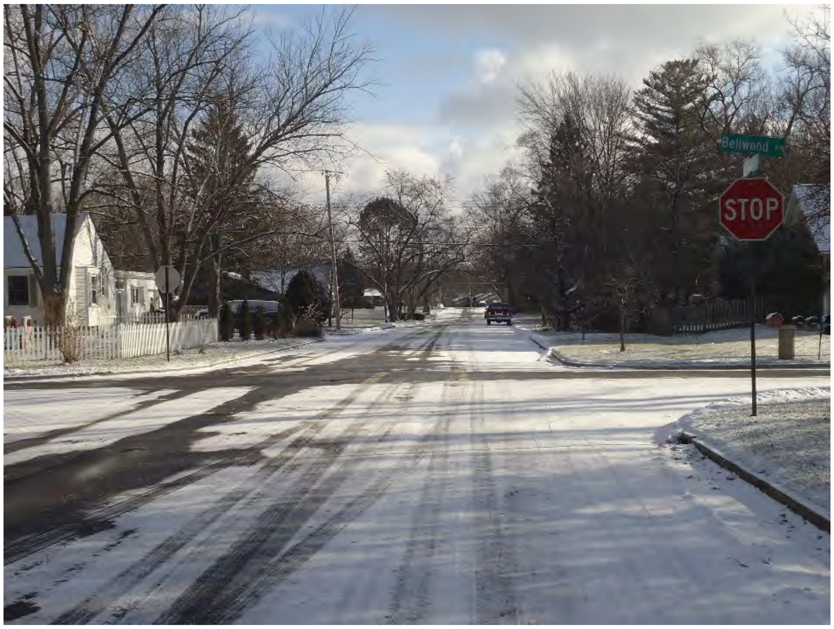
i. Alternative One: $2,935,000
ii. Alternative Two: $2,948,000

Conceptual Plans
Preliminary conceptual plans for each option are attached.

Photos
Representative photos of the project area are attached.

Appendix D

Photos of Area with Recommended Improvements



Looking east on Norwood from Bellwood

Looking east on Norwood from Fernwood

Looking south on Fernwood from Norwood

Looking south on Fernwood near Packard

Looking east on Packard from Fernwood

Looking west on Packard from Fernwood

Appendix E

Preliminary Cost Estimates

Project Summary
Engineer's Opinion of Probable Project Costs

Owner: City of Ann Arbor
Project: Sanitary Sewer Improvement Project
Work: AREA D - OPTION 1
Upsize existing sewer from 8 inch to 12 inch
Norwood - Bellwood to Fernwood
Fernwood- Norwood to Packard

Date: 3/8/2017
Project No. 0028-15-0051
Prepared By: E.Gumpper
Reviewed By:

Item No.	Item Description	Est. Quantity	Unit	Unit Price	Total Cost
1	Mobilization (5%)	1	LS	$83,000	$83,000
2	Soil Erosion and Sediment Control (1%)	1	LS	$16,000	$16,000
3	Traffic Maintenance and Control (6%)	1	LS	$93,000	$93,000
4	Digital Video Route Survey	1	LS	$2,000	$2,000
5	Exploratory Excavations	6	EA	$2,000	$12,000
6	Sewer, 12 inch, Tr Det B (10'-20' Deep) (sand)	1520	FT	$150	$228,000
7	Sewer, 12 inch, Bore & Jack in Steel Casing	100	FT	$400	$40,000
8	Sewer, Replace Lateral	20	EA	$3,000	$60,000
9	Trench Under Cut and Back Fill (6A)	150	CYD	$50	$7,500
10	Dewatering Trench	150	FT	$50	$7,500
11	Bypass Pumping (during sewer re-connections)	1	LS	$10,000	$10,000
12	Sanitary Sewer Manhole, 4 ft diameter	7	EA	$12,000	$84,000
13	Water Main, 8 inch Ductile Iron	760	FT	$120	$91,200
14	Fire Hydrants	2	EA	$5,000	$10,000
15	Gate Valve and Well, 8 inch	2	EA	$12,000	$24,000
16	Replace Water Service	20	EA	$1,500	$30,000
17	Storm Sewer, 12 inch	1420	FT	$100	$142,000
18	Storm Drain Structure	20	EA	$10,000	$200,000
19	Gas Main Replacement	500	FT	$40	$20,000
20	Green Streets Initiatives	1600	FT	$50	$80,000
21	Pavement Remove and Replacement	5170	SYD	$50	$258,500
22	Curb and Gutter, Remove and Replace	3410	FT	$25	$85,250
23	Driveway Replacement	500	SYD	$60	$30,000
24	Subgrade Undercutting	300	CYD	$100	$30,000
25	Road Grading	16	STA	$4,000	$64,000
26	Clearing & Tree Removal	1	LS	$2,000	$2,000
27	Green Belt Restoration	5200	SYD	$5	$26,000
28	Utility Relocation Allowance	1	LS	$5,000	$5,000
29	Easement Acqusition Allowance	1	LS	$1,000	$1,000
30	Permit Application Allowance	1	LS	$500	$500
31	General Conditions & Requirements	10	%		$174,000.00
	CONSTRUCTION SUBTOTAL				**$1,917,000.00**
	Engineering, Contract Admin, Constr Eng, Observation	25	%		**$480,000.00**
	Geotechnical Services	3	%		**$58,000.00**
	Contingencies	25	**%**		**$480,000.00**
	ENGINEER'S OPINION OF PROJECT COST				**$2,935,000.00**
	PROJECT ASSUMPTIONS				
	Replace exist. WM (in Fernwood)	yes			
	Replace exist. Storm	yes			
	Replace existing sidewalk (none existing)				
	Replace full width of pavement	yes			
	Assumed pavement thickness	3"	asphalt	8"	agg base
	Easement needed	no			
	Construction method	open cut			
	Proposed sewer pipe is 12" diameter. Pipe slope is about 0.3% slope.				
	Section under Packard to be jacked and bored.				
	Existing soils information not known.				
	Replace laterals up to the ROW line.				
	Assume existing sewer will be bulkheaded and left in place. (not filled)				
	Geotechnical investigations and existing utility research was out of the scope of this study.				
	Replace entire road along the sewer route. Assume 3" asphalt over 8" aggregate (bit=$100/ton)				
	Pavement work includes costs for removal and replacement of HMA, aggregate base, underdrain, and pavement markings.				

Project Summary
Engineer's Opinion of Probable Project Costs

Owner: City of Ann Arbor
Project: Sanitary Sewer Improvement Project
Work: AREA D - OPTION 2
Upsize existing sewer from 8 inch to 12 inch
In Norwood from Bellwood to Whitewood

Date: 3/8/2017
Project No. 0028-15-0051
Prepared By: E.Gumpper
Reviewed By:

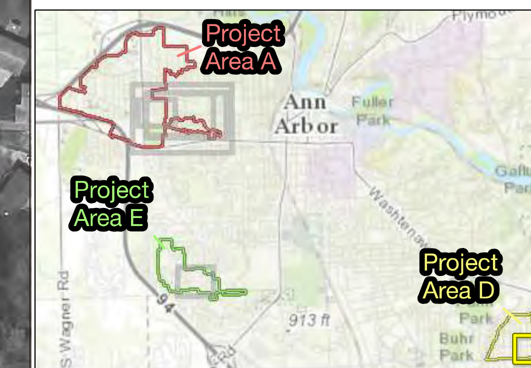
Item No.	Item Description	Est. Quantity	Unit	Unit Price	Total Cost
1	Mobilization (5%)	1	LS	$84,000	$84,000
2	Soil Erosion and Sediment Control (1%)	1	LS	$16,000	$16,000
3	Traffic Maintenance and Control (3%)	1	LS	$48,000	$48,000
4	Digital Video Route Survey	1	LS	$2,000	$2,000
5	Exploratory Excavations	6	EA	$2,000	$12,000
6	Sewer, 12 inch, Tr Det B (10'-20' Deep) (sand)	1700	FT	$150	$255,000
7	Sewer, Replace Lateral	6	EA	$3,000	$18,000
8	Trench Under Cut and Back Fill (6A)	170	CYD	$50	$8,500
9	Dewatering Trench	170	FT	$50	$8,500
10	Connection to existing 24 inch with Dewatering	1	LS	$10,000	$10,000
11	Cured In Place Pipe (CIPP) 8" diameter sewer	760	FT	$40	$30,400
12	Bypass Pumping (during sewer reconnections and CIPP)	1	LS	$20,000	$20,000
13	Sanitary Sewer Manhole, 4 ft diameter	8	EA	$12,000	$96,000
14	Water Main, 8 inch Ductile Iron (replacement of ex 6")	680	FT	$120	$81,600
15	Fire Hydrants	2	EA	$5,000	$10,000
16	Gate Valve and Well, 8 inch	2	EA	$12,000	$24,000
17	Replace Water Service	8	EA	$1,500	$12,000
18	Storm Sewer, 12 inch	1020	FT	$100	$102,000
19	Storm Sewer 18 inch	680	FT	$130	$88,400
20	Storm Drain Structures	8	EA	$10,000	$80,000
21	Storm Drain Manhole, 5 ft diameter	4	EA	$15,000	$60,000
22	Gas Main Replacement	200	FT	$40	$8,000
23	Green Streets Initiatives	1700	FT	$50	$85,000
24	Pavement Remove and Replacement	6240	SYD	$50	$312,000
25	Curb and Gutter, Remove and Replace	3300	FT	$25	$82,500
26	Sidewalk , Remove and Replace	7400	SFT	$5	$37,000
27	Driveway Replacement	500	SYD	$60	$30,000
28	Subgrade Undercutting	200	CYD	$100	$20,000
29	Road Grading	17	STA	$4,000	$68,000
30	Clearing & Tree Removal	1	LS	$2,000	$2,000
31	Green Belt Restoration	6660	SYD	$5	$33,300
32	Utility Relocation Allowance	1	LS	$5,000	$5,000
33	Easement Acqusition Allowance	1	LS	$1,000	$1,000
34	Permit Application Allowance	1	LS	$500	$500
35	General Conditions & Requirements	10	%		$175,000.00
	CONSTRUCTION SUBTOTAL				**$1,926,000.00**
	Engineering, Contract Admin, Constr Eng, Observation	25	%		**$482,000.00**
	Geotechnical Services	3	%		**$58,000.00**
	Contingencies	25	%		**$482,000.00**
	ENGINEER'S OPINION OF PROJECT COST				**$2,948,000.00**
	PROJECT ASSUMPTIONS				
	Replace exist. WM (Pittsfield to Whitewood)	**yes**			
	Replace exist. Storm	**yes**			
	Replace existing sidewalk (Pittsfield to Whitewood)	**yes**			
	Replace full width of pavement (34ft b to b of curb)	**yes**			
	Assumed pavement thickness	**3"**	**asphalt**	**8"**	**agg base**
	Easement needed		**yes**		
	construction method	**open cut**			
	Proposed sewer pipe is 12" diameter at about 0.30% slope.				
	Open cut construction method will be used.				
	Existing soils information not known.				
	Replace laterals up to the ROW line.				
	Assume existing sewer will be bulkheaded and left in place. (not filled)				
	Geotechnical investigations and existing utility research was out of the scope of this study.				
	Replace entire road along the sewer route. Assume 3" asphalt over 8" aggregate (bit=$100/ton)				
	Pavement work includes costs for removal and replacement of HMA, aggregate base, underdrain, and pavement markings.				

Appendix F

Preliminary Conceptual Plans

Ann Arbor Sanitary Sewer Improvements

Area D - Option 1



Improvement Areas
- Area A
- Area D
- Area E

Proposed Sanitary Mains - Size
- 12"
- 18"
- 21"
- Sanitary Manhole

Sanitary Main - Type
- Collector
- Force Main
- Storm Manhole
- Storm Discharge Point
- Storm Catchbasin
- Storm Main

Project Areas
- Project Area A
- Project Area D
- Project Area E

0 200 400
Feet

1 " = 200 '

Source: Data provided by Washtenaw County and the City of Ann Arbor. OHM Advisors does not warrant the accuracy of the data and/or the map. This document is intended to depict the approximate spatial location of the mapped features within the Community and all use is strictly at the user's own risk.

Coordinate System: NAD 1983 StatePlane Michigan South FIPS 2113 Feet Intl

Map Published: March 9, 2017

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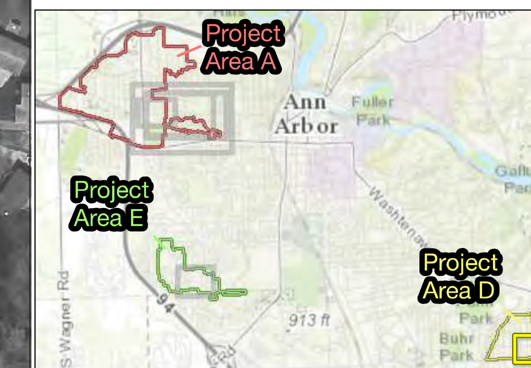
Ann Arbor Sanitary Sewer Improvements

Area D - Option 2



Improvement Areas
- Area A
- Area D
- Area E

Proposed Sanitary Mains - Size
- 12"
- 18"
- 21"
- Sanitary Manhole

Sanitary Main - Type
- Collector
- Force Main
- Storm Manhole
- Storm Discharge Point
- Storm Catchbasin
- Storm Main

Project Areas
- Project Area A
- Project Area D
- Project Area E

0 200 400
Feet

1 " = 200 '

Source: Data provided by Washtenaw County and the City of Ann Arbor. OHM Advisors does not warrant the accuracy of the data and/or the map. This document is intended to depict the approximate spatial location of the mapped features within the Community and all use is strictly at the user's own risk.

Coordinate System: NAD 1983 StatePlane Michigan South FIPS 2113 Feet Intl

Map Published: March 9, 2017

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Area E Objective

During the 2013 SSWWEP study, Area E, Glen Leven, was found to have hydraulic modeling results showing surcharging in approximately 1,800 feet of sewer. The action plan following the 2013 study, was to perform SSES to better understand the inflow and infiltration sources in the area. As part of the 2016 SSIPE project, basement elevation surveys, pipeline inspections, manhole inspections, and smoke tests were done. The SSES results are discussed in detail in Volume 2: Field Data Collection and SSES Report, and the original project sheets describing this area are found in Appendix A of the SSES Report. Figure 1 shows the location of Area E.

Area E Modeling Results

The 2013 hydraulic model was used to re-evaluate Area E. With the new basement survey elevation data, the hydraulic model showed that although the pipes were overloaded and caused surcharging, the hydraulic grade line did not reach the lowest basement elevation. This is shown in Figure 2, below. It was determined based on discussion with the City that this level of surcharging was acceptable, and no improvements were recommended for this area.

CITY OF ANN ARBOR MICHIGAN

Ann Arbor Sanitary Sewer Improvements

Area E Study Area

Figure 1

- R Rain Gage
- M Flow Meter
- SanManholes
- Collector
- Force Main
- Area E

Source: Data provided by Washtenaw County and the City of Ann Arbor. OHM Advisors does not warrant the accuracy of the data and/or the map. This document is intended to depict the approximate spatial location of the mapped features within the Community and all use is strictly at the user's own risk.

Coordinate System: NAD 1983 StatePlane Michigan South FIPS 2113 Feet Intl

Map Published: June 29, 2017

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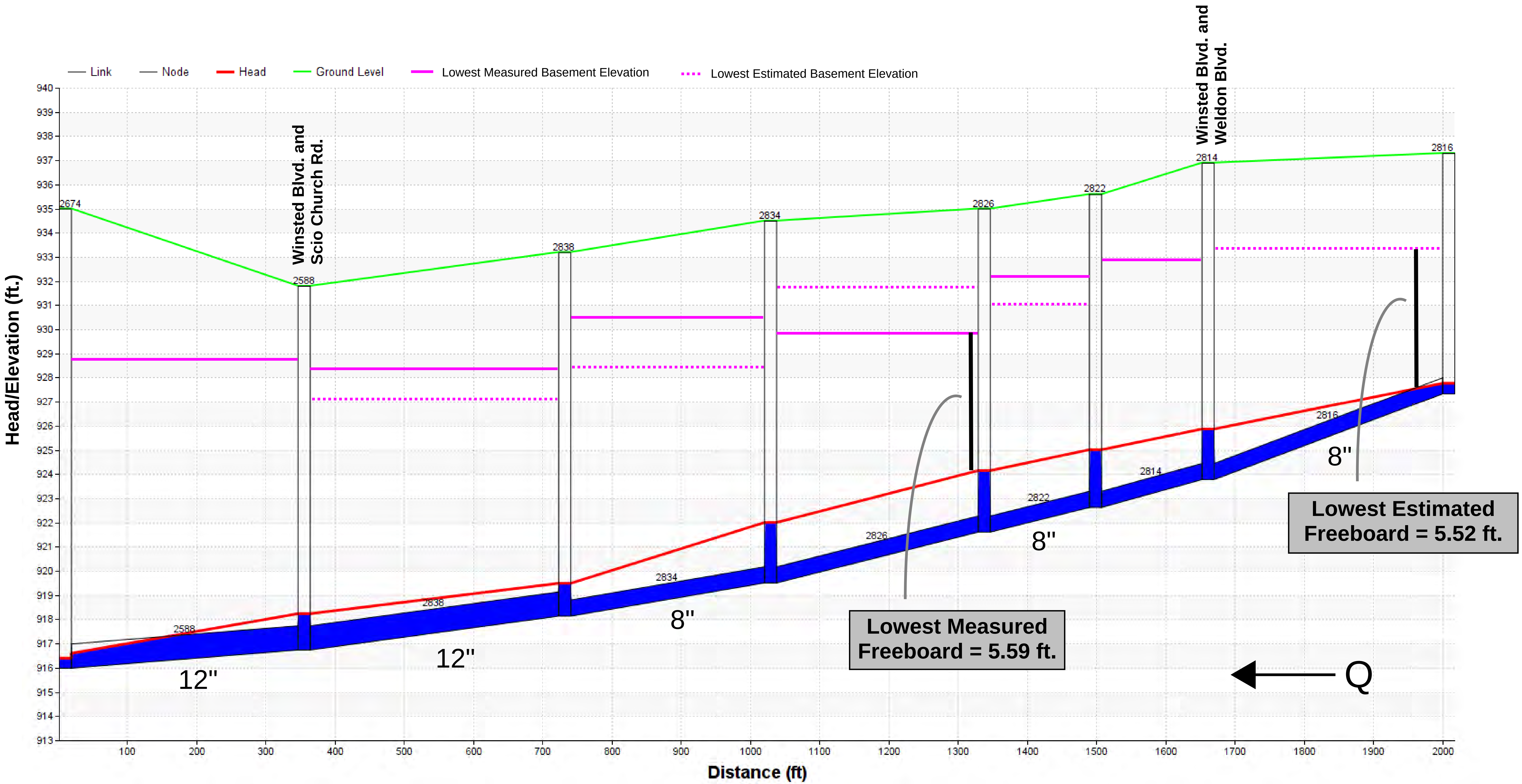
P:\0000_0100\0028150050_SS_Improvements_Preliminary_Eng_GIS\ArcLayouts\20170629 Area E SSIPE Flow Metering.mxd

Area E - Winsted Blvd.



Existing Conditions

Area F Objective

See Appendix G for the memorandum detailing the findings, model analysis, and recommendations for Project Area F.

Appendix G

Area F Diversion Memorandum

OHM
Advancing Communities®

memorandum

Date: October 20, 2017

To: Troy Baughman, City of Ann Arbor
Brian Slizewski, City of Ann Arbor

From: Mackenzie Johnson, OHM Advisors

Re: Area F – Glen/Fuller Sewer Diversion Structure

Enclosed in this memorandum is a summary of the findings resulting from an analysis of the sanitary sewer diversion structure in the City of Ann Arbor. The information contained in this memorandum will be included in the Modeling and Preliminary Engineering Report.

The Glen/Fuller diversion structure is located in Fuller Road just east of Glen Court and west of the University of Michigan hospital. It helps move flow from the southern interceptor, via a cut-out in the circular southern interceptor sewer pipe, acting as a weir, to the northern interceptor. It alleviates capacity constraints in the southern interceptor by making use of the available capacity in the northern interceptor.

There is concern that the existing diversion structure does not accomplish the desired flow split between the northern and southern interceptors. The desired split is based on the design event sanitary sewer flow modeling results. The City prepared a proposed design of an upgrade to the diversion structure and requested an evaluation of the design.

<u>Executive Summary of Findings</u>

An overall summary of the findings from this study are as follows:

- The identified overloading in the southern interceptor requires the use of a diversion structure to eliminate the need for expensive relief sewers downstream of the Glen/Fuller diversion.
- The existing diversion structure configuration would not be able to divert the desired amount of flow. It is desired to send about 65% of the peak wet weather flow over the diversion weir, but the existing structure will result in diverting only about 35%.
- The modified diversion structure depicted in the design plans from the City could work; however, continuous maintenance issues are likely.
- Design suggestions include the following:
    - o A custom flume could be installed in the existing structure that would achieve the desired flow split during both dry and wet weather.
    - o A new diversion structure could be constructed at or near the existing diversion manhole to achieve the desired flow split. This structure could be designed to allow for ease of access for maintenance and could be located out of traffic to provide greater safety for maintenance staff.

Details of the comments on the City's proposed design and other suggestions for the design of the structure are outlined in the memo.

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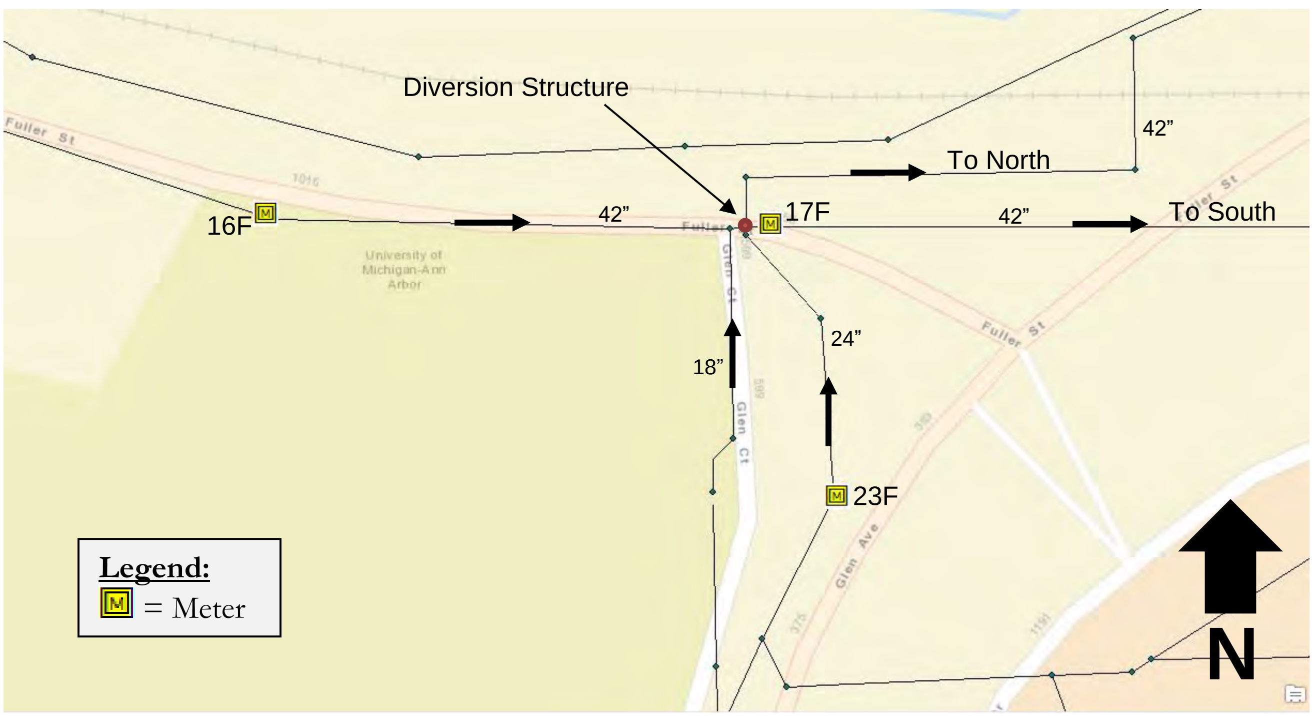
Existing Conditions

The existing manhole structure with the diversion contains a 42-inch pipe suspended about four feet above the bottom of the inflow manhole. It also contains an incoming 24-inch pipe from the south and an outgoing 42-inch pipe to the north, both of which have inverts at or near the bottom of the manhole. Flow through the 42-inch suspended pipe enters the manhole structure from the west and exits to the east as it continues to make its way to the wastewater treatment plant (WWTP) via the southern interceptor. A schematic of the area is shown below in Figure 1. The meter locations are indicated by the yellow squares in the figure, and the diversion structure is located in the manhole highlighted in red in the figure. Flow diversion occurs through a side-weir that was constructed by cutting off the top half of the southern interceptor sewer pipe inside the diversion manhole along the length that is located within the manhole. The purpose of this weir is to allow dry weather flow to continue to the WWTP via the southern interceptor, but to have wet weather flow spill over the sides of the pipe and flow into the lower 42-inch pipe where it would reach the WWTP via the northern interceptor.

The southern interceptor downstream of the diversion structure near the WWTP experiences capacity constraints during wet weather events; thus, the weir was intended to help alleviate the southern interceptor by redirecting some of the wet weather flow to the northern interceptor, which has available capacity. All flow heading to the WWTP via the northern interceptor must be pumped to the plant. It is desired to only allow wet weather flow to spill into the northern interceptor to minimize pumping. It is further understood that the pumps downstream of the northern interceptor are screw pumps, which are being operated on a continuous basis.

Figure 1: Diversion Schematic



Flow Diversion Analysis

In order to understand how the weir currently operates, field measurements were taken while the suspended pipe was dammed diverting all flow over the weir. The weir height and depth of water in the blocked suspended pipe were measured. The depth of water flowing over the weir was measured to be 0.3 feet. Based on the day of the year and the time of day the depth measurement was taken, a flow rate of 9 cfs at that same time and date was extrapolated from past meter data to be used in the standard weir equation. The equation produced a theoretical depth of 0.36 feet at this flow rate. The similarity between the measured and theoretical depths indicate that the weir is operating like a normal weir without side-overflow inefficiencies at that flow rate. Thus, the standard weir equation could be used for analysis at this flow rate.

The 2013 Scenario B design event model was used to analyze the performance of this weir structure. The distance between the bottom of the 42-inch southern interceptor sewer pipe and the crest where the pipe is cut-off was measured to be 21-inches (1.7 feet). The figure in Appendix A shows a plan and profile view of the diversion structure. Several assumptions were made in the model, including:

- Lateral flow contribution from the 18-inch pipe in Glen Ct. is negligible (connects at Fuller St. between meters 16F and 17F).
- The manhole diameter is 78-inches (6.5 feet), so the weir length is assumed to be 78-inches on each side (for a total length of 13 ft.) since the weir appears to extend along the entire diameter of the manhole.

Table 1 below summarizes the modeling results, and the analysis of the results follows.

Table 1: Wet Weather Model Results

Scenario	Wet Weather		
	Southern Interceptor (cfs)	Northern Interceptor (cfs)	Surcharging Downstream (ft.)
Existing Flow Split	13.5	7.5	2
Flow Split 1	7.5	13.5	0
*Flow Split 2	10	11	1
Divert All Flow to North	0	21	0

*Selected Flow Split

1. The wet weather model results show that a flow split of 7.5 cfs to the southern interceptor and 13.5 cfs diverted over the weir to the northern interceptor would be sufficient to resolve the southern interceptor capacity issues. A flow split of 10cfs/11cfs would result in 1 foot of surcharging in the southern interceptor, and the existing flow split would result in 2 feet of surcharging in the southern interceptor.
2. Flow metering data shows that the average dry weather flow through the diversion structure is about 6.5 cfs while the daily peak dry weather flow is about 10 cfs (see Appendix B).
   a. Ideally, all dry weather flow would continue along the southern interceptor while the wet weather flow would be diverted. This way only wet weather flow, and not daily dry weather flow, would be pumped again at the treatment plant. Although the flow split of 7.5 cfs to the south and 13.5 cfs to the north will resolve the capacity constraints, some dry weather flow will be diverted on a daily basis.
   b. A flow split of 10 cfs to the south and 11 cfs to the north would allow all of the dry weather flow to be conveyed via the southern interceptor and only minimal surcharging would occur. Field surveys would be necessary to ensure one foot of surcharging in the southern interceptor will not cause basement backups (see Appendix C).

3. Provided that one foot of surcharging is deemed to be acceptable following field surveys, the desired flow split at the diversion manhole is 10 cfs to the southern interceptor (dry weather flow) and 11 cfs diverted over the weir to the northern interceptor (wet weather flow).
4. The existing weir crest is 21-inches or 1.7 feet above the 42-inch suspended pipe invert. This means that the downstream system must produce a depth of at least 21-inches to drive flow over the weir.
5. The model shows that at 10 cfs discharged to the southern interceptor, the flow depth downstream of the weir is 1.4 feet in the 42-inch suspended pipe. This depth is not sufficient to drive flow over the weir, indicating that the desired flow split will not occur with the existing structure and more flow will be conveyed via the southern interceptor than desired.
6. With the current weir height, the flow split will approximately be 7.5 cfs over the weir and 13.5 cfs downstream, which will cause downstream issues in the southern interceptor.
7. A diversion of 11 cfs would result in a depth over the weir of 0.4 feet using the standard weir equation. This depth may be higher if there are side overflow weir inefficiencies at this flow rate. This depth over the weir requires a depth of 2.1 feet in the 42-inch suspended pipe (computed from the weir crest of 1.7 feet plus the weir depth of 0.4 feet).
8. Given the above computations, the desired flow split will not occur without modifications to the existing structure. Neither of the potential modification options to the structure are desirable:
    a. Lower the weir height: The weir would have to be cut so low that the suspended pipe is likely to experience structural integrity issues. The required weir height would be one foot above the invert of the 42-inch suspended pipe (computed from the 1.4 feet of depth created in the downstream system at 10 cfs minus the 0.4 feet required to drive 11 cfs over the weir).
    b. Add another weir downstream to back-up the flow: This would cause excessive sedimentation and maintenance issues at the downstream weir.
9. Based on these findings, installation of a new diversion pipe with a flume in the existing structure or construction of a new diversion structure is recommended as outlined below.

Summary of Options

Following the analysis of the model results, the desired flow split between the northern and southern interceptors can be accomplished with one of the two options described below.

1. Install a Custom Flume in the Existing Structure
    a. A flume could be designed to back up the flow without causing sedimentation or other maintenance issues. A properly designed flume is a self-cleaning device in that the flow velocity increases as the flow goes through the converging inlet of the flume. The flume could be designed to back up the flow enough to drive 11 cfs over the weir.
    b. The flume, either plastic or steel, would replace the section of suspended pipe to avoid any future risk of structural failure with the existing pipe.
    c. The flume design will depend on how much flow is to be diverted and the depth of flow to be backed up.
        i. Based on these parameters, the design of the flume may result in the flume not fitting within the existing manhole structure, in which case this option would not be feasible.

2. Construct a New Structure
    a. A new structure could be constructed with a flexible weir height and vertical access shafts for maintenance operations.
        i. The weir could be adjustable to different heights and could be able to divert all flow to the north to allow for southern interceptor maintenance operations.
    b. There is potential to relocate the diversion to the manhole directly upstream.
        i. This manhole is located in the sidewalk and would avoid the need for traffic re-routing during maintenance operations.

A more detailed explanation of these options and additional design comments are provided in the next section.

Review of the City's Proposed Design and Additional Design Comments

1. Evaluation of Reducing the Weir Height in the Existing Structure

In order to achieve the desired flow split within the existing manhole structure, the weir height or length would need to be modified. Since the weir length is assumed to equal the manhole structure diameter, only the weir height (i.e. height of pipe walls) could be adjusted in the existing structure. The weir height could be reduced from 1.7 feet to 1 foot; however, this would compromise the structural integrity of the pipe.

2. *Evaluation of Installing a Custom Flume in the Existing Structure*

Since modification to the existing diversion pipe is not desired, a custom flume could be installed in the diversion manhole to back up the flow enough to drive it over the weir. A properly designed flume is self-cleaning in that the flow velocity increases as the flow travels through the converging inlet of the flume, allowing for sediments to be washed away. This makes a flume more desirable than a weir for backing up flow. The flume design is based on the amount of flow pushing through it and the desired depth of flow to be backed up. These two metrics will determine how long the flume needs to be and whether it will fit in the existing manhole structure. If it is determined that the flume will fit in the existing diversion structure, it is recommended to use a plastic or steel flume to reduce the risk of structural failure.

3. Comments on Diverting All Flow to the Northern Interceptor

To avoid the time and cost associated with modifying the existing diversion pipe, another option would be to divert all of the flow from the southern interceptor to the northern interceptor at the diversion location. This would require the 42-inch suspended pipe to be cut out and removed from the structure, and the upper 42-inch pipe exiting the structure to be blocked. Both dry and wet weather flow would then flow through the northern interceptor. This would also require all of the flow, not just the wet weather flow, to be pumped at the WWTP.

Further feasibility analyses would be needed to assess the impacts of this change on the system. It would be necessary to evaluate the impact of hydrogen sulfide generation in the diversion structure due to the approximately four-foot drop of flow that would occur inside the diversion manhole. It would also be necessary to evaluate the impact to the screw pumps downstream of the northern interceptor. It was determined that the screw pumps will require more energy, thus generating more cost, with higher flows.

The critical analysis, however, involves the impact on the self-cleansing velocity in the two-foot diameter double barrel siphon located approximately one mile downstream of the southern interceptor. The 10 States Standards requires an average flow velocity of at least 2 fps to dislodge sediment build-up and clean the pipe. Without a sufficient self-cleansing velocity, the siphon is likely to experience frequent blockages requiring maintenance services. The dry weather flow modeling results show that with the current flow split, the velocity in the siphon averages at about 4 fps. When all of the flow is diverted to the north at the diversion manhole, the velocity in the siphon averages around 1 fps. This velocity is not sufficient to clean the siphon, thus the option of diverting all flow to the northern interceptor is not desirable. Table 2 below summarizes these results.

Table 2: Wet Weather and Dry Weather Model Results

Scenario	Wet Weather			Dry Weather		
	Northern Interceptor (cfs)	Southern Interceptor (cfs)	Surcharging Downstream (ft.)	Northern Interceptor (cfs)	Southern Interceptor (cfs)	Velocity in Siphon (fps)
Existing	7.5	13.5	2	0	10	4
Flow Split 1	13.5	7.5	0	2.5	7.5	3.5
*Flow Split 2	11	10	1	0	10	4
Divert All Flow to North	21	0	0	10	0	1

*Selected Flow Split

4. Review of the City's Proposed Design

The City prepared a proposed design of an upgrade to the existing structure and requested it be evaluated. The design includes a diversion plate to be installed 10.25-inches above the invert on the downstream end of the suspended pipe. This plate would restrict some flow from going into the southern interceptor and cause more flow to spill over the sides to be diverted to the north. A secondary plate would also be installed that could be lowered to divert all flow to the north should any downstream maintenance on the southern interceptor be necessary.

Analysis of this design resulted in the determination that this is not an ideal design. The diversion plate on the downstream end of the pipe would reduce the flow area by about 80%. This provides only a very small area of 1.5 ft^2 for flow to pass through and into the southern interceptor. This design could result in numerous maintenance problems as the diversion plates may not move freely due to the excessive ragging which can be expected in a sanitary pipe. This could result in a total blockage of the pipe.

5. Comments on Designing a New Diversion Structure

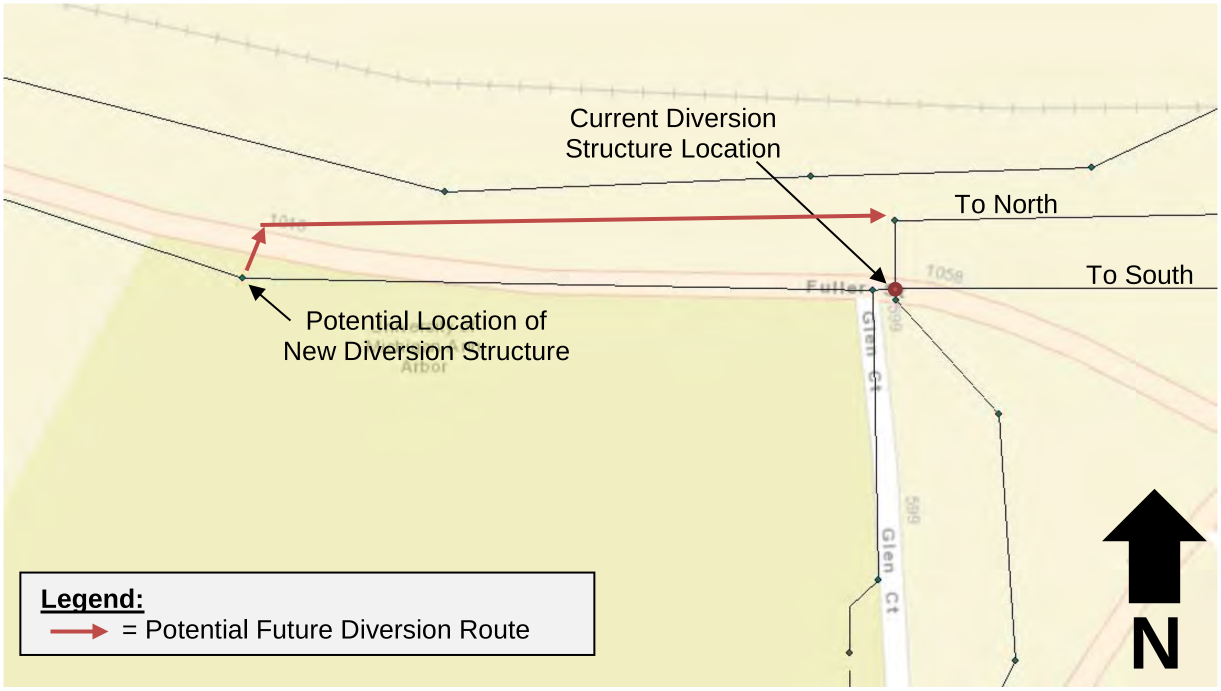
A new structure could be constructed over the existing 42-inch southern interceptor that would allow for a diversion of 11 cfs of wet weather flow to the northern interceptor while allowing the dry weather flow to continue to the southern interceptor. Designing a new diversion structure would involve several suggested revisions to the City's proposed design.

The new diversion structure could include flexible weir height operation to adjust the amount of flow to be diverted (e.g. adjust amount of flow diversion based on system improvements or long-term flow metering). It could also include flexibility to divert all flow from the southern to the northern interceptor to allow for southern interceptor maintenance activities. Flow control could be accomplished by incorporating sluice gates into the structure. The new manhole structure would need to be about 12 ft. by 12 ft. to accommodate the size of the weir and vertical access shafts for maintenance operations.

6. Diversion Structure Relocation Considerations

If a new diversion structure is desired, built-in considerations for ease of access and maintenance could be included. Access to the current structure necessitates traffic re-routing near the University of Michigan hospital. To avoid traffic re-routing, the new diversion structure could be constructed at the location of the manhole upstream of the current diversion structure as this manhole is located in the sidewalk. The new diversion structure would direct flow north and east where it would connect into the northern interceptor as shown in Figure 2 below. Traffic re-routing would be necessary during the construction of the diversion structure, but would not be necessary for future maintenance activities.

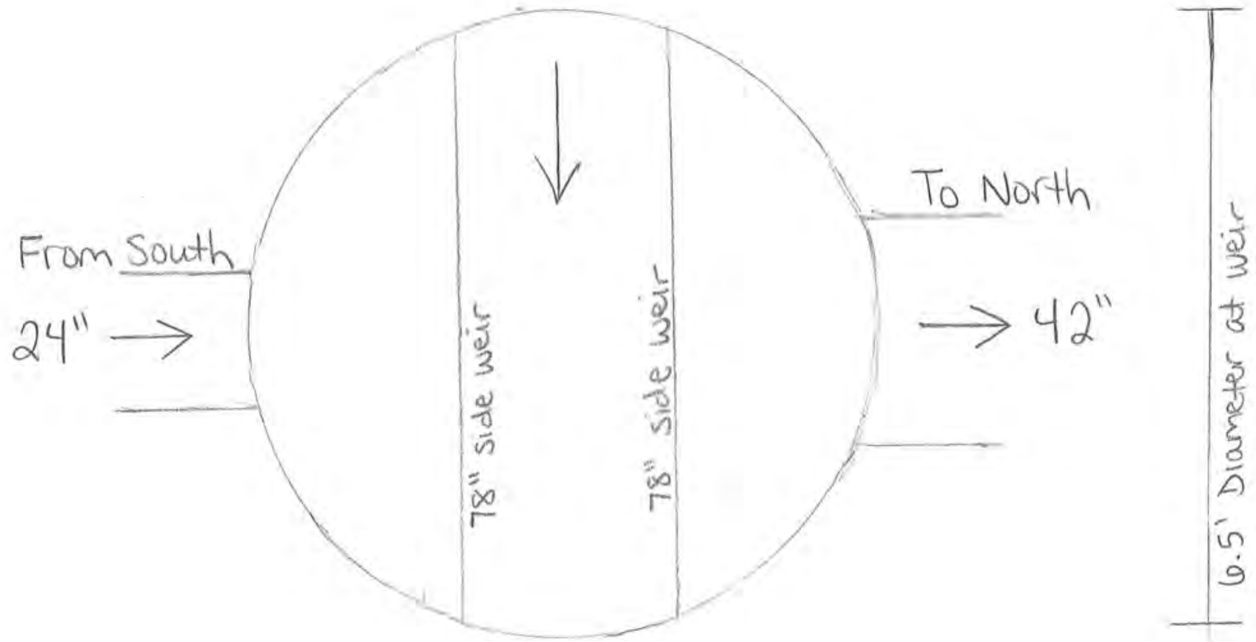
Figure 2: Potential Location of New Diversion Structure



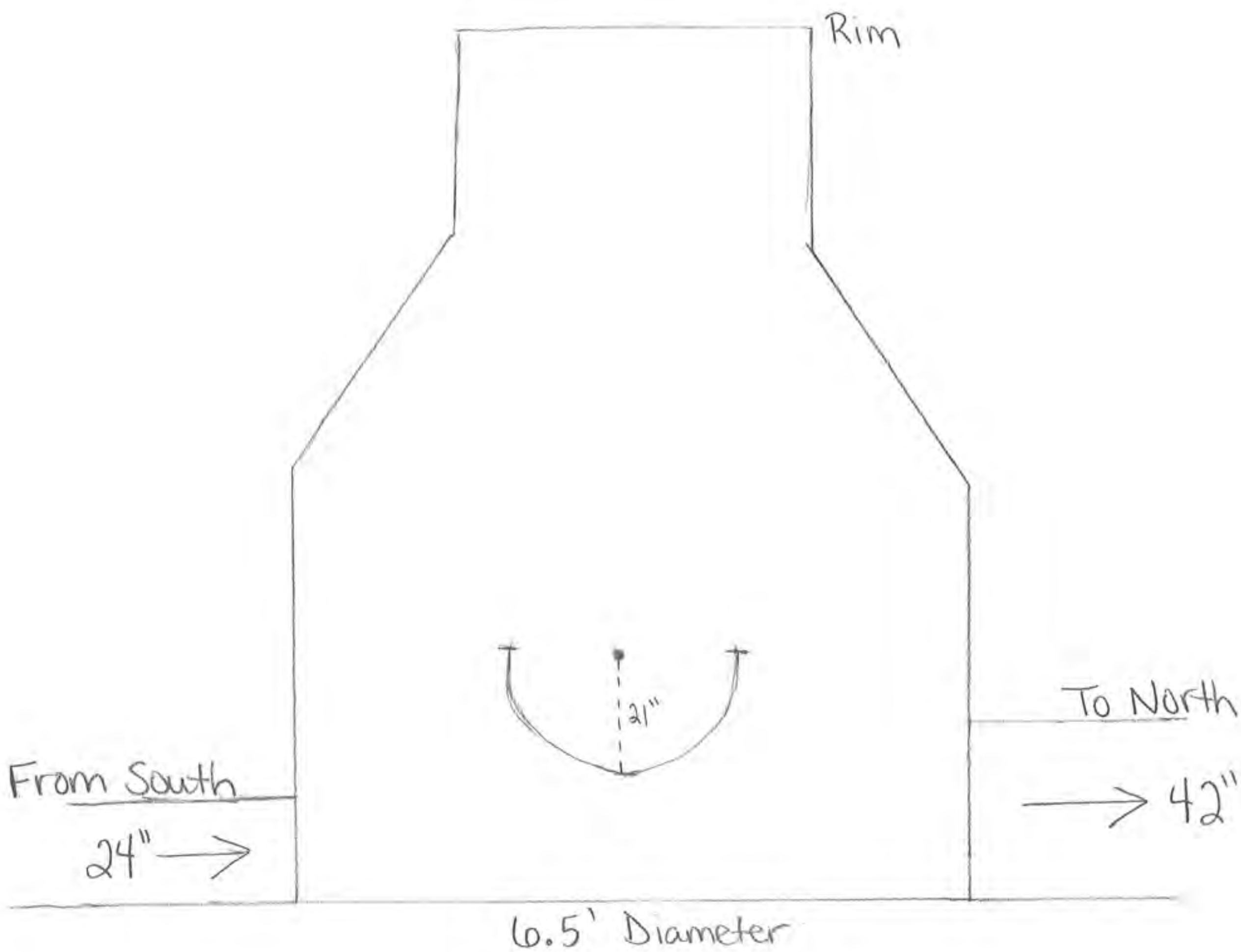
Appendix A

Diversion Structure Plan and Profile

Plan View



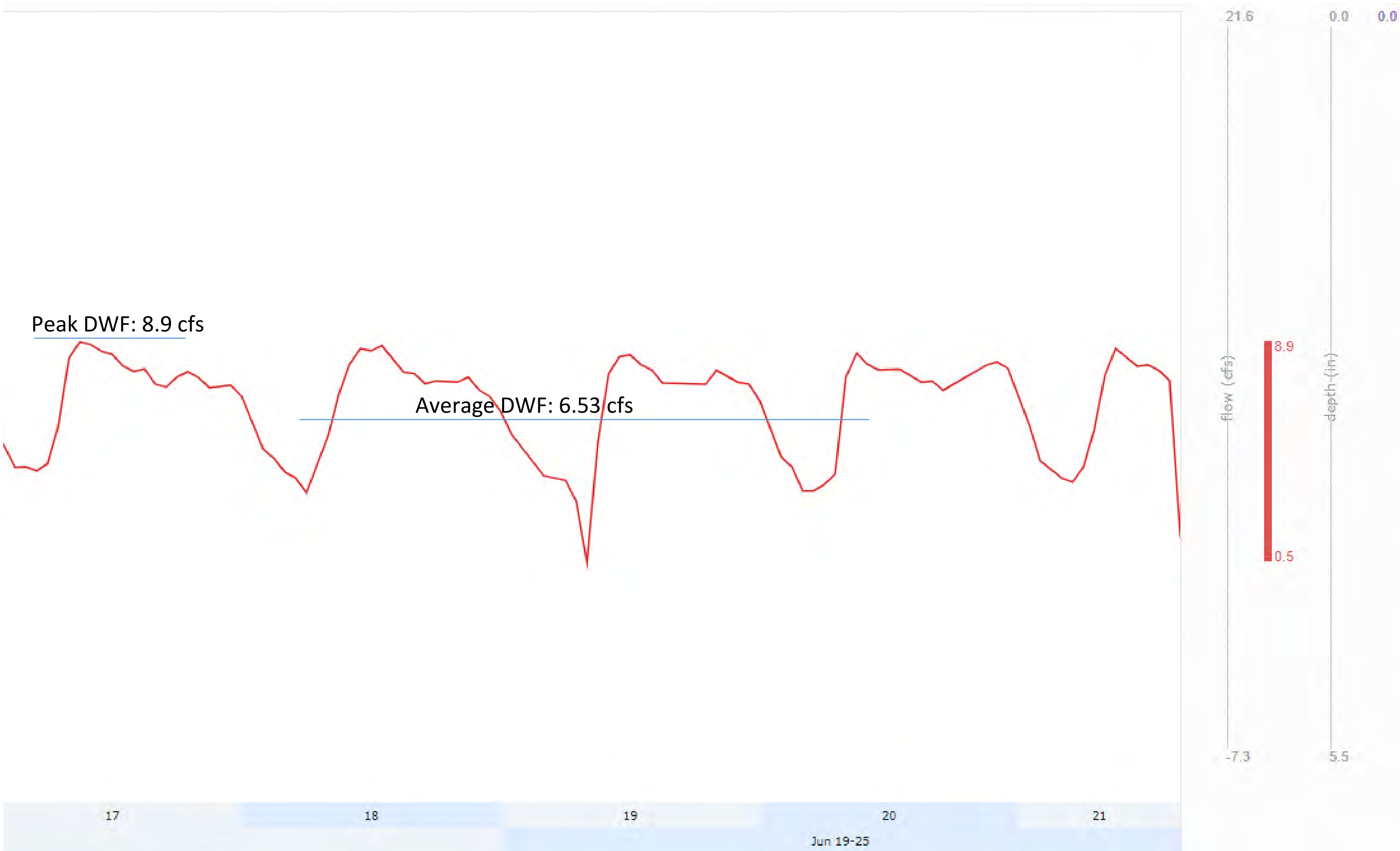
Profile View



Appendix B

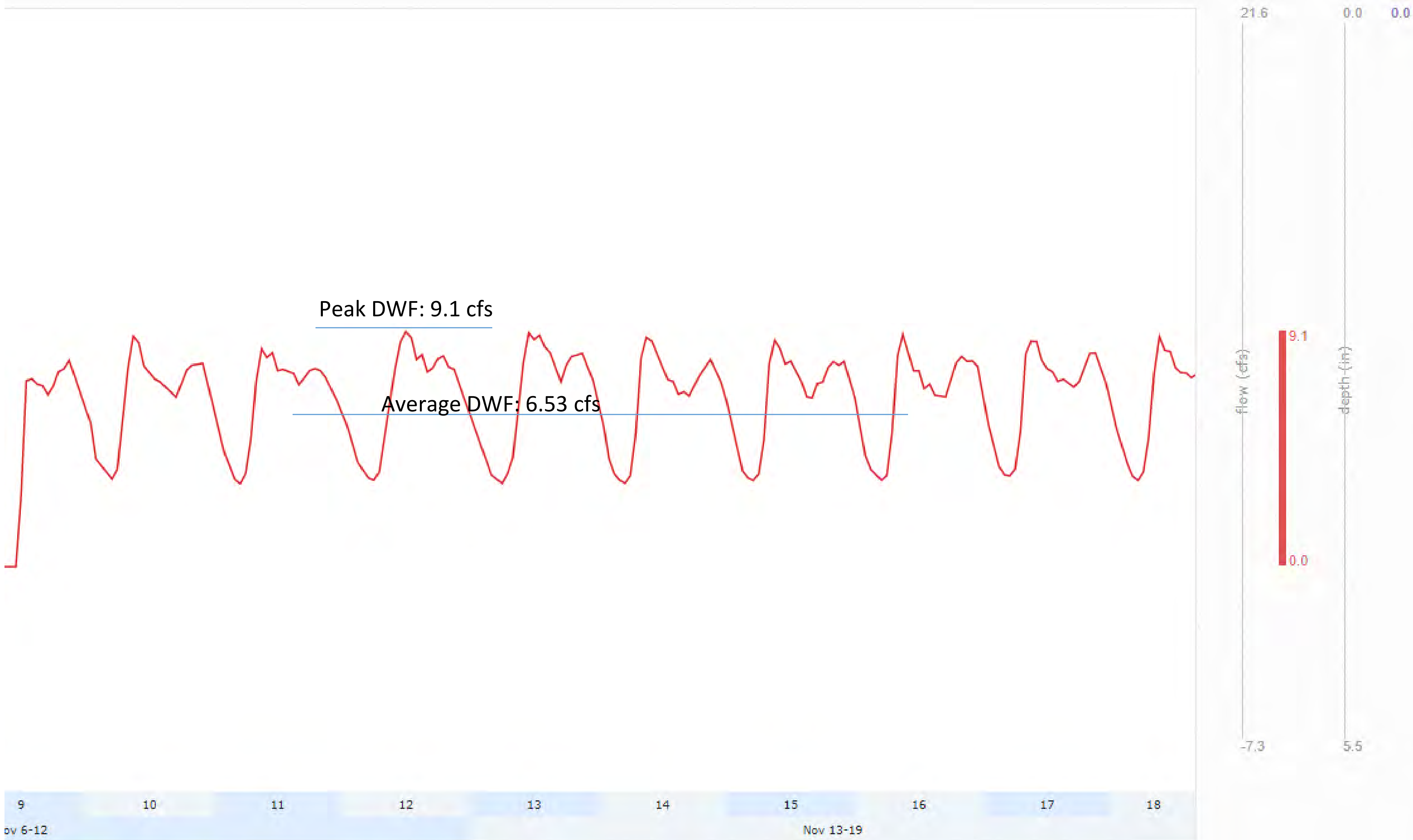
Diversion Dry Weather Flow Data

Meter 17F Dry Weather Flow Data from H2OMetrics

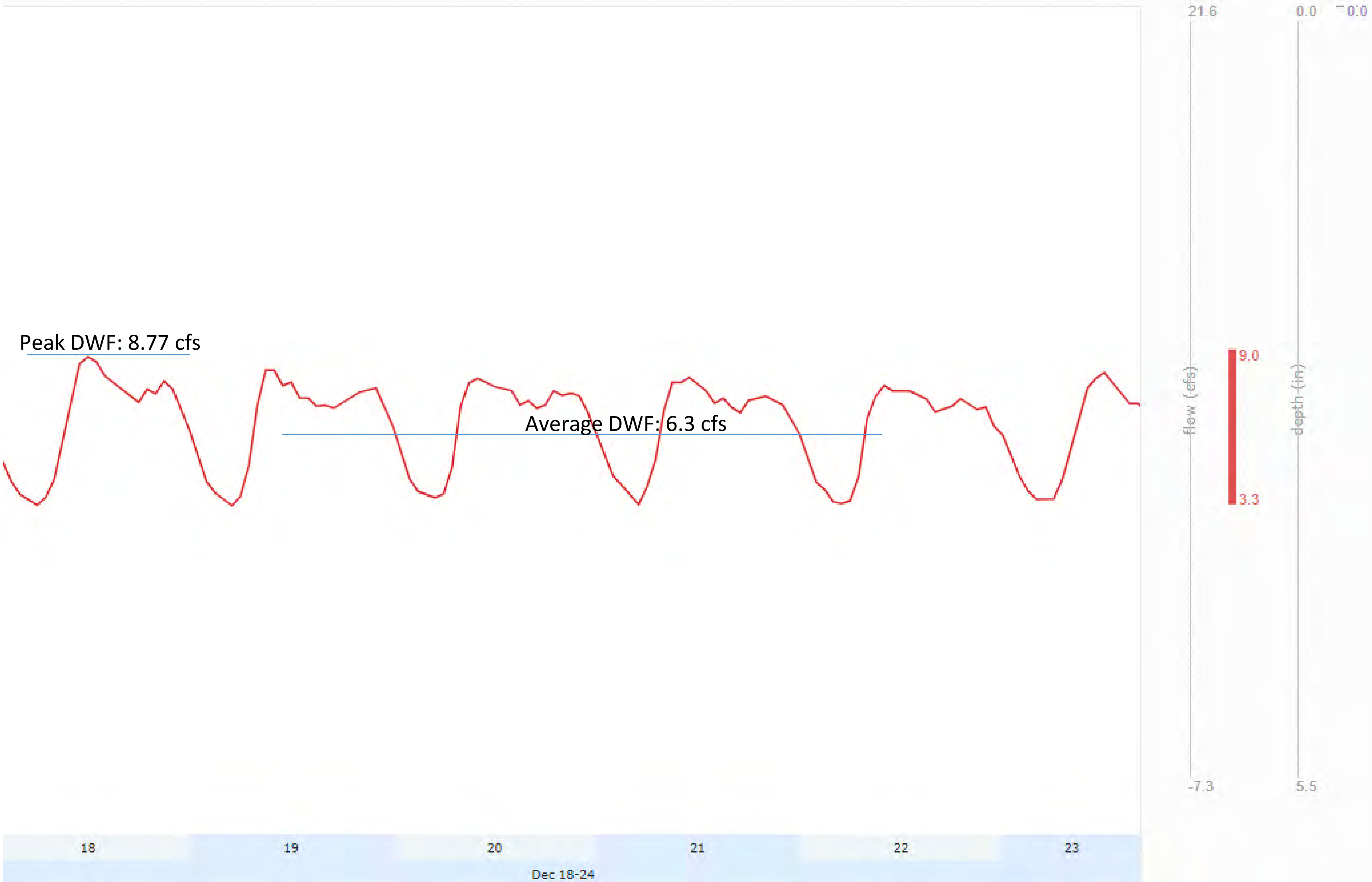


June 17 – June 21

September 18 – September 25



November 9 – November 18



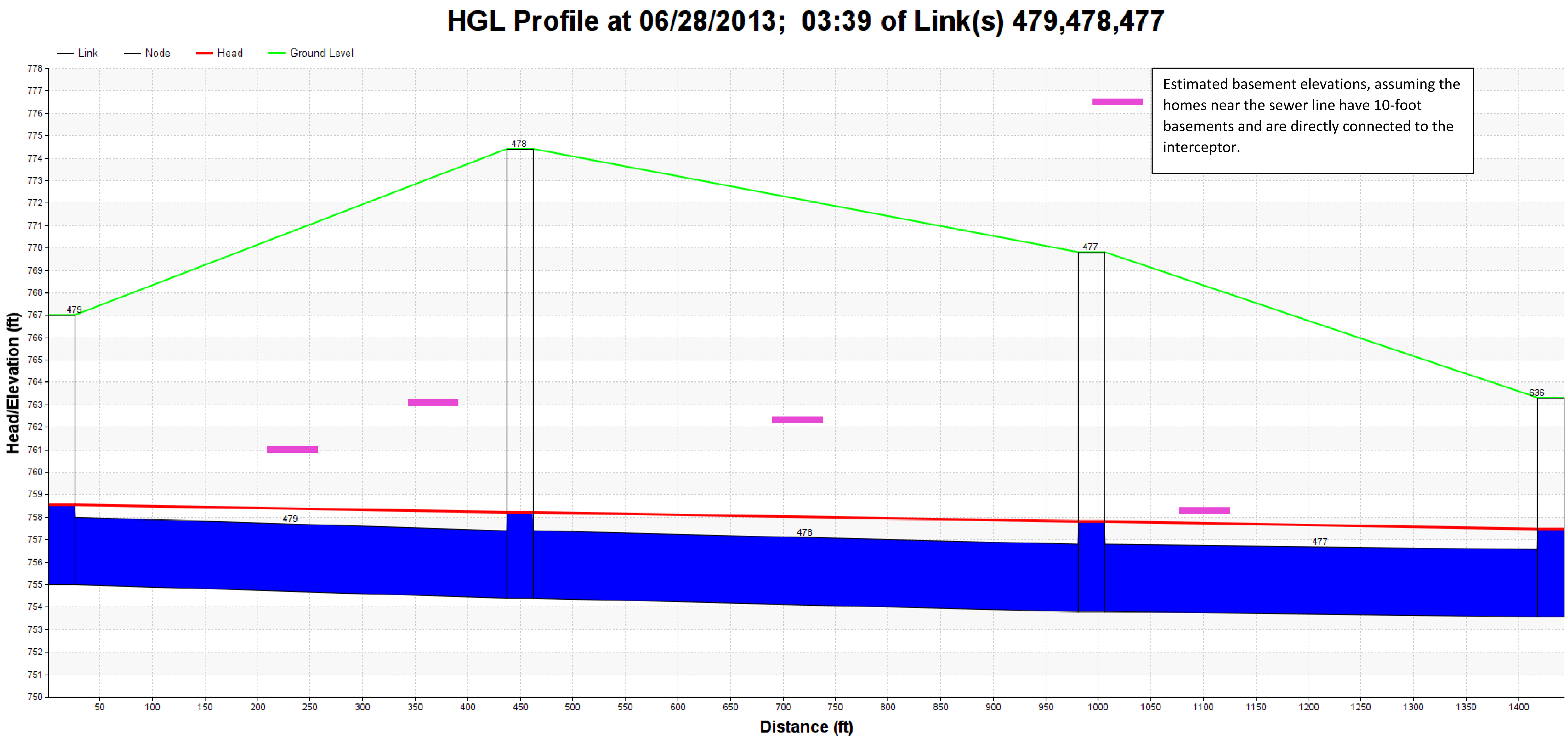
December 18 – December 23

Appendix C

Southern Interceptor HGL and Estimated Basement Elevations

Downstream Southern Interceptor HGL

Flow Split: 10 cfs to south, 11 cfs to north



A flow split of 10 cfs to the south and 11 cfs to the north results in about one foot of surcharging in the southern interceptor. This surcharging is not expected to impact local basements based on estimated basement elevations, however field surveys will be necessary to verify.

0.996
1.000
1.000
1.000
This one would've had a basement elevation within the pipe, so assumed it was not directly connected.
1.000
1.000
1.000
1.000