Appendix C:

C1: Wayne County RVSDS LTCAP: Hydraulic and Hydrologic Model Development, ASI, REVISED November 2016

C2: RVSDS: Updated Geodatabase for Initial Asset Inventory, OHM, September 2015

C1: Wayne County RVSDS LTCAP: Hydraulic and Hydrologic Model Development, ASI, REVISED November 2016

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Wayne County Rouge Valley Sewage Disposal System
Long Term Corrective Action Plan

Hydraulic and Hydrologic Model Development

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1. Background

Wayne County is currently in the process of executing a Corrective Action Plan for the control of sanitary sewer overflow (SSO) in the Rouge Valley Sewage Disposal System (RVSDS) as required by the Final Order of Abatement (FOA) 2117 issued by the Michigan Department of Environmental Quality (MDEQ). The system improvement projects of the Corrective Action Plan are divided into two categories.

The first category consists of projects that were developed from a detailed Sanitary Sewer Evaluation Study (SSES) completed in 2008. These projects are considered short-term solutions and mainly focused on structural defects and localized capacity issues. These Short-Term Corrective Action Plan (STCAP) projects were implemented in 2012. The second category of projects will consist of broader system capacity issues that will most likely require large scale construction projects and will serve as a long-term solution. As such, these Long-Term Corrective Action Plan (LTCAP) projects will require a more detailed analysis.

This report presents the efforts undertaken to develop and calibrate a computational model of the RVSDS. This model is to be used as part of the development of the LTCAP projects as well as analyzing the effectiveness of the completed STCAP projects.

2. System Characteristics

The RVSDS is a network of Wayne County owned and maintained interceptor sewers that transport wastewater from local client communities to the Detroit Water and Sewerage Department (DWSD) Wastewater Treatment Plant for treatment and disposal. The total acreage of land tributary to the RVSDS is 131,725 acres or 205.8 square miles. The total 2010 Census population of the RVSDS is 551,103 people. The RVSDS boundary and interceptor network is shown on Figure 2-1 and Table 2-1 presents a listing of the communities served by the RVSDS along with their tributary services areas.

Figure 2-1 also depicts the interior boundary of the Western Townships Utility Authority (WTUA) service area. The WTUA communities operationally split their wastewater discharges between the RVSDS and the Ypsilanti Community Sewer Authority (YCUA) system. In the past 4 years, 29.0% to 47.8% of the wastewater generated by the WTUA communities has been discharged to the RVSDS.

Table 2-1
Tributary Service Area by RVSDS Community

Community	Sanitary Area (acres)	Combined Area (acres)	Other Area (acres)	Total Contributing Area (acres)
Canton Township	23,121.3	--	--	23,121.3
Dearborn Heights *(part)*	3,268.9	1,143.7	--	4,412.6
Garden City	3,751.3	--	--	3,751.3
Inkster *(part)*	2,462.5	1,040.1	--	3,502.6
Livonia	22,543.9	--	--	22,543.9
Northville	1,242.6	--	--	1,242.6
Northville Township	10,606.8	--	--	10,606.8
Novi *(part)*	16,538.1	--	--	16,538.1
Plymouth	1,294.3	--	--	1,294.3
Plymouth Township	10,121.6	--	--	10,121.6
Redford Township *(part)*	3,020.5	3,614.7	--	6,635.2
Romulus *(part)*	1,678.7	--	4,881.3	6,560.0
Salem Township *(part)*	--	--	347.7	347.7
Van Buren Township *(part)*	6,078.3	--	--	6,078.3
Wayne	3,357.2	--	--	3,357.2
Westland	11,611.5	--	--	11,611.5
Total	120,697.5	5,798.5	5,229.0	131,725.0
WTUA Total	43,849.7	--	347.7	44,197.4
Total - WTUA	76,847.8	5,798.5	4,881.3	87,527.6

Notes:
(part) – Indicates that the acreages shown are only of the part of the community within the RVSDS
Other Area – Areas that only contribute industrial discharges into the RVSDS.

Rouge Valley Sewage Disposal System

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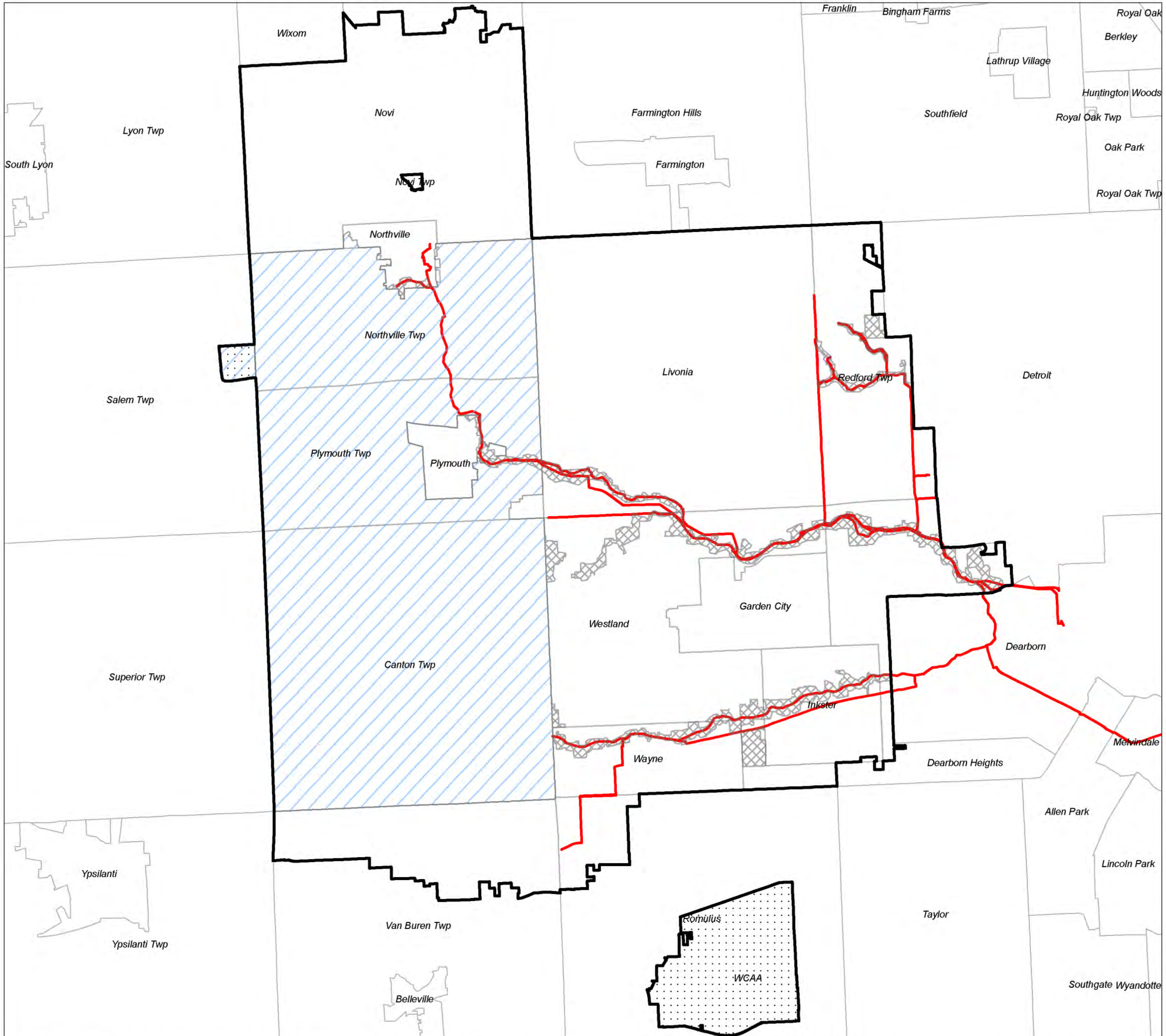

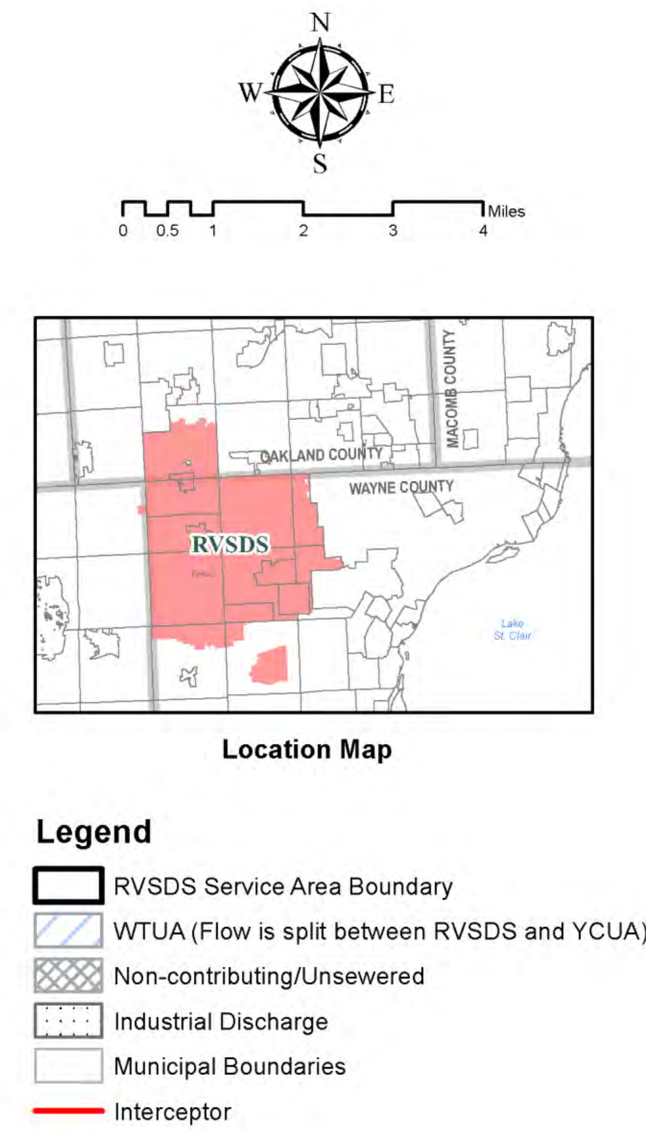

Figure 2-1
District and Community Boundaries

Prepared By:

Applied Science, Inc.

Date: 8/24/2015

H:\2013\1315 -- Wayne County LTCAP Project Plan\Memos\H&H Report\Fig 2-1 - RVSDS District and Community Boundaries.mxd

3. System Monitoring Data

A system monitoring program (SMP) was implemented by Wayne County after the completion of the STCAP projects. The SMP went online in July 2012 and is scheduled to continue for the indefinite future as Wayne County utilizes this data for many other types of analyses and reviews. The data utilized for this analysis spanned from July 2012 through December 2014.

Sewage Flow

The sewage flow data collected by the SMP is comprised of a combined network of metering devices owned and operated either by Wayne County, the RVSDS communities and authorities, or the Detroit Water and Sewerage Department (DWSD). Table 3-1 provides information on each of the metering device used for the analysis. Figure 3-1 presents a map of the location of each flow monitoring device in the RVSDS. Figure 3-2 presents a schematic layout of the meter connectivity.

The flow data is recorded on a five minute interval and consists of a directly measured depth and velocity value and a computed flow rate. The flow meters undergo periodic dye-dilution testing to verify their accuracy. Adjustment factors determined through dye-dilution testing were applied to the data in the analysis. Table 3-2 presents a list of the adjustment factors applied during the analysis.

Two level sensors also exist in the system to provide set points and feedback for facility operation. These are located at Junction Chambers JC 2-8 and JC 18A and are also shown on Figure 3-1.

Precipitation

Similar to the sewage flow data, the precipitation data utilized for the SMP is comprised of a combined network of precipitation gages owned and operated by various entities. Precipitation data for the SMP was obtained from the following sources:

- The Detroit Water and Sewerage Department (DWSD),
- The National Climatic Data Center (NCDC),
- The Western Townships Utilities Authority (WTUA),
- The Counties of Wayne and Oakland, and
- The Cities of Garden City, Livonia, and Novi.

Precipitation data were recorded as hundredths of an inch over various storage intervals depending on the source of the rainfall data with the majority being five minute interval data. No adjustments were made to the rainfall data retrieved. However, the data were checked for errors during each event and any erroneous data was marked and excluded from the analysis of that event. Table 3-3 provides information on each precipitation gage and Figure 3-3 presents a map of the precipitation gage locations with respect to the RVSDS boundary.

Table 3-1
System Monitoring Flow Devices

Branch	Device ID	Operated By	Device Type	Location
Middle Rouge	BG1	Novi	Badger 2100 Flume	8 Mile Road
	P1	Wayne County	ADS Triton+	5 Mile Road and Edward Hines Drive
	P3	Wayne County	ADS Triton+	Edward Hines Drive east of I-275
	P26	Wayne County	ADS Triton+	Edward Hines Drive east of I-275
	P7	Wayne County	ADS Triton+	Ann Arbor Trail east of Parkside Drive
	LV16	Livonia	ADS Triton+	Joy Road between Farmington Road and Edward Hines Drive
	FE22	WTUA	Accusonics 7510	Eckles Road and Joy Road
	A	WTUA	Sigma 910	Sheldon Road south of North Territorial
	B	WTUA	Sigma 910	Sheldon Road north of Ann Arbor Road
	C	WTUA	Sigma 910	Ann Arbor Road west of Lilley Road
	P8	Wayne County	ADS Triton+	Ann Arbor Trail east of Parkside Drive
	WE14	Wayne County	ADS Triton	Hawthorn Dog Park along Edward Hines Drive west of Merriman Road
	LV-15	Livonia	ADS Triton+	Merriman Road south of McKenzie Drive
	M2	Garden City	ADS Triton	Merriman Road north of Warren Road
	M1	Garden City	ADS Triton	Middlebelt Road north of Warren Road
	LV14	Livonia	ADS Triton+	In field west of Inkster Road between Ann Arbor Trail and Edward Hines Drive
	LV20	Livonia	ADS Triton	Middlebelt Road north of Rayburn
	LV Basin	Wayne County	ADS FlowShark	Inkster Road north of Lyndon Boulevard
	LV4	Livonia	ADS Triton+	Five Mile and Alpine Drive
	LV11	Livonia	ADS Triton+	Inkster Road south of Lyndon Street
	P12	Wayne County	ADS Triton+	Inkster Road north of Edward Hines Drive
	P9	Wayne County	ADS Triton+	Edward Hines Drive east of Inkster Road
	P10	Wayne County	ADS Triton+	Edward Hines Drive east of Inkster Road
	P11	Wayne County	ADS Triton+	Edward Hines Drive east of Inkster Road
	P13	Wayne County	ADS Triton+	Telegraph Road and Cathedral Avenue
	P14	Wayne County	ADS Triton+	Brady Road north of Willoway Road
Lower Rouge	P15	Wayne County	ADS Triton+	Ecorse Road and Hannan Road
	P17	Wayne County	ADS Triton+	North of Michigan Avenue near Heywood Street
	FE19	WTUA	Brooks Magnetic	Haggerty Road north of Michigan Avenue
	WE25	Wayne County	ADS Triton	Thinbark Street and Upland Court
	P19	Wayne County	ADS Triton+	Josephine Street north of Michigan Avenue
	WE28	Wayne County	ADS Triton	Merriman Road north of Grand Traverse Street
	P21	Wayne County	ADS Triton+	Henry Ruff Street north of Michigan Avenue
	P25	Wayne County	ADS Triton+	South Gulley Road south of Hillcrest Drive
	P20	Wayne County	ADS Triton+	Michigan Avenue east of Henry Ruff Street
	P24	Wayne County	ADS Triton+	North of Michigan Avenue west of Telegraph Road
RVSDS Outlet	WCS1	DWSD	Accusonics	Fort Street south of Oakwood Boulevard
	WCS2	DWSD	Accusonics	Ford Road and Evergreen Road
	WCS3	DWSD	MGD (ADFM)	Southfield Road south of Hubbard Drive

Table 3-2
Dye-Dilution Test Summary

Meter	Test Date	Adjustment Factor
LV Basin	11/26/2013	0.92
P1	11/7/2013	1.08
P9	10/8/2014	1.12
P10	4/23/2013	1.03
P11	4/23/2013	0.93
P12	4/22/2013	0.90
P13	5/2/2013	1.04
P14	5/2/2013	1.01
P17	12/2/2013	0.90
P19	11/25/2013	0.96
P20	11/25/2013	0.98
P24	12/4/2014	0.83
P25	5/6/2013	1.07

Table 3-3
System Monitoring Precipitation Gages

Gage ID	Operated By	Location
R10	Wayne County	11111 Wayne Road, Romulus
R11	Wayne County	14973 Northville Road, Northville Township
R12	Wayne County	7651 Merriman Road, Westland
R13	Wayne County	3501 Henry Ruff Road, Inkster
R14	Wayne County	Willow Run Airport, Van Buren Township
R15	Wayne County	20195 Trolley, Taylor
R18	Wayne County	130 4th Street, Belleville
R27	Wayne County	2001 Inkster Road, Inkster
R28	Wayne County	23800 Hines Drive, Dearborn Heights
R29	Wayne County	15145 Beech Daly Road, Redford
PG007	DWSD	7404 Inkster Rd, West Bloomfield Township
PG009	DWSD	Curtis and Southfield Freeway, Detroit
PG010	DWSD	16540 Rotunda Drive, Dearborn
PG012	DWSD	15600 West Grand River Avenue, Detroit
PG013	DWSD	20440 James Couzens Street, Detroit
PG030	DWSD	Stoepel Park and W. Chicago, Detroit
PG032	DWSD	20920 East Street, Southfield
PG033	DWSD	30365 Schoolcraft, Livonia
PG034	DWSD	20650 West Warren, Detroit
PG035	DWSD	8 Mile Road & Southfield Fwy, Detroit
PG036	DWSD	Rouge River & Warren Ave, Dearborn Heights
PG037	DWSD	Rouge River & Plymouth Road, Detroit
LV RG01	Livonia	Schoolcraft Road, Livonia
LV RG02	Livonia	Whispering Willows Golf Course, Livonia
DTW	NOAA	Wayne County Metro Airport, Romulus
GC RG01	Garden City	Moeller Park, Garden City
WTUA LR EQ Basin	WTUA	3501 Haggerty Road, Canton
WTUA MR EQ Basin	WTUA	40905 Joy Road, Plymouth
0831	Oakland County	19625 Middlesex Street, Southfield
0837	Oakland County	25515 Clara Lane, Southfield
0843	Oakland County	34189 12 Mile Road, Farmington Hills
0850	Oakland County	46351 West Road, Walled Lake

Notes:

1. NOAA = National Oceanic and Atmospheric Association

Rouge Valley
Sewage Disposal System

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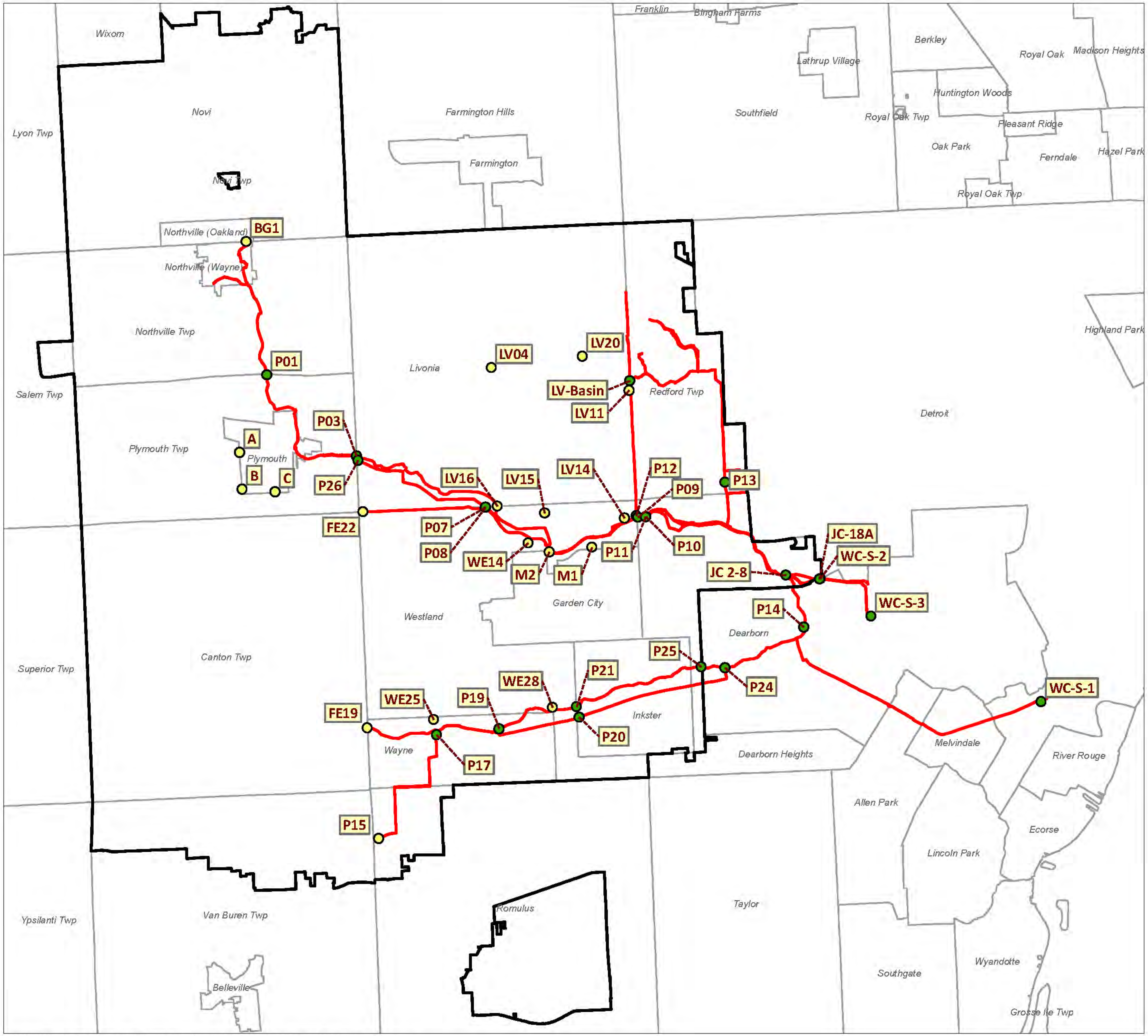

N
W E
S

0 0.5 1 2 3 4 Miles

Legend

Interceptor
RVSDS Boundary
Muncipal Boundaries

Monitoring Point

Interceptor
Community Connection

Figure 3-1
Meter District and
Line Connection Areas

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Applied Science, Inc.

Date: 8/24/2015

H:\2013\1315 -- Wayne County LTCAP Project Plan\Memos\H&H Report\Fig 3-1 - Flow Monitoring Locations.mxd

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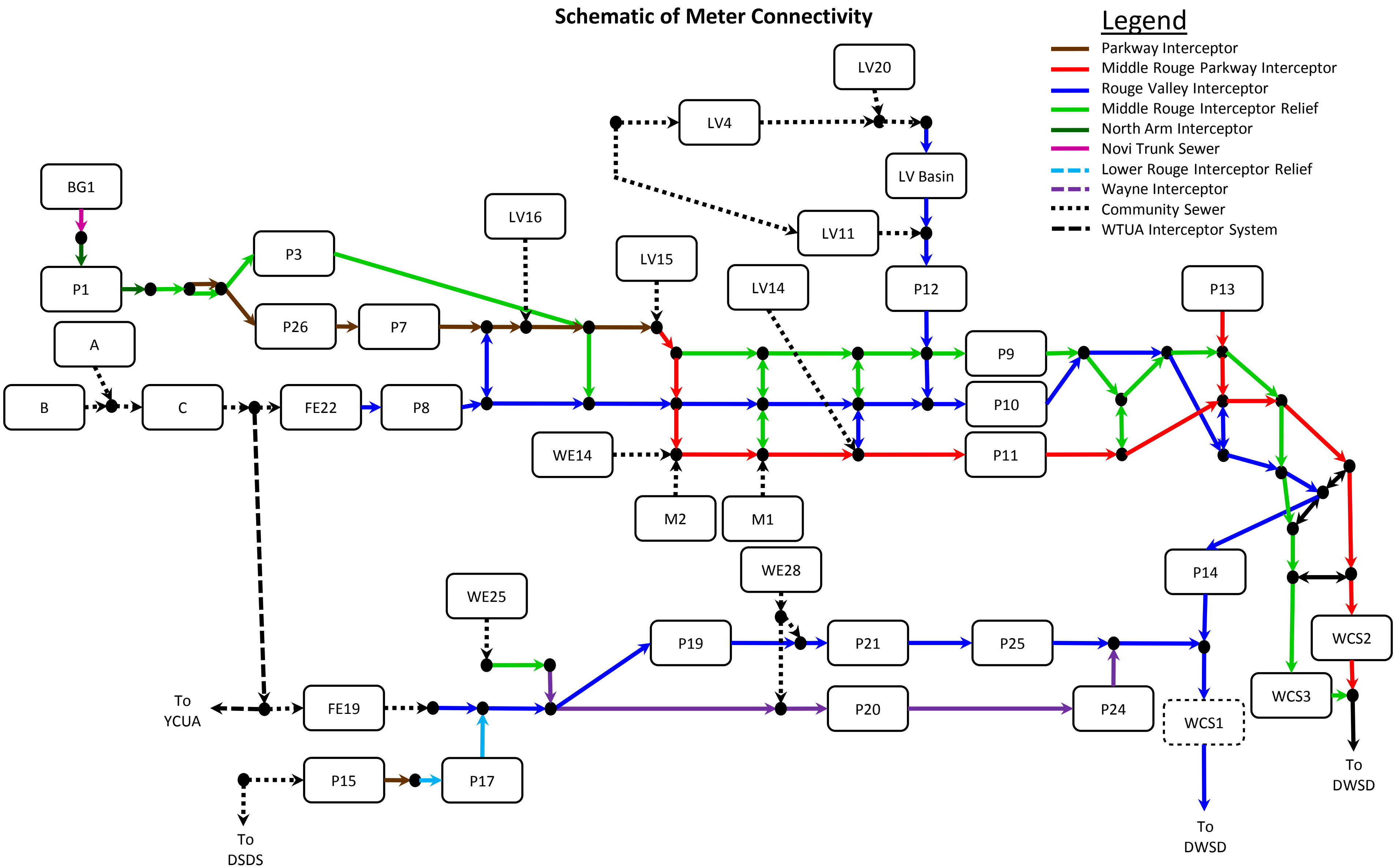
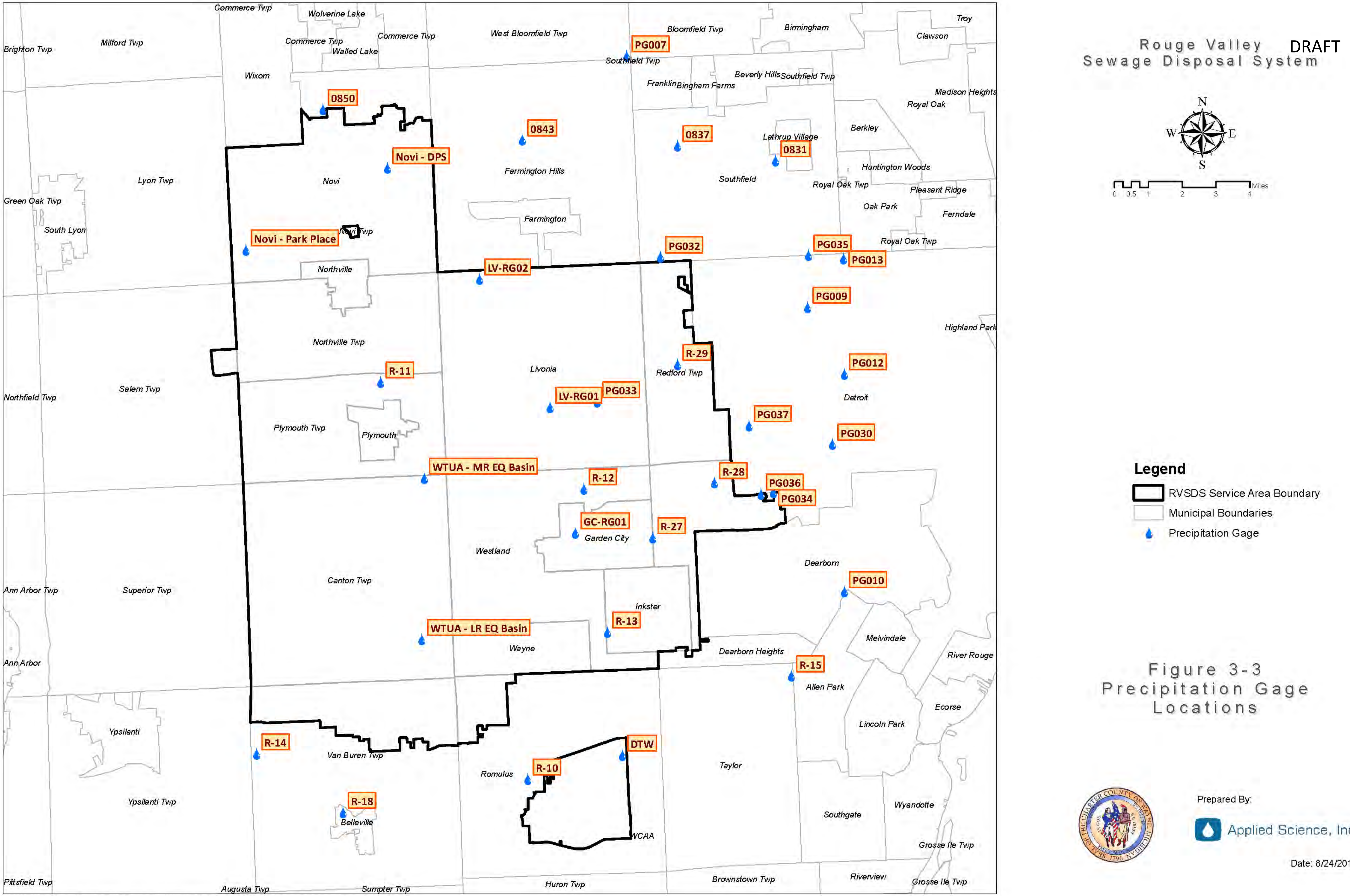
Figure 3-2
Schematic of Meter Connectivity





Rouge Valley Sewage Disposal System

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Legend

- RVSDS Service Area Boundary
- Municipal Boundaries
- Precipitation Gage

Figure 3-3 Precipitation Gage Locations

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Applied Science, Inc.

Date: 8/24/2015

H:\2013\1315 -- Wayne County LTCAP Project Plan\Memos\H&H Report\Fig 3-3 - RVSDS Precipitation Gages.mxd

4. Hydraulic Model Development

A previous computational model of the RVSDS exists and was developed as part of the Greater Detroit Regional Sewer System (GDRSS) model and uses the Storm Water Management Model Version 5 (SWMM5) program. The most recent iteration of the GDRSS model, dated December 2012, was obtained from CDM and the region representing the RVSDS was extracted from it.

Various modeling software packages were reviewed for their potential utilization in making the updates to the RVSDS model. These included: InfoWorks, InfoSWMM, and SWMM5. The computational models in these three programs are very similar. The main distinctions between them are that InfoWorks and InfoSWMM are both proprietary programs which integrate within a Geographic Information System (GIS) environment, whereas SWMM5 is an open source program that is not directly integrated with GIS.

SWMM5 was selected as the modeling platform for the update of the RVSDS model for the following reasons:

- SWMM5 is a free public domain software that is widely used by consulting firms and accepted by regulatory agencies;
- Model input data is stored as a tab delimited text files which are easy to share among consultants and Wayne County staff;
- The updated RVSDS model will be able to be integrated back into the GDRSS model with minimal conversion efforts; and
- The ability to view the model network overlaid with other GIS attributes was not deemed necessary for the current modeling efforts, however the modeling information can be easily transferred into a GIS based modeling program in the future if needed.

Since the GDRSS model was a regional modeling effort, the portion representing the RVSDS was fairly generalized and did not contain the entire extent of the RVSDS interceptors. While such a model could yield overall flows and capacities of sewer reaches, the development of LTCAP improvements will require a more detailed understanding of the RVSDS for exact project locations and sizes to be specified. The model was fundamentally overhauled with the following improvements:

- Adding a representation for each of the pipes, regulators, siphons, manholes, and interconnections in the RVSDS interceptor system.
- Expanding the modeled sewer reaches to encompass the full extent of the RVSDS.
- Including existing storage facilities such as the equalization basins (EQs) and combined sewer retention treatment basins (RTBs);
- Providing a representation for each customer line connection to the interceptor system; and

- Using model control rules to simulate the actual operational procedures of facilities.

The information utilized to build the hydraulic model was derived from the following sources:

- Previous modeling efforts and results;
- As-built drawings of sewer contracts;
- Geographic information system (GIS) data;
- Operation and maintenance (O&M) manuals;
- System inventories, reports, and special studies.

This information was reviewed and brought into the model representation as required. When conflicting/ambiguous information was discovered, sources were ranked based on their reliability, and, if needed, confirmed with the originator of the data or through a field investigation. The hydraulic model was primarily developed from an extensive review of all available record as-built drawings and subsequent translation of the information into representative model elements. Table D-1 presents a list of the sewer contracts incorporated into the model.

Since construction of these sewer contracts spanned across several decades, the vertical datum used to represent invert elevations varied. This is an important aspect to keep track of for modeling purposes since all of these sewers must be properly aligned in the same datum when combined as a coherent whole. As municipal engineering projects of their day, there are only three possible base datums for these drawings:

1. The Detroit Datum
2. The National Geodetic Vertical Datum of 1929 (NGVD29)
3. The United States Lake Survey Datum of 1935 (USLSD35)

Base datum assumptions were made using the following hierarchy:

1. A datum was explicitly specified on the drawing. However, this still required some guesswork as the datum was typically stated as some kind of official name du jour instead of the actual base datum name. Using clarification documents from Wayne County, the following associations were made:
   i. Wayne County 1960 Publication Datum = NGVD29
   ii. Wayne County Bench Mark Datum (U.S.C & G.S.) = NGVD29
   iii. Wayne County Precise Datum = USLSD35
   iv. Wayne County Road Commissioner Precise Datum = USLSD35
   v. Wayne County Road Commissioner Benchmarks = NGVD29

2. The datum was not specified on the contract drawing set, however there is a common element such as an existing manhole that matches invert elevation with the same manhole on a drawing set that does specify the datum.
3. The datum is not specified and there is no contextual information that provides a definitive comparison. In this case the publishing entity and the date of the drawing set were used to assume the most likely datum:
   i. Any contract pre-1935 = NGVD29
   ii. Wayne County Road Commissioner contracts between 1935-1960 = USLSD35
   iii. Any City of Detroit contract with invert values typically ranging from 100-200 feet = Detroit Datum

Table D-1 also provides the assumed datum for each of the contract drawings. All invert elevations were initially converted to NGVD29 using the following formulas:

- NGVD29 = Detroit Datum + 479.76 [ft]
- NGVD29 = USLSD35 - 0.51 [ft]

The current vertical datum standard for Wayne County is the North American Vertical Datum of 1988 (NAVD88). Conversion from NGVD29 to NAVD88 can be made using the following formula:

- NAVD88 = NGVD29 - **fac** [ft]

Where **fac** is a variable conversion factor that depends on the longitude and latitude of the location of the vertical point. The specific conversion factor for each structure within the RVSDS was determined using CORPSCON7, a free utility provided by the U.S. Army Corps of Engineers. By analyzing the furthest possible extents, this factor was found to range between 0.41 and 0.55 feet for the RVSDS.

All modeled structures were cross-referenced with spatial information provided by the GIS data of the 2007 RVSDS sewer system evaluation survey (SSES). When a structure was found to have no representation in the SSES, an approximate location was determined using landmarks and distances shown on the record drawing. Figure 4-1 presents a screenshot of the model network which shows it covering the extent of the RVSDS and in the proper spatial alignment.

Local municipal line connections to the interceptor were included when the information was available. This ranged from modeling only the first few local manholes upstream of the RVSDS interceptor to modeling the majority of the local trunk sewer. In the case of the Lefler-Ready sewer district in Dearborn Heights, the SWMM5 model of this district was obtained from Wade Trim Associates and appended to the RVSDS model.

Combined sewer areas regulators were represented from either information provided by Wayne County inventories or from special studies and adjustments or improvements that were made to the regulators by either the County or the municipality the regulator is servicing. Table 4-2 presents the regulator assumptions for each regulator in the RVSDS that has been assigned a National Pollutant Discharge Elimination System (NPDES) permit number. The current overflow status of these regulators is also presented as many of these regulators have been modified through sewer improvement programs to eliminate their overflow potential or send their overflow to an RTB.

Due to the complex operation of the EQs, RTBs, and pumping stations, the dewatering and regulator flows from the facilities, when available, were represented as direct flow inputs into the model. However, when not available or for theoretical design events, the operational flows were modeled using protocols provided by system operators and O&M manuals. These protocols were implemented in the SWMM5 model using the control rule logical statement editor. The following facilities are represented in the RVSDS model:

- Lift Station 1A
- Redford RTB
- Dearborn Heights RTB
- Inkster RTB
- Middlebelt RTB
- Wayne EQ
- Livonia EQ

The boundary conditions of the model for calibration storms were also directly input using recorded level data. This is due to the levels in the downstream end of the RVSDS system being largely driven by backwater from the DWSD wastewater treatment plant and operations. Wayne County is seeking a commitment from Detroit to provide maximum boundary conditions for the theoretical 25 year, 24 hour design storm and for actual storms that occur.

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Table 4-1
Sewer Contracts Utilized for Hydraulic Model Development

Issuing Entity	Contract Name	Year Built	Assumed Datum
City of Dearborn Heights	Rouge River Wet Weather Combined Sewer Overflow Control Phase II • Collector Sewer and Regulator Modification • City of Dearborn Heights	2005	NGVD29
City of Detroit Department of Public Works	Northwest Interceptor • Southfield Section	1950	Detroit Datum
City of Detroit Department of Public Works	Oakwood Interceptor Tunnel	1937	Detroit Datum
City of Detroit Department of Public Works	Southfield Road Sewer • Section No. 1	1926	Detroit Datum
City of Detroit Department of Public Works	Southfield Road Sewer • Section No. A	1929	Detroit Datum
City of Inkster	1.9 M.G. Retention Treatment Facility Western Outfalls L-46 and 009	2008	NGVD29
City of Livonia	Sanitary Sewer Plan • Five Mile Road	1955	USLSD35
City of Wayne	City of Wayne • Equalization Basin Design	1997	NGVD29
Nankin Township, Michigan	30" Interceptor Sewer Extension • Nankin Township, Wayne Co., Michigan • Water Supply & Sewage Disposal System • Revenue Bond Project	1951	USLSD35
Oakland County Department of Public Works	Novi Sanitary Trunk Sewer • Huron-Rouge Sewage Disposal System	1963	NGVD29
Wayne County Department of Environment	North Huron Valley-Rouge Valley Wastewater Control System • Contract No. 1A • City of Dearborn Heights Lift Station	1997	NGVD29
Wayne County Department of Public Services	North Huron Valley/Rouge Valley Sewage Disposal System • Short Term Corrective Action Plan	2009	NGVD29
Wayne County Department of Public Services	North Huron Valley-Rouge Valley Wastewater Control System • City of Dearborn Heights Local Improvements	1990	NGVD29
Wayne County Department of Public Services	North Huron Valley-Rouge Valley Wastewater Control System • Contract No. 1 • Middle Rouge Interceptor Relief • Southfield Connection to Ford Road	1989	NGVD29
Wayne County Department of Public Services	North Huron Valley-Rouge Valley Wastewater Control System • Contract No. 2 • Middle Rouge Interceptor Relief • Ford Road to Telegraph Road	1990	NGVD29
Wayne County Department of Public Services	North Huron Valley-Rouge Valley Wastewater Control System • Contract No. 3 • Middle Rouge Interceptor Relief • Telegraph Road to Inkster Road	1990	NGVD29
Wayne County Department of Public Services	North Huron Valley-Rouge Valley Wastewater Control System • Contract No. 4A • Middle Rouge Interceptor Relief • Inkster Road to Merriman Road	1991	NGVD29
Wayne County Department of Public Services	North Huron Valley-Rouge Valley Wastewater Control System • Contract No. 5A • Middle Rouge Interceptor Relief • Farmington Road to Newburgh Road	1991	NGVD29
Wayne County Department of Public Services	North Huron Valley-Rouge Valley Wastewater Control System • Contract No. 5B • Middle Rouge Interceptor Relief • NewBurgh Road to Hannan Road (Ext.)	1991	NGVD29
Wayne County Department of Public Services	North Huron Valley-Rouge Valley Wastewater Control System • Contract No. 5C • Middle Rouge Interceptor Relief • Hannan Road (Ext.) to Haggerty Road	1991	NGVD29
Wayne County Department of Public Services	North Huron Valley-Rouge Valley Wastewater Control System • Contract No. 6 • Middle Rouge Interceptor Relief • Haggerty Road to Wilcox Road	1991	NGVD29
Wayne County Department of Public Services	North Huron Valley-Rouge Valley Wastewater Control System • Contract No. 7 • Middle Rouge Interceptor Relief • Inkster Arm Retention Facility City of Livonia	1990	NGVD29
Wayne County Department of Public Services	North Huron Valley-Rouge Valley Wastewater Control System • Contract No. 9 • Lower Rouge Interceptor Relief • Van Born Road • Michigan Avenue at C&O Railroad	1990	NGVD29
Wayne County Department of Public Services	North Huron Valley-Rouge Valley Watewater Control System • Contract No. 1B • Regulator Adjustments and Flow Metering	1990	NGVD29
Wayne County Department of Public Services	Rouge River Wet Weather Combined Sewer Overflow Control Basin Demonstration Project • Contract No. 1 • Retention Basin • Charter Township of Redford	1994	NGVD29
Wayne County Department of Public Services	Rouge River Wet Weather Combined Sewer Overflow Control Basin Demonstration Project • Contract No. 1 • Retention Basin • City of Inkster	1994	NGVD29
Wayne County Department of Public Services	Rouge River Wet Weather Combined Sewer Overflow Control Basin Demonstration Project • Contract No. 2 • Collector Sewers • Charter Township of Redford	1994	NGVD29
Wayne County Department of Public Services	Rouge River Wet Weather Combined Sewer Overflow Control Basin Demonstration Project • Contract No. 2 • Collector Sewers • City of Inkster	1994	NGVD29
Wayne County Department of Public Services	Rouge River Wet Weather Combined Sewer Overflow Control Basin Demonstration Project • Contract No. 3 • Retention Basin • City of Dearborn Heights	1994	NGVD29
Wayne County Department of Public Services	Rouge River Wet Weather Combined Sewer Overflow Control Basin Demonstration Project • Contract No. 4 • Collector Sewers • City of Dearborn Heights	1994	NGVD29
Wayne County Drain Commissioner	Plan and Profile of Proposed • Middle Rouge Parkway Interceptor Extension • Section I	1955	USLSD35
Wayne County Drain Commissioner	Plan and Profile of Proposed • Middle Rouge Parkway Interceptor Extension • Section IA	1955	USLSD35
Wayne County Drain Commissioner	Plan and Profile of Proposed • Middle Rouge Parkway Interceptor Extension • Section II	1955	USLSD35
Wayne County Drain Commissioner	Plan and Profile of Proposed • Middle Rouge Parkway Interceptor Extension • Section III	1955	USLSD35
Wayne County Drain Commissioner	Plan and Profile of Proposed • Middle Rouge Parkway Interceptor Extension • Section IV	1955	USLSD35
Wayne County Drain Commissioner	Plan and Profile of Proposed • Middle Rouge Parkway Interceptor Extension • Section V	1955	USLSD35
Wayne County Drain Commissioner	Plan and Profile of Proposed • Middle Rouge Parkway Interceptor Extension • Section VI	1955	USLSD35

Table 4-1 (continued)
Sewer Contracts Utilized for Hydraulic Model Development

Issuing Entity	Contract Name	Year Built	Assumed Datum
Wayne County Drain Commissioner	Plan and Profile of Proposed • Middle Rouge Parkway Interceptor Extension • Section VII	1955	USLSD35
Wayne County Public Works	Huron Valley Treatment Works Grant • Contract No. 1 • North Arm Interceptor	1985	NGVD29
Wayne County Public Works	Rouge Valley Sewage Disposal System • Contract No. 1	1966	USLSD35
Wayne County Public Works	Rouge Valley Sewage Disposal System • Contract No. 10	1966	USLSD35
Wayne County Public Works	Rouge Valley Sewage Disposal System • Contract No. 12	1963	USLSD35
Wayne County Public Works	Rouge Valley Sewage Disposal System • Contract No. 13	1962	USLSD35
Wayne County Public Works	Rouge Valley Sewage Disposal System • Contract No. 14	1963	USLSD35
Wayne County Public Works	Rouge Valley Sewage Disposal System • Contract No. 15	1963	USLSD35
Wayne County Public Works	Rouge Valley Sewage Disposal System • Contract No. 16	1963	USLSD35
Wayne County Public Works	Rouge Valley Sewage Disposal System • Contract No. 2	1966	USLSD35
Wayne County Public Works	Rouge Valley Sewage Disposal System • Contract No. 3	1966	USLSD35
Wayne County Public Works	Rouge Valley Sewage Disposal System • Contract No. 4	1966	USLSD35
Wayne County Public Works	Rouge Valley Sewage Disposal System • Contract No. 5	1964	USLSD35
Wayne County Public Works	Rouge Valley Sewage Disposal System • Contract No. 6	1963	USLSD35
Wayne County Public Works	Rouge Valley Sewage Disposal System • Contract No. 7	1963	USLSD35
Wayne County Public Works	Rouge Valley Sewage Disposal System • Contract No. 8	1963	USLSD35
Wayne County Public Works	Rouge Valley Sewage Disposal System • Contract No. 9	1963	USLSD35
Wayne County Road Commissioner	Michigan Avenue C.W.A. Sewer	1934	USLSD35
Wayne County Road Commissioner	Plan and Profile of Proposed • Lola Valley Interceptor • Contract LVI-1 • Wayne County Sewage Treatment Project	1938	USLSD35
Wayne County Road Commissioner	Plan and Profile of Proposed • Middle Rouge Parkway Interceptor • Contract PWI-1	1939	USLSD35
Wayne County Road Commissioner	Plan and Profile of Proposed • Middle Rouge Parkway Interceptor • Contract PWI-1A	1939	USLSD35
Wayne County Road Commissioner	Plan and Profile of Proposed • Middle Rouge Parkway Interceptor • Contract PWI-2	1939	USLSD35
Wayne County Road Commissioner	Plan and Profile of Proposed • Middle Rouge Parkway Interceptor • Contract PWI-3	1939	USLSD35
Wayne County Road Commissioner	Plan and Profile of Proposed • Middle Rouge Parkway Interceptor • Contract PWI-4	1940	USLSD35
Wayne County Road Commissioner	Plan and Profile of Proposed • Middle Rouge Parkway Interceptor • Contract PWI-5	1939	USLSD35
Wayne County Road Commissioner	Plan and Profile of Proposed • Wayne County Sewage Treatment Project • The Wayne Interceptor • Contract No. W.I.-1	1937	USLSD35
Wayne County Road Commissioner	Wayne County Metropolitan Sewerage and Sewage Disposal System • Wayne-Romulus-Vanburen • Interceptor Sewer	1966	NGVD29

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Table 4-2
Assumed Regulator Settings and Overflow Statuses

NPDES Permit ID	Line Connection ID	Tributary Communities	Tributary Area (acres)	Regulator Element	Overflow Status
M-33	13	Dearborn Heights	116.9	6" Vortex Valve	Diverted to Dearborn Heights RTB
M-18	7, 199	Dearborn Heights	169.0	7.3" Vortex Valve	Diverted to Dearborn Heights RTB
M-16	12	Dearborn Heights	73.2	6" Vortex Valve	Diverted to Dearborn Heights RTB
M-15	10	Dearborn Heights	87.8	6.5" Vortex Valve	Diverted to Dearborn Heights RTB
M-17	9	Dearborn Heights	29.5	6" Vortex Valve	Diverted to Dearborn Heights RTB
M-14	17	Dearborn Heights	71.7	8" Ø pipe	Active
M-13	16	Dearborn Heights	85.0	12"W x 9"H Milwaukee	Active
M-19	4	Dearborn Heights	35.4	6" Vortex Valve	Diverted to Dearborn Heights RTB
L-42	23	Dearborn Heights	101.2	6"W x 12"H Milwaukee	Active
L-43	22	Dearborn Heights	36.0	12" Ø pipe	Active
L-41	46, 52	Dearborn Heights/Inkster	1,172.7	15.8" CH Reg-U-Flo	Active
L-46	28	Inkster	625.4	10" Vortex Valve	Diverted to Middlebelt Rd RTB
L-47	31	Inkster	37.8	6"W x 5"H Brown & Brown	Diverted to Inkster Rd RTB
L-48	29	Inkster	387.7	12"W x 9"H Milwaukee	Diverted to Inkster Rd RTB
L-39	45, 46	Inkster	857.3	8.1" CH Reg-U-Flo	Diverted to Inkster Rd RTB
L-38	43	Inkster	65.4	8.1" CH Reg-U-Flo	Diverted to Inkster Rd RTB
M-26	63	Livonia	66.3	12" Ø pipe	Uncertain, assumed active
U-06	105	Redford/Livonia	2,023.1	24" Tipping Gate	Diverted to Redford RTB
U-07	106	Redford	51.4	8" Tipping Gate	Diverted to Redford RTB
U-08	107	Redford	163.9	10" Tipping Gate	Diverted to Redford RTB
U-05	113	Redford	147.7	8.7" CH Reg-U-Flo	Active
U-03	114	Redford	66.2	8.3" CH Reg-U-Flo	Active
U-04	115	Redford	31.2	10.2" C Reg-U-Flo	Active
U-11	116	Redford	712.7	24" Tipping Gate	Active
U-09	120	Redford	304.6	13.01" CH Reg-U-Flo	Active

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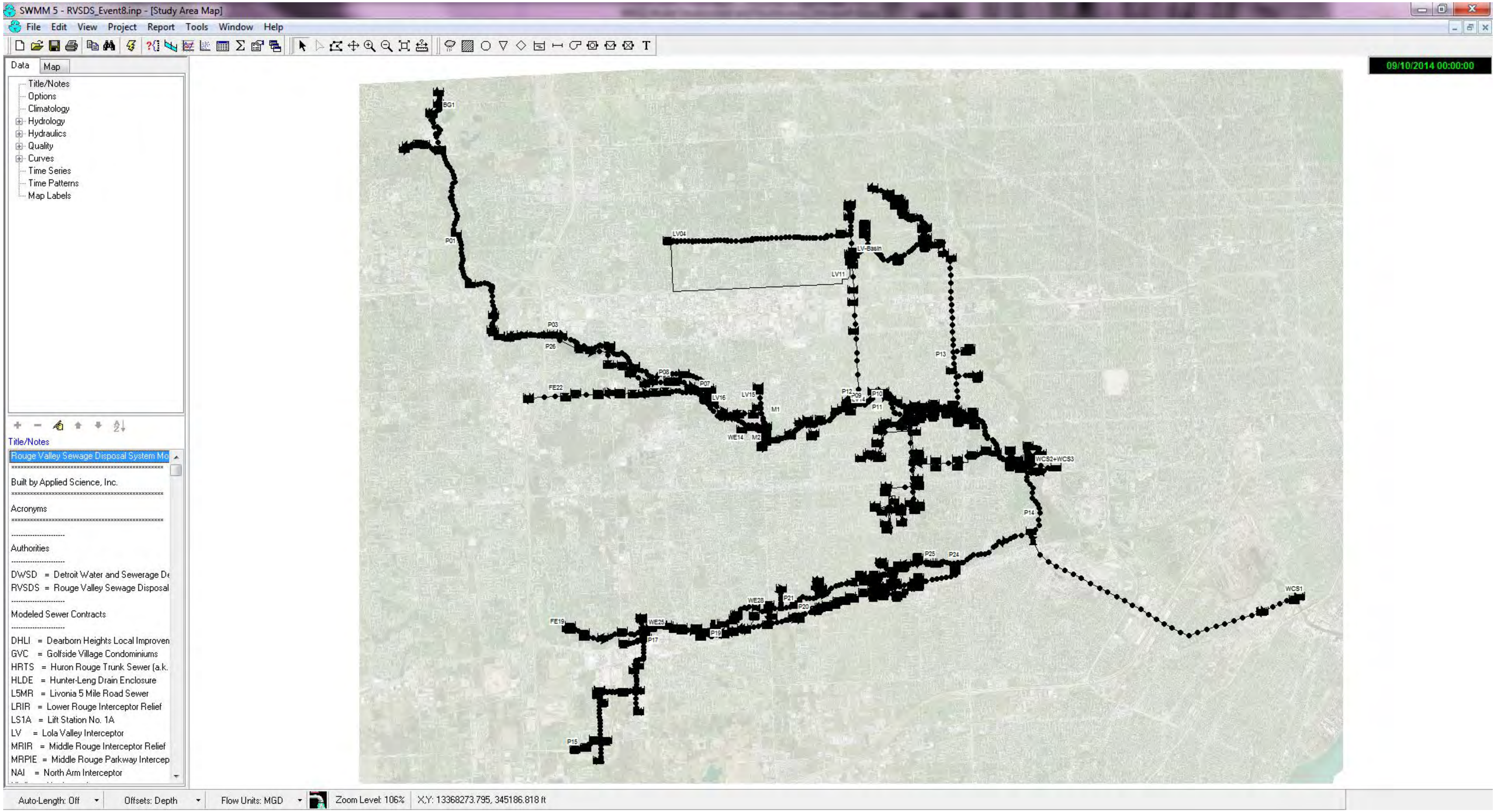
Table 4-2 (continued)
Assumed Regulator Settings and Overflow Statuses

NPDES Permit ID	Line Connection ID	Tributary Communities	Tributary Area (acres)	Regulator Element	Overflow Status
U-10	121	Redford	115.5	8.5" CH Reg-U-Flo	Active
U-02	122	Redford	2,466.7	24" Tipping Gate	Active
U-01	11	Dearborn Heights	73.9	8.35" CH Reg-U-Flo	Active
L-36	158	Wayne	1,041.1	12" Ø Wall Opening	Bulkheaded during local sewer seperation project
L-37	160	Wayne	43.6	12"W x 9"H Opening	Bulkheaded during local sewer seperation project
L-35	153	Wayne	93.4	6" Ø Wall Opening	Bulkheaded during local sewer seperation project
L-34	184	Wayne/Westland	270.7	12"W by 11"H Opening	Bulkeaded during STCAP
M-22	74, 191	Livonia	1,143.5	12" Shear Gate	Active
M-21	75	Livonia	1,287.6	16" Shear Gate	Active
M-25	73	Livonia	1,187.8	12" Shear Gate	Active
M-20	27	Garden City/Westland	1,923.8	22" Ø Wall Opening	Bulkheaded during local sewer seperation project
M-24	26	Garden City/Westland	1,868.3	18" by 18" wall opening	Bulkheaded during local sewer seperation project, w/high relief
L-45	193	Inkster	6.9	15" Ø pipe	Diverted to Inkster Rd RTB
L-40	40	Inkster	17.7	8" Ø pipe	Diverted to Inkster Rd RTB
L-44	48	Inkster	19.0	8" Ø pipe	Diverted to Inkster Rd RTB

Figure 4-1
Screenshot of SWMM5 Model Network



5. Tributary Service Areas

In order to develop hydrologic input parameters for the model, a detailed understanding of the tributary service areas for each load point was needed. A complete re-delineation of the tributary area of each community connection to the RVSDS was undertaken. To make these delineations, maps of historic community sewage districts were used as a starting point and updated or refined using the latest sewer network GIS information from each community. Figure 5-1 presents a map of the delineated community connection service areas Appendix A presents a detailed schematic of the RVSDS with each community connection called out. Table 5-1 presents the acreages for each community connection. For connections with tributary areas that cover more than a single community, the acreages are provided for each community separately. The acreages are split into categories based on the type of collection system:

- Sanitary: Only sanitary sewage is conveyed by the collection system.
- Combined: Storm water and sanitary sewage share the same collection system; these areas utilize regulator structures at their connection to the interceptor.
- Other: Various types of industrial flows that are discharged into the interceptor such as landfill leachate or airplane de-icing glycol.

Once a service area was delineated for each community connection, service areas for each system monitoring point when then developed. Since the RVSDS contains flow divisions and parallel interceptor arms, there are many cases where flow meter additions and subtractions were required in order to yield a distinct service area. Since hydrologic factors require a distinct service area, these formulas remained throughout the analysis and include the following:

- [WCS2] + [WCS3] + [P14]
- [P24] + [P25]
- [P20] + [P21]
- [LV11] + [LV4]
- [LV Basin] - [LV4]
- [C] - [B] - [A]
- [P3] + [P25]
- [P9] + [P10] + [P11]

Figure E-1 also presents the delineated meter service areas. For analysis purposes, the meter districts were divided into two different categories:

- **Independent meter districts**: Districts that have no meter districts upstream, therefore the flow observed in the meter data is entirely attributable to that meter district.
- **Dependent meter districts**: Districts that have one or more meter districts upstream that flow into them, therefore the flow is attributable to multiple sources and subtraction of the upstream flow from the total metered flow must be employed to yield parameters specific to the meter district. The term **cumulative** is used when

specifying the total flow or area and the term **incremental** is used when specifying the total flow or area minus the upstream flow or area.

Table 5-2 presents the incremental acreages for each meter service areas along with the district type and any next upstream meters.

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Table 5-1
Community Connection Tributary Service Areas

Line Connection	Community	Sanitary Area (acres)	Combined Area (acres)	Other Area (acres)	Total Contributing Area (acres)
1	Dearborn Heights	81.8	--	--	81.8
2	Dearborn Heights	87.9	--	--	87.9
3	Dearborn Heights	689.8	--	--	689.8
4	Dearborn Heights	--	35.4	--	35.4
5	Dearborn Heights	17.0	--	--	17.0
6	Dearborn Heights	98.0	--	--	98.0
7	Dearborn Heights	--	152.0	--	152.0
8	Dearborn Heights	143.9	--	--	143.9
9	Dearborn Heights	--	29.4	--	29.4
10	Dearborn Heights	--	87.7	--	87.7
11	Dearborn Heights	--	73.8	--	73.8
12	Dearborn Heights	--	73.3	--	73.3
13	Dearborn Heights	--	116.9	--	116.9
14	Dearborn Heights	32.5	--	--	32.5
15	Dearborn Heights	1,776.9	--	--	1,776.9
16	Dearborn Heights	--	85.1	--	85.1
17	Dearborn Heights	--	71.6	--	71.6
18	Dearborn Heights	33.9	--	--	33.9
19	Dearborn Heights	33.9	--	--	33.9
20	Dearborn Heights	106.4	--	--	106.4
21	Dearborn Heights	99.5	--	--	99.5
22	Dearborn Heights	--	36.0	--	36.0
23	Dearborn Heights	--	101.2	--	101.2
24	Dearborn Heights	42.0	--	--	42.0
25	Dearborn Heights	25.4	--	--	25.4
26	Garden City	1,841.6	--	--	1,841.6
26	Westland	26.7	--	--	26.7
27	Garden City	1,909.7	--	--	1,909.7
27	Westland	14.1	--	--	14.1
28	Inkster	109.8	407.6	--	517.4
28	Westland	108.0	--	--	108.0
29	Inkster	273.5	114.2	--	387.7
30	Inkster	4.3	--	--	4.3
31	Inkster	--	37.8	--	37.8
32	Inkster	106.2	--	--	106.2
33	Inkster	58.5	--	--	58.5
33	Westland	15.6	--	--	15.6
34	Inkster	242.9	--	--	242.9
34	Westland	124.7	--	--	124.7
35	Inkster	47.8	--	--	47.8
36	Inkster	16.4	--	--	16.4

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Table 5-1 (continued)
Community Connection Tributary Service Areas

Line Connection	Community	Sanitary Area (acres)	Combined Area (acres)	Other Area (acres)	Total Contributing Area (acres)
37	Inkster	32.9	--	--	32.9
38	Inkster	33.8	--	--	33.8
39	Inkster	28.3	--	--	28.3
40	Inkster	12.1	--	--	12.1
41	Inkster	7.7	--	--	7.7
42	Inkster	8.9	--	--	8.9
43	Inkster	--	65.3	--	65.3
44	Inkster	17.7	--	--	17.7
45	Inkster	--	74.9	--	74.9
46	Inkster	566.9	42.1	--	609.0
47	Inkster	20.2	--	--	20.2
48	Inkster	--	19.1	--	19.1
49	Inkster	241.3	30.3	--	271.6
50	Inkster	--	32.7	--	32.7
51	Inkster	40.3	--	--	40.3
52	Dearborn Heights	--	264.5	--	264.5
52	Inkster	546.5	209.3	--	755.8
53	Inkster	5.4	--	--	5.4
54	Inkster	9.5	--	--	9.5
55	Inkster	4.4	--	--	4.4
56	Inkster	5.7	--	--	5.7
57	Inkster	21.5	--	--	21.5
58	Livonia	149.0	--	--	149.0
59	Livonia	40.2	--	--	40.2
60	Livonia	472.8	--	--	472.8
61	Livonia	161.3	--	--	161.3
62	Livonia	28.6	--	--	28.6
63	Livonia	66.4	--	--	66.4
64	Livonia	89.2	--	--	89.2
65	Livonia	78.0	--	--	78.0
66	Livonia	30.8	--	--	30.8
67	Livonia	51.0	--	--	51.0
68	Livonia	43.4	--	--	43.4
69	Livonia	14.5	--	--	14.5
70	Livonia	142.3	--	--	142.3
71	Livonia	96.1	--	--	96.1
72	Livonia	79.0	--	--	79.0
73	Livonia	1,187.9	--	--	1,187.9
74	Livonia	792.4	--	--	792.4
74	Westland	5.2	--	--	5.2
75	Livonia	1,287.7	--	--	1,287.7

Table 5-1 (continued)
Community Connection Tributary Service Areas

Line Connection	Community	Sanitary Area (acres)	Combined Area (acres)	Other Area (acres)	Total Contributing Area (acres)
76	Livonia	2,343.1	--	--	2,343.1
77	Livonia	5,113.7	--	--	5,113.7
78	Livonia	152.4	--	--	152.4
79	Livonia	1,892.1	--	--	1,892.1
80	Livonia	3,469.4	--	--	3,469.4
81	Livonia	3,437.0	--	--	3,437.0
82	Livonia	38.0	--	--	38.0
83	Livonia	775.7	--	--	775.7
84	Livonia	20.7	--	--	20.7
85	Livonia	21.7	--	--	21.7
86	Livonia	37.9	--	--	37.9
87	Livonia	11.1	--	--	11.1
88	Livonia	12.7	--	--	12.7
89	Northville	40.6	--	--	40.6
90	Northville	89.8	--	--	89.8
91	Northville	22.6	--	--	22.6
92	Northville	78.8	--	--	78.8
93	Northville	404.2	--	--	404.2
93	Northville Township	18.1	--	--	18.1
94	Northville	373.9	--	--	373.9
94	Northville Township	4.5	--	--	4.5
95	Northville	170.4	--	--	170.4
96	Novi	16,538.1	--	--	16,538.1
97	Plymouth	105.9	--	--	105.9
98	Plymouth	93.2	--	--	93.2
99	Plymouth	603.0	--	--	603.0
100	Plymouth	46.6	--	--	46.6
101	Plymouth	445.6	--	--	445.6
102	Plymouth Township	99.2	--	--	99.2
103	Plymouth Township	109.7	--	--	109.7
104	Redford Township	210.7	--	--	210.7
105	Livonia	407.8	--	--	407.8
105	Redford Township	701.0	913.9	--	1,614.9
106	Redford Township	--	51.4	--	51.4
107	Redford Township	86.8	77.0	--	163.8
108	Redford Township	27.6	--	--	27.6
109	Redford Township	35.2	--	--	35.2
110	Redford Township	13.5	--	--	13.5
111	Redford Township	48.7	--	--	48.7
112	Redford Township	229.2	--	--	229.2
113	Redford Township	--	147.8	--	147.8

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Table 5-1 (continued)
Community Connection Tributary Service Areas

Line Connection	Community	Sanitary Area (acres)	Combined Area (acres)	Other Area (acres)	Total Contributing Area (acres)
114	Redford Township	--	66.3	--	66.3
115	Redford Township	--	31.2	--	31.2
116	Redford Township	275.9	436.7	--	712.6
117	Redford Township	16.4	--	--	16.4
118	Redford Township	30.0	--	--	30.0
119	Redford Township	39.7	--	--	39.7
120	Redford Township	123.3	181.3	--	304.6
121	Redford Township	--	115.5	--	115.5
122	Redford Township	873.0	1,593.6	--	2,466.6
123	Redford Township	58.8	--	--	58.8
124	Redford Township	35.7	--	--	35.7
125	Redford Township	149.1	--	--	149.1
126	Redford Township	65.9	--	--	65.9
127	Romulus	36.5	--	--	36.5
128	Romulus	175.5	--	--	175.5
129	Romulus	377.2	--	--	377.2
130	Romulus	253.7	--	--	253.7
131	Romulus	191.4	--	--	191.4
132	Romulus	34.1	--	--	34.1
133	Romulus	145.4	--	--	145.4
134	Romulus	23.5	--	--	23.5
135	Romulus	441.4	--	--	441.4
136	Van Buren Township	6,078.3	--	--	6,078.3
137	Wayne	157.7	--	--	157.7
138	Wayne	70.0	--	--	70.0
139	Wayne	66.1	--	--	66.1
140	Wayne	185.6	--	--	185.6
141	Wayne	57.6	--	--	57.6
142	Wayne	307.4	--	--	307.4
143	Wayne	5.4	--	--	5.4
144	Wayne	11.5	--	--	11.5
145	Wayne	7.4	--	--	7.4
146	Wayne	43.0	--	--	43.0
147	Wayne	156.7	--	--	156.7
148	Wayne	80.8	--	--	80.8
149	Wayne	73.7	--	--	73.7
150	Wayne	97.1	--	--	97.1
151	Wayne	177.2	--	--	177.2
152	Wayne	9.2	--	--	9.2
153	Wayne	93.3	--	--	93.3
154	Wayne	3.8	--	--	3.8

Table 5-1 (continued)
Community Connection Tributary Service Areas

Line Connection	Community	Sanitary Area (acres)	Combined Area (acres)	Other Area (acres)	Total Contributing Area (acres)
155	Wayne	20.8	--	--	20.8
156	Wayne	35.3	--	--	35.3
157	Wayne	11.9	--	--	11.9
158	Wayne	1,041.1	--	--	1,041.1
159	Wayne	26.4	--	--	26.4
160	Wayne	43.6	--	--	43.6
161	Wayne	338.0	--	--	338.0
162	Westland	22.0	--	--	22.0
163	Westland	39.9	--	--	39.9
164	Westland	75.2	--	--	75.2
165	Westland	21.1	--	--	21.1
166	Westland	90.2	--	--	90.2
167	Westland	35.2	--	--	35.2
168	Westland	11.3	--	--	11.3
169	Westland	27.0	--	--	27.0
170	Westland	13.7	--	--	13.7
171	Westland	2.2	--	--	2.2
172	Westland	3.9	--	--	3.9
173	Westland	33.1	--	--	33.1
174	Westland	4,107.7	--	--	4,107.7
175	Westland	29.2	--	--	29.2
176	Westland	197.2	--	--	197.2
177	Westland	20.7	--	--	20.7
178	Westland	144.4	--	--	144.4
179	Westland	167.2	--	--	167.2
180	Westland	30.5	--	--	30.5
181	Westland	156.2	--	--	156.2
182	Westland	187.2	--	--	187.2
183	Wayne	82.8	--	--	82.8
183	Westland	2,599.7	--	--	2,599.7
184	Wayne	38.8	--	--	38.8
184	Westland	232.0	--	--	232.0
185	Wayne	4.2	--	--	4.2
185	Westland	422.4	--	--	422.4
186	Westland	1,664.2	--	--	1,664.2
187	Westland	20.9	--	--	20.9
188	Westland	27.8	--	--	27.8
189	Westland	29.5	--	--	29.5
190	Westland	516.8	--	--	516.8
191	Westland	346.0	--	--	346.0
192	Westland	42.8	--	--	42.8

Table 5-1 (continued)
Community Connection Tributary Service Areas

Line Connection	Community	Sanitary Area (acres)	Combined Area (acres)	Other Area (acres)	Total Contributing Area (acres)
193	Inkster	--	6.8	--	6.8
194	Canton Township	51.8	--	--	51.8
195	Canton Township	194.6	--	--	194.6
196	Canton Township	21,015.7	--	--	21,015.7
197	Canton Township	1,859.2	--	--	1,859.2
197	Northville	62.3	--	--	62.3
197	Northville Township	10,584.2	--	--	10,584.2
197	Plymouth Township	9,912.7	--	--	9,912.7
197	Salem Township	--	--	347.7	347.7
198	Romulus	--	--	4,881.3	4,881.3
199	Dearborn Heights	--	16.8	--	16.8
200	Wayne	110.8	--	--	110.8
	Total	**120,697.5**	**5,798.5**	**5,229.0**	**131,725.0**

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Table 5-2
Meter District Incremental Tributary Service Areas

Meter District	Type	Next Upstream Meter(s)	Sanitary Area (acres)	Combined Area (acres)	Other Area (acres)	Total Incremental Area (acres)
[WCS2]+[WCS3]+[P14]	Dependent	*[P9], [P10], [P11]*	3,334.8	742.0	--	4,076.8
[P24]+[P25]	Dependent	*[P20], [P21]*	3,148.1	1,441.8	--	4,589.9
[M2]	Independent	--	1,911.1	--	--	1,911.1
[M1]	Independent	--	1,923.8	--	--	1,923.8
[P20]+[P21]	Dependent	*[WE28], [WE25], [P19]*	2,212.2	--	4,881.3	7,093.5
[P7]	Dependent	*[P26]*	1,245.9	--	--	1,245.9
[P8]	Dependent	*[FE22]*	650.2	--	--	650.2
[LV16]	Independent	--	1,187.9	--	--	1,187.9
[LV15]	Independent	--	797.6	--	--	797.6
[LV14]	Independent	--	1,287.7	--	--	1,287.7
[LV Basin]-[LV4]	Independent	--	9,534.1	--	--	9,534.1
[LV11]+[LV4]	Independent	--	6,906.4	--	--	6,906.4
[P12]	Dependent	*[LV Basin], [LV11]*	826.4	--	--	826.4
[P1]	Dependent	*[BG1]*	1,202.9	--	--	1,202.9
[BG1]	Independent	--	16,538.1	--	--	16,538.1
[P3]+[P26]	Dependent	*[P1]*	848.7	--	--	848.7
[C-B-A]	Independent	--	445.6	--	--	445.6
[FE22]	Independent	--	22,873.7	--	347.7	23,221.4
[P13]	Independent	--	3,362.4	3,614.7	--	6,977.1
[P17]	Dependent	*[P15]*	2,528.5	--	--	2,528.5
[P15]	Independent	--	6,078.3	--	--	6,078.3
[P19]	Dependent	*[WE25], [FE19], [P17]*	1,024.5	--	--	1,024.5
[P9]+[P10]+[P11]	Dependent	*[LV14], [LV15], [LV16], [M1], [M2], [P3], [P7], [P8], [P12], [WE14]*	1,358.5	--	--	1,358.5
[WE14]	Independent	--	4,107.7	--	--	4,107.7
[WE25]	Independent	--	2,682.5	--	--	2,682.5
[WE28]	Independent	--	1,664.2	--	--	1,664.2
[FE19]	Independent	--	21,015.7	--	--	21,015.7
		Total:	**120,697.5**	**5,798.5**	**5,229.0**	**131,725.0**

Rouge Valley Sewage Disposal System

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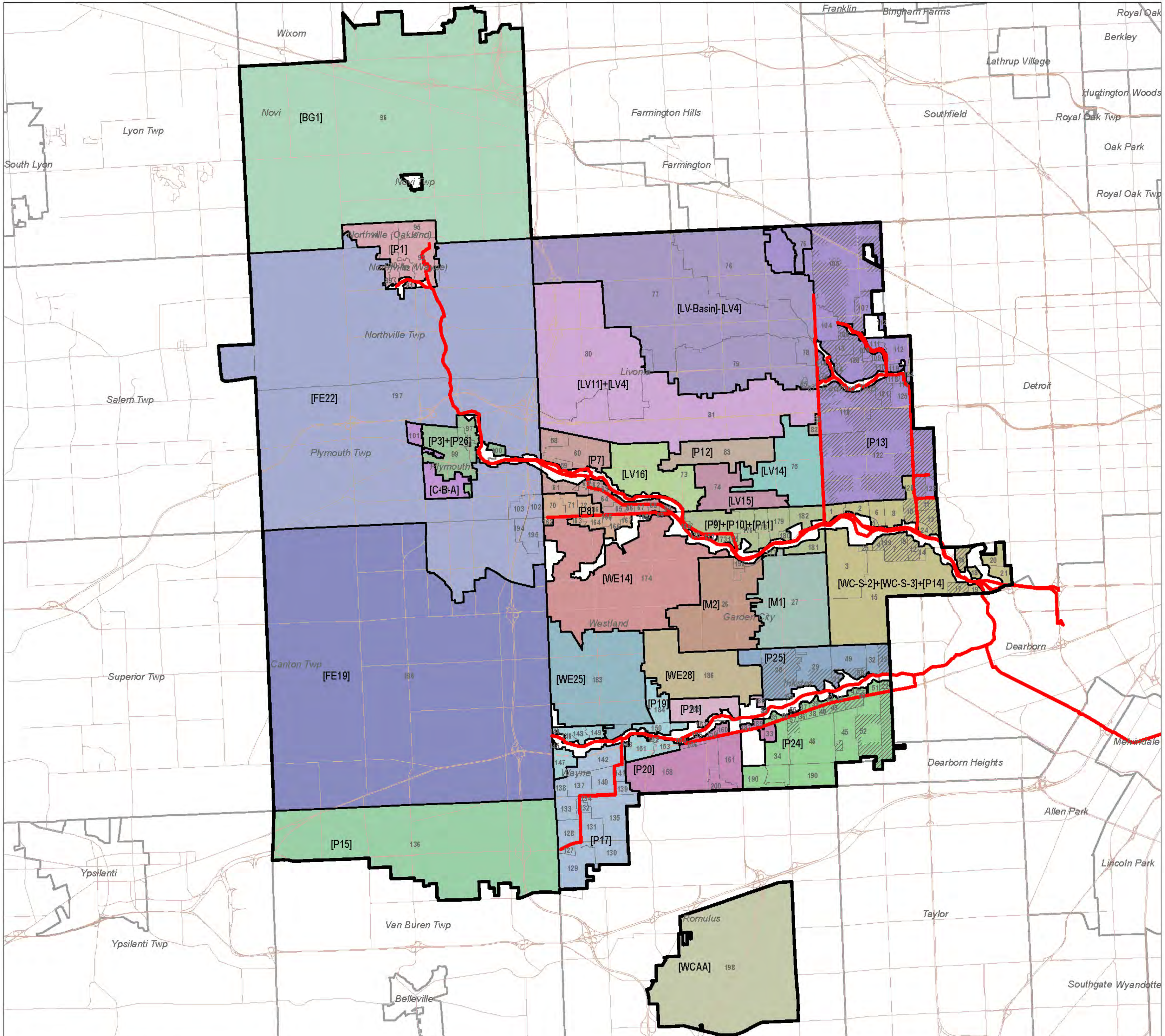

N W E S

0 0.5 1 2 3 4 Miles

Legend

- Interceptor
- Meter District
- Line Connection Area
- Combined Area
- Community Boundary
- Service Area Boundary
- Roads

Figure 5-1
Community Connection and Meter District Tributary Service Areas

Prepared By:

Applied Science, Inc.

Date: 8/24/2015

H:\2013\1315 -- Wayne County LTCAP Project Plan\Memos\H&H Report\Fig 5-1 - RVSDS Community Connection and Meter District Tributary Areas.mxd

6. Dry Weather Flows

Determining the typical dry weather flows (DWF) provides the foundation for understanding flows and their distribution in the RVSDS. The data from the SMP was reviewed and DWF values were determined for each meter district. These values were then apportioned throughout the community connections in the SWMM5 model. The analysis period was also compared to previous years to determine whether it was an appropriate representative period for determining DWF.

Methodology

A single set of dry days was used to estimate the dry weather flow rates for all of the meters. The dry weather days were determined by analyzing the daily flow rate traces for meters near the downstream end of the interceptor system. The meters used for this analysis include: the summation of Meters [P9] + [P10] + [P11] which represent the Middle Rouge interceptor system near Inkster Road, Meters [P24] + [P25] which represent the Lower Rouge interceptor system, and Meters [WCS1] + [WCS2] + [WCS3] which represent the entire RVSDS. These meter sums were chosen because they are near the downstream end of the interceptor system, include some dewatering flow rates, and provide a well-defined sort of dry/wet days. Two methods were used for screening out dry and wet weather days using average daily flow rates.

The first method was designed to flag days that exhibited abrupt changes in average daily flow rate from the preceding or following days. This criterion was selected because wet weather events will significantly raise the average daily flow rate when compared to the preceding day. Likewise, the average daily flow rate on the day following a wet weather event will exhibit a decrease as the flow rates subside.

The second method was designed to flag additional wet weather days that were typically found during large, multiple day events that elevated the metered flow rates for a few days. When this happens, the days in the middle of the event are not flagged by the first method because there is no change in the already elevated flow rate. For this method, the average daily flow rate on dry days was constrained to remain below two standard deviations of the three month average flow rate. Any day with a daily average above this was flagged as a wet day. The monitoring period data was analyzed in three month increments: January through March, April through June, July through September, and October through December.

Results

From this sort of dry days, two DWF conditions were determined: the springtime high and the yearly average. These two values provide insight into how much groundwater infiltration a meter district may experience during the wet springtime months. Table 6-1 presents the incremental dry weather and per-capita flow rates by meter district along with the meter math utilized to calculated the values. Some dependent meter districts were grouped together with upstream districts to provide larger incremental populations to determine the values from. The following groupings were made:

Group [P12] includes upstream meters [LV4], [LV11], [LV20], and [LV Basin]

Group [P9] + [P10] + [P11] includes upstream meters [P1], [P3], [P7], [P8], and [P26]

Group [P20] + [P21] includes upstream meter [P19]

The springtime high dry weather flow rate for March 2014 and the 2014 annual average dry weather flow rates for each meter district are provided in Table 6-2. The dry weather flow rates are presented for all months in 2014 in Table 6-3. Two combinations of meters can be used to calculate the total outlet flow from the RVSDS:

Total RVSDS Outlet = [WCS2] + [WCS3] + [P14] + [P24] + [P25] + [C - B - A] - [FE19] - [FE22]

Total RVSDS Outlet = [WCS1] + [WCS2] + [WCS3] + [C - B - A] - [FE19] - [FE22]

These two options are also included on Table 6-2 and are in very close agreement.

Comparisons to Other Years

Table 6-4 lists the monthly precipitation and the departure from normal at the Detroit Metropolitan Wayne County Airport (DTW) for 2014. The total precipitation at DTW during 2014 was 37.57 inches, which is 4.10 inches above normal. The monthly average dry weather flow rates for Meters [WCS1] + [WCS2] + [WCS3] from 2010 through 2014 are listed on Table 6-5. On average, the dry weather flow rates for 2014 were slightly above average, and were the second highest of the five year record. These two comparisons show that determining DWF values using data from the analysis period provides a conservative estimate.

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Table 6-1
Incremental Dry Weather Flow Rates

Branch	Meter District / Group	Meter Math	Census 2010 Population	Dry Weather Flow Rate			
				Springtime High March 2014		Annual Average Year 2014	
				(MGD)	(gpcd)	(MGD)	(gpcd)
Middle Rouge	[BG1]	*[BG1]*	43,217	5.03	116	4.66	108
	[C-B-A]	*[C]-[B]-[A]*	3,074	1.36	442	1.27	414
	[FE22]	*[FE22] - [C-B-A]*	-	5.74	-	3.67	-
	[LV16]	*[LV16]*	5,147	1.40	272	1.16	226
	[WE14]	*[WE14]*	26,724	4.11	154	3.58	134
	[LV15]	*[LV15]*	6,570	1.82	277	1.41	215
	[M2]	*[M2]*	13,739	2.89	210	2.17	158
	[M1]	*[M1]*	14,943	2.47	165	1.71	114
	[LV14]	*[LV14]*	7,738	1.65	213	1.24	160
	Group [P12]	*[P12]*	68,311	9.86	144	8.45	124
	Group [P9] + [P10] + [P11]	*[P9] + [P10] + [P11] - [P12] - [M1] - [M2] - [WE14] - [LV14] - [LV15] - [LV16] - [BG1] - [FE22]*	33,818	4.60	136	2.76	82
	[P13]	*[P-13]*	48,847	9.84	202	7.13	146
	[WCS2] + [WCS3] + [P14]	*[WCS2] + [WCS3] + [P14] - [P9] - [P10] - [P11] - [P13]*	36,637	7.22	197	5.66	154
Lower Rouge	[P15]	*[P15]*	6,938	1.08	155	0.80	115
	[P17]	*[P17] - [P15]*	2,623	0.88	335	0.77	295
	[FE19]	*[FE19]*	-	0.00	-	0.00	-
	[WE25]	*[WE25]*	16,269	2.40	148	1.81	111
	Group [P20] + [P21]	*[P20] + [P21] - [P17] - [FE19] - [WE25]*	37,944	6.44	170	4.77	126
	[P24] + [P25]	*[P24] + [P25] - [P20] - [P21]*	32,245	5.39	167	4.43	137
		Total RVSDS:	**404,784**	**74.18**	**183**	**57.46**	**142**

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Table 6-2
Cumulative Dry Weather Flow Rates

Branch	Meter	Year 2010 Population	Dry Weather Flow Rate (MGD)			
			Springtime High March 2014		Annual Average Year 2014	
			(MGD)	(gpcd)	(MGD)	(gpcd)
Middle Rouge	[BG1]	43,217	5.03	116	4.66	108
	[P1]	49,143	5.63	115	5.22	106
	[P3] + [P26]	55,091	6.29	114	6.01	109
	[P7]	4,814	1.56	324	1.34	279
	[C - B - A]	3,074	1.36	442	1.27	414
	[FE22]	-	7.10	-	4.95	-
	[P8] - [FE22]	4,395	0.68	155	0.41	94
	[LV16]	5,147	1.40	272	1.16	226
	[WE14]	26,724	4.11	154	3.58	134
	[LV15]	6,570	1.82	277	1.41	215
	[M2]	13,739	2.89	210	2.17	158
	[M1]	14,943	2.47	165	1.71	114
	[LV14]	7,738	1.65	213	1.24	160
	[LV Basin] - [LV4]	39,591	5.69	144	4.30	109
	[LV11] + [LV4]	28,266	5.84	207	4.79	169
	[P12]	68,311	9.86	144	8.45	124
	[P9] + [P10] + [P11] - [FE22]	223,281	33.83	152	27.14	122
	[P13]	48,847	9.84	202	7.13	146
	[WCS2] + [WCS3] + [P14] - [FE22]	308,765	50.89	165	39.93	129
Lower Rouge	[P15]	6,938	1.08	155	0.80	115
	[P17]	9,561	1.96	205	1.57	165
	[FE19]	-	0.00	-	0.00	-
	[WE25]	16,269	2.40	148	1.81	111
	[P19] - [FE19]	32,127	5.27	164	3.99	124
	[WE28]	14,096	1.11	79	1.00	71
	[P20] + [P21] - [FE19]	63,774	10.80	169	8.16	128
	[P24] + [P25] - [FE19]	96,019	16.18	169	12.59	131
Outlet	[WCS2] + [WCS3] + [P14] + [P24] + [P25] + [C - B - A] - [FE19] - [FE22]	68.43	169	53.79	133	68.43
	[WCS1] +[WCS2] + [WCS3] + [C - B - A] - [FE19] - [FE22]	69.75	172	54.24	134	69.75

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Table 6-3
Cumulative Dry Weather Flow Rates by Month

Branch	Meter	Dry Weather Flow Rate (MGD)												
		Jan-14	Feb-14	Mar-14	Apr-14	May-14	Jun-14	Jul-14	Aug-14	Sep-14	Oct-14	Nov-14	Dec-14	Average Annual
Middle Rouge	[BG1]	4.55	4.50	5.03	4.82	4.87	4.94	4.48	4.50	4.61	4.50	4.48	4.67	4.66
	[P1]	5.09	4.95	5.63	5.49	5.55	5.65	5.01	4.98	5.15	5.00	4.92	5.15	5.22
	[P3]	6.22	5.94	6.21	6.38	6.51	6.29	5.66	5.63	5.75	5.52	5.38	5.76	5.94
	[P26]	0.08	0.05	0.07	0.06	0.08	0.12	0.05	0.08	0.09	0.06	0.05	0.05	0.07
	[P7]	1.31	1.19	1.56	1.52	1.56	1.54	1.31	1.34	1.38	1.17	1.07	1.15	1.34
	[A]	0.39	0.41	0.38	0.32	0.32	0.30	0.25	0.24	0.25	0.26	0.24	0.24	0.30
	[B]	0.77	0.71	0.89	0.90	0.89	0.88	0.72	0.56	0.63	0.66	0.56	0.67	0.74
	[C]	2.16	2.04	2.63	2.61	2.58	2.65	2.17	2.16	2.32	2.17	1.96	2.27	2.31
	[FE22]	4.87	4.32	7.10	6.12	6.01	5.73	4.19	4.26	4.78	4.21	3.54	4.19	4.95
	[P8]	5.25	4.61	7.78	6.46	6.28	6.17	4.54	4.61	5.24	4.61	4.09	4.65	5.36
	[LV16]	1.17	1.10	1.40	1.48	1.41	1.25	0.96	1.10	1.26	1.02	0.87	0.96	1.16
	[WE14]	3.66	3.40	4.11	4.02	3.99	3.84	3.18	3.43	3.53	3.30	3.15	3.37	3.58
	[LV15]	1.44	1.27	1.82	1.77	1.79	1.45	1.04	1.20	1.55	1.20	1.12	1.27	1.41
	[M2]	2.19	1.92	2.89	2.79	2.81	2.35	1.69	1.98	2.13	1.83	1.57	1.87	2.17
	[M1]	1.83	1.76	2.47	2.25	2.08	1.72	1.29	1.30	1.43	1.44	1.31	1.58	1.71
	[LV14]	1.23	1.09	1.65	1.57	1.57	1.24	0.90	1.07	1.42	1.11	0.97	1.05	1.24
	[LV4]	3.04	2.65	3.64	3.68	3.49	3.18	2.35	2.75	3.15	2.63	2.32	2.49	2.95
	[LV20]	0.06	0.07	0.06	0.07	0.07	0.06	0.05	0.05	0.07	0.06	0.07	0.08	0.07
	[LV Basin]	7.34	6.57	9.33	9.24	8.85	8.17	5.63	6.27	7.12	6.22	5.62	6.56	7.25
	[LV11]	1.83	1.60	2.20	2.07	2.00	1.84	1.65	1.79	1.95	1.68	1.63	1.80	1.84
	[P12]	8.09	6.74	9.86	10.58	10.73	9.73	7.03	7.71	8.66	7.53	6.99	7.61	8.45
	[P9]	3.29	2.71	5.23	4.79	4.50	3.81	2.11	2.40	3.16	2.58	2.19	2.73	3.29
	[P10]	19.58	18.11	24.07	23.01	22.54	20.85	16.58	17.43	19.22	17.34	16.07	17.70	19.38
	[P11]	9.58	8.85	11.62	10.99	10.89	10.04	8.03	8.61	9.54	8.43	7.69	8.63	9.41
	[P13]	7.58	6.70	9.84	10.02	9.53	6.65	4.53	5.22	6.88	6.46	5.53	6.60	7.13
	[P14]	29.50	27.61	34.21	33.69	33.03	30.80	25.73	27.25	29.80	27.53	25.50	28.38	29.43
Lower Rouge	[P15]	0.90	0.86	1.08	0.95	0.92	0.72	0.64	0.67	0.75	0.68	0.68	0.73	0.80
	[P17]	1.66	1.61	1.96	1.71	1.74	1.71	1.41	1.28	1.54	1.37	1.41	1.48	1.57
	[FE19]	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00
	[WE25]	1.95	1.70	2.40	2.25	2.26	2.03	1.52	1.60	1.62	1.47	1.38	1.59	1.81
	[P19]	4.34	3.98	5.27	4.66	4.50	3.94	2.96	3.19	3.73	3.72	3.64	3.91	3.99
	[WE28]	0.84	0.75	1.11	1.05	1.17	1.00	0.70	1.02	1.26	1.13	0.95	1.02	1.00
	[P21]	6.05	5.52	7.27	6.53	6.55	5.98	4.47	4.78	5.29	4.69	4.43	4.98	5.55
	[P25]	9.03	8.17	10.26	9.10	10.03	8.84	6.16	5.95	8.20	7.19	6.79	7.93	8.14
	[P20]	2.99	2.95	3.53	3.85	3.40	2.66	2.13	2.06	2.35	1.99	1.67	1.83	2.61
	[P24]	4.82	4.92	5.93	5.69	5.06	4.44	3.91	3.95	4.31	3.68	3.24	3.53	4.45
RVSDS Outlet	[WCS1]	44.20	41.15	51.71	49.93	49.24	44.93	35.89	38.06	42.37	38.31	35.11	38.66	42.47
	[WCS2]	10.22	8.68	12.53	12.25	12.46	10.63	7.44	8.02	9.44	7.94	6.49	8.88	9.59
	[WCS3]	6.59	4.77	11.25	9.48	8.35	6.43	3.17	4.45	5.34	3.91	3.10	3.36	5.86
	[WCS1] +[WCS2] + [WCS3]	61.01	54.61	75.49	71.65	70.05	61.98	46.50	50.54	57.15	50.16	44.71	50.90	57.91
	[WCS2] + [WCS3] + [P14] + [P24] + [P25]	60.16	54.16	74.18	70.21	68.92	61.14	46.41	49.64	57.10	50.25	45.12	52.08	57.46

Table 6-4
Monthly Precipitation at Detroit Metropolitan Airport for 2014

Month	Monthly Total Precipitation (inches)	Departure from Normal[1]
January	2.92	0.96
February	2.82	0.80
March	1.49	-0.79
April	2.57	-0.33
May	4.87	1.49
June	4.00	0.48
July	2.43	-0.94
August	6.32	3.32
September	4.71	1.44
October	2.36	-0.16
November	1.67	-1.12
December	1.41	-1.05
Total	**37.57**	**4.10**

Notes: 1. Normal values were computed over the period from 1981 through 2010.

Table 6-5
Cumulative Dry Weather Flow Rates at RVSDS Outlet for 2010 through 2014

Month	Meters [WCS1] + [WCS2] + [WCS3] (MGD)					
	2010	2011	2012	2013	2014	Average
January	54.95	48.00	73.75	48.04	61.01	56.42
February	52.16	51.38	69.33	58.57	54.61	57.36
March	66.62	86.06	70.11	62.83	75.49	70.00
April	60.24	77.24	55.98	70.19	71.65	64.98
May	69.92	84.18	49.34	58.94	70.05	63.23
June	65.59	66.55	41.35	56.36	61.98	57.13
July	50.99	46.09	41.28	62.76	46.50	48.85
August	47.42	49.04	40.70	47.53	50.54	46.98
September	41.29	48.60	38.20	46.75	57.15	45.85
October	40.29	54.13	38.67	43.60	50.16	45.50
November	40.20	52.17	38.84	56.82	44.71	46.44
December	47.07	82.66	40.13	59.79	50.90	54.55
Average	***51.53***	***59.33***	***49.01***	***55.29***	***57.32***	***54.33***

7. Wet Weather Event Identification

The precipitation data for all wet weather events in the post-STCAP monitoring period were analyzed to identify which events were significant enough to merit further analysis in the development of hydrologic parameters. This is an important consideration because as events become greater in scale they are less influenced by the effects of antecedent moisture conditions, typically have low spatial variability, and there is a more apparent distinction between the wet weather flow rates in the meter data. This leads to increased certainty when projecting any determined hydrologic parameters to design event levels.

Any event with an inter-event time less than 24 hours and an average precipitation depth greater than one inch was considered significant. Using climatological data provided by the NCDC weather station at the Detroit Metropolitan Airport, each event was also confirmed that the precipitation did not fall as snowfall and no melting of snowfall/snowpack was occurring. Table 7-1 presents the precipitation depths for every event that met this criterion. In total, there were 21 significant events during the post-STCAP monitoring period. From this group of significant events, a second selection was made to determine which events would be used for hydrologic parameter development.

The significant events were first reviewed for spatial uniformity. A coefficient of variation (CV) was determined for each significant event by computing the standard deviation of precipitation depth and dividing it by the arithmetic average. Table 7-2 presents the spatial uniformity statistics for each significant event.

Next, the significant events were reviewed in how the rainfall was distributed over time. For analysis purposes, it is ideal that the event occurred over a single peak of intensity. This allows a clear cause-and-effect relationship to be distinguished between the rainfall and the response of the sewer system. This helps better determine the shape of inflow hydrographs and the expected travel times through the system.

The flood frequency of the Rouge River was also considered when selecting events. Table 7-3 shows the return estimated flood frequency in months, based on the 15-minute peak flow rate of the Rouge River during each significant event.

Each significant event was reviewed independently against the factors described above. In general, the events selected for hydrologic parameter development had large rainfall amounts, low CVs, and occurred as a single burst. In total, eight of the significant events shown highlighted on Tables 7-1 and 7-2 were selected for further use in the hydrologic analysis.

Table 7-1
Rain Gauge Volume by Significant Event

Significant Event No.	Start Date/Time	Stop Date/Time	Duration (hours)	DWSD			Garden City	Livonia		Wayne County										DTW	WTUA		Novi		Oakland County	
				PG032	PG033	PG034	RG-01	RG-01	RG-02	R10	R11	R12	R13	R14	R15	R18	R27	R28	R29		LR EQ Basin	MR EQ Basin	DPS	Park Place	0843	0850
1	7/26/12 12:00 AM	7/28/12 6:00 AM	54	2.25	2.46	2.15	1.41	2.68	2.39	0.85	1.28	2.31	1.28	0.29	2.26	0.47	1.64	2.55	2.46	1.26					1.85	1.57
2	8/9/12 2:00 AM	8/11/12 10:00 AM	56	1.68	1.43	1.50	1.14	1.43	1.86	0.86	1.43	0.00	1.09	1.06	1.34	1.01	1.41	1.45	1.70	0.80					1.44	2.06
3	1/28/13 12:00 AM	1/31/13 12:00 AM	72	1.61	1.43	1.18	1.33	1.48	1.34	0.54	1.77	1.72	0.80	0.00	2.15	1.40	0.95	1.49	0.19	1.33					3.25	1.83
4	2/26/13 12:00 AM	3/1/13 12:00 AM	72	1.06	1.07	1.57	1.07	1.10	0.95	1.31	0.78	1.40	0.92	0.00	1.66	1.55	1.56	1.55	1.47	1.63					0.17	0.87
5	4/10/13 12:00 AM	4/12/13 6:00 AM	54	2.05	1.96	2.10	1.67	1.95	1.61	0.00	2.15	2.10	0.00	2.14	2.01	2.01	2.29	2.15	2.24	1.92	1.91	1.89			0.00	2.00
6	4/17/13 12:00 PM	4/19/13 12:00 PM	48	1.97	1.90	2.17	1.69	1.73	1.70	0.14	1.67	1.69	0.00	2.12	1.67	2.75	2.17	0.91	2.03	1.81	1.76	1.77			1.91	1.84
7	5/27/13 12:00 PM	5/29/13 12:00 AM	36	1.07	1.43	1.11	0.98	1.22	1.02	0.00	0.83	1.12	0.92	0.90	0.96	0.93	0.93	1.13	1.04	0.99	0.83	0.93			0.92	0.58
8	6/12/13 12:00 PM	6/13/13 12:00 PM	24	1.77	2.05	1.40	1.69	1.78	1.05	1.54	1.30	1.89	1.26	1.46	1.43	0.88	0.00	1.67	1.84	1.73	1.09	1.39			0.86	1.49
9	6/25/13 6:00 AM	6/29/13 12:00 AM	90	1.69	2.16	1.54	1.87	2.26	2.20	2.08	1.93	2.20	1.09	1.97	1.40	2.29	0.00	1.92	2.14	2.58	2.02	2.00			1.85	1.70
10	7/8/13 12:00 PM	7/10/13 6:00 PM	54	0.51	2.53	3.09	1.55	1.98	0.18	0.58	1.50	1.94	0.85	1.91	1.38	0.81	0.00	2.00	1.04	0.74	1.05	2.55			1.27	0.43
11	7/15/13 12:00 PM	7/16/13 6:00 PM	30	0.16	1.09	1.69	0.32	0.25	0.02	0.27	0.14	0.10	0.19	0.27	1.49	0.63	0.00	1.56	1.50	0.28	0.16	0.12			0.33	0.13
12	8/12/13 6:00 AM	8/13/13 6:00 AM	24	0.68	0.86	0.87	0.98	0.87	0.75	0.00	0.95	0.95	1.00	2.35	1.62	2.16	0.00	0.92	0.90	2.46	1.53	0.99			0.88	0.98
13	10/30/13 6:00 PM	11/1/13 6:00 AM	36	1.50	1.67	1.64	1.71	1.48	1.42	2.07	1.56	1.80	1.68	2.04	1.93	1.84	1.97	2.02	1.78	2.02	1.80	1.62			1.58	0.08
14	12/19/13 12:00 AM	12/22/13 12:00 PM	84	0.47	0.53	0.56	1.15	0.32	1.40	1.61	1.97	1.46	0.00	1.48	1.48	1.57	1.63	1.72	1.53	1.47					1.60	1.58
15	4/29/14 12:00 AM	4/30/14 6:00 AM	30	1.26	1.20	1.35	1.10	0.71	0.87	0.97	0.98	1.23	0.00	0.95	1.25	0.80	1.32	1.28	1.26	1.10					0.58	0.97
16	5/12/14 6:00 AM	5/15/14 12:00 PM	78	1.72	1.93	0.00	1.44	1.81	2.89	2.54	3.06	1.50	0.00	1.72	1.76	1.66	1.95	1.66	1.85	2.34					2.62	2.61
17	5/27/14 12:00 PM	5/28/14 6:00 PM	30	1.23	1.24	0.00	1.77	1.39	1.57	1.08	0.95	1.50	0.00	0.71	1.53	0.24	2.02	1.20	1.41	1.75					1.05	0.74
18	6/18/14 12:00 AM	6/19/14 6:00 PM	42	1.26	1.97	1.16	1.67	1.76	2.00	0.16	1.78	1.88	0.00	1.52	2.54	1.20	2.37	2.24	2.63	2.01					1.70	0.00
19	8/11/14 6:00 AM	8/13/14 12:00 AM	42	3.12	3.58	4.90	5.11	2.80	3.66	4.26	3.09	4.74	0.00	2.52	4.73	2.20	6.07	6.05	3.53	4.85	2.94	4.35	2.15	0.88	3.08	1.64
20	9/10/14 6:00 AM	9/11/14 12:00 AM	18	0.00	0.00	0.00	1.63	1.52	1.32	1.54	1.36	1.60	1.66	1.79	1.77	1.77	1.70	1.71	1.57	1.41	1.51	1.56			1.43	1.42
21	11/22/14 6:00 AM	11/24/14 6:00 PM	60	0.00	0.00	0.00	1.38	1.07	1.24	1.36	1.32	1.28	1.35	1.43	1.63	1.22	1.39	1.48	1.34	1.30	1.21	1.16				1.56

Key
Suspect Data
Missing Data

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Table 7-2
Summary Statistics of Significant Events

Significant Event No.	Hydrologic Analysis Event No.	Start Date/Time	Stop Date/Time	Duration (hours)	Rainfall Depth (inches)				Coefficient of Variation[2]
					Minimum	Numerical Average	Maximum	Std. Dev	
1	-	7/26/12 12:00 AM	7/28/12 6:00 AM	54	0.29	1.76	2.68	0.72	41%
2	1	8/9/12 2:00 AM	8/11/12 10:00 AM	56	0.80	1.37	2.06	0.33	24%
3	-	1/28/13 12:00 AM	1/31/13 12:00 AM	72	1.18	1.54	2.15	0.26	17%
4	-	2/26/13 12:00 AM	3/1/13 12:00 AM	72	0.78	1.27	1.66	0.30	24%
5	2	4/10/13 12:00 AM	4/12/13 6:00 AM	54	1.61	2.01	2.29	0.17	9%
6	3	4/17/13 12:00 PM	4/19/13 12:00 PM	48	1.67	1.91	2.75	0.27	14%
7	4	5/27/13 12:00 PM	5/29/13 12:00 AM	36	0.83	1.01	1.43	0.14	14%
8	5	6/12/13 12:00 PM	6/13/13 12:00 PM	24	1.05	1.55	2.05	0.28	18%
9	-	6/25/13 6:00 AM	6/29/13 12:00 AM	90	1.40	1.99	2.58	0.28	14%
10	-	7/8/13 12:00 PM	7/10/13 6:00 PM	54	0.43	1.46	3.09	0.76	52%
11	-	7/15/13 12:00 PM	7/16/13 6:00 PM	30	0.02	0.53	1.69	0.57	107%
12	-	8/12/13 6:00 AM	8/13/13 6:00 AM	24	0.68	1.19	2.46	0.55	46%
13	6	10/30/13 6:00 PM	11/1/13 6:00 AM	36	1.42	1.76	2.07	0.20	12%
14	-	12/19/13 12:00 AM	12/22/13 12:00 PM	84	0.47	1.37	1.97	0.44	32%
15	-	4/29/14 12:00 AM	4/30/14 6:00 AM	30	0.58	1.07	1.35	0.22	21%
16	-	5/12/14 6:00 AM	5/15/14 12:00 PM	78	1.44	2.06	3.06	0.51	25%
17	-	5/27/14 12:00 PM	5/28/14 6:00 PM	30	0.24	1.26	2.02	0.44	35%
18	-	6/18/14 12:00 AM	6/19/14 6:00 PM	42	1.16	1.86	2.63	0.45	24%
19	7	8/11/14 6:00 AM	8/13/14 12:00 AM	42	0.88	3.65	6.07	1.37	38%
20	8	9/10/14 6:00 AM	9/11/14 12:00 AM	18	1.32	1.57	1.79	0.15	9%
21	-	11/22/14 6:00 AM	11/24/14 6:00 PM	60	1.07	1.34	1.63	0.14	11%

Notes:

1) Events where the average rainfall depth exceeds 1 inch are considered significant events.
2) The Coefficient of Variation (CV) is the ratio of the standard deviation to the average. It provides a normalized assessment of the degree of spatial variability for a given event. This allows comparisons to be made between events regarding their uniformity over the service area independent of the magnitude of each event. A low CV means the event's rainfall was evenly distributed over the district, a high CV means the storm event had pockets of intense rainfall within the district.

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Table 7-3
Rouge River Flood Frequency in the STCAP Monitoring Period

Hydrologic Analysis Event No.	Significant Event No.	Start Date	End Date	Peak 15-Minute Flow Rate (cfs)		Estimated Flood Frequency (months)	
				Middle Rouge USGS Gage #04167000	Lower Rouge USGS Gage #04168000	Middle Rouge USGS Gage #04167000	Lower Rouge USGS Gage #04168000
-	1	7/26/2012	7/29/2012	619	594	5	3
1	2	8/9/2012	8/11/2012	291	288	1	1
-	3	1/28/2013	1/31/2013	590	606	4	3
-	4	2/26/2013	3/2/2013	239	277	1	1
2	5	4/10/2013	4/13/2013	652	809	5	5
3	6	4/17/2013	4/20/2013	828	992	9	7
4	7	5/27/2013	5/29/2013	252	196	1	1
5	8	6/12/2013	6/14/2013	706	624	6	3
-	9	6/25/2013	6/29/2013	690	727	5	4
-	10	7/8/2013	7/11/2013	690	935	5	6
-	11	7/15/2013	7/16/2013	214	216	1	1
-	12	8/12/2013	8/14/2013	269	448	1	2
6	13	10/30/2013	11/2/2013	442	621	3	3
-	14	12/19/2013	12/23/2013	485	891	3	5
-	15	4/29/2014	5/1/2014	343	344	1	1
-	16	5/12/2014	5/17/2014	925	742	11	4
-	17	5/27/2014	5/29/2014	497	715	3	4
-	18	6/18/2014	6/20/2014	722	776	6	5
7	19	8/11/2014	8/13/2014	1,890	1,590	107 (8.9 years)	40 (3.3 years)
8	20	9/10/2014	9/11/2014	627	801	5	5
-	21	11/22/2014	11/25/2014	463	643	3	3

Frequency Curves

Estimated Flood Frequency	04167000 (cfs)	04168000 (cfs)
1-month	315	352
6-month	734	954
1-year	944	1,212
2-year	1,066	1,317
5-year	1,549	1,938
10-year	1,988	2,507
100-year	3,255	4,171

8. Hydrograph Volume Parameters

The parameters that determine the volume of flows generated by a sewage district are determined through an analysis of flow meter data whereby various components of sewage flow are quantified.

Flow Rate Decomposition

The U.S. EPA Sanitary Sewer Overflow Analysis and Planning Toolbox (SSOAP) program was used for decomposition of the total meter flow rate data into its various constituents. SSOAP is a public domain analysis software that was developed by the U.S. EPA. SSOAP may be downloaded for free from the U.S. EPA's website at:

http://www.epa.gov/nrmrl/wswrd/wq/models/ssoap/index.html#download

The flows in a sanitary sewer are divided into the following categories by SSOAP:

- Dry Weather Flows (DWF)
  - Base wastewater (sanitary) flow (BWWF)
  - Groundwater Infiltration (GWI)
- Wet Weather Flows
  - Rainfall dependent inflow and infiltration (RDI/I)

First, an average diurnal dry weather flow pattern is determined by statistically selecting dry weather flow days and averaging the value of each timestep on every dry weather day. The dry weather day statistics used in the analysis removed any days that met the following criteria:

- Days with an average flow rate that was greater than two standard deviations of all daily averages;
- Days with less than 100% of the flow rate data; and
- Days during daylight savings time as this creates a skew that SSOAP does not currently have the ability to account for.

The GWI during dry weather days is assumed to be equal to the nighttime minimum flow rate. The GWI during wet weather days is aligned with the recorded data preceding the event and increased until over the event until it matches the recession of the event. Subtracting the total metered flow rate from the estimated DWF trace yields the estimated RDI/I trace for the event.

Event Rainfall

Because of the large land area of the RVSDS and the availability of numerous precipitation gages, the Thiessen polygon method was used to compute a weighted average rainfall depth for each meter district. This method helps reduce the effects of any spatial variability that may have occurred during each event. Since the set of rain gages were in service varied between each event, the polygons were delineated specifically for each event for the gages in service during that event. The polygons were created using the ArcMap 10 GIS software and are presented in Appendix B along with their weighting values. Table 8-1 presents the computed Theissen polygon area-weighted event rainfall depths by meter district.

Capture Coefficients

The capture coefficient is the fraction of rainfall that fell over the meter district that becomes RDI/I. It is calculated as the quotient of a RDI/I volume and rainfall (both given in inches over the meter district). SWMM5 utilizes a capture coefficient, along with the shape parameters discussed in the next section, for calculating the volume generated by RDI/I that is to be input into the system model.

The RDI/I trace that was estimated using SSOAP was used to calculate the total event RDI/I volume for each of the eight hydrologic parameter development events for each meter. The RDI/I volume was then divided by the event rainfall volume and the meter districts area to determine the event capture coefficient.

A spreadsheet containing a simplified schematic of the RVSDS was created for each event in order to visualize the meter connectivity and to make event-specific adjustments to account for meters going in and out-of-service. The schematic spreadsheets were used to perform the calculation of the incremental capture coefficient for dependent meter districts.

For this analysis, RDI/I was considered to be the rainfall volume that fell within the meter district that entered the sewer through cracks and defects in the sewer walls and manhole structures. Much of the RVSDS is located in a floodplain and river inflow can potentially become a significant source of wet weather flows that will obscure any RDI/I determination. Flows from combined sewer systems will also merge with the RDI/I flow. These combined sewers are regulated at their connections and theoretically only allow an agreed upon “sanitary” portion through. However, many of the RVSDS regulators are in poor or unknown condition and could potentially be contributing more flow than expected.

Likewise, flows leaving the meter district will ideally all pass through the metering location, however unmetered flow diversions and SSO will not. The only unmetered flow diversions that actively exist in the RVSDS are upstream of the WTUA meters FE19 and FE22 where a portion of unmetered flow is sent to the YCUA WWTP. Another diversion exists upstream of Meter P15 where wet weather flows can be diverted to the Downriver Sewage Disposal System; however, this diversion was not operated in the analysis period.

Table 8-2 presents the cumulative and incremental areas for each meter district and the meter math utilized. Table 8-3 presents the cumulative capture coefficient calculated for every meter district for every event. Table 8-4 presents the incremental capture coefficients with events that are suspected to have SSO or river inflow are highlighted in the table. Meter District P9+P10+P11 includes upstream Meter P8. This was required as the incremental area of P8 was not sufficiently large enough to accurately determine its capture coefficient.

Combined Sewer Areas

Combined sewer areas were represented in the model using subcatchment elements. The parameters for these subcatchments were taken directly from the GDRSS model and are presented in Table 8-5. The directly connected impervious area (DCIA) percentages were updated to reflect the most recent delineation of community connection service areas by intersecting each area with the Southeast Michigan Counsel of Governments (SEMCOG) land use data. Table 8-6 presents the assumed DCIA percentage for each land use category. Table 8-7 presents the area-weighted DCIAs for each combined sewer area in the RVSDS.

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Table 8-1
Thiessan Polygon Rainfall Depths in Inches

Branch	Meter District	Event 1	Event 2	Event 3	Event 4	Event 5	Event 6	Event 7	Event 8
		8/9/2012	4/10/2013	4/17/2013	5/27/2013	6/12/2013	10/30/2013	8/11/2014	9/10/2014
Middle Rouge	[BG1]	1.97	1.93	1.81	0.69	1.39	1.50	2.16	1.40
	[P1]	1.45	2.13	1.67	0.84	1.29	1.55	1.97	1.36
	[P3]+[P26]	1.43	2.10	1.69	0.85	1.32	1.57	3.32	1.40
	[C-B-A]	1.43	2.00	1.73	0.89	1.35	1.60	3.83	1.48
	[FE22]	1.45	2.12	1.67	0.84	1.29	1.55	3.13	1.36
	[LV16]	1.43	1.97	1.72	1.21	1.79	1.52	3.04	1.53
	[WE14]	1.16	1.82	1.72	0.98	1.60	1.69	4.75	1.60
	[LV15]	1.42	2.06	1.71	1.15	1.88	1.73	4.32	1.58
	[M2]	1.14	1.71	1.69	0.99	1.71	1.72	5.07	1.63
	[M1]	1.35	2.16	2.05	0.95	1.74	1.91	5.79	1.68
	[LV14]	1.82	2.00	1.85	1.35	2.00	1.71	3.90	1.59
	[LV Basin]-[LV4]	1.67	1.86	1.82	1.14	1.55	1.52	3.42	1.44
	[LV11]+[LV4]	1.53	1.89	1.75	1.17	1.60	1.51	3.21	1.46
	[P12]	1.43	1.96	1.83	1.34	1.93	1.59	3.24	1.53
	[P9]+[P10]+[P11]	1.35	2.00	1.75	1.04	1.65	1.70	4.43	1.58
	[P13]	1.63	2.16	2.02	1.08	1.79	1.76	3.99	1.60
	[WCS2]+[WCS3]+[P14]	1.45	2.20	2.17	1.05	1.63	1.96	5.93	1.71
Lower Rouge	[P15]	0.99	2.00	2.01	0.87	1.24	1.89	2.76	1.63
	[P17]	0.90	1.95	1.79	0.85	1.24	1.89	3.38	1.52
	[FE19]	1.18	1.93	1.81	0.87	1.23	1.77	3.33	1.56
	[WE25]	1.13	1.85	1.74	0.87	1.26	1.77	3.56	1.55
	[P19]	1.07	1.82	1.74	0.88	1.21	1.74	3.71	1.59
	[WE28]	1.12	1.67	1.69	0.96	1.53	1.70	5.11	1.64
	[P20]+[P21]	1.09	1.82	1.76	0.92	1.25	1.69	4.60	1.65
	[P24]+[P25]	1.18	2.19	2.07	0.93	1.29	1.76	5.75	1.67

Table 8-2
Meter District Areas and Incremental Math

Branch	Meter District	Meter Math	Incremental Area (acres)	Upstream Area (acres)	Cumulative Area (acres)
Middle Rouge	[BG1]	*[BG1]*	16,538.1	--	16,538.1
	[P1]	*[P1]-[BG1]*	1,202.9	16,538.1	17,741.0
	[P3]+[P26]	*[P3]+[P26]-[P1]*	848.7	17,741.0	18,589.7
	[P7]-[P26]R	*[P7]-[P26]R*	1,245.9	--	1,245.9
	[C-B-A]	*[C-B-A]*	445.6	--	445.6
	[LV16]	*[LV16]*	1,187.9	--	1,187.9
	[WE14]	*[WE14]*	4,107.7	--	4,107.7
	[LV15]	*[LV15]*	797.6	--	797.6
	[M2]	*[M2]*	1,911.1	--	1,911.1
	[M1]	*[M1]*	1,923.8	--	1,923.8
	[LV14]	*[LV14]*	1,287.7	--	1,287.7
	[LV Basin]-[LV4]	*[LV Basin]-[LV4]*	9,534.1	--	9,534.1
	[LV11]+[LV4]	*[LV11]+[LV4]*	6,906.4	--	6,906.4
	[P12]	*[P12]-[LV Basin]-[LV11]*	826.4	16,440.5	17,266.9
	[P9]+[P10]+[P11]	*[P9]+[P10]+[P11]-[FE22]-[P12]-[P3]-[P26]-[LV14]-[LV15]-[LV16]-[M1]-[M2]-[WE14]*	2,008.7	48,318.3	50,327.0
	[P13]	*[P13]*	6,977.5	--	6,977.5
	[WCS2]+[WCS3]+[P14]	*[WC-S-2]+[WCS3]+[P14]-[FE22]-[P13]-[P9]-[P10]-[P11]*	4,077.0	57,304.5	61,381.5
Lower Rouge	[P15]	*[P15]*	6,078.3	--	6,078.3
	[P17]	*[P17]-[P15]*	2,528.5	6,078.3	8,606.8
	[WE25]	*[WE25]*	2,682.5		2,682.5
	[P19]	*[P19]*	1,024.5	11,289.3	12,313.8
	[WE28]	*[WE28]*	1,664.2	--	1,664.2
	[P20]+[P21]	*[P20]+[P21]-[FE19]-[P17]-[WE25]-[WE28]*	2,212.2	13,978.0	16,190.2
	[P24]+[P25]	*[P24]+[P25]-[FE19]-[P20]-[P21]*	4,589.9	16,190.2	20,780.1
Total RVSDS		***[WCS1]+[WCS2]+[WCS3]+[C-B-A]-[FE19]-[FE22]***	**82,607.2**	**--**	**82,607.2**

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Table 8-3
Cumulative Capture Coefficients

Branch	Meter District	Event 1	Event 2	Event 3	Event 4	Event 5	Event 6	Event 7	Event 8
		8/9/2012	4/10/2013	4/17/2013	5/27/2013	6/12/2013	10/30/2013	8/11/2014	9/10/2014
Middle Rouge	[BG1]	0.05%	0.25%	0.43%	0.13%	0.27%	0.16%	0.14%	0.23%
	[P1]	0.13%	0.34%	0.63%	0.15%	0.37%	0.20%	0.15%	0.31%
	[P3]+[P26]	0.15%	0.43%	0.71%	0.18%	0.38%	0.22%	0.12%	0.33%
	[P7]-$[P26]_R$	0.33%	1.65%	2.94%	0.60%	2.66%	0.67%	1.68%	0.92%
	[C-B-A]	1.27%	3.09%	5.48%	0.73%	0.77%	1.63%	4.49%	2.86%
	[LV16]	1.56%	3.28%	3.65%	3.02%	3.65%	2.18%	2.69%	3.10%
	[WE14]	N/A	1.17%	1.61%	0.60%	1.16%	0.36%	1.17%	0.88%
	[LV15]	3.32%	6.20%	9.92%	3.84%	6.02%	4.23%	5.83%	5.48%
	[M2]	1.46%	6.55%	9.36%	2.19%	6.08%	3.11%	5.48%	6.01%
	[M1]	3.70%	10.33%	16.00%	4.08%	10.54%	5.45%	6.66%	6.95%
	[LV14]	1.13%	4.61%	6.32%	1.62%	5.16%	2.76%	3.71%	5.47%
	[LV Basin]-[LV4]	0.35%	0.67%	0.86%	0.63%	0.59%	0.35%	0.55%	0.72%
	[LV11]+[LV4]	0.70%	2.05%	2.61%	0.60%	1.55%	1.01%	0.93%	1.09%
	[P12]	0.42%	1.27%	1.72%	0.46%	1.06%	0.73%	1.11%	0.97%
	[P9]+[P10]+[P11]	0.99%	2.44%	3.87%	0.92%	2.14%	1.19%	1.57%	1.89%
	[P13]	1.47%	3.16%	4.57%	2.71%	3.34%	2.07%	3.07%	3.24%
	[WCS2]+[WCS3]+[P14]	1.26%	3.29%	4.46%	1.69%	4.91%	1.39%	2.13%	2.70%
Lower Rouge	[P15]	0.14%	0.39%	0.49%	0.19%	0.33%	0.19%	0.18%	0.27%
	[P17]	0.21%	0.46%	0.71%	0.26%	0.35%	0.23%	0.27%	0.34%
	[WE25]	N/A	1.72%	2.15%	0.75%	1.61%	0.73%	1.56%	1.45%
	[P19]	0.24%	1.10%	1.70%	0.40%	1.10%	0.55%	1.01%	1.10%
	[WE28]	N/A	3.04%	4.98%	0.80%	2.44%	0.98%	2.78%	2.33%
	[P20]+[P21]	0.40%	1.99%	2.59%	0.82%	1.65%	0.98%	1.50%	1.59%
	[P24]+[P25]	1.24%	3.93%	6.68%	1.52%	2.49%	1.87%	1.86%	2.44%
Total RVSDS		**1.67%**	**4.80%**	**6.86%**	**1.75%**	**5.44%**	**1.20%**	**2.19%**	**3.16%**

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Table 8-4
Incremental Capture Coefficients

Branch	Meter District	Event 1	Event 2	Event 3	Event 4	Event 5	Event 6	Event 7	Event 8
		8/9/2012	4/10/2013	4/17/2013	5/27/2013	6/12/2013	10/30/2013	8/11/2014	9/10/2014
Middle Rouge	[BG1]	0.05%	0.25%	0.43%	0.13%	0.27%	0.16%	0.14%	0.23%
	[P1]	0.98%	1.94%	2.98%	0.62%	1.39%	0.77%	0.09%	1.30%
	[P3]+[P26]	0.59%	2.05%	2.53%	0.83%	0.81%	0.83%	0.78%	0.91%
	[P7]-$[P26]_R$	0.33%	1.65%	2.94%	0.60%	2.66%	0.67%	1.68%	0.92%
	[C-B-A]	1.27%	3.09%	5.48%	0.73%	0.77%	1.63%	4.49%	2.86%
	[LV16]	1.56%	3.28%	3.65%	3.02%	3.65%	2.18%	2.69%	3.10%
	[WE14]	N/A	1.17%	1.61%	0.60%	1.16%	0.36%	1.17%	0.88%
	[LV15]	3.32%	6.20%	9.92%	3.84%	6.02%	4.23%	5.83%	5.48%
	[M2]	1.46%	6.55%	9.36%	2.19%	6.08%	3.11%	5.48%	6.01%
	[M1]	3.70%	10.33%	16.00%	4.08%	10.54%	5.45%	6.66%	6.95%
	[LV14]	1.13%	4.61%	6.32%	1.62%	5.16%	2.76%	3.71%	5.47%
	[LV Basin]-[LV4]	0.35%	0.67%	0.86%	0.63%	0.59%	0.35%	0.55%	0.72%
	[LV11]+[LV4]	0.70%	2.05%	2.61%	0.60%	1.55%	1.01%	0.93%	1.09%
	[P12]	0.85%	5.34%	6.45%	0.63%	4.81%	1.94%	0.86%	1.82%
	Group [P9]+[P10]+[P11]	1.27%	11.42%	13.77%	0.27%	3.18%	1.82%	1.40%	4.43%
	[P13]	1.47%	3.16%	4.57%	2.71%	3.34%	2.07%	3.07%	3.24%
	[WCS2]+[WCS3]+[P14]	4.77%	16.84%	21.32%	9.47%	40.93%	4.99%	14.11%	13.88%
Lower Rouge	[P15]	0.14%	0.39%	0.49%	0.19%	0.33%	0.19%	0.18%	0.27%
	[P17]	0.34%	0.58%	1.10%	0.44%	0.40%	0.33%	0.56%	0.45%
	[WE25]	N/A	1.72%	2.15%	0.75%	1.61%	0.73%	1.56%	1.45%
	[P19]	1.48%	3.28%	7.57%	0.75%	4.29%	2.51%	4.97%	5.79%
	[WE28]	N/A	3.04%	4.98%	0.80%	2.44%	0.98%	2.78%	2.33%
	[P20]+[P21]	N/A	6.27%	6.06%	3.23%	3.90%	3.31%	4.13%	4.00%
	[P24]+[P25]	4.30%	11.97%	22.47%	4.03%	5.64%	5.16%	4.18%	5.48%
Total RVSDS		**1.67%**	**4.80%**	**6.86%**	**1.75%**	**5.44%**	**1.20%**	**2.19%**	**3.16%**

Table 8-5
Subcatchment Parameters Obtained from GDRSS Model

Runoff Parameters

Average surface slope:	1%
Average surface length:	100 ft
Manning's coefficient of impervious areas:	0.014
Manning's coefficient of pervious areas:	0.2
Depression storage of impervious areas:	0.06 in
Depression storage of pervious areas:	0.29 in
Percent of impervious area with no depression storage:	25%

Infiltration Parameters

Infiltration method:	Horton
Maximum growing season infiltration rate:	2.9 in/hr
Maximum non-growing season infiltration rate:	0.2 in/hr
Minimum infiltration rate:	0.2 in/hr
Decay constant:	4.68 hr^{-1}
Time to fully dry:	0.01781 days

Table 8-6
DCIA Assumptions for SEMCOG Land Use Categories

Land Use Category	DCIA
Commercial	32%
Governmental / Institutional	32%
Industrial	49%
Airport	90%
Multiple-Family Residential	20%
Single-Family Residential	10%
Parks, Recreation, and Open Space	0%
Transportation, Communication, Utility	60%
Agricultural	0%
Water	0%

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Table 8-7
Area Weighted DCIA Percentages

Community Connection ID	Community	Commercial	Governmental / Institutional	Industrial	Airport	Multiple-Family Residential	Single-Family Residential	Parks, Recreation, and Open Space	TCU	Agricultural	Water	Area Weighted DCIA
4	Dearborn Heights	--	--	--	--	--	25.7	--	9.7	--	--	23.7%
7	Dearborn Heights	7.3	0.3	0.7	--	--	96.0	0.1	47.6	--	--	26.9%
9	Dearborn Heights	1.2	--	--	--	--	19.4	--	8.8	--	--	25.9%
10	Dearborn Heights	11.0	1.1	0.4	--	1.0	42.2	--	32.0	--	--	31.6%
11	Dearborn Heights	3.8	5.1	--	--	--	37.1	--	27.8	--	--	31.5%
12	Dearborn Heights	4.4	4.1	0.4	--	--	41.0	--	23.4	--	--	28.7%
13	Dearborn Heights	2.8	--	--	--	--	72.7	--	41.4	--	--	28.2%
16	Dearborn Heights	6.4	--	--	--	--	46.3	0.3	32.1	--	--	30.5%
17	Dearborn Heights	5.1	--	--	--	--	41.6	0.1	24.8	--	--	28.9%
22	Dearborn Heights	4.0	--	--	--	--	20.7	--	11.3	--	--	28.1%
23	Dearborn Heights	--	--	--	--	--	79.5	--	21.7	--	--	20.7%
28	Inkster	8.1	51.4	--	--	1.0	245.9	2.3	98.9	--	--	25.3%
29	Inkster	2.8	--	--	--	--	76.1	1.0	34.3	--	--	25.5%
31	Inkster	2.5	--	--	--	--	24.3	--	11.0	--	--	26.0%
43	Inkster	21.2	2.2	3.7	--	4.5	15.8	--	17.9	--	--	34.5%
45	Inkster	8.8	3.0	10.8	--	--	25.8	0.5	26.0	--	--	36.4%
46	Inkster	10.7	7.8	--	--	--	11.2	--	12.4	--	--	34.4%
48	Inkster	6.1	--	--	--	--	5.8	--	7.2	--	--	35.9%
49	Inkster	0.6	--	--	--	--	20.6	--	9.1	--	--	25.5%
50	Inkster	--	--	--	--	--	23.8	--	8.9	--	--	23.6%
52	Dearborn Heights	34.0	21.6	33.6	--	--	100.1	--	75.2	--	--	33.8%
52	Inkster	9.7	16.1	--	--	7.2	122.6	--	53.7	--	--	25.9%
105	Redford Township	40.6	39.7	9.5	--	--	558.9	5.9	259.3	--	--	26.5%
106	Redford Township	--	9.4	--	--	--	25.2	--	16.8	--	--	30.4%
107	Redford Township	0.4	--	--	--	--	52.1	0.2	24.3	--	--	25.9%
113	Redford Township	--	9.3	--	--	--	91.9	--	46.6	--	--	27.1%
114	Redford Township	0.3	0.8	--	--	--	24.8	23.2	17.2	--	--	19.8%
115	Redford Township	0.4	--	--	--	--	21.0	--	9.8	--	--	26.0%
116	Redford Township	2.3	37.8	20.4	--	--	227.0	--	149.2	--	--	30.9%
120	Redford Township	5.2	8.8	--	--	--	106.4	--	60.9	--	--	28.5%
121	Redford Township	--	--	--	--	--	77.4	--	38.1	--	--	26.5%
122	Redford Township	106.9	143.1	207.4	--	2.1	699.5	5.7	428.7	--	0.2	32.0%
193	Inkster	--	--	--	--	--	5.0	--	1.8	--	--	23.2%
199	Dearborn Heights	0.8	--	--	--	--	9.1	--	6.9	--	--	31.6%

9. Hydrograph Shape Parameters

Once the volume of wet weather flow is quantified by determining the capture coefficients as detailed in the previous section, the distribution of this volume over time must be quantified. This is achieved by utilizing a unit hydrograph method. SWMM5 uses the RTK method for distributing the RDI/I generated by a sanitary area during wet weather.

R, T, and K are the parameters that define the size and shape of the response hydrograph. The first parameter, R, is the capture coefficient. The second parameter, T, is the time (in hours) from the start of rainfall to the peak of the unit hydrograph. The last parameter, K, is the ratio of time to recession to the time to peak.

SWMM5 uses the summation of three RTK unit hydrographs to create a response. For this analysis, the values of the three RTK unit hydrographs were constrained to typically fall in the ranges shown in Table 9-1 to represent the fast, medium, and slow responses in the sewer system. This allows a quantification to be made as to how flashy the inflow occurs and allows for comparisons to be made to other meter districts.

The shaping factors for the RTK unit hydrographs were only determined for the independent flow meters. This is because determining them for dependent meters requires removing the influence of upstream meters through subtraction. Because of travel time differences and inherent meter inaccuracies, this subtraction leads to much uncertainty in the results. Instead, the RTK parameters for the dependent districts were assigned the average values of the independent districts. Meter P13 was excluded from this analysis since it is highly affected by combined sewage flows.

An optimization spreadsheet was developed that uses Microsoft Excel's Solver Add-in Analysis Tool to adjust RTK parameters within the bounds of Table 9-1 until the sum of the squares of the difference between the metered and computed RDI/I responses was minimized. This spreadsheet allows RTK parameters to be fit to one or multiple events by specifying a weighting factor for each. It also displays how well the RTK parameters fit other events that were not used in the determination for verification purposes.

In general, the RTK parameters were developed using September 10, 2014 event (Hydraulic Analysis Event No. 8). Event 8 was a spatially uniform, single peaked event. Multiple peak events were excluded from the optimization because of the difficulty in determining a single set of parameters that provide flow rates that match all peaks. Table 9-2 presents the optimized RTK parameters used as input into the SWMM5 model for the independent meter districts and Appendix C presents the detailed optimizer spreadsheet results for each analyzed flow meter.

Table 9-1
Typical Ranges of RTK Parameters for Analysis

Triangle No.	R (fraction)		T (hrs)		K (ratio)	
	Lower	Upper	Lower	Upper	Lower	Upper
(1) Fast	0.00	1.00	0.25	1.50	1.00	3.00
(2) Medium	0.00	1.00	1.50	3.00	1.00	6.00
(3) Slow	0.00	1.00	3.00	8.00	1.00	12.00

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Table 9-2
RTK Parameters for Independent Meter Districts

Meter	R Fraction of Total Capture			T, Time to Peak (hours)			K, Recession Multiplier		
	1	2	3	1	2	3	1	2	3
[BG1]	0.00	0.51	0.49	1.50	2.89	3.82	3.00	1.00	6.35
[LVBASIN]-[LV4]	0.07	0.53	0.40	1.25	3.00	7.00	1.00	2.80	2.71
[LV11]+[LV4]	0.18	0.35	0.47	0.38	1.50	3.00	3.00	4.23	6.85
[LV14]	0.27	0.29	0.44	0.64	2.47	7.59	3.00	3.30	3.37
[LV15]	0.20	0.48	0.32	0.90	3.00	3.00	3.00	6.00	11.37
[LV16]	0.21	0.27	0.52	0.31	1.58	5.93	3.00	3.11	4.19
[M1]	0.24	0.06	0.71	1.26	1.50	3.75	3.00	3.00	6.52
[M2]	0.07	0.41	0.52	0.60	2.27	7.75	3.00	3.78	3.52
[P15]	0.01	0.38	0.61	1.12	1.51	5.40	1.77	5.95	5.36
[WE14]	0.08	0.26	0.66	1.50	3.00	3.75	3.00	6.00	1.19
[WE25]	0.16	0.22	0.63	1.10	2.76	3.25	3.00	1.87	8.50
[WE28]	0.18	0.51	0.30	1.50	3.00	3.00	3.00	2.69	11.23
Average	**0.14**	**0.37**	**0.49**	**1.04**	**2.42**	**4.63**	**2.75**	**3.57**	**6.34**

10. Model Calibration

Two wet weather events were selected for model calibration purposes and were the April 17, 2013 event (Hydraulic Analysis Event No. 3 and the September 10, 2014 event (Hydraulic Analysis Event No. 8). These events had large amounts of intense rainfall that occurred uniformly over the RVSDS. Both events had other rainfall events in their days prior which led to elevated groundwater infiltration and RDI/I capture coefficients since much of the natural storage potential of the system was already being utilized. This is preferred in the development of design event parameters as it is likely that a wet weather event on the scale of a design event will also reach such conditions.

The DWF trace for each meter district was taken from the SSOAP analysis and apportioned to each community line connection based on area. These flows were loaded as a direct timeseries input.

Results

Tables 10-1 through 10-3 present summary values for the calibration results and Appendix D presents the individual model to meter calibration plots for each meter for each event. In general, the model-predicted flow rates matched well with the flow rates measured by the meters. This is expected as the hydrologic parameters are derived from the flow rates of the calibration events. Unexpectedly, for Event No. 8 there are areas of the system where the modeled and metered flow rates are in reasonable agreement, but the modeled depth was significantly less than the metered depth, particularly the surcharging of the downstream end of the Middle Rouge interceptors. The discrepancy can be seen in the meter to model depth comparison plots for Meters P9, P10, P11, P12, and LV Basin.

Various model refinements were made in an attempt to explain this discrepancy including:

- Increasing the minor losses experienced in bends and transitions,
- Increasing the roughness coefficient of the pipe walls,
- Increasing losses at special structures such as siphons, junction chambers, and crossings, and
- Increasing the capture coefficients of the meter service areas.

Each of these adjustments was taken to its reasonable extent and it was found that the modeled depths still did not reach observed depths. Possible explanations for this included:

- River inflow and subsequent outflow occurring between interceptor monitoring points,
- Unknown blockages or restrictions,
- Inadequate venting of air, or

- Greater than expected losses occurring in structures.

The model is the primary tool for the development of LTCAP projects to address sanitary sewer overflows due to unacceptable sewage depths. Understanding this discrepancy is important as the hydrologic parameters from Event No. 8 are proposed to be utilized for the modeling of the 25 year, 24 hour design event by which any relief projects are to be designed to. Since there is a significant portion of the system that has actual surcharging that is greater than the model-predicted surcharging, there is the potential to miss important LTCAP needs using the existing model. With several plausible explanations for the discrepancy, additional investigation is needed to identify and reconcile the depth differences.

For instance, the surcharging along the Middle Rouge creates a backwater zone up the Inkster Arm which potentially leads to SSO near the Bell Branch crossing. This backwater zone however creates uncertainty to the degree of relief required as it is unclear how much flow the Inkster Arm is currently conveying on its own and how much flow is potentially being lost as overflow. The HGL profile was plotted for the discrepancy reach and is presented on Figures 10-1 through 10-4.

Other findings included:

- During Event No. 8, higher backwater than designed on DWSD's North West Interceptor adversely affected LS1A operations by submerging and causing a fault at the level sensor located at JC 18-A which triggered Slide Gate 3 to prematurely reopen and allow recirculation thus severely limiting the overall throughput of the station during the peak of the event.
    - On May 12, 2015, the JC 18-A level sensor parameters were reprogrammed to remedy this issue. However, since this fix, the level sensor has not experienced submerged conditions to fully test the updated logic.
- Oakwood Interceptor flow rates by gravity are restricted by the high wet well levels at the influent pump station to the DWSD wastewater treatment plant.
- LS1A is not reaching its firm capacity of 250 cfs while surcharging at JC 2-8 is occurring. Inlet screen clogging and improper diversion weir height settings may be an issue in restricting flow rate into the LS1A wet well and creating upstream backwater on the Middle Rouge interceptors.

Table 10-1
Summary of Flow Rate Calibration Results for Individual Meters

Individual Meters	Maximum Rolling Hourly Average Flow Rate (MGD)			
	4/18/2013 Event		9/10/2014 Event	
	Metered	Modeled	Metered	Modeled
BG1	10.7	9.3	9.6	8.9
P1	12.1	12.3	10.1	10.9
P3	13.1	11.5	10.0	10.2
P26	1.4	3.0	1.2	1.8
P7	4.4	5.7	3.2	3.1
P8	21.8	24.1	19.1	21.9
P12	29.9	29.6	26.0	27.3
LV Basin	19.1	26.1	18.3	19.0
LV4	7.4	6.0	5.7	4.8
LV11	10.9	10.4	13.2	9.0
LV14	7.5	7.0	8.9	8.3
LV15	6.5	6.8	5.7	5.6
LV16	4.1	4.5	5.1	5.6
WE14	7.8	11.5	7.7	10.4
M1	20.7	27.1	20.1	18.3
M2	12.4	16.5	11.2	11.6
P9	20.7	21.0	17.7	20.7
P10	65.6	71.2	60.0	66.3
P11	26.3	26.8	24.6	26.8
P13	27.8	31.7	25.1	32.9
P14	78.8	82.6	55.7	56.1
P15	2.9	2.8	2.2	2.0
P17	5.4	5.4	4.1	4.3
P19	18.7	22.3	16.1	17.0
WE25	6.6	7.1	5.3	5.4
WE28	6.4	9.5	7.1	7.2
P20	9.5	10.1	9.7	10.8
P21	32.2	34.8	28.0	24.6
P24	15.7	18.3	16.8	18.3
P25	50.1	41.4	34.7	30.7
WCS1	123.0	119.1	97.7	100.4
WCS2	42.5	--	63.2	--
WCS3	61.1	--	57.3	--

Table 10-2
Summary of Flow Rate Calibration Results for Meter Summations

Meter Summation	Maximum Rolling Hourly Average Flow Rate (MGD)			
	4/18/2013 Event		9/10/2014 Event	
	Metered	Modeled	Metered	Modeled
P3+P26	14.5	14.5	11.1	12.0
P9+P10+P11	111.8	117.8	100.1	110.7
P20+P21	41.5	43.8	37.5	35.2
P24+P25	63.9	57.8	49.9	48.5
WCS2+WCS3	103.4	137.5	120.1	129.9
WCS2+WCS3+P14	178.8	186.5	160.7	172.0
WCS2+WCS3+P14+P24+P25	229.4	244.0	206.5	218.4
WCS1+WCS2+WCS3	225.4	244.5	209.1	222.3

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Table 10-3
Summary of Depth Calibration Results

Meter	Maximum Rolling Hourly Average Depth (ft)			
	4/18/2013 Event		9/10/2014 Event	
	Metered	Modeled	Metered	Modeled
P01	1.55	1.56	1.43	1.46
P03	1.66	1.06	1.40	0.99
P26	0.60	0.99	0.51	0.75
P07	1.50	2.03	1.33	1.47
P08	2.68	3.24	2.03	2.31
P12	8.99	7.68	7.84	4.67
LVBASIN	14.78	10.13	8.51	5.79
LV04	2.46	1.47	2.19	1.29
LV11	6.51	2.37	3.66	1.06
LV14	4.90	2.70	2.94	1.74
LV15	5.94	2.11	4.52	1.78
LV16	1.33	1.23	1.34	1.36
WE14	6.20	4.93	3.76	1.84
M1	9.06	9.28	8.31	9.28
M2	7.17	6.92	4.07	2.45
P09	8.74	7.48	7.78	4.68
P10	8.70	7.76	8.51	5.33
P11	7.25	7.97	7.57	4.96
P13	6.64	7.36	8.09	7.30
P14	9.51	10.61	12.72	13.14
P15	1.41	1.30	1.33	1.04
P17	1.25	1.71	1.20	1.54
P19	2.63	3.12	3.89	2.63
WE25	1.90	1.80	1.45	1.02
WE28	1.28	1.96	1.37	1.67
P20	2.89	4.74	3.09	3.05
P21	4.25	2.76	2.43	2.22
P24	7.26	8.42	7.24	7.38
P25	5.63	7.73	3.53	4.33
JC2-8	8.21	8.15	7.98	11.11

Figure 10-1
Inkster Arm Profile from Bell Branch to Middle Rouge · September 10, 2014 Event

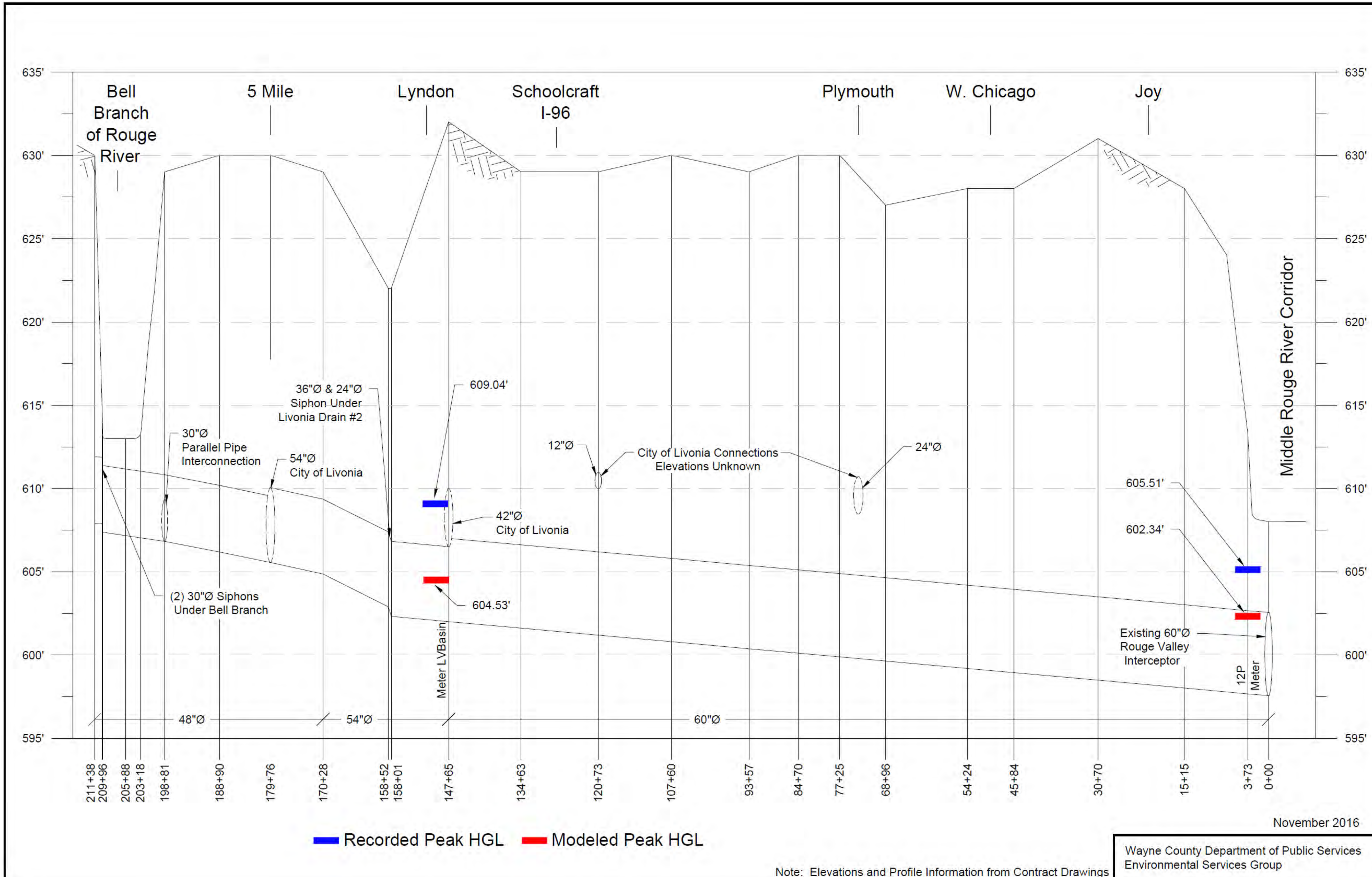

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Figure 10-2
Middle Rouge Interceptor Profile from Inkster to LS1A · September 10, 2014 Event

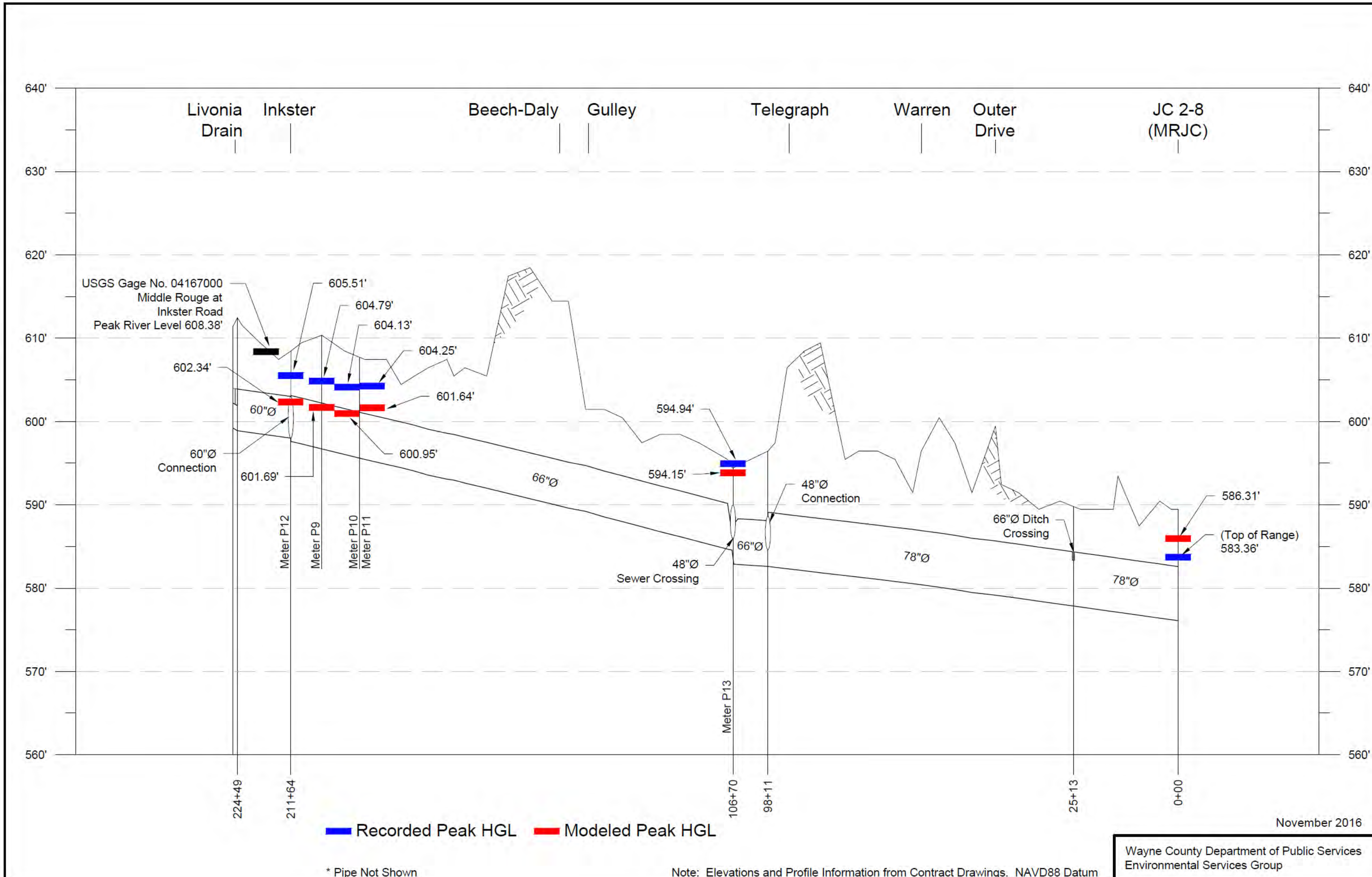


Figure 10-3
Middle Rouge Interceptor Profile from Merriman to Inkster · September 10, 2014 Event

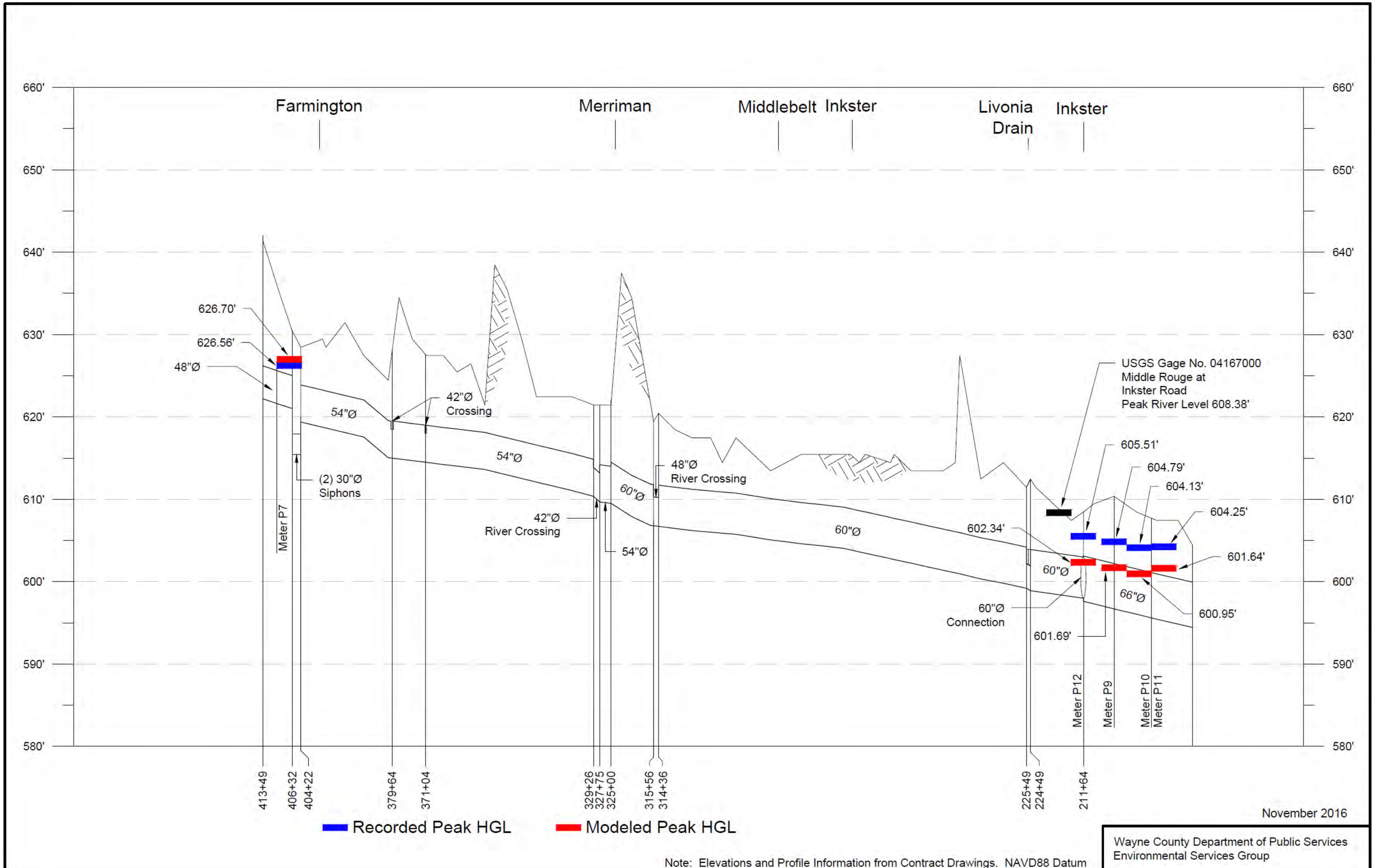
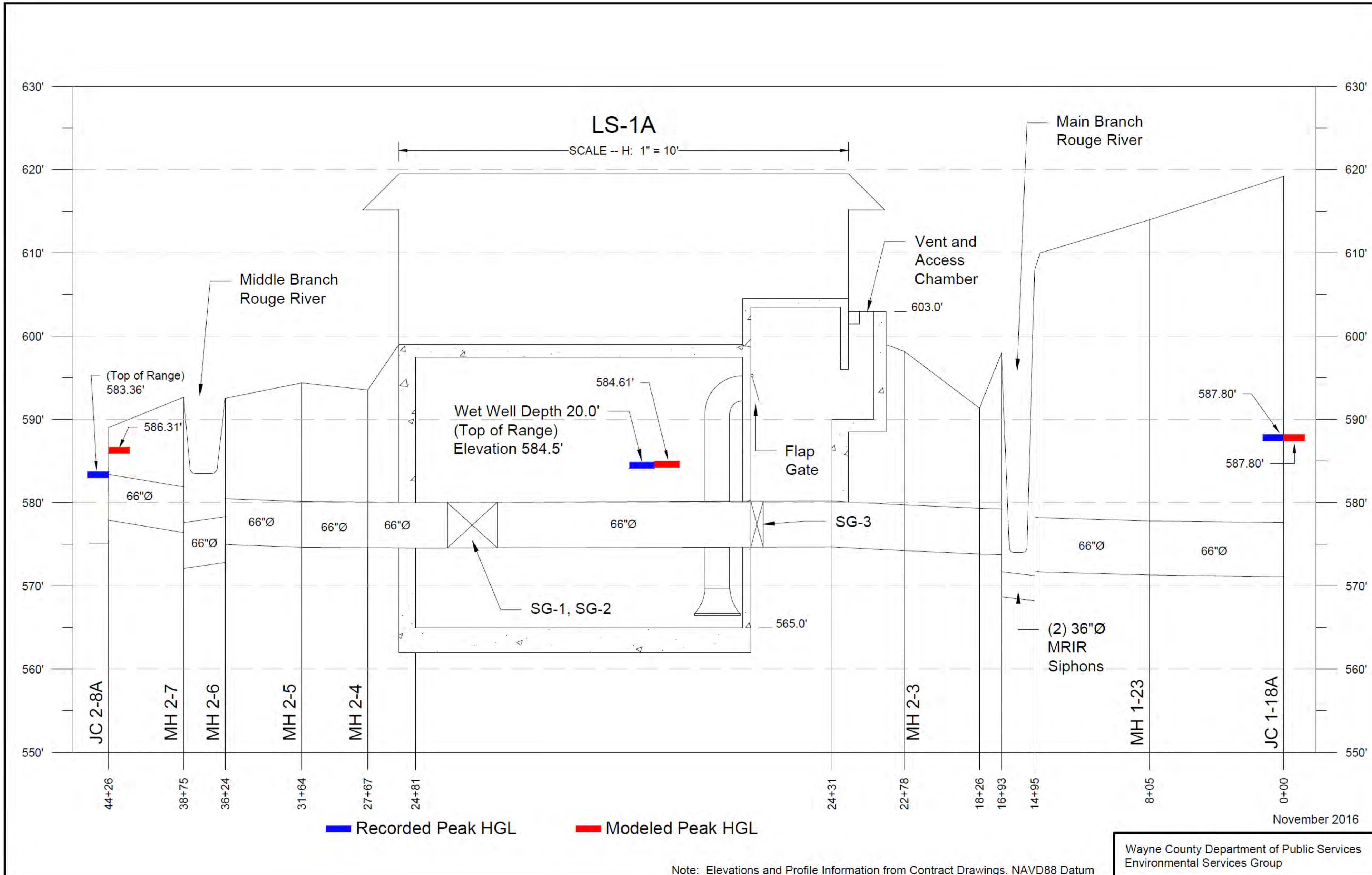


Figure 10-4
Middle Rouge Interceptor Relief Profile through LS1A · September 10, 2014 Event



11. Recommendations

A detailed work plan to resolve the depth discrepancy and move forward with some initial LTCAP projects has been developed and provided to Wayne County. To achieve this, the LTCAP is being divided into two phases with the first phase consisting of the following action items pertaining to resolving the discrepancy:

- Field surveys of several system components necessary to update the RVSDS hydraulic model representation, in particular the regulator structures that had unclear information on current appurtenances and settings. This is important information as the LTCAP may include modifications to these regulators;
- Installation of additional flow meters and level sensors along the reach with the depth discrepancy in order to provide a finer understanding of the hydraulic losses. This includes monitoring points on some local municipal sewers that connect along the reach;
- Inspection and analysis of junction chambers to identify any unique hydraulic characteristics that may be generating greater than expected hydraulic losses;
- Inspection and cleaning of siphons and restrictions to ensure no unforeseen blockages are causing the discrepancy;
- SCADA system upgrades and historization to better track system operations and control levels and an overall review to ensure the current operational protocols are optimal.
- Inspection of floodplain manholes for inflow and/or outflow potential, especially for the local municipal sewer reaches that were not originally included in the 2007 SSES, and development of recommended retrofits;
- Evaluate locations where system venting is needed as this will help prevent manholes from becoming dislodged and possibly alleviate hydraulic losses; and
- Deploy a wet weather response team to attempt to observe and track some of the system hydraulic issues as they occur.

The second phase of the LTCAP will then consist of the finalization of the model calibration and the development of the suite of recommended LTCAP projects.

Appendix A
Detailed RVSDS Schematic

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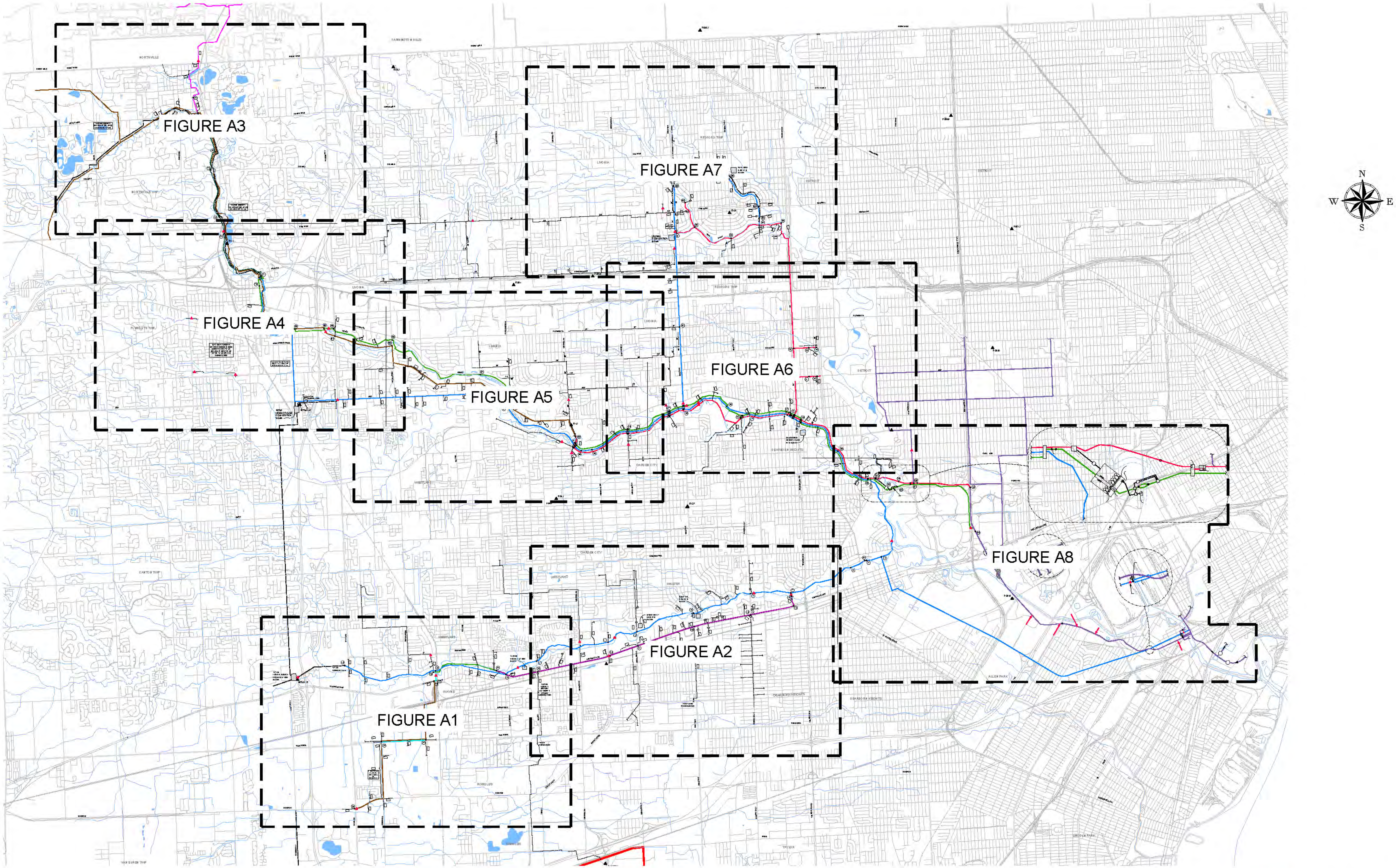

ROUGE VALLEY SEWAGE DISPOSAL SYSTEM

INTERCEPTOR SCHEMATIC

SYSTEM MONITORING

INDEX SHEET

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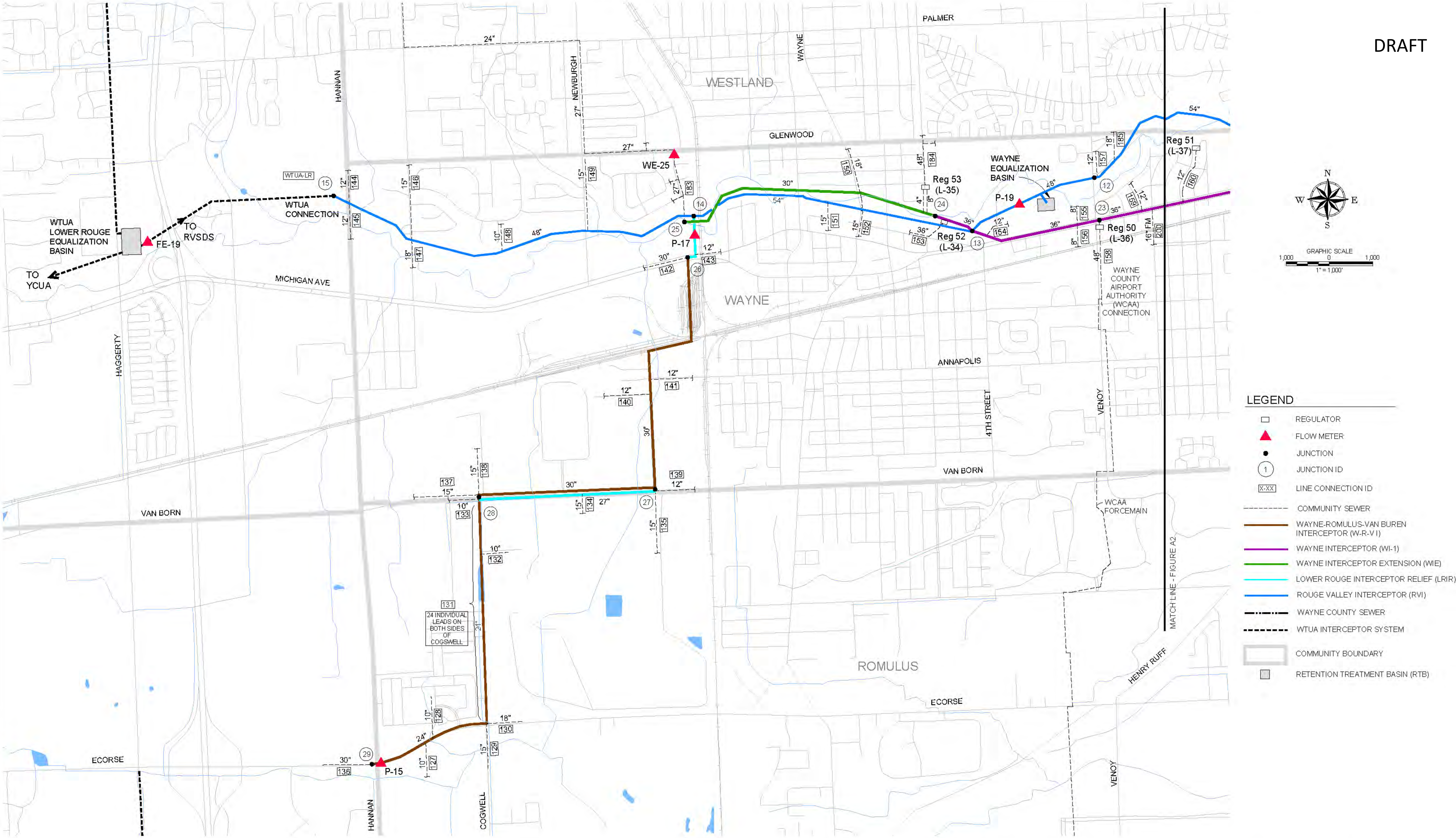
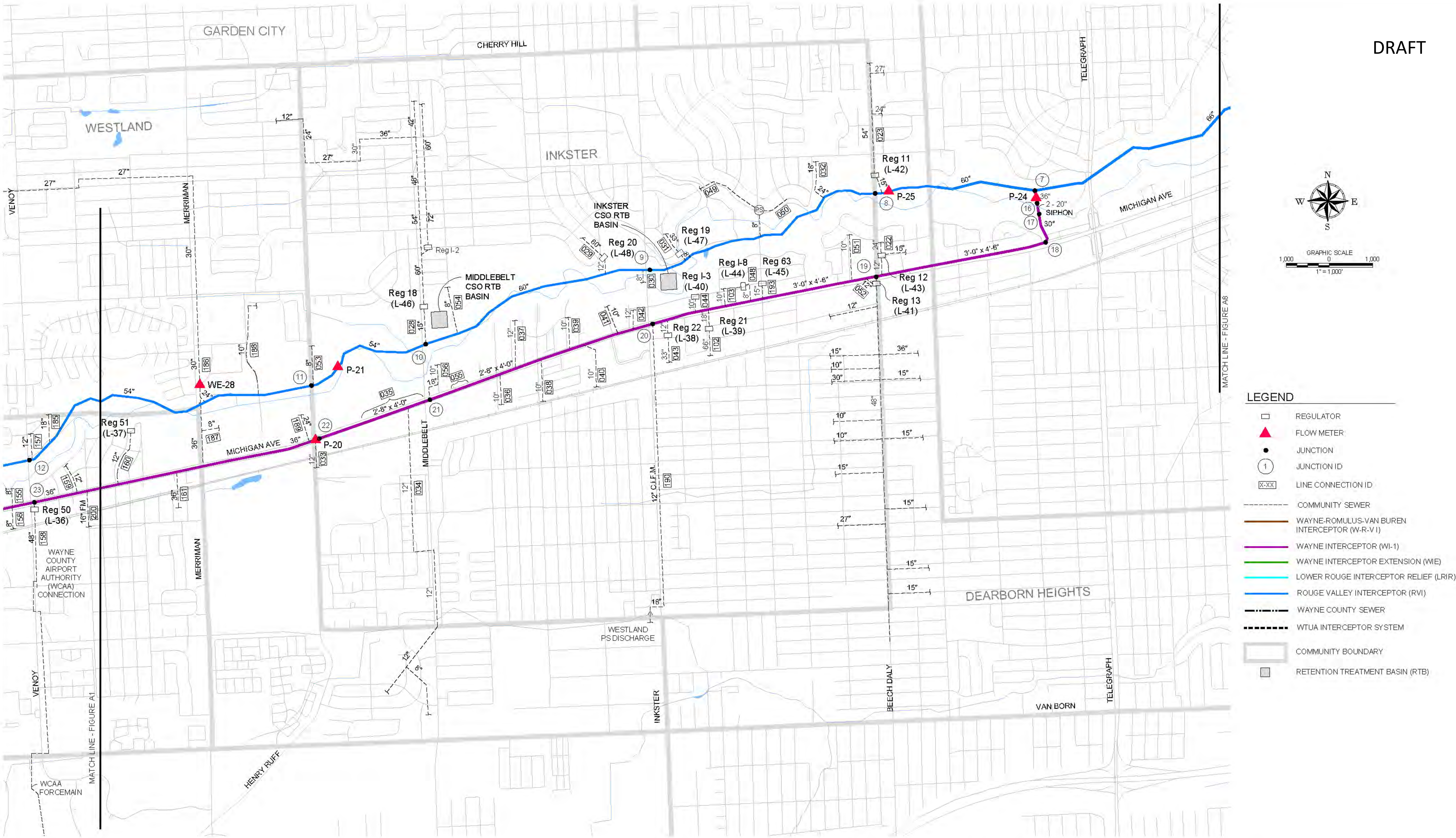


ROUGE VALLEY SEWAGE DISPOSAL SYSTEM
LOWER ROUGE INTERCEPTOR SCHEMATIC
HANNAN TO VENOY

SYSTEM MONITORING PLAN

FIGURE A1 OF 8

DRAFT



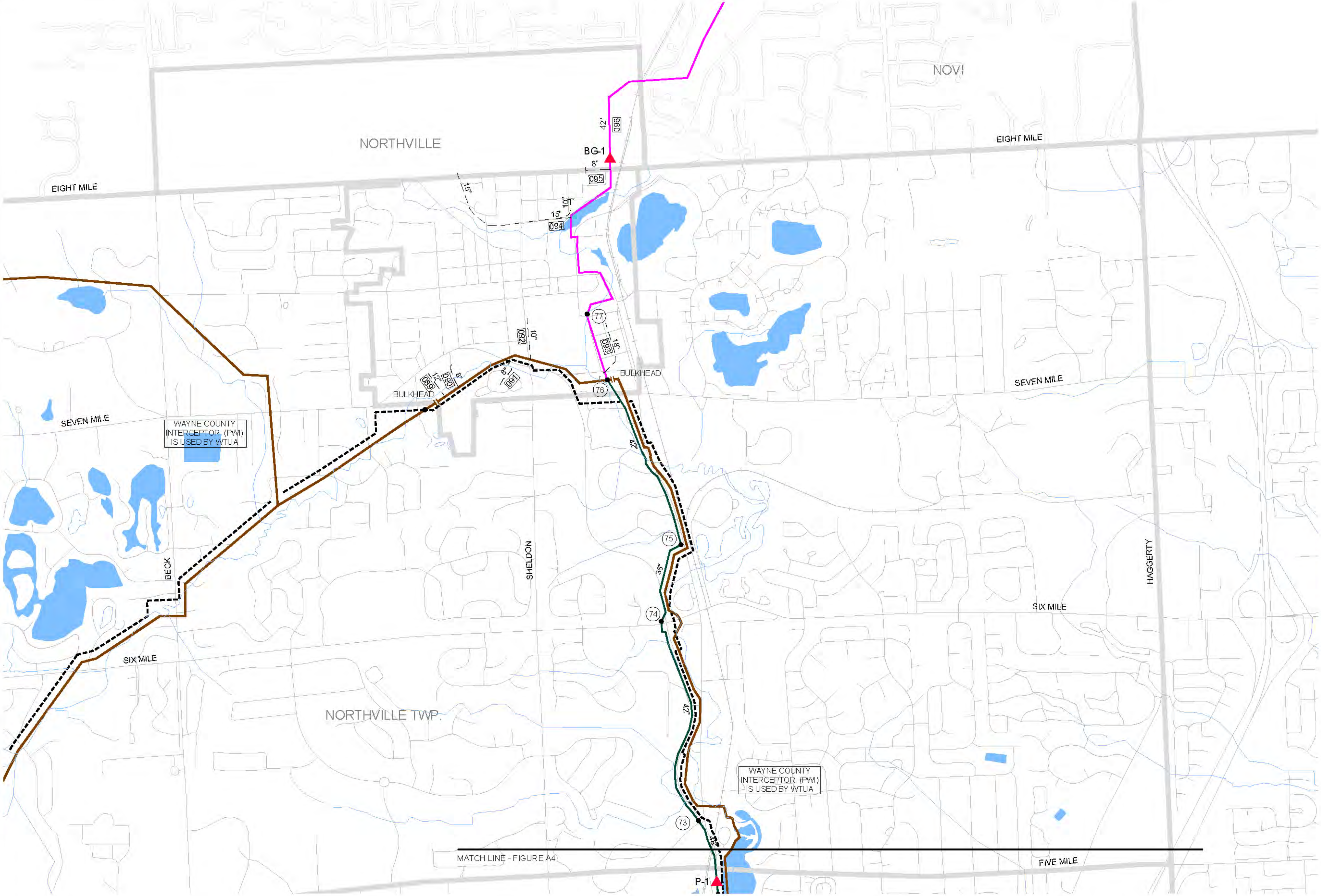
ROUGE VALLEY SEWAGE DISPOSAL SYSTEM

LOWER ROUGE INTERCEPTOR SCHEMATIC
VENOY TO TELEGRAPH

SYSTEM MONITORING PLAN

FIGURE A2 OF 8

DRAFT



LEGEND

- REGULATOR
- FLOW METER
- JUNCTION
- JUNCTION ID
- LINE CONNECTION ID
- COMMUNITY SEWER
- PARKWAY INTERCEPTOR (PWI)
- MIDDLE ROUGE PARKWAY INTERCEPTOR EXTENSION (MRPIE)
- ROUGE VALLEY INTERCEPTOR (RVI)
- MIDDLE ROUGE INTERCEPTOR RELIEF (MRIR)
- NORTH ARM INTERCEPTOR (NAI)
- NOVI TRUNK SEWER
- LS1A
- WAYNE COUNTY SEWER
- WTUA INTERCEPTOR SYSTEM
- COMMUNITY BOUNDARY
- RETENTION TREATMENT BASIN (RTB)

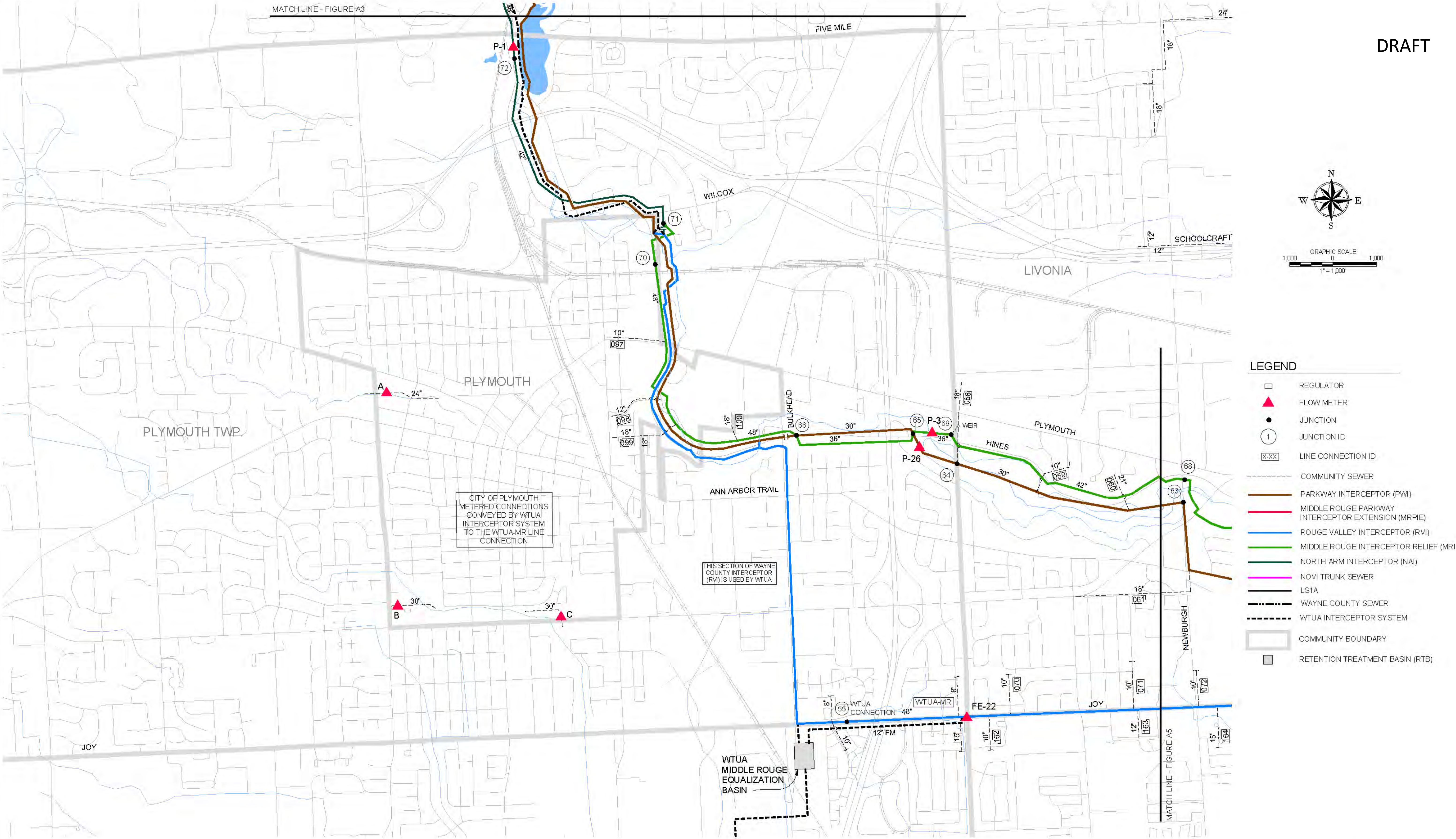
ROUGE VALLEY SEWAGE DISPOSAL SYSTEM

MIDDLE ROUGE INTERCEPTOR SCHEMATIC NORTHVILLE TO 5 MILE ROAD

SYSTEM MONITORING PLAN

FIGURE A3 OF 8

DRAFT

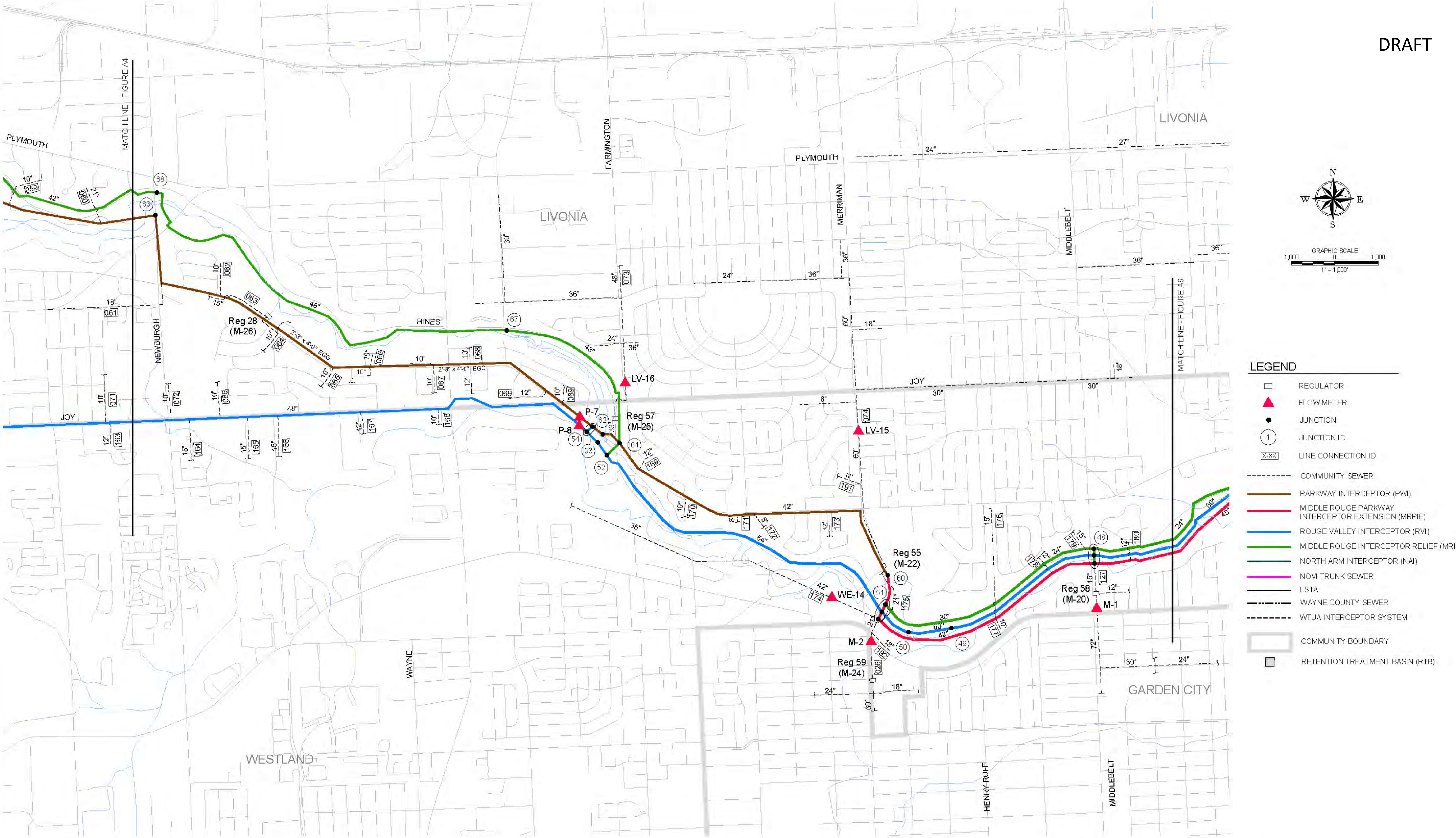


ROUGE VALLEY SEWAGE DISPOSAL SYSTEM

MIDDLE ROUGE INTERCEPTOR SCHEMATIC
5 MILE ROAD TO NEWBURGH

SYSTEM
MONITORING PLAN
FIGURE A4 OF 8

DRAFT



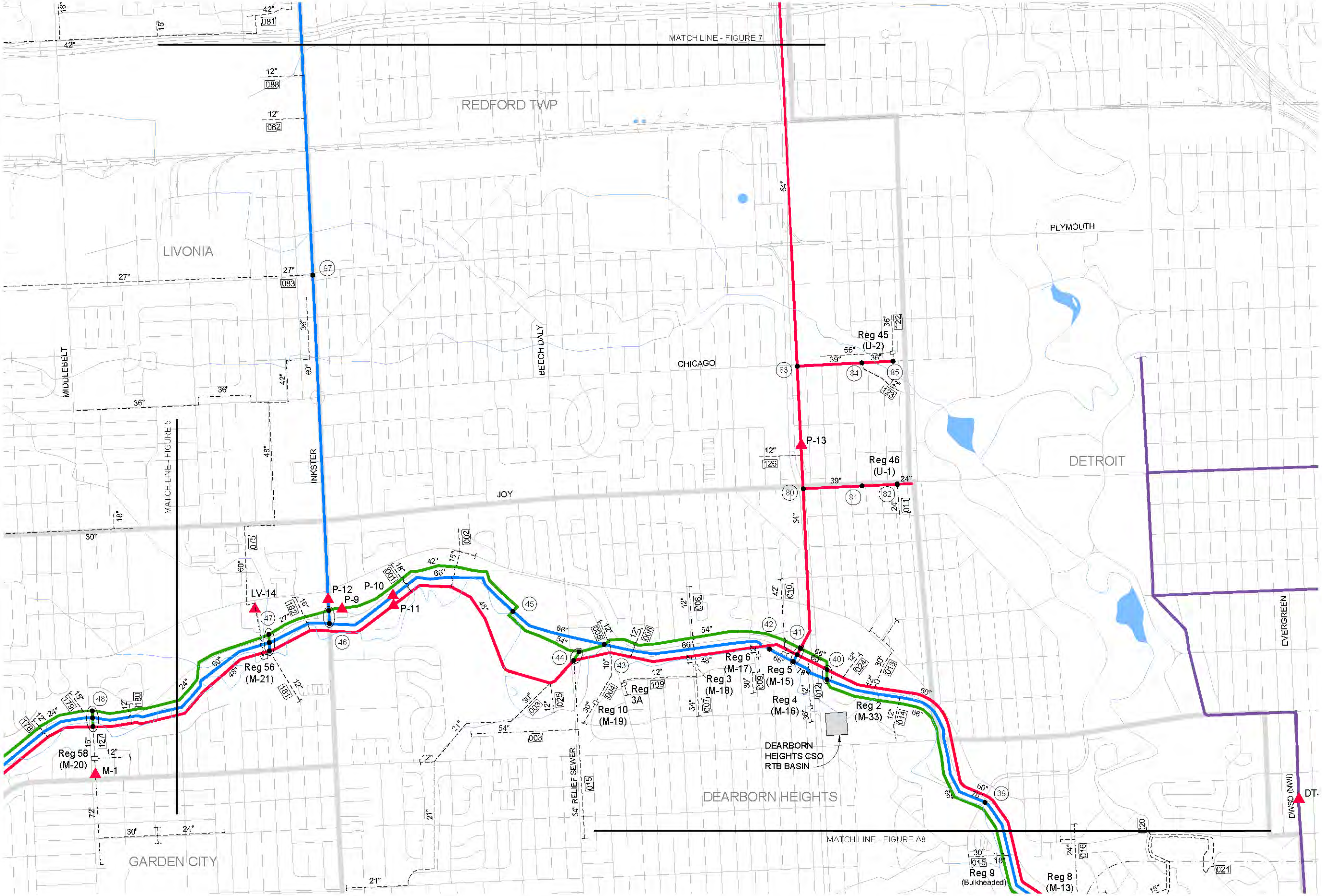
ROUGE VALLEY SEWAGE DISPOSAL SYSTEM

MIDDLE ROUGE INTERCEPTOR SCHEMATIC NEWBURGH TO MIDDLEBELT

SYSTEM MONITORING PLAN

FIGURE A5 OF 8

DRAFT



N
W E
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GRAPHIC SCALE
1,000 0 1,000
1" = 1,000'

LEGEND

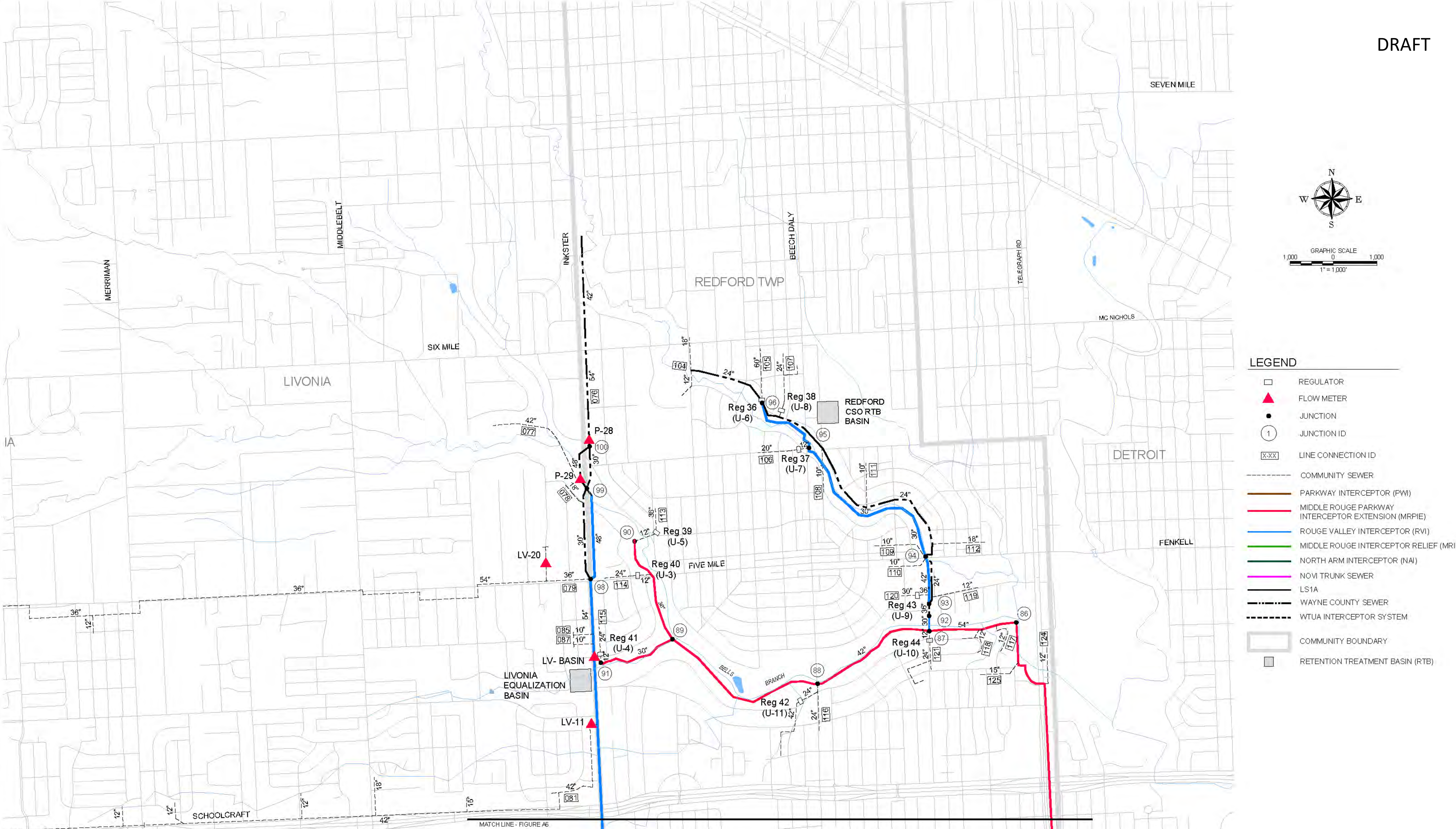
- REGULATOR
- FLOW METER
- JUNCTION
- JUNCTION ID
- LINE CONNECTION ID
- COMMUNITY SEWER
- PARKWAY INTERCEPTOR (PWI)
- MIDDLE ROUGE PARKWAY INTERCEPTOR EXTENSION (MRPIE)
- ROUGE VALLEY INTERCEPTOR (RVI)
- MIDDLE ROUGE INTERCEPTOR RELIEF (MRIR)
- NORTH ARM INTERCEPTOR (NAI)
- NOVI TRUNK SEWER
- LS1A
- WAYNE COUNTY SEWER
- WTUA INTERCEPTOR SYSTEM
- COMMUNITY BOUNDARY
- RETENTION TREATMENT BASIN (RTB)

ROUGE VALLEY SEWAGE DISPOSAL SYSTEM

MIDDLE ROUGE INTERCEPTOR SCHEMATIC MIDDLEBELT TO OUTER DRIVE

SYSTEM MONITORING PLAN

FIGURE A6 OF 8

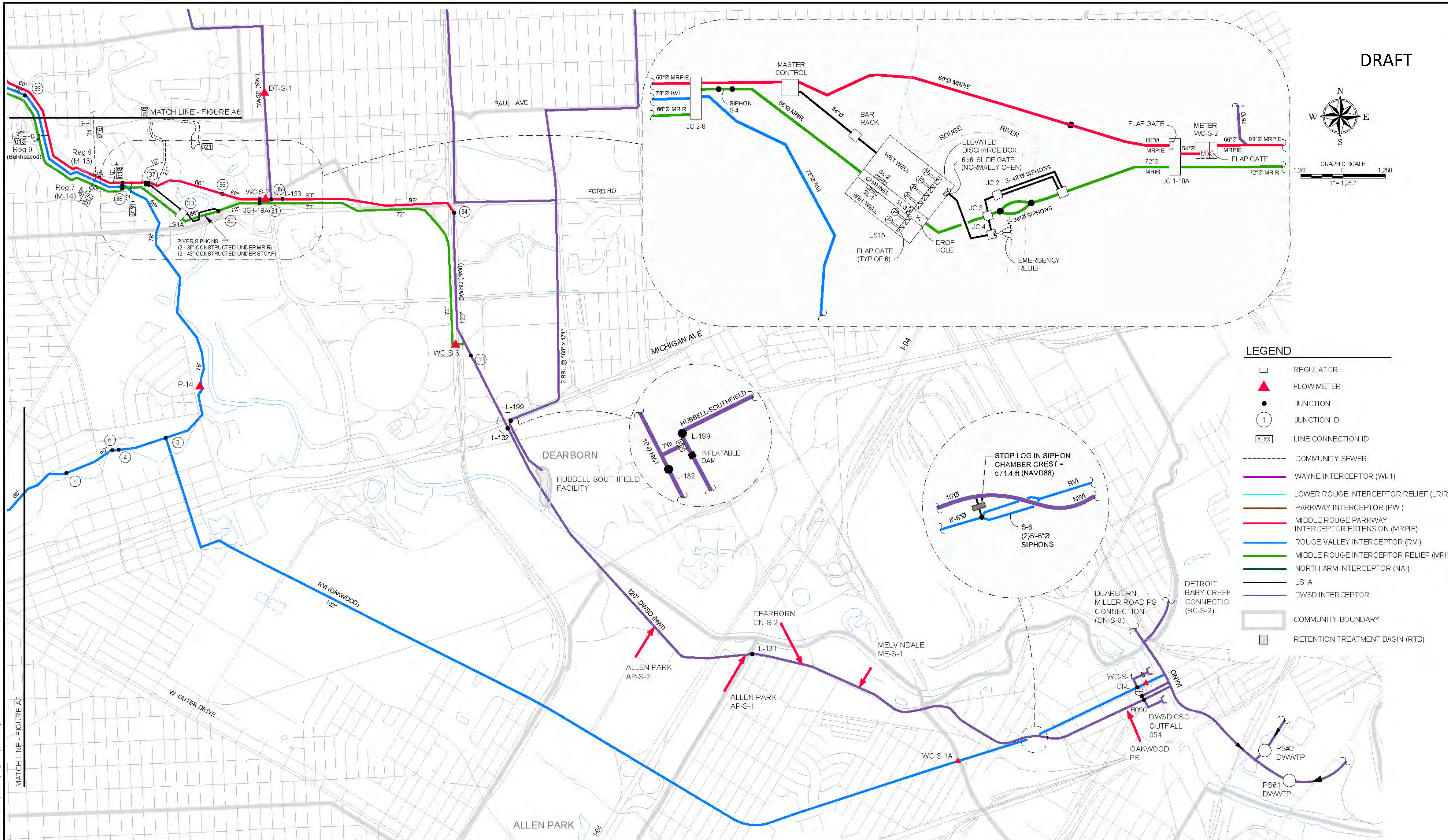


ROUGE VALLEY SEWAGE DISPOSAL SYSTEM

MIDDLE ROUGE INTERCEPTOR SCHEMATIC INKSTER AND REDFORD ARMS

SYSTEM MONITORING PLAN

FIGURE A7 OF 8



ROUGE VALLEY SEWAGE DISPOSAL SYSTEM

INTERCEPTOR SYSTEM SCHEMATIC
DOWNSTREAM END OF SYSTEM

SYSTEM MONITORING PLAN

FIGURE A8 OF 8

Appendix B
Theissan Polygon Delineations

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Figure B-1
Rouge Valley Sewage Disposal System
Thiessen Polygons - Event 1

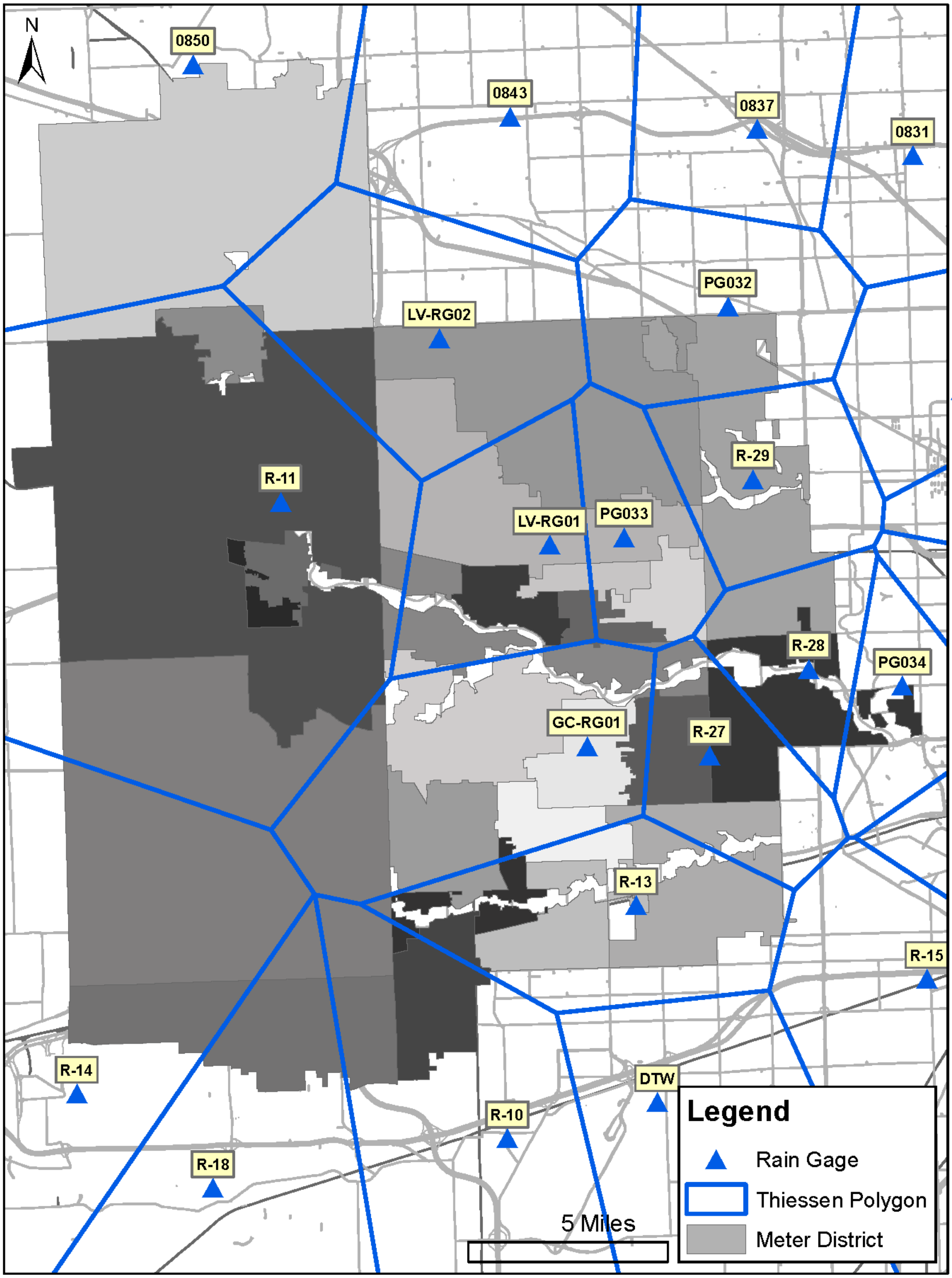

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Figure B-2
Rouge Valley Sewage Disposal System
Thiessen Polygons - Event 2

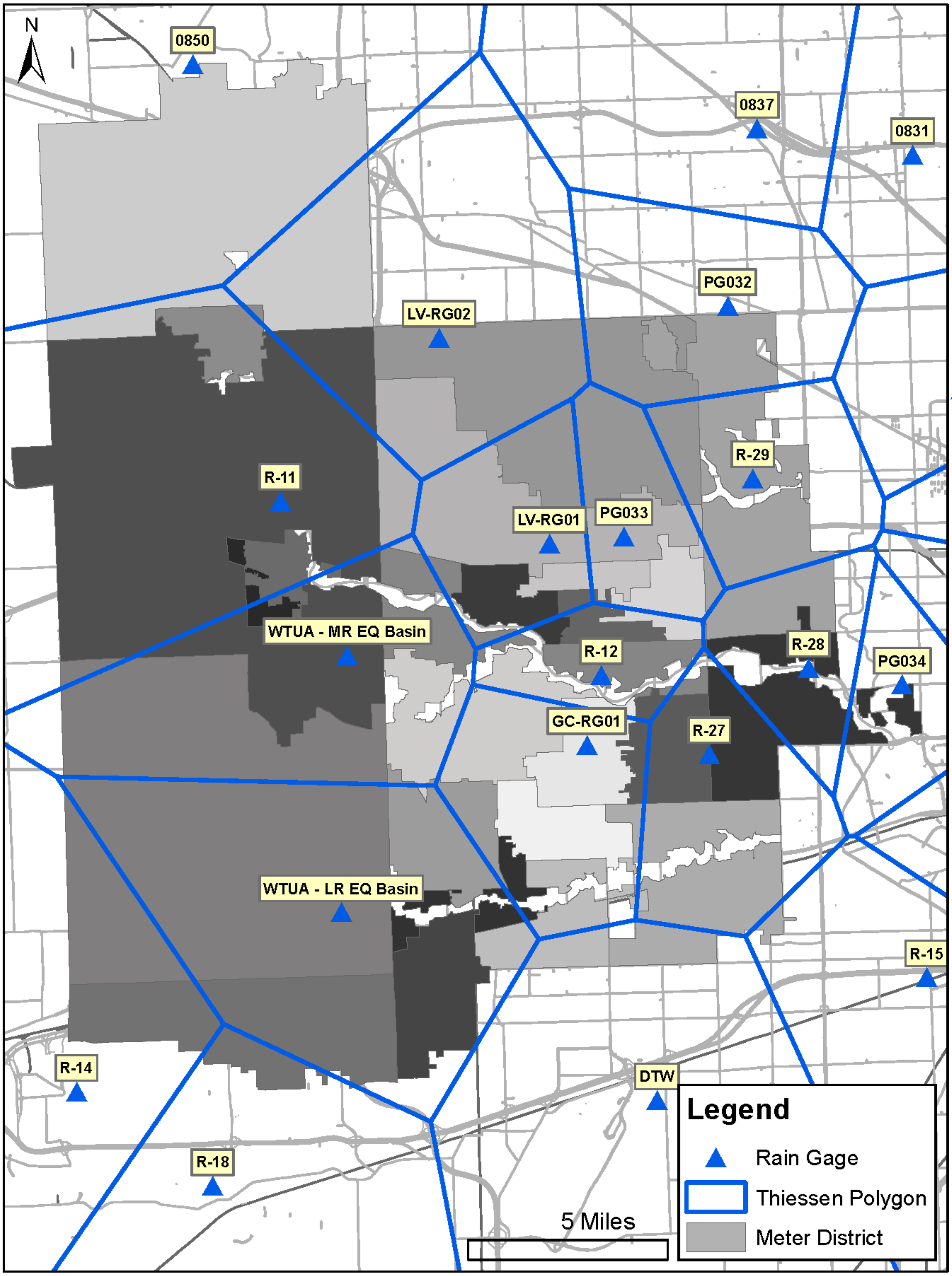

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Figure B-3
Rouge Valley Sewage Disposal System
Thiessen Polygons - Event 3

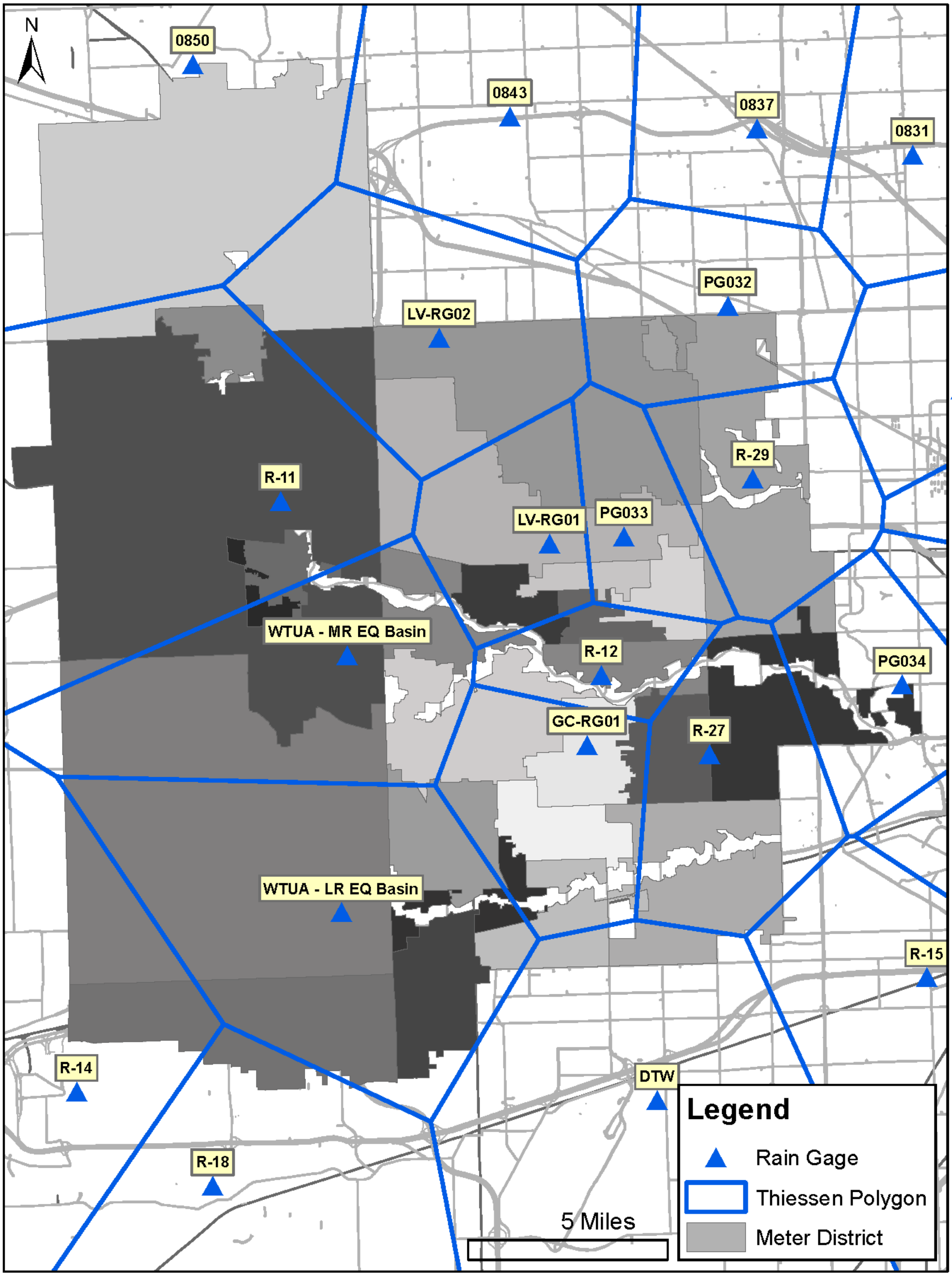

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Figure B-4
Rouge Valley Sewage Disposal System
Thiessen Polygons - Event 4

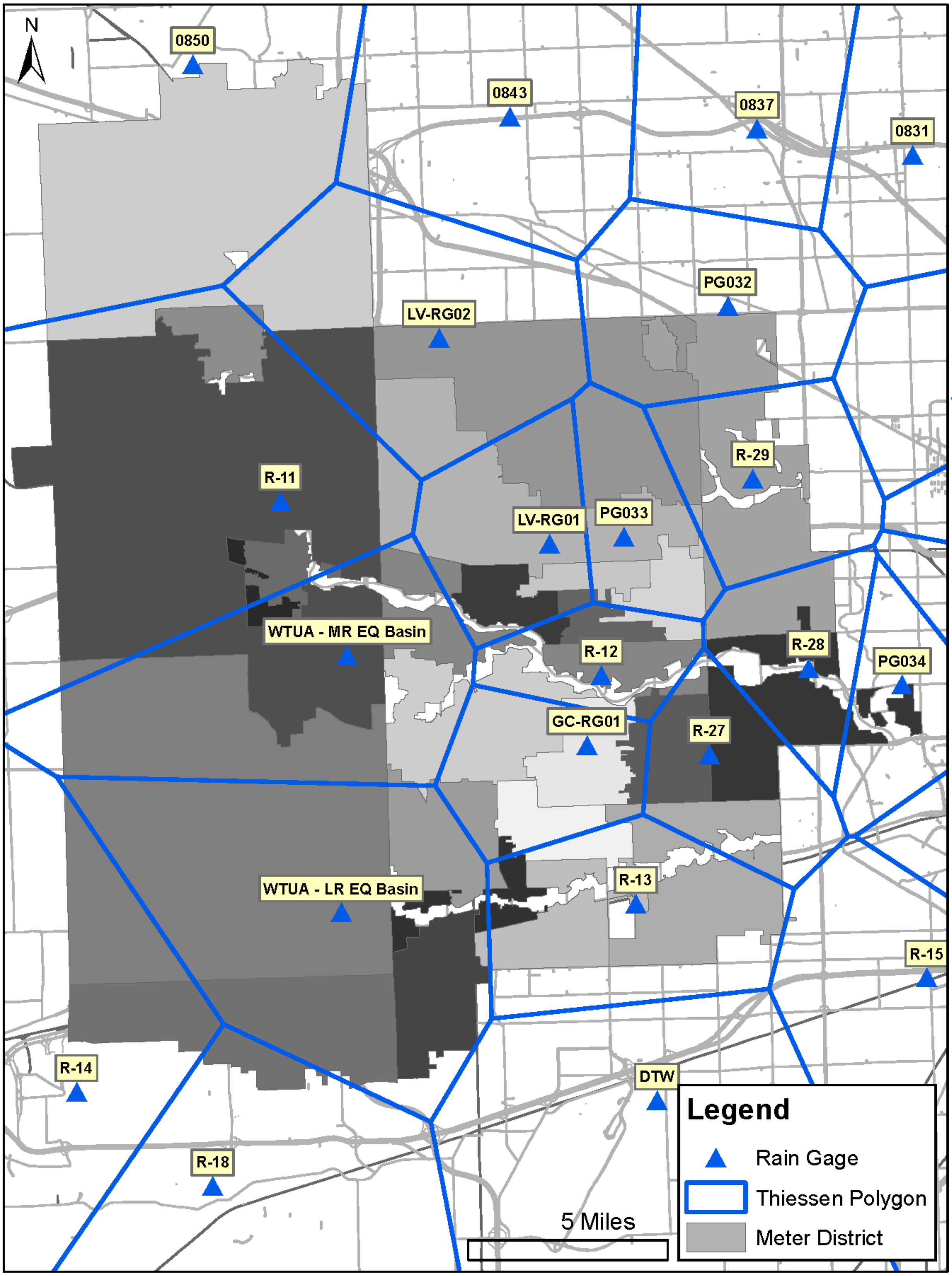

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Figure B-5
Rouge Valley Sewage Disposal System
Thiessen Polygons - Event 5

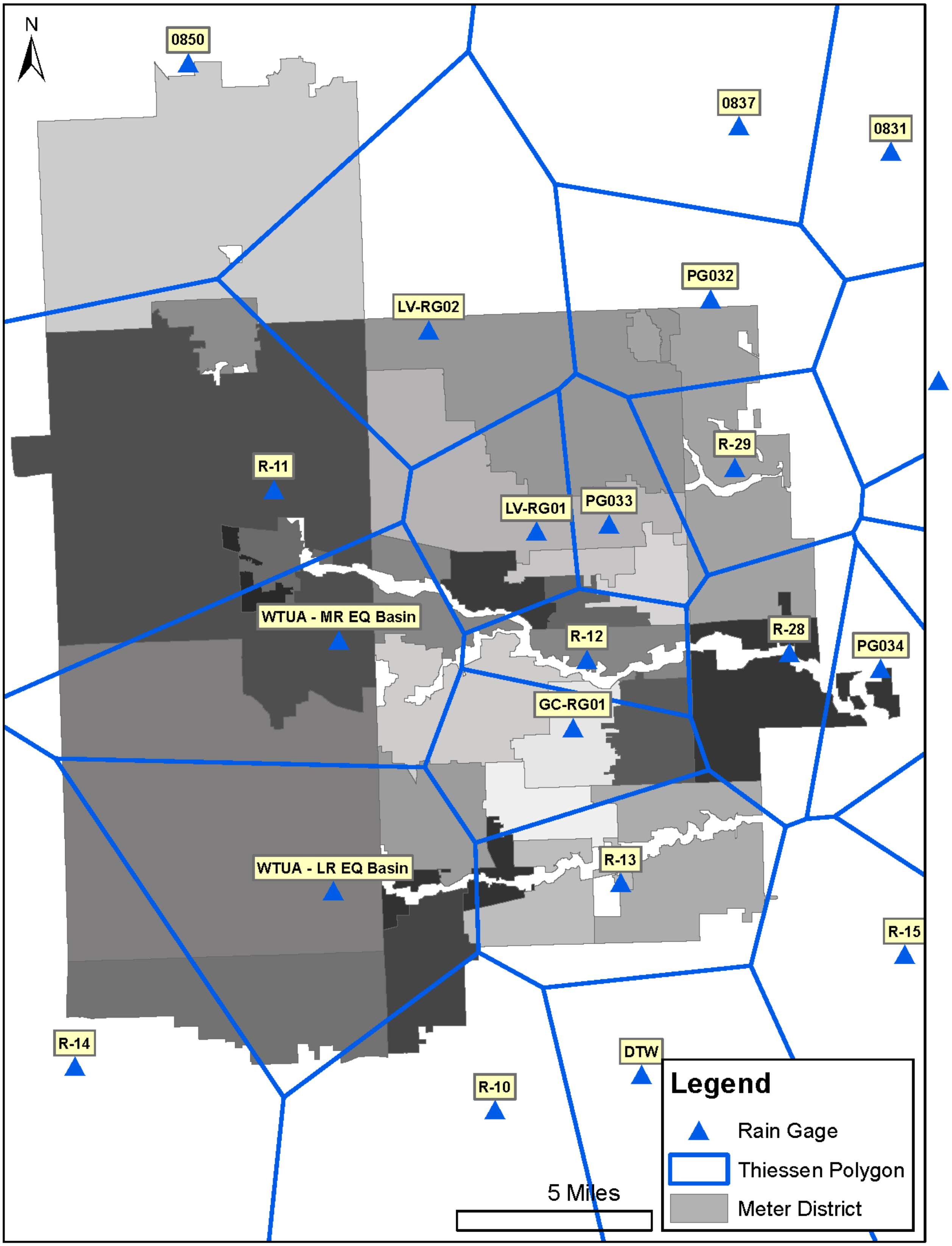

Figure B-6
Rouge Valley Sewage Disposal System
Thiessen Polygons - Event 6

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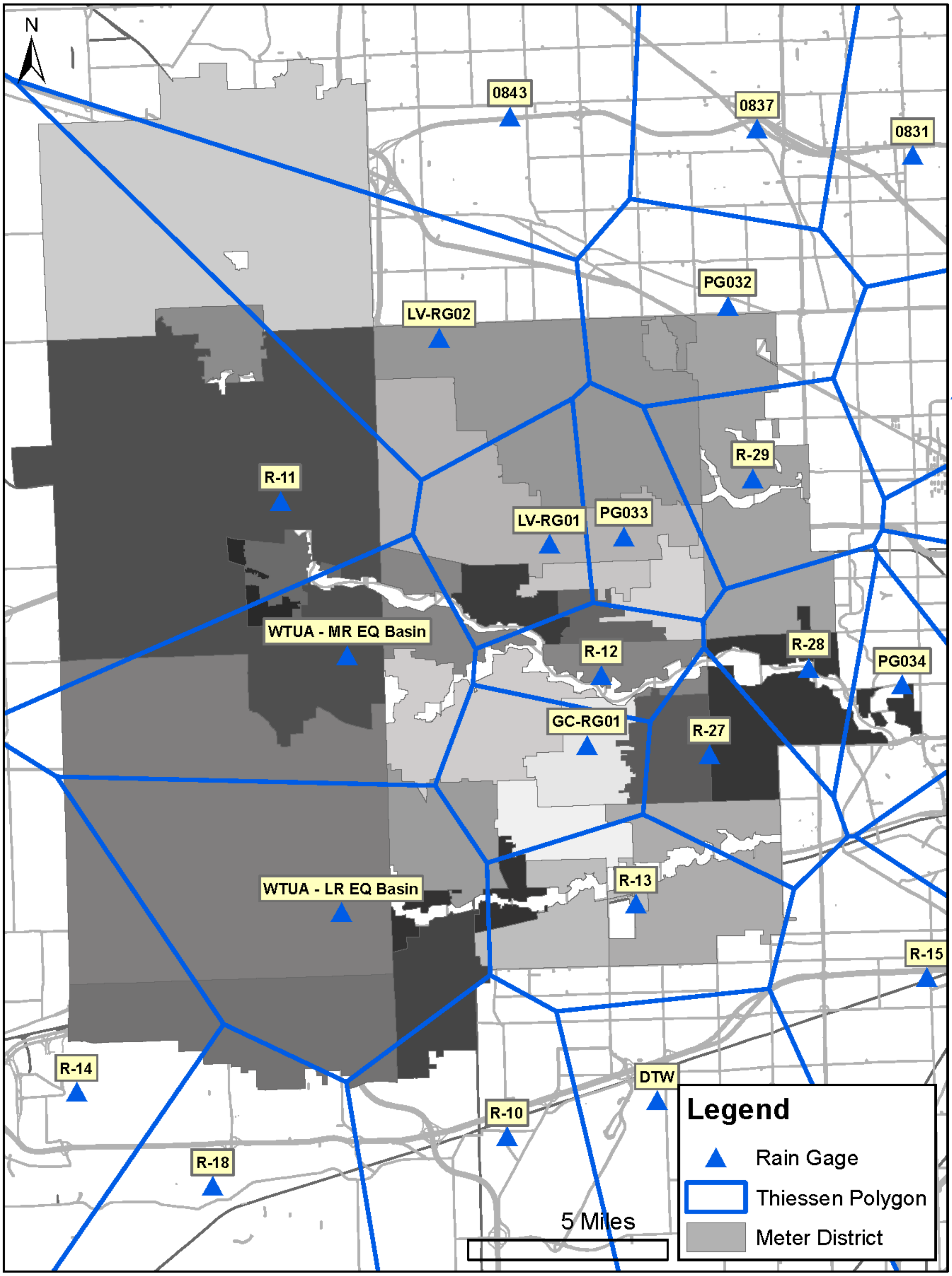

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Figure B-7
Rouge Valley Sewage Disposal System
Thiessen Polygons - Event 7

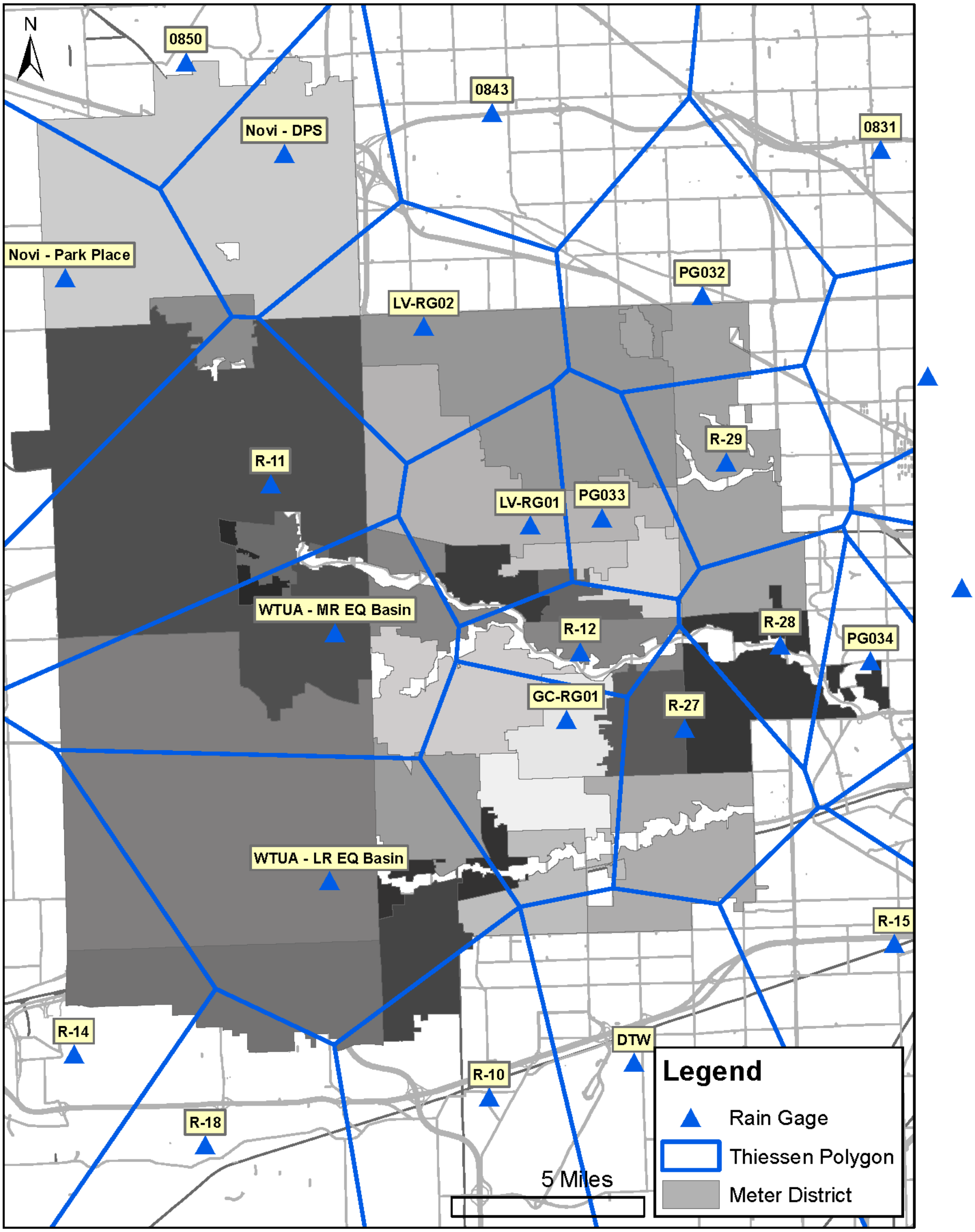

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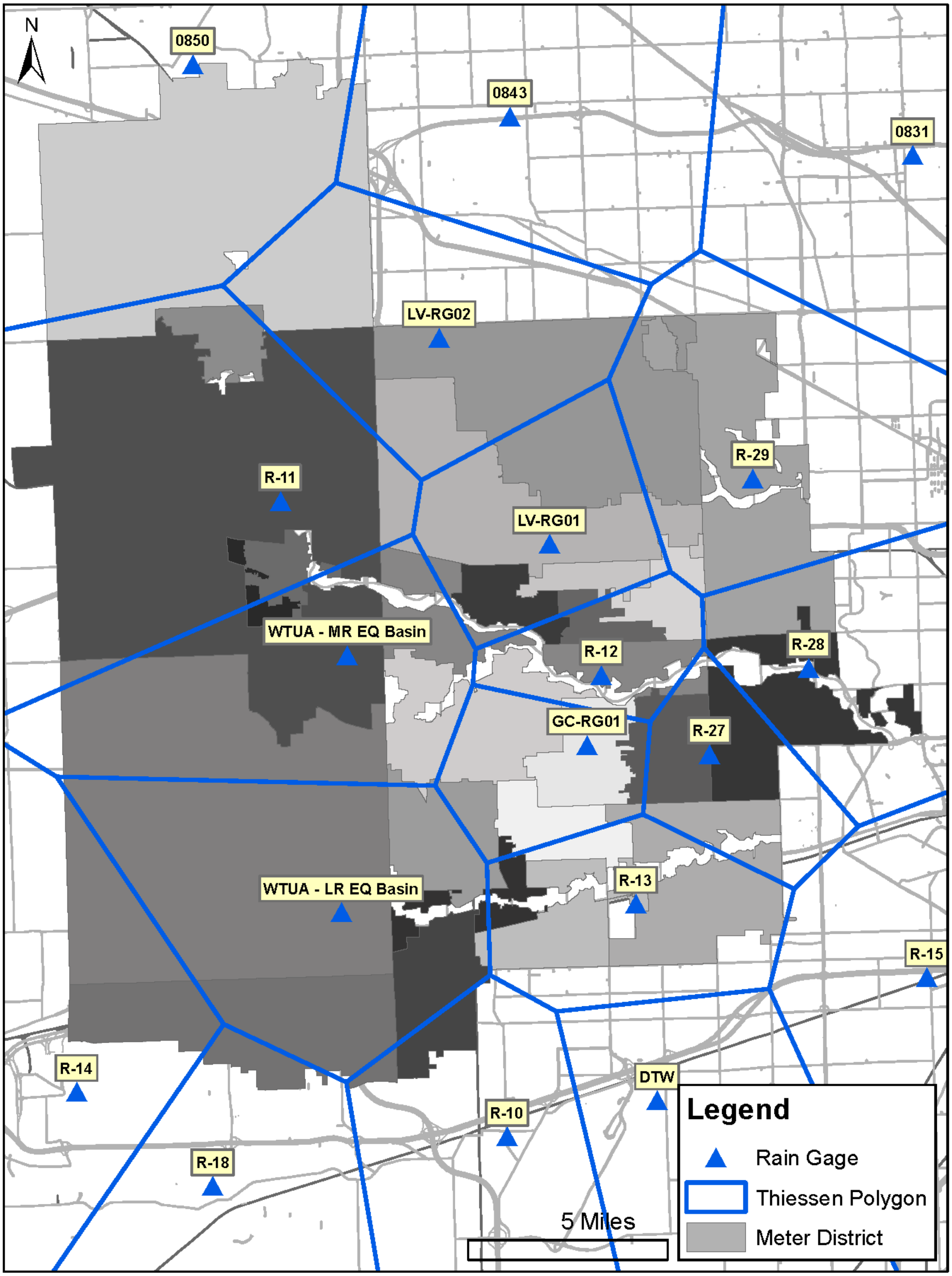
Figure B-8
Rouge Valley Sewage Disposal System
Thiessen Polygons - Event 8



Appendix C
RTK Parameter Optimization Speadsheets

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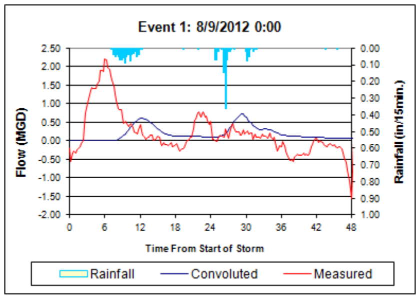
RTK Parameter Optimization

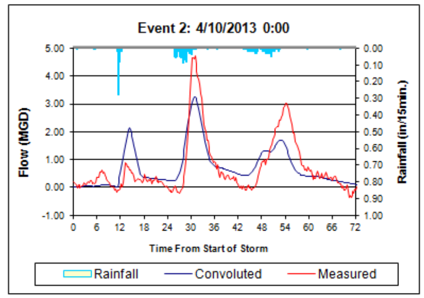
Meter BG-1

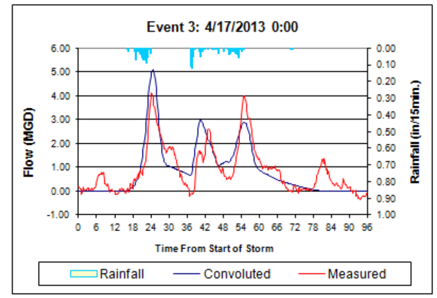
Area = 16538 acres

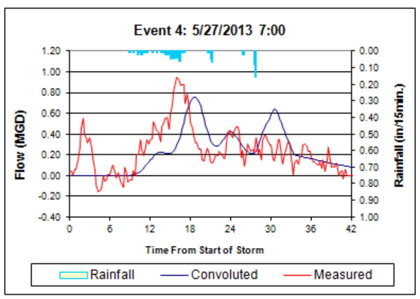
Unit Hydrograph Parameters				
	R (fraction)	T (hrs)	K (ratio)	Base Time (hours)
Triangle 1	0.00	1.50	3.00	6.00
Triangle 2	0.51	2.89	1.00	5.77
Triangle 3	0.49	3.82	6.35	28.08
			Initial Abstraction:	0 inches

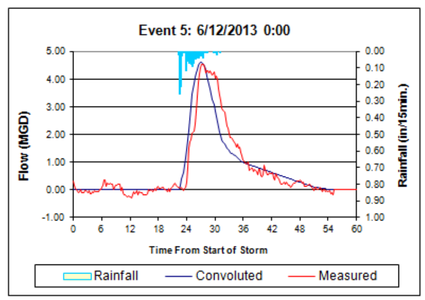
Goodness of Fit				Event Summary					Notes
Event No.	Weight	Difference Value	Weighted Difference Value	Rain Gauge	Rainfall (in)	Excess Rainfall (in)	RDI/I Volume (MG)	Event Capture	
1	0	9.14	--	0850	2.01	2.01	0.40	0.04%	Time stamp of meter data incorrect
2	0	9.94	--	0850	2.01	2.01	2.17	0.24%	
3	0	11.17	--	0850	1.84	1.84	3.46	0.42%	
4	0	2.91	--	LV-RG02	1.02	1.02	0.42	0.09%	Rainfall data suspect
5	0	6.73	--	0850	1.49	1.49	1.70	0.25%	
6	0	4.17	--	LV-RG02	1.42	1.42	1.14	0.18%	
7	0	16.02	--	0850	1.64	1.64	1.36	0.19%	High spatial variability
8	1	4.32	4.32	0850	1.44	1.44	1.43	0.22%	
Total	**N/A**	**64.40**	**4.32**	**N/A**	**12.87**	**12.87**	**12.09**	**0.20%**	

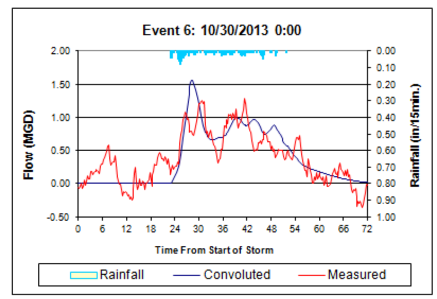


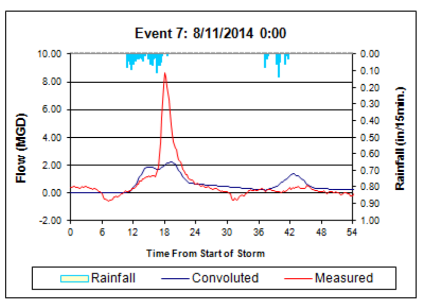


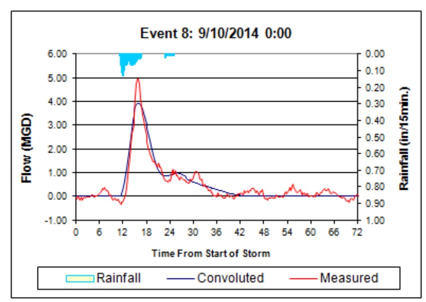












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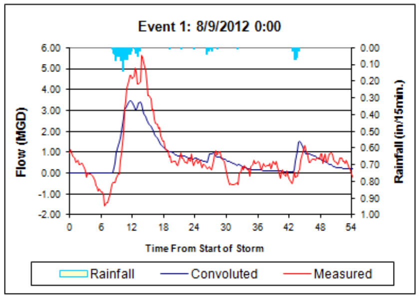
RTK Parameter Optimization

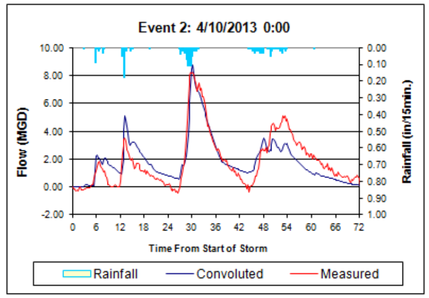
Meter LV11+LV04

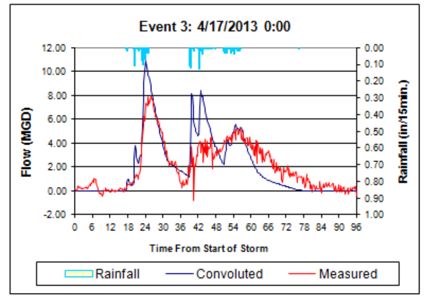
Area = 6906 acres

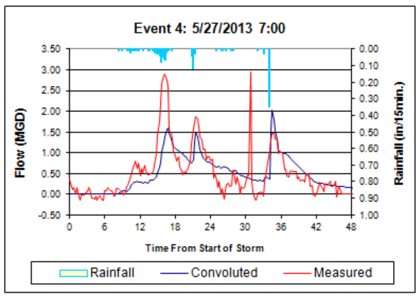
Unit Hydrograph Parameters				
	R (fraction)	T (hrs)	K (ratio)	Base Time (hours)
Triangle 1	0.18	0.38	3.00	1.54
Triangle 2	0.35	1.50	4.23	7.85
Triangle 3	0.47	3.00	6.85	23.54
		Initial Abstraction:	0 inches	

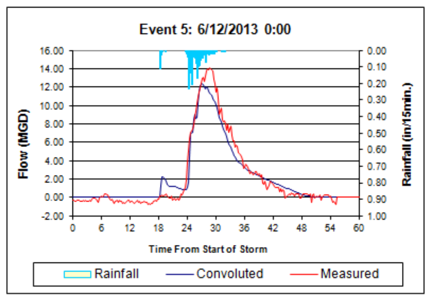
Goodness of Fit				Event Summary						
Event No.	Weight	Difference Value	Weighted Difference Value	Rain Gauge	Rainfall (in)	Excess Rainfall (in)	RDI/I Volume (MG)	Event Capture	Notes
1	0	10.94	--	LV-RG01	1.43	1.43	1.83	0.68%	DWF timing issue at start
2	0	15.84	--	LV-RG01	1.96	1.96	5.73	1.56%	
3	0	26.38	--	LV-RG01	1.73	1.73	8.17	2.52%	
4	0	5.87	--	LV-RG01	1.22	1.22	1.03	0.45%	
5	0	13.37	--	LV-RG01	1.78	1.78	5.08	1.52%	
6	0	8.87	--	LV-RG01	1.48	1.48	3.17	1.14%	
7	0	30.91	--	LV-RG01	2.80	2.80	8.55	1.63%	High spatial variability
8	1	7.36	7.36	LV-RG01	1.54	1.54	3.26	1.13%	
Total	N/A	119.53	7.36	N/A	13.94	13.94	36.81	1.33%	

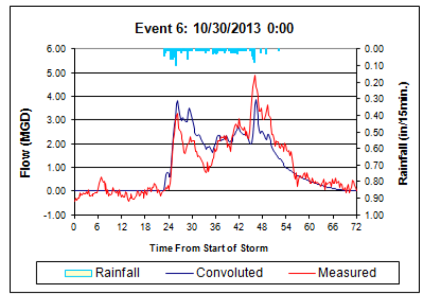


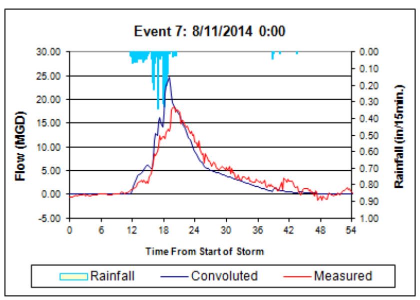


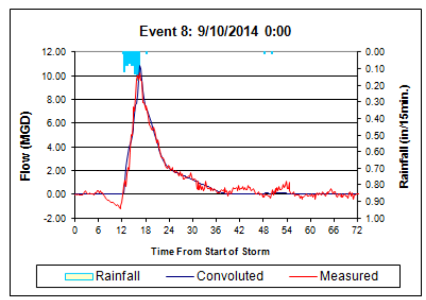












RTK Parameter Optimization

Meter LV14

Area = 1288 acres

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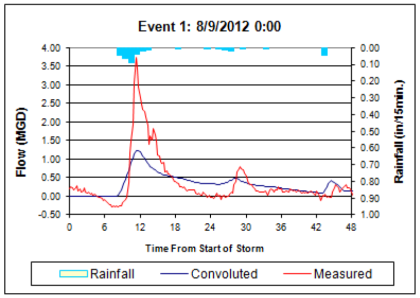
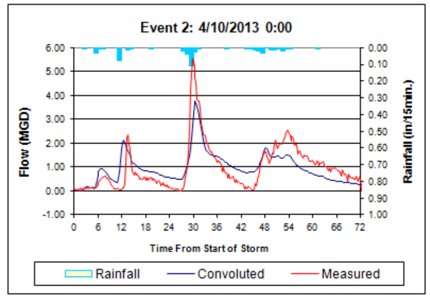
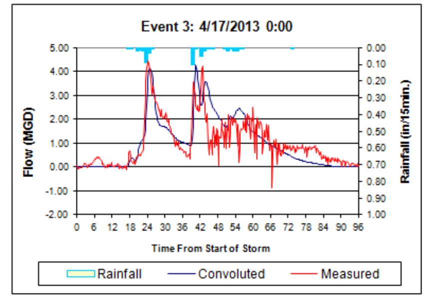
Unit Hydrograph Parameters				
	R (fraction)	T (hrs)	K (ratio)	Base Time (hours)
Triangle 1	0.28	0.84	3.00	3.36
Triangle 2	0.14	2.78	2.77	10.50
Triangle 3	0.57	6.96	4.03	34.99

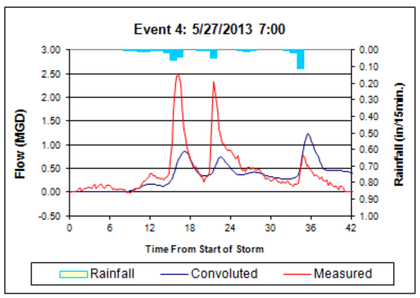
Initial Abstraction: 0 inches

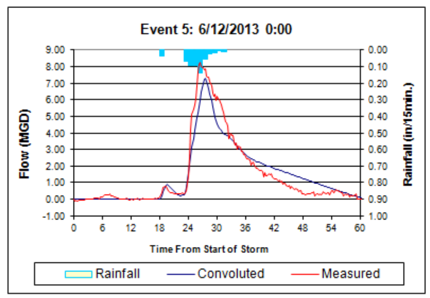
Goodness of Fit				Event Summary					Notes
Event No.	Weight	Difference Value	Weighted Difference Value	Rain Gauge	Rainfall (in)	Excess Rainfall (in)	RDI/I Volume (MG)	Event Capture	
1	0	6.50	--	PG-033	1.42	1.42	0.72	1.45%	
2	0	10.06	--	PG-033	1.98	1.98	2.95	4.26%	
3	0	12.05	--	PG-033	1.90	1.90	4.08	6.14%	
4	0	6.04	--	PG-033	1.43	1.43	0.76	1.52%	
5	0	9.75	--	PG-033	2.05	2.05	3.61	5.04%	
6	0	4.71	--	PG-033	1.67	1.67	1.63	2.80%	
7	0	16.40	--	PG-033	3.58	3.58	4.85	3.88%	High spatial variability
8	1	5.27	5.27	R-12	1.63	1.63	3.04	5.34%	
Total	**N/A**	**70.80**	**5.27**	**N/A**	**15.66**	**15.66**	**21.65**	**3.58%**	

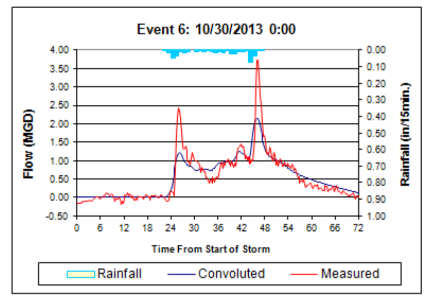


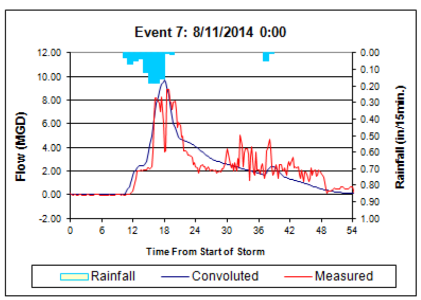


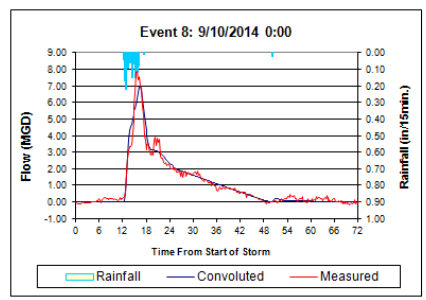












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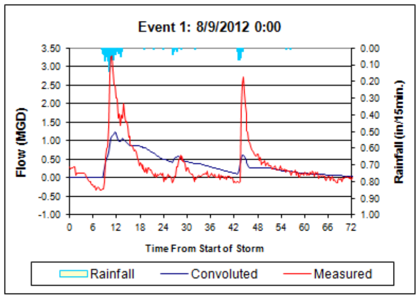
RTK Parameter Optimization

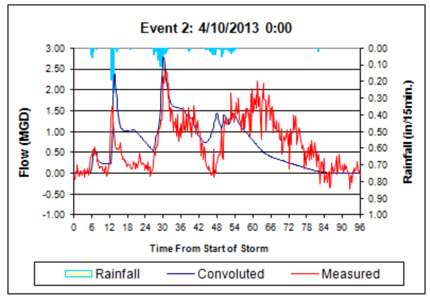
Meter LV15

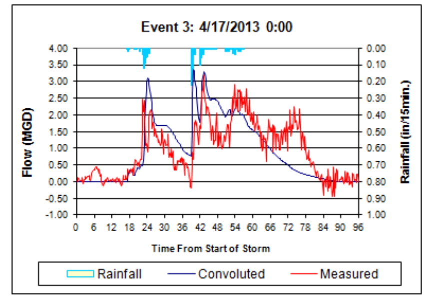
Area = 798 acres

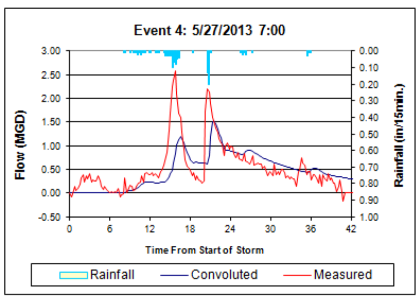
	Unit Hydrograph Parameters			
	R (fraction)	T (hrs)	K (ratio)	Base Time (hours)
Triangle 1	0.16	0.59	3.00	2.37
Triangle 2	0.27	2.00	5.88	13.75
Triangle 3	0.56	8.00	3.35	34.82
		Initial Abstraction:	0 inches	

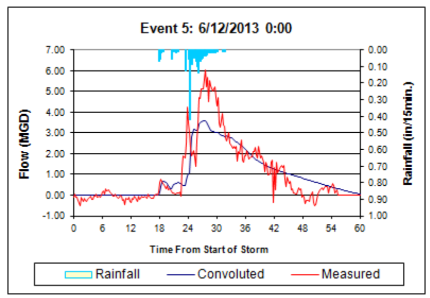
Goodness of Fit				Event Summary					Notes
Event No.	Weight	Difference Value	Weighted Difference Value	Rain Gauge	Rainfall (in)	Excess Rainfall (in)	RDI/I Volume (MG)	Event Capture	
1	0	8.01	--	LV-RG01	1.43	1.43	1.02	3.29%	Rain gauge not in service
2	0	11.43	--	R-12	2.11	2.11	2.77	6.06%	
3	0	12.79	--	R-12	1.69	1.69	3.75	10.23%	
4	0	5.28	--	R-12	1.12	1.12	0.92	3.79%	
5	0	11.32	--	R-12	1.89	1.89	2.44	5.97%	
6	0	5.17	--	R-12	1.80	1.80	1.62	4.15%	
7	0	19.33	--	R-12	4.74	4.74	5.33	5.19%	High spatial variability
8	1	4.74	4.74	R-12	1.63	1.63	1.87	5.28%	
Total	**N/A**	**78.07**	**4.74**	**N/A**	**16.41**	**16.41**	**19.71**	**5.81%**	

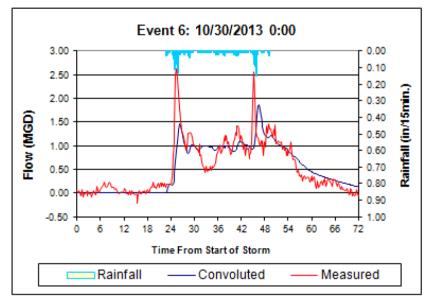


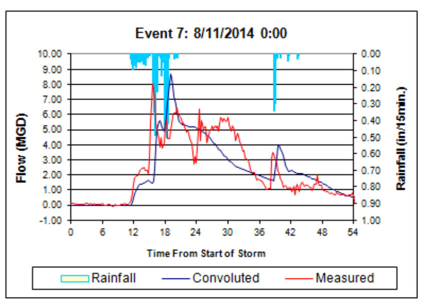


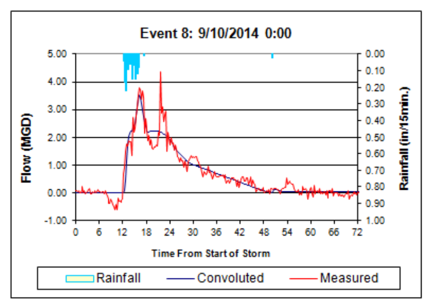












DRAFT

RTK Parameter Optimization

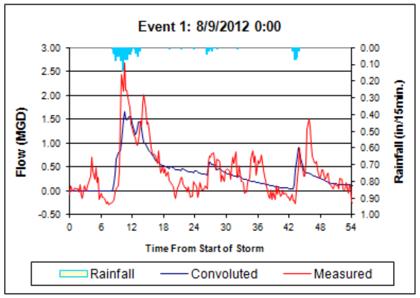
Meter LV16

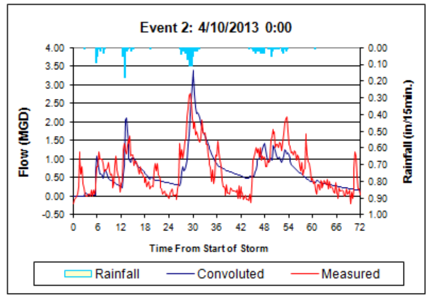
Area = 1188 acres

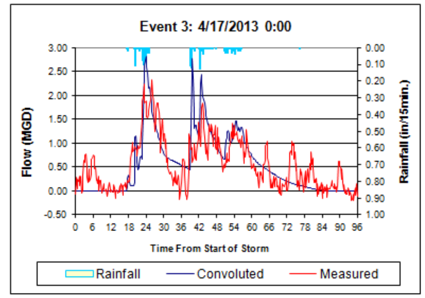
Unit Hydrograph Parameters	R (fraction)	T (hrs)	K (ratio)	Base Time (hours)
Triangle 1	0.21	0.31	3.00	1.25
Triangle 2	0.27	1.58	3.11	6.50
Triangle 3	0.52	5.93	4.19	30.76

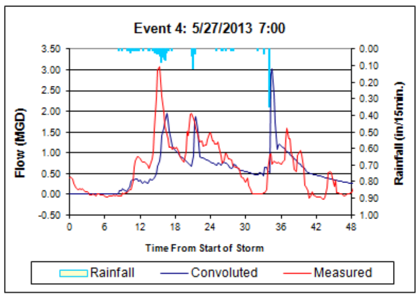
Initial Abstraction: 0 inches

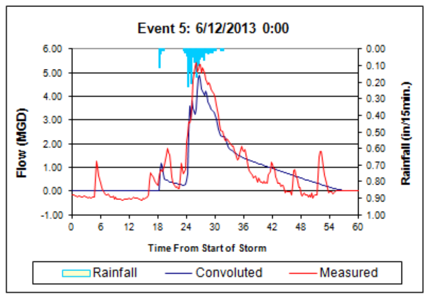
Goodness of Fit				Event Summary					Notes
Event No.	Weight	Difference Value	Weighted Difference Value	Rain Gauge	Rainfall (in)	Excess Rainfall (in)	RDI/I Volume (MG)	Event Capture	
1	0	5.19	--	LV-RG01	1.43	1.43	0.92	1.99%	
2	0	7.33	--	LV-RG01	1.96	1.96	2.13	3.36%	
3	0	7.86	--	LV-RG01	1.73	1.73	2.20	3.94%	
4	0	7.52	--	LV-RG01	1.22	1.22	1.26	3.21%	
5	0	8.55	--	LV-RG01	1.78	1.78	2.12	3.69%	
6	0	6.01	--	LV-RG01	1.48	1.48	1.24	2.60%	
7	0	13.72	--	LV-RG01	2.80	2.80	2.70	2.99%	High spatial variability
8	1	7.38	7.38	LV-RG01	1.54	1.54	1.64	3.30%	
Total	**N/A**	**63.57**	**7.38**	**N/A**	**13.94**	**13.94**	**14.20**	**3.13%**	

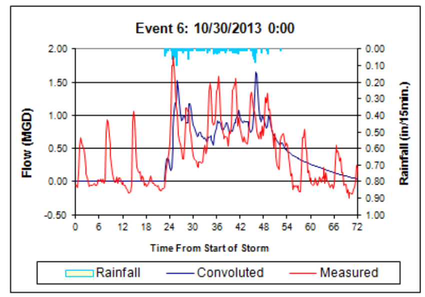


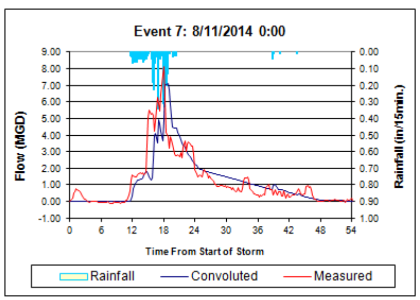


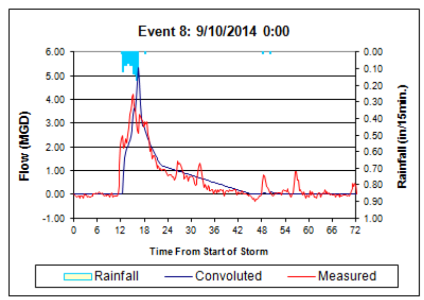












DRAFT

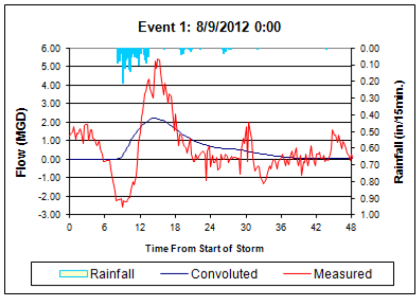
RTK Parameter Optimization

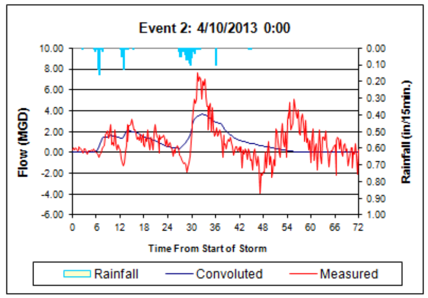
Meter LVBASIN-LV04

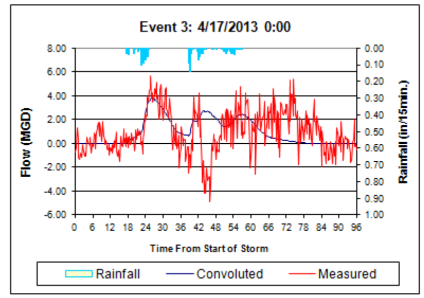
Area = 9534 acres

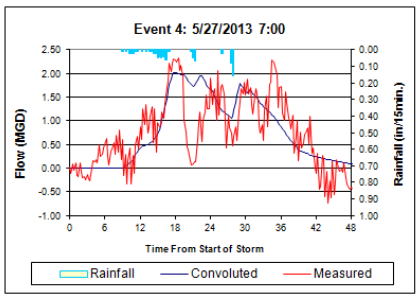
Unit Hydrograph Parameters				
	R (fraction)	T (hrs)	K (ratio)	Base Time (hours)
Triangle 1	0.07	1.25	1.00	2.50
Triangle 2	0.53	3.00	2.80	11.40
Triangle 3	0.40	7.00	2.71	25.98
			Initial Abstraction:	0 inches

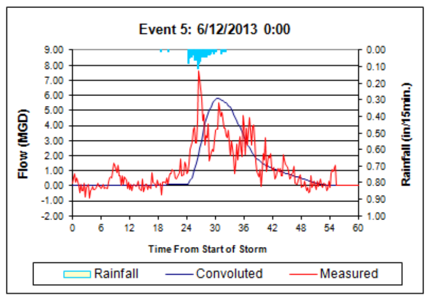
Goodness of Fit				Event Summary					Notes
Event No.	Weight	Difference Value	Weighted Difference Value	Rain Gauge	Rainfall (in)	Excess Rainfall (in)	RDI/I Volume (MG)	Event Capture	
1	0	16.98	--	LV-RG02	1.84	1.84	1.15	0.24%	DWF timing issue at start
2	0	25.64	--	LV-RG02	1.61	1.61	2.90	0.70%	
3	0	35.60	--	LV-RG02	1.70	1.70	3.80	0.86%	Upstream SSO occurred
4	0	8.04	--	LV-RG02	1.02	1.02	1.58	0.60%	
5	0	18.00	--	LV-RG02	1.05	1.05	2.71	1.00%	
6	0	12.25	--	LV-RG02	1.42	1.42	1.82	0.50%	
7	0	72.42	--	LV-RG02	3.66	3.66	7.23	0.76%	High spatial variability/Upstream SSO occurred
8	1	11.76	11.76	LV-RG02	1.33	1.33	3.00	0.87%	
Total	**N/A**	**200.69**	**11.76**	**N/A**	**13.63**	**13.63**	**24.20**	**0.69%**	

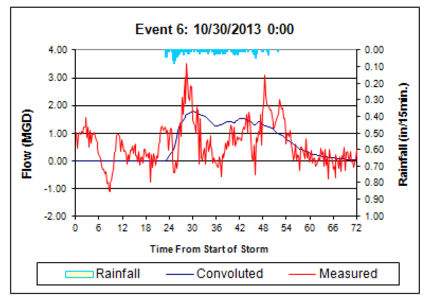


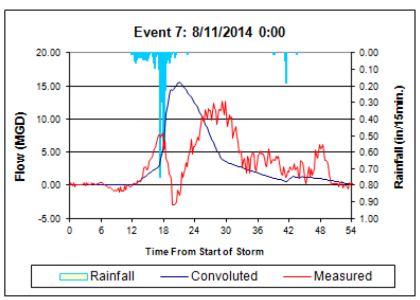


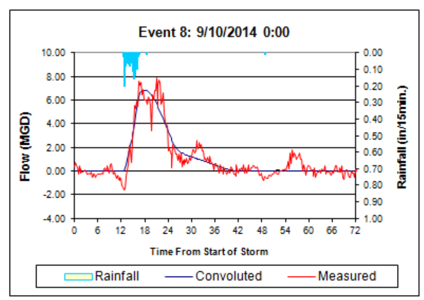












DRAFT

RTK Parameter Optimization

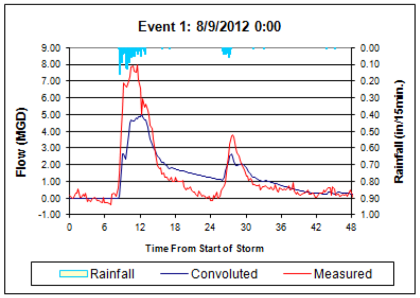
Meter M1

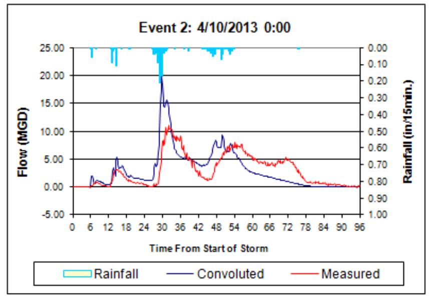
Area = 1924 acres

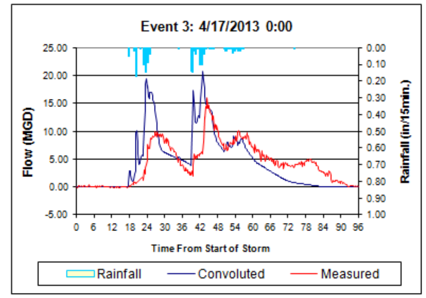
Unit Hydrograph Parameters				
	R (fraction)	T (hrs)	K (ratio)	Base Time (hours)
Triangle 1	0.16	0.31	3.00	1.25
Triangle 2	0.22	2.35	1.00	4.70
Triangle 3	0.62	3.00	9.26	30.79

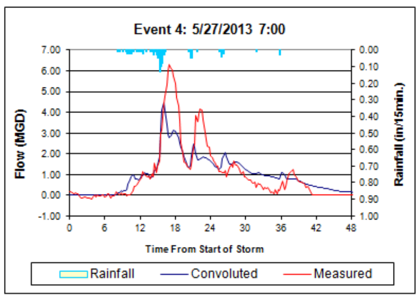
Initial Abstraction: 0 inches

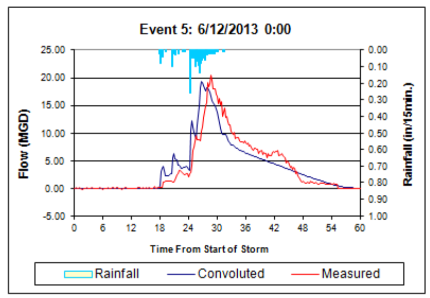
Goodness of Fit				Event Summary					Notes
Event No.	Weight	Difference Value	Weighted Difference Value	Rain Gauge	Rainfall (in)	Excess Rainfall (in)	RDI/I Volume (MG)	Event Capture	
1	0	14.27	--	R-27	1.39	1.39	2.60	3.59%	
2	0	48.16	--	R-27	2.30	2.30	11.66	9.70%	
3	0	69.16	--	R-27	2.17	2.17	17.13	15.11%	
4	0	10.70	--	R-27	0.93	0.93	2.01	4.13%	
5	0	31.94	--	R-28	1.67	1.67	9.35	10.72%	
6	0	11.11	--	R-27	1.97	1.97	5.43	5.28%	
7	0	93.91	--	R-27	6.07	6.07	19.67	6.20%	High spatial variability
8	1	12.37	12.37	R-27	1.70	1.70	6.10	6.87%	
Total	**N/A**	**291.62**	**12.37**	**N/A**	**18.20**	**18.20**	**73.95**	**7.70%**	

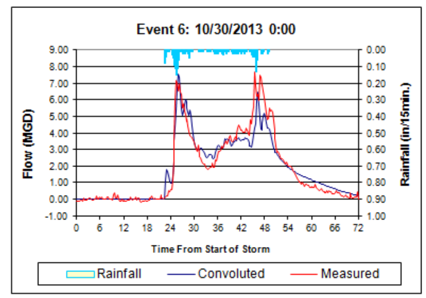


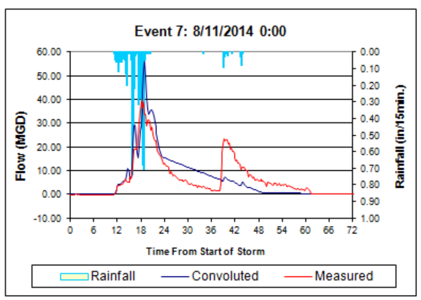


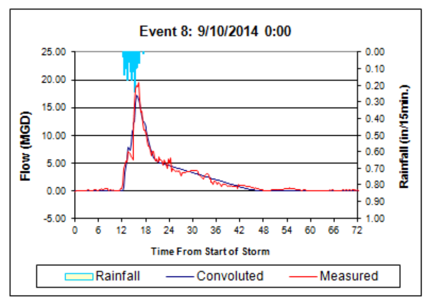












RTK Parameter Optimization

Meter M2

Area = 1911 acres

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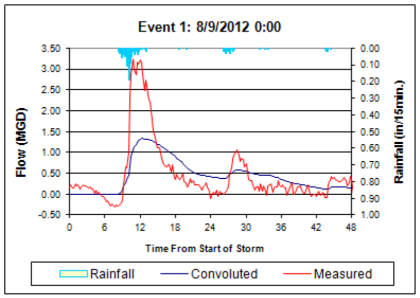
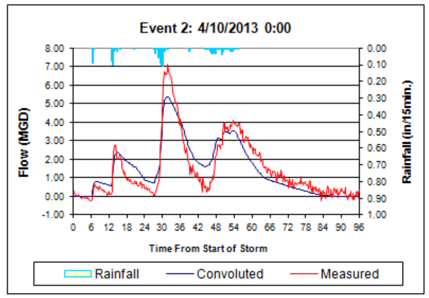
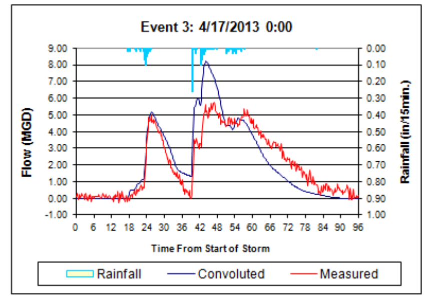
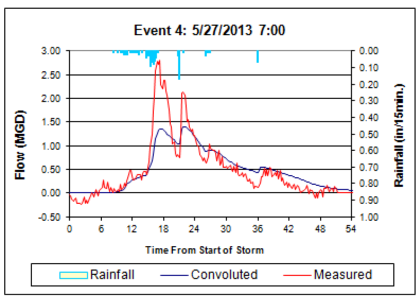
Unit Hydrograph Parameters				
	R (fraction)	T (hrs)	K (ratio)	Base Time (hours)
Triangle 1	0.07	0.60	3.00	2.41
Triangle 2	0.41	2.27	3.78	10.83
Triangle 3	0.52	7.75	3.52	35.03
			Initial Abstraction:	0 inches

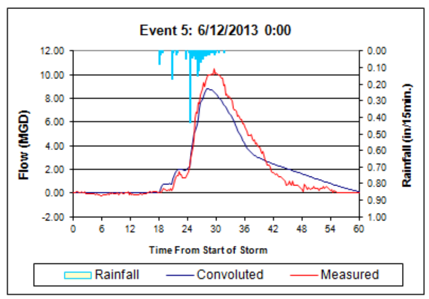
Goodness of Fit				Event Summary						Notes
Event No.	Weight	Difference Value	Weighted Difference Value	Rain Gauge	Rainfall (in)	Excess Rainfall (in)	RDI/I Volume (MG)	Event Capture		
1	0	7.30	--	GC-RG01	1.14	1.14	0.92	1.56%	
2	0	11.93	--	GC-RG01	1.68	1.68	5.81	6.67%	
3	0	19.69	--	GC-RG01	1.69	1.69	8.26	9.42%	Upstream SSO suspected
4	0	4.81	--	GC-RG01	0.98	0.98	1.09	2.14%	
5	0	12.64	--	GC-RG01	1.69	1.69	5.33	6.08%	
6	0	6.36	--	GC-RG01	1.71	1.71	2.77	3.12%	
7	0	43.72	--	GC-RG01	5.11	5.11	14.20	5.36%	High spatial variability/Upstream SSO suspected
8	1	3.07	3.07	GC-RG01	1.65	1.65	5.06	5.92%	
Total	N/A	109.51	3.07	N/A	15.65	15.65	43.46	5.03%	

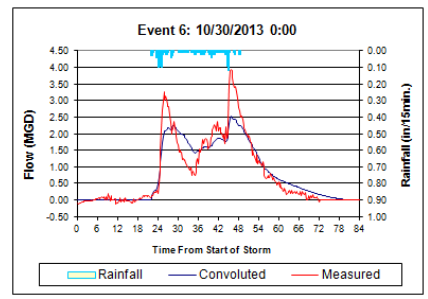


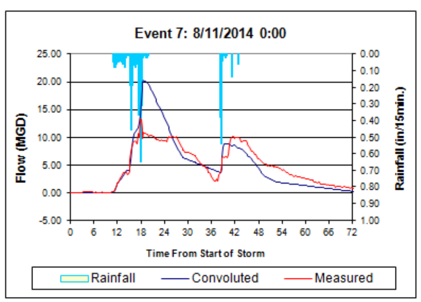


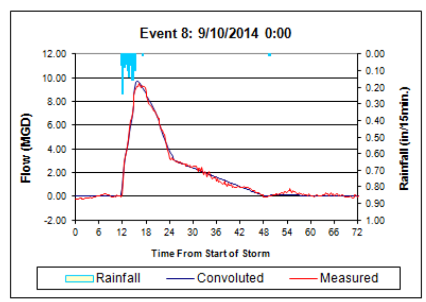












DRAFT

RTK Parameter Optimization

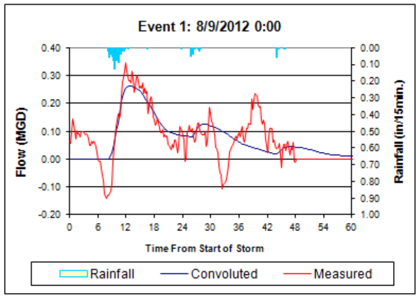
Meter P15

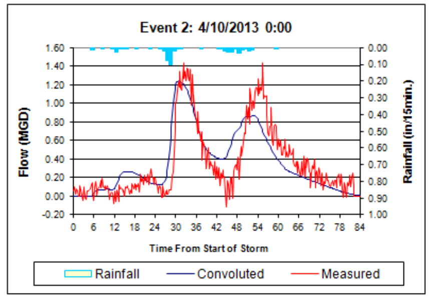
Area = 6078 acres

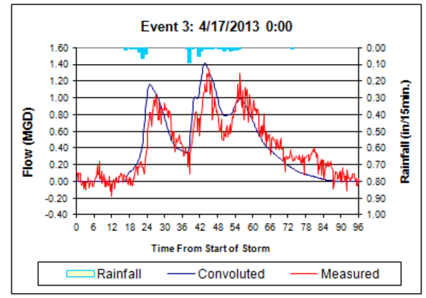
Unit Hydrograph Parameters				
	R (fraction)	T (hrs)	K (ratio)	Base Time (hours)
Triangle 1	0.01	1.12	1.77	3.10
Triangle 2	0.38	1.51	5.95	10.48
Triangle 3	0.61	5.40	5.36	34.33

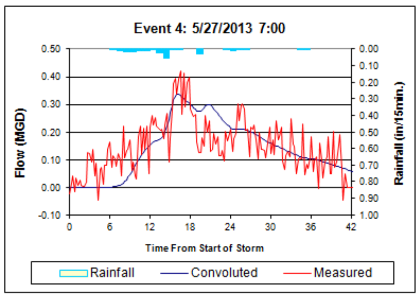
Initial Abstraction: 0 inches

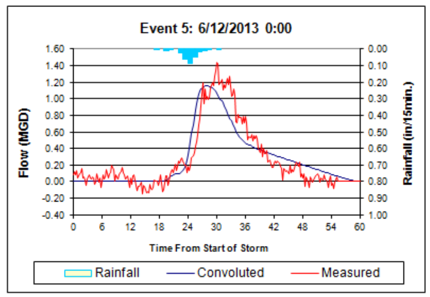
Goodness of Fit				Event Summary					Notes
Event No.	Weight	Difference Value	Weighted Difference Value	Rain Gauge	Rainfall (in)	Excess Rainfall (in)	RDI/I Volume (MG)	Event Capture	
1	0	1.03	--	R-14	1.04	1.04	0.19	0.11%	
2	0	3.78	--	WTUA LR	1.92	1.92	1.26	0.40%	
3	0	3.65	--	WTUA LR	1.76	1.76	1.64	0.56%	
4	0	1.00	--	WTUA LR	0.83	0.83	0.26	0.19%	
5	0	2.41	--	WTUA LR	1.09	1.09	0.66	0.37%	
6	0	2.31	--	WTUA LR	1.80	1.80	0.62	0.21%	
7	0	2.23	--	WTUA LR	2.94	2.94	0.81	0.17%	High spatial variability
8	1	1.43	1.43	WTUA LR	1.52	1.52	0.75	0.30%	
Total	**N/A**	**17.84**	**1.43**	**N/A**	**12.90**	**12.90**	**6.18**	**0.34%**	

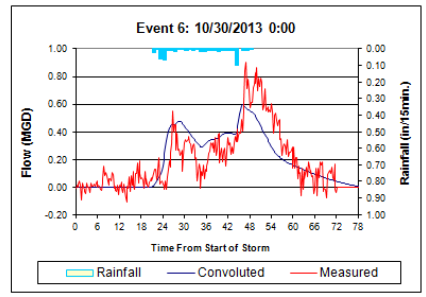


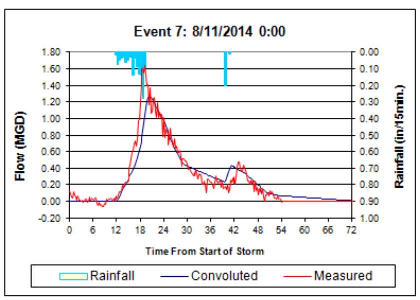


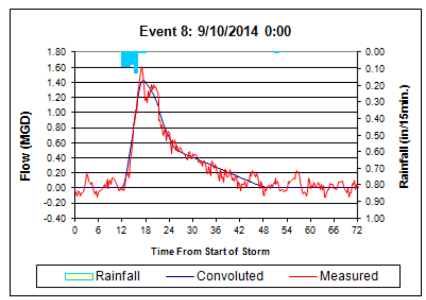












DRAFT

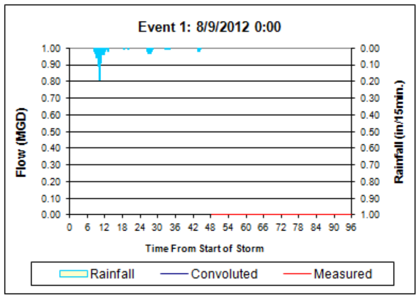
RTK Parameter Optimization

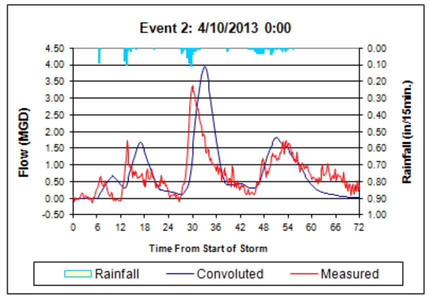
Meter WE14

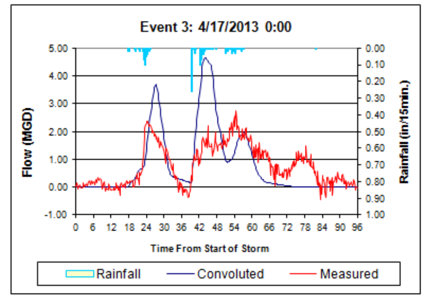
Area = 4108 acres

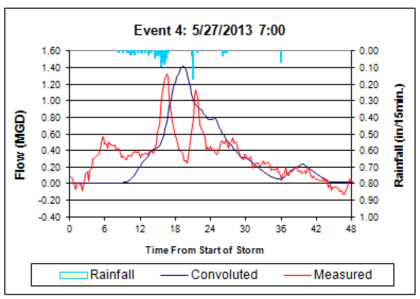
Unit Hydrograph Parameters				
	R (fraction)	T (hrs)	K (ratio)	Base Time (hours)
Triangle 1	0.08	1.50	3.00	6.00
Triangle 2	0.26	3.00	6.00	21.00
Triangle 3	0.66	3.75	1.19	8.21
			Initial Abstraction:	0 inches

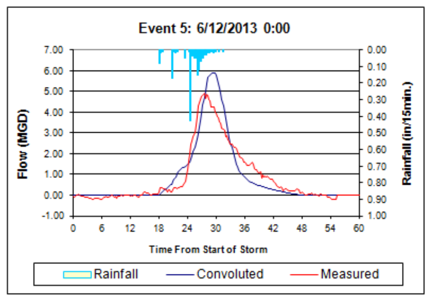
Goodness of Fit				Event Summary						Notes
Event No.	Weight	Difference Value	Weighted Difference Value	Rain Gauge	Rainfall (in)	Excess Rainfall (in)	RDI/I Volume (MG)	Event Capture		
1	0	--	--	GC-RG01	1.14	1.14	N/A	0.00%		Meter not in service
2	0	11.32	--	GC-RG01	1.68	1.68	2.26	1.20%		
3	0	17.50	--	GC-RG01	1.69	1.69	3.11	1.65%		Upstream SSO suspected
4	0	4.40	--	GC-RG01	0.98	0.98	0.65	0.59%		
5	0	8.22	--	GC-RG01	1.69	1.69	2.03	1.08%		
6	0	3.96	--	GC-RG01	1.71	1.71	0.67	0.35%		
7	0	30.88	--	GC-RG01	5.11	5.11	6.16	1.08%		High spatial variability/Upstream SSO suspected
8	1	3.58	3.58	GC-RG01	1.65	1.65	1.47	0.80%		
Total	**N/A**	**79.85**	**3.58**	**N/A**	**15.65**	**15.65**	**16.35**	**0.97%**		

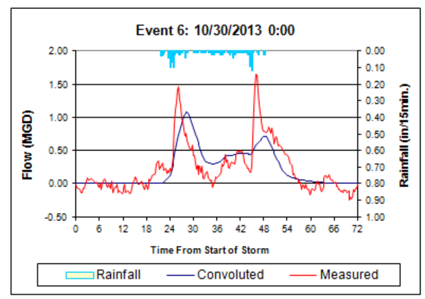


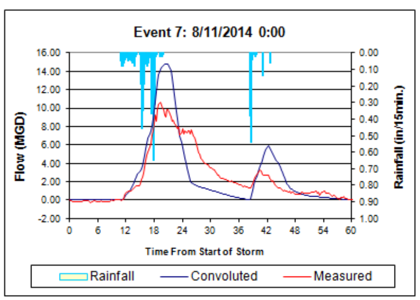


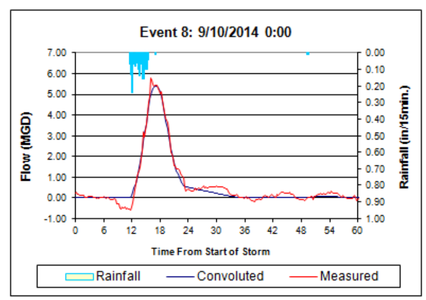












RTK Parameter Optimization

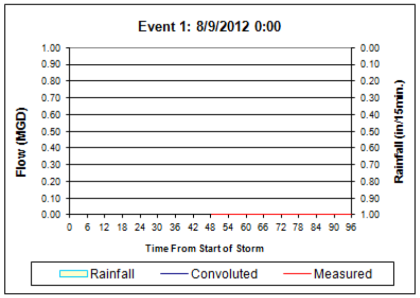
Meter WE25

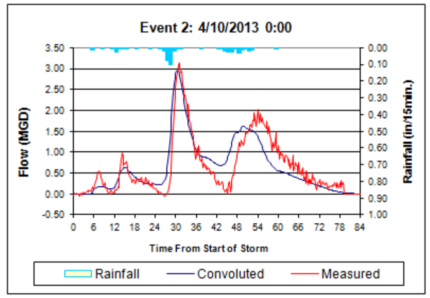
Area = 2682 acres

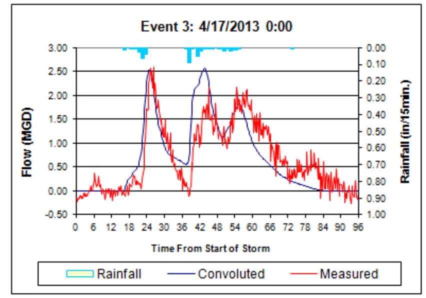
DRAFT

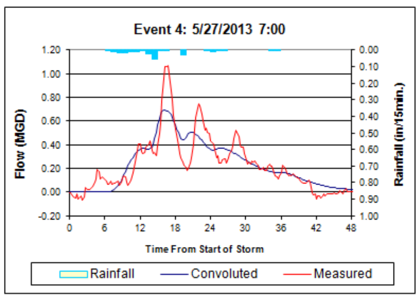
Unit Hydrograph Parameters				
	R (fraction)	T (hrs)	K (ratio)	Base Time (hours)
Triangle 1	0.16	1.10	3.00	4.40
Triangle 2	0.22	2.76	1.87	7.91
Triangle 3	0.63	3.25	8.50	30.87
		Initial Abstraction:		0 inches

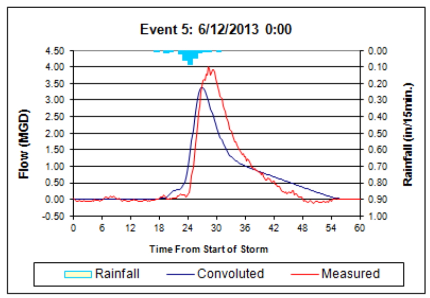
Goodness of Fit				Event Summary					Notes
Event No.	Weight	Difference Value	Weighted Difference Value	Rain Gauge	Rainfall (in)	Excess Rainfall (in)	RDI/I Volume (MG)	Event Capture	
1	0	--	--	WTUA LR	0.00	0.00	#N/A	0.00%	Meter not in service
2	0	6.33	--	WTUA LR	1.92	1.92	2.24	1.60%	
3	0	8.41	--	WTUA LR	1.76	1.76	2.76	2.15%	
4	0	1.56	--	WTUA LR	0.83	0.83	0.46	0.77%	
5	0	6.81	--	WTUA LR	1.09	1.09	1.48	1.86%	
6	0	3.27	--	WTUA LR	1.80	1.80	0.94	0.72%	
7	0	8.31	--	WTUA LR	2.94	2.94	4.01	1.87%	High spatial variability
8	1	1.54	1.54	WTUA LR	1.52	1.52	1.64	1.48%	
Total	N/A	36.22	1.54	N/A	11.86	11.86	13.53	1.49%	

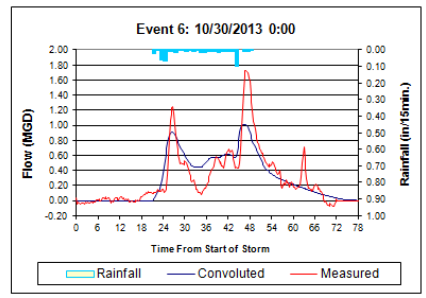


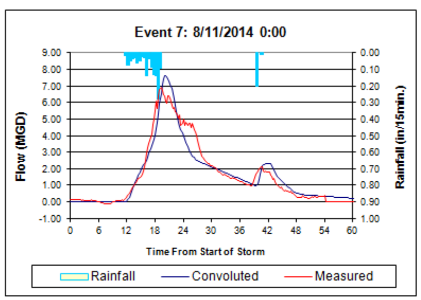


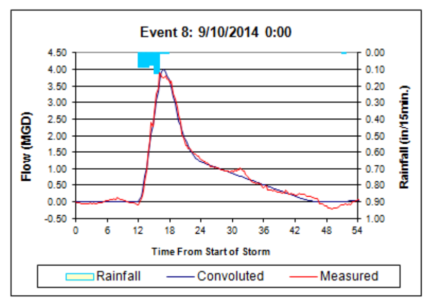












DRAFT

RTK Parameter Optimization

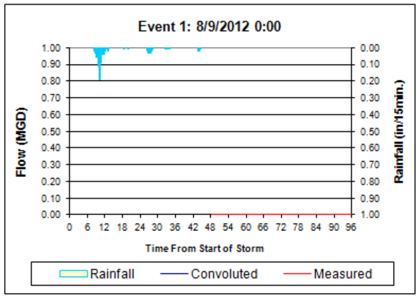
Meter WE28

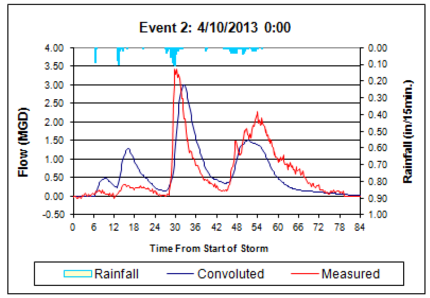
Area = 1664 acres

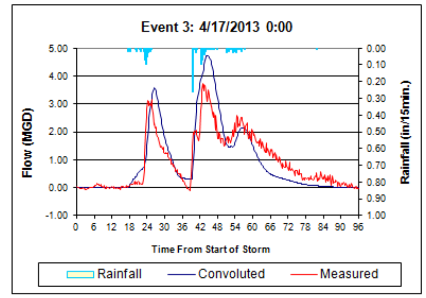
Unit Hydrograph Parameters				
	R (fraction)	T (hrs)	K (ratio)	Base Time (hours)
Triangle 1	0.18	1.50	3.00	6.00
Triangle 2	0.51	3.00	2.69	11.08
Triangle 3	0.30	3.00	11.23	36.69

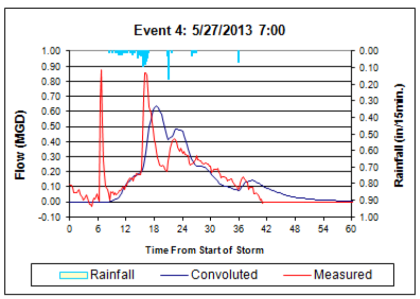
Initial Abstraction: 0 inches

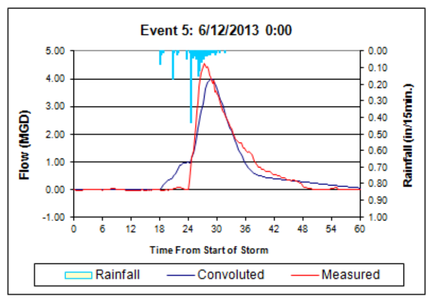
Goodness of Fit				Event Summary					Notes
Event No.	Weight	Difference Value	Weighted Difference Value	Rain Gauge	Rainfall (in)	Excess Rainfall (in)	RDI/I Volume (MG)	Event Capture	
1	0	--	--	GC-RG01	1.14	1.14	#N/A	0.00%	Meter not in service
2	0	9.31	--	GC-RG01	1.68	1.68	2.16	2.85%	
3	0	11.11	--	GC-RG01	1.69	1.69	3.76	4.92%	
4	0	2.11	--	GC-RG01	0.98	0.98	0.35	0.79%	
5	0	5.36	--	GC-RG01	1.69	1.69	1.66	2.18%	
6	0	4.00	--	GC-RG01	1.71	1.71	0.75	0.97%	
7	0	24.61	--	GC-RG01	5.11	5.11	6.35	2.75%	High spatial variability
8	1	2.77	2.77	GC-RG01	1.65	1.65	1.72	2.31%	
Total	**N/A**	**59.28**	**2.77**	**N/A**	**15.65**	**15.65**	**16.76**	**2.40%**	

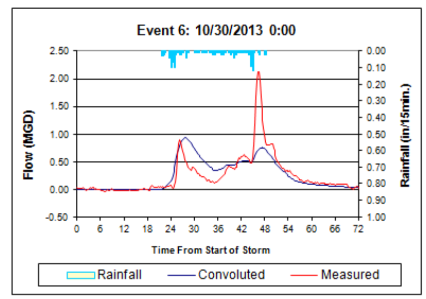


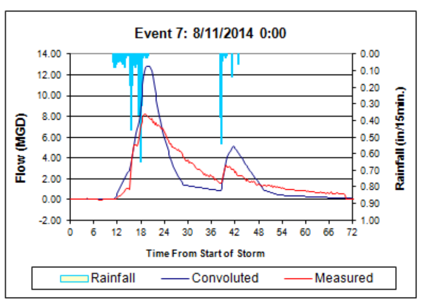


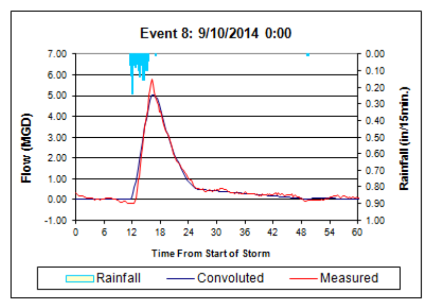












Appendix D
Model Calibration Results

C2: RVSDS: Updated Geodatabase for Initial Asset Inventory, OHM, September 2015

memorandum

Date: September 25, 2015

To: Kelly Cave, Razik Alsaigh, and Andra Mealey, Wayne County
cc: Karen Ridgway, ASI
From: Greg Kacvinsky, OHM

Re: RVSDS: Updated Geodatabase for Initial Asset Inventory

OHM has finished collecting the survey data consistent with the scope outlined under Task 2, Field Work, as amended on July 31, 2015. All survey data have been assembled in a geodatabase package containing the survey information collected, MACP compliant structure assessments, and some existing GIS feature updates. The junction chamber, manhole, gravity main, and regulator feature classes have all been updated and added to this geodatabase. The complete geodatabase has been uploaded to Dropbox and can be downloaded by clicking on the following link:

https://www.dropbox.com/sh/ns6hxw6ufzmyml5/AABVXMq0cfsj2BnDvi1KCT0ua?dl=0

If DropBox prompts you to log in (it is not necessary), click the "x" to close out of the login screen. In the top right, hit the download button to begin your download of a zip file containing the .gdb file.

The geodatabase is a comprehensive deliverable, including all available structure metadata, videos, photos, and sketches. It is the intent to rely on the geodatabase as a central repository for all available structure data. As such, this memorandum serves as a summary of the data collected and does not include the individual structure data. Any additional detail on the structures can be retrieved from the geodatabase by using GIS software. If you wish to have OHM provide you and/or your staff with a "test drive" of the geodatabase, we would be happy to set up a meeting at a facility of your choosing.

This is an interim product. During the continuing efforts of the RVSDS Long Term Corrective Action Plan (LTCAP), additional enhancements will be made to the hydraulic model and additional system characteristics will be revealed. This geodatabase will be updated upon the completion of the RVSDS LTCAP to reflect those enhancements.

MANHOLES

All of the changes to the manhole feature class can be found in the following areas:

- Red Run Sanitary Sewer: 18 new manholes were added from MR II-10 to Dearborn Heights' SA06SW002 on Warren St. 15 of the manholes were surveyed, while the other three were added based on Dearborn Heights' GIS information (three of the manholes could not be found during our survey effort).

- Lefler-Ready Relief Sewer: Eight new manholes were added from NHV 3-38 to Dearborn Heights' SA06SE017 on Beech Daly Road just north of Warren St. Six of the manholes were surveyed, while the other two were added based on Dearborn Heights' GIS information (two of the manholes could not be found during our survey effort).

- Bell Branch Park: There were three additional manhole lids/access points found during our field survey. Two of which pertain to the old siphon (WC-09B and WC-10B); the other is a connection point for the new 48-inch interceptor downstream of the new siphon and the 42-inch sewer owned by the City of Livonia (NEW_MH).

GRAVITY MAIN

Some minor updates and changes were made to this feature class to better reflect the sewer network in the areas that were surveyed. The spatial accuracy, placement method, source, pipe size, pipe material, jurisdiction, and maintenance responsibility were all updated for the new gravity main features. A few minor tweaks were made to the sewers connecting the regulator and junction chamber structures, but the most significant changes can be found in the following areas:

- Red Run Sanitary Sewer: Sanitary Gravity Main features were added to connect the 18 new manholes that were added from MR II-10 to Dearborn Heights' SA06SW002 on Warren St. All of these features were drawn in as collector subtypes with "Unknown" listed under the Jurisdiction and Maintenance Responsibility, as it is not known whether this sewer falls under the jurisdiction of the County or the City.

- Lefler-Ready Relief Sewer: Sanitary Gravity Main features were added to connect the eight new manholes that were added from NHV 3-38 to Dearborn Heights' SA06SE017 on Beech Daly Road just north of Warren St. All of these features were drawn in as collector subtypes with "Unknown" listed under the Jurisdiction and Maintenance Responsibility, as it is not known whether this sewer falls under the jurisdiction of the County or the City.

- Bell Branch Park: There were three additional manhole lids/access points found during the survey. Two of these pertain to the old siphon (WC-09B and WC-10B) and the other is a connection point for the new 48-inch interceptor downstream of the new siphon and the 42-inch sewer owned by the City of Livonia (NEW_MH). The gravity main in this area was adjusted to accommodate these three new points that were added to the database. Further downstream of the siphons at manhole RVI 12-16, the sewer was also adjusted to better reflect the deflection in the 48-inch Wayne County interceptor (Inkster Arm). The deflection was confirmed in the field at RVI 12-16, so the record drawings were then used to more accurately represent the sewer location.

JUNCTION CHAMBERS

Previously, all junction chambers were represented as single points, located at any arbitrary location on the structure. They were in one feature class and will remain in that same feature class, with updated points from the survey. Because some junction chambers have multiple access points, we felt it would be more accurate and useful to have multiple points in the geodatabase, rather than a single point. Therefore, for each of the junction chambers that were surveyed, we have added the GPS locations for each access point. For example, Junction Chamber 2-8 used to be one point named "JC 2-8" placed in the center of the structure, but the survey found it has two access points, both of which are now in the Junction Chambers feature class and labeled as "JC 2-8A" and "JC 2-8B".

REGULATORS

Previously, all regulators were represented by single points, most of which looked to be slightly incorrect (in terms of horizontal placement). The regulators were also split across several feature classes. In an effort to provide more consistency, we combined all the points into one feature class called “Regulators_Combined”. Because some regulators have multiple access points or associated structures, we felt it would be more accurate and useful to have multiple points in the GIS, rather than a single point. Therefore, for each of the regulators that were surveyed, we have added the GPS locations for each access point or associated structure. The renaming naming protocol for the regulators is the same one used for the junction chambers.

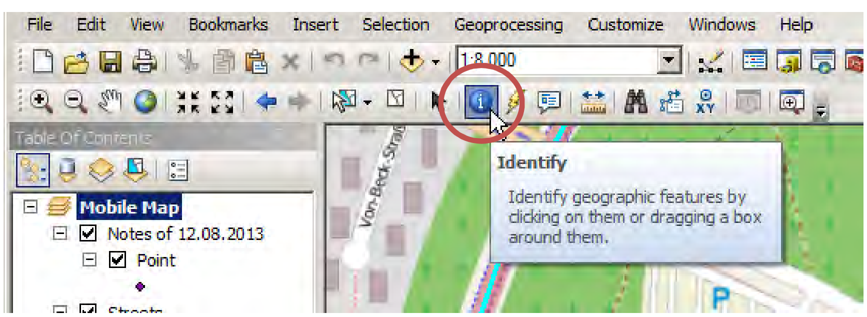
We also considered creating new points in the manhole feature class for each lid/access point that was found during the survey, naming the manholes not currently in the geodatabase according to the County’s naming convention, and then placing a single point in the “Regulators_Combined” feature class on the manhole in which the regulator is installed. This would require more work and input from the County, however. Please let us know if you prefer this method or have another method in mind. We are happy to adjust the geodatabase to better fit your needs.

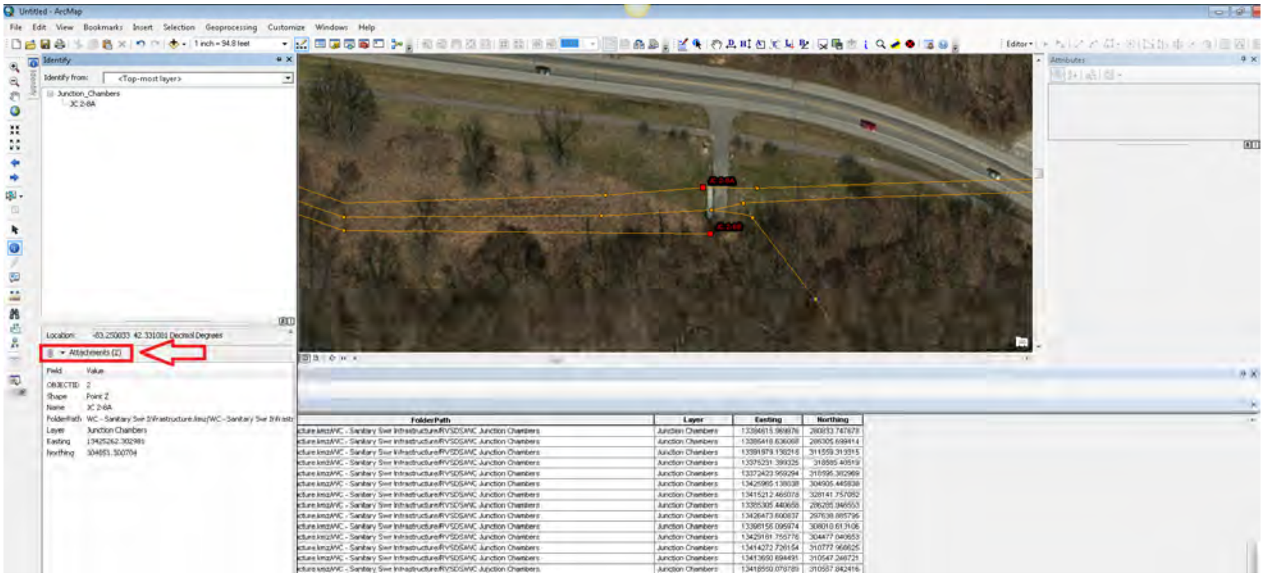
MACP COMPLIANT STRUCTURE ASSESSMENTS

Condition assessments were completed on 26 of the structures during the survey effort (only those structures known to be under the County’s jurisdiction). A NASSCO-certified individual performed each assessment from inside the structure according to NASSCO’s Manhole Assessment Certification program (MACP). Please refer to the “RELATED TABLES” section in the geodatabase for accessing the MACP ratings. Two tables containing all of the MACP defects and ratings can also be found in Attachments 1 and 2.

FEATURE ATTACHMENTS

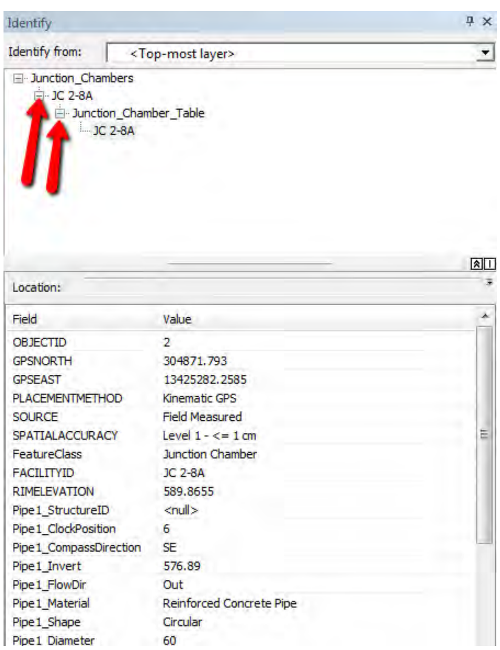
In addition to updated locations and elevations, a detailed sketch and interior video were attached to 26 of the regulator and junction chamber features that were surveyed. All of a feature’s attachments can be viewed by clicking the GIS “Identify” button (illustrated below) on that feature then selecting the attachment from the dropdown menu in the information tab for that particular feature (please refer to the screenshot on the following page showing where to find the attachments).

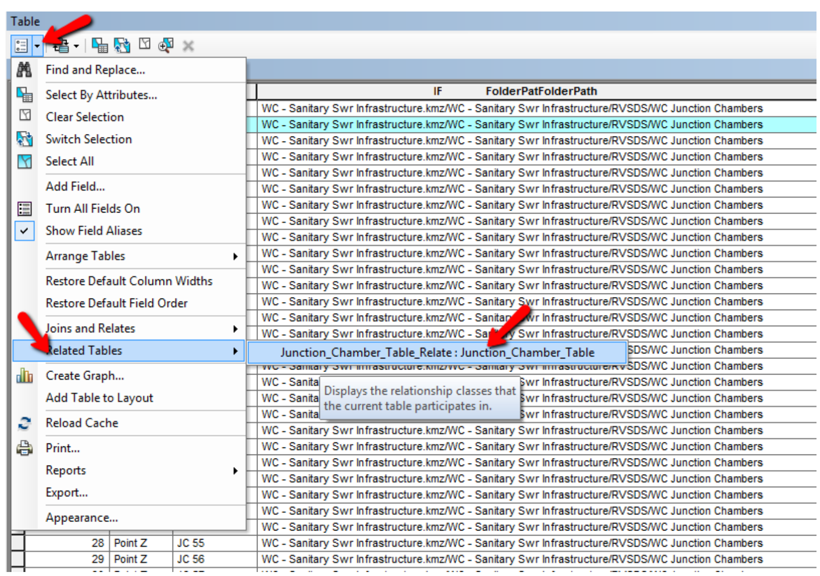




RELATED TABLES

The field survey data table was related to its associated feature class. There are two ways to view this data. The first is to use the GIS ‘Identify’ button to retrieve data on the point in question and then click the ‘+’ symbol, as seen to the left. This will allow you to view the attributes. Another way is to select the feature you are looking at and then open the attribute table and follow the arrows as seen below.





SURVEY SCOPE AND COMPLETED TASKS

The text below is a duplicate of the survey scope from the RVSDS LTCAP Work Plan and is consistent with our scope of services for Task 2. The text in **RED** summarizes what OHM surveyors encountered. Although the vast majority of information was successfully surveyed and recorded, some information was not obtained due to missing structures, obstructions, or similar problems.

1. There are 5 tipping gate regulators in Redford for which we need additional data. These are Regulators U2, U6, U7, U8, and U11. The tipping gates need to be inspected to determine size, model number and current pin setting. Also, for Regulator U6, a new regulator chamber structure was built downstream of the older regulator. Verify the current conditions in the older regulator and whether there is still a gate or wall opening.
   U2 – Could not obtain model number.
   U6 – Done; old regulator has been removed.
   U7 – Could not obtain model number.
   U8 – Could not obtain model number.
   U11 – Done.

2. There are 3 former CSO outfalls that are now SSO outfalls, M-21, M-22 and M-25. We assume that the regulators are fully open shear gates on wall pipes at these regulators and this needs confirmation. These regulators were surveyed by Wade-Trim (WTA) in 2008 as part of the Sanitary Sewer Evaluation Survey (SSES). Survey data shall include: the incoming pipe, the regulator itself, the connection to the interceptor, the interceptor, the overflow weir, the BWG and the SSO outfall.
   M-21 – Done.
   M-22 – Done.
   M-22C – Unable to access due to an ADS meter. I didn't want to move their data logger to gain access to the structure for fear of damaging/disconnecting their equipment. We do have a rim and updated mapping for this structure though.
   M-22D – Seems to be plated over and full of dirt as a result of some recent electrical work.
   M-25 – Done.

3. There are two locations in the Lower Rouge system with interconnections between the Lower Rouge Interceptor and the Wayne Interceptor. Stop logs may or may not exist at these interconnections. These interconnections are included in the RVSDS hydraulic model as fully open. One interconnection is at RVI 15-18B (JC16) in Wayne; the other is near RVI 15 MH-1 at Merriman Road in Westland. Survey shall include elevations of connecting pipes and verification of the presence/absence of stop logs.
   RVI 15-18B JC-16 (aka JC27) – Done; one stop log present.
   RVI 15-1A – Done.

4. There are two complex junction chambers along the Middle Rouge interceptor system. One chamber is where the Redford Arm connects to the Middle Rouge interceptor system; the other is where the Inkster Arm connects. The following information needs to be collected for JC 2-38 (Telegraph Road) and JC 3-37 (Inkster Road): dimensions, layout, presence of sludge deposits, and key elevations (rim, invert, overflow) of interconnection chambers.
   JC 2-38 – Done.
   JC 3-37 – Done.

5. JC 2-8 was rebuilt and raised as part of the STCAP. But the top elevation of the structure is not on the as-built drawings. The structure was raised to accommodate the gate operators and the top elevation was determined during construction in the field. The top elevation needs to be surveyed, as well as the dimensions, layout, and all invert elevations of the interior of the junction chamber.

JC 2-8 – Unable to obtain the invert or centerline for the middle outgoing pipe. Flows were heavy and it was treacherous footing in the structure.
Top elevation = 591.35.
Survey can clean this area up if more information is needed.

6. There is an old 30-inch sewer along Inkster Road that runs from the Bell Branch to near the LV Basin (Livonia EQ Basin) flow meter. It runs from RVI 12 MH-19 to MH-16 and is shown to be interconnected with the RVI interceptor at these locations. This sewer shall be surveyed with invert elevations, rim elevations, interconnections and diameters of incoming pipes.
Done.

7. There is a regulator/CSO outfall in Livonia, M26, whose status is unknown. The regulator and CSO outfall are included in the hydraulic model but it is suspected the outfall was bulkheaded by Livonia during a sewer separation project in the 1990s. The regulator and CSO outfall will be surveyed to confirm the operational status.
Unable to locate the regulator. There was a bulkheaded pipe in the sewer that would have pointed toward the river.
8. There is an overflow weir chamber that discharges to the connecting pipe to LS1A. The weir plate is adjustable and the setting is not known. In the hydraulic model, it was assumed that the weir plate top elevation is at the MRPIE interceptor crown elevation in the model. The top elevation of the weir plate will be surveyed.
Could not access the gate to measure the opening. There is a steel plate on the upstream side of the gate that would need to be removed to gain access to the upstream end of the overflow chamber (understood to be MC1 after asking for clarification). There is a large steel plate immediately upstream of the gate valve that we did not try to open. No overflow was visible in the main chamber- assuming that it is upstream of the gate valve and under the plate. I was unable to measure the opening at the gate valve due to the configuration of the structure downstream of the gate. We can go back out but would be looking for assistance from the County with the plate.

9. There is an old regulator chamber at Warren Avenue along Middlebelt Road in Garden City. The regulator chamber is on a 72 inch sewer (which was previously combined) that diverted low flows into a pumping station that discharged westerly towards Merriman Road. The regulator chamber also had a diversion dam and backwater gate. The survey shall confirm that no flow occurs through the old regulator towards Merriman Road. The survey shall also include a confirmation of the presence and elevation of the diversion dam and backwater gate.
Done. 6 inches of sludge in pipe. Former backwater gates are gone; there are just square openings now. Potential overflow to pump station under weir.

10. There is an existing regulator chamber at the Middle Rouge River and Middlebelt Road that serves Garden City and Westland (M-20). This regulator chamber is at the downstream end of the 72 inch sewer on Middlebelt Road. A 22 inch diameter opening trough the regulator chamber that controls the flow rate into the MRPIE interceptor has been assumed in the hydraulic model. Previously, a 22 inch vortex valve existed at this location. The outfall to the river is reportedly bulkheaded. Also, there are two parallel 16 inch ductile iron siphons downstream of the regulator chamber that connect to the MRPIE interceptor. The regulator chamber shall be surveyed including the regulator opening dimensions and elevations, the presence/absence (and model number) of a vortex valve, and top elevations of all manholes and chamber openings, including the downstream siphon manholes.
Done. This structure is in ROUGH shape. There is a missing manhole cover and a missing hatch that will allow the structure to SSO as well as take inflow when the river level rises. A large piece of a tree trunk was blocking flows and was removed during the manhole entry
M-20A – Outlet to river has been bulkheaded.

11. Verify information for select local sewers and their connections to the RVSDS. This will require coordination with Wayne County and local community staff. At this time, additional information is needed about the following sewers connected to RVSDS:
    i. Lefler-Ready sewer,
    Postponed due to leaf out.
    ii. Lefler-Ready Relief sewer,
    Done.
    iii. Red Run sanitary sewer
    Done.
    iv. Two parallel sewers servicing Dearborn Heights (Area 13).
    Postponed due to leaf out.

Attachment 1 - Structure Defect List

Defect No.	Timestamp	Structure ID	Depth from Rim (feet)	Component	Defect: Group	Defect: Descriptor	Defect: Modifier/Severity	Defect: Code	Continuous Length (feet)	Value: S/M/L	Value: Inches 1st	Value: Inches 2nd	Value: %	Joint	Step	Clock Location: At/From	Clock Location: To	Remarks	Associated Structural Grade	Associated O&M Grade	Calculated Structural Grade	Calculated O&M Grade
1	9/21/15 6:19 PM	JC 2-38	0.70	Cone	Infiltration	Stain	Joint	ISJ						Yes		7	8		0	0	0	0
2	9/21/15 6:22 PM	JC 2-38	3.00	Cone	Infiltration	Stain	Joint	ISJ						Yes		11	12		0	0	0	0
3	9/21/15 6:23 PM	JC 2-38	6.00	Wall	Surface Damage	Aggregate Visible	Chemical	SAVC	6.00					Yes	Yes	12	12		3	0	18	0
4	9/21/15 6:26 PM	JC 2-38	13.00	Pipes	Deposits	Attached	Ragging	DAR					10	No		7	8		0	2	0	2
5	9/21/15 6:27 PM	JC 2-38	13.00	Pipes	Deposits	Settled	Gravel	DSGV					5	No		6			0	2	0	2
6	9/21/15 6:30 PM	G-1A	3.10	Cone	Infiltration	Stain	Joint	ISJ						Yes		5			0	0	0	0
7	9/21/15 6:31 PM	G-1A	5.60	Wall	Deposits	Attached	Encrustation	DAE	5.50				5	Yes	Yes	1	5		0	2	0	12
8	9/21/15 6:32 PM	G-1A	7.80	Wall	Infiltration	Dripper	Joint	IDJ						Yes		3			0	3	0	3
9	9/21/15 6:32 PM	G-1A	9.80	Wall	Deposits	Attached	Encrustation	DAE	9.30				5	Yes	Yes	12	12		0	2	0	20
10	9/21/15 6:34 PM	G-1B	6.60	Wall	Deposits	Attached	Encrustation	DAE	9.50				5	Yes		7	2		0	2	0	20
11	9/21/15 6:36 PM	G-1B	19.40	Wall	Infiltration	Dripper	Joint	IDJ						Yes		5			0	3	0	3
12	9/21/15 6:36 PM	G-1B	23.00	Bench	Deposits	Settled	Hard/Compacted	DSC					10	No		1	5		0	2	0	2
13	9/21/15 6:37 PM	G-1B	20.00	Wall	Surface Damage	Aggregate Visible	Chemical	SAVC						Yes	Yes	12	12		3	0	3	0
14	9/21/15 6:39 PM	JC 2-8A	2.00	Cone	Infiltration	Stain	Joint	ISJ						Yes		1	5		0	0	0	0
15	9/21/15 6:42 PM	JC 2-8A	7.00	Wall	Surface Damage	Aggregate Visible	Chemical	SAVC						Yes	Yes	12	12		3	0	3	0
16	9/21/15 6:45 PM	JC 2-8A	13.00	Pipes	Deposits	Attached	Ragging	DAR					5	No		1	3		0	2	0	2
17	9/21/15 6:48 PM	JC 3-37A	3.00	Cone	Infiltration	Stain	Joint	ISJ						Yes		12	12		0	0	0	0
18	9/21/15 6:49 PM	JC 3-37A	3.00	Cone	Surface Damage	Aggregate Visible	Chemical	SAVC	1.00					Yes		12	12		3	0	3	0
19	9/21/15 6:50 PM	JC 3-37A	5.00	Wall	Surface Damage	Aggregate Visible	Chemical	SAVC	2.00					Yes	Yes	12	12		3	0	6	0
20	9/21/15 6:52 PM	JC 3-37A	11.00	Pipes	Surface Damage	Reinforcement Visible	Chemical	SRVC						No		6			5	0	5	0
21	9/21/15 6:54 PM	JC 3-37B	3.00	Cone	Infiltration	Stain	Joint	ISJ						Yes		12	12		0	0	0	0
22	9/21/15 6:54 PM	JC 3-37B	3.00	Cone	Surface Damage	Aggregate Visible	Chemical	SAVC						Yes	Yes	12	12		3	0	3	0
23	9/21/15 6:55 PM	JC 3-37B	5.50	Wall	Surface Damage	Aggregate Visible	Chemical	SAVC						Yes	Yes	12	12		3	0	3	0
24	9/21/15 6:58 PM	JC 27	1.30	Chimney	Brickwork	Missing Mortar	Small	MMS						Yes		12	12		2	0	2	0
25	9/21/15 6:59 PM	JC 27	9.80	Wall	Deposits	Attached	Encrustation	DAE	1.00				5	Yes	Yes	3	6		0	2	0	2
26	9/21/15 7:00 PM	JC 27	6.00	Wall	Surface Damage	Aggregate Visible	Chemical	SAVC						Yes	Yes	12	12		3	0	3	0
27	9/21/15 7:05 PM	M-20A	3.00	Wall	Surface Damage	Aggregate Visible	Chemical	SAVC	5.00					Yes	Yes	12	12		3	0	15	0
28	9/21/15 7:06 PM	M-20A	9.00	Bench	Obstacles and Obstructions	Other Objects		OBZ					15	No		7	9	Concrete chunks, manhole cover, steel p	0	3	0	3
29	9/21/15 7:10 PM	M-20B	0.80	Wall	Surface Damage	Aggregate Projecting	Chemical	SAPC	6.00					Yes		12	12		3	0	18	0
30	9/21/15 7:11 PM	M-20B	8.00	Pipes	Obstacles and Obstructions	Other Objects		OBZ					15	No		12	12	large branches/steel rod	0	3	0	3
31	9/21/15 7:12 PM	M-21A	0.70	Chimney	Surface Damage	Aggregate Projecting	Chemical	SAPC	1.00					Yes		12	12		3	0	3	0
32	9/21/15 7:14 PM	M-21A	2.00	Wall	Surface Damage	Aggregate Projecting	Chemical	SAPC	6.00					Yes	Yes	12	12		3	0	18	0
33	9/21/15 7:19 PM	M-21B	0.70	Chimney	Surface Damage	Aggregate Projecting	Chemical	SAPC	1.00					Yes		12	12		3	0	3	0
34	9/21/15 7:22 PM	M-21B	4.00	Wall	Joint	Separated	Medium	JSM	1.60					Yes		12	12		1	0	2	0
35	9/21/15 7:25 PM	M-21C	0.70	Chimney	Surface Damage	Aggregate Visible	Chemical	SAVC						Yes		12	12		3	0	3	0
36	9/21/15 7:25 PM	M-21C	5.00	Pipes	Deposits	Attached	Encrustation	DAE					5	No		5	7		0	2	0	2
37	9/21/15 7:28 PM	M-21D	6.30	Pipes	Deposits	Attached	Encrustation	DAE					5	No		1	2		0	2	0	2
38	9/21/15 7:31 PM	M-22A	0.80	Chimney	Brickwork	Missing Mortar	Small	MMS	2.00					Yes		12	12		2	0	4	0
39	9/21/15 7:36 PM	M-22A	14.00	Pipes	Deposits	Attached	Encrustation	DAE					5	No		12			0	2	0	2
40	9/21/15 7:38 PM	M-22B	0.80	Chimney	Brickwork	Missing Mortar	Small	MMS	2.00					Yes		12	12		2	0	4	0
41	9/21/15 7:41 PM	M-22B	15.00	Pipes	Deposits	Attached	Grease	DAGS					5	No		12	12		0	2	0	2
42	9/21/15 7:42 PM	M-22B	9.00	Wall	Surface Damage	Roughness Increased	Chemical	SRIC						Yes		10	4		1	0	1	0
43	9/21/15 7:43 PM	M-22C	1.00	Chimney	Miscellaneous	General Observation		MGO						Yes		7		flow meter	0	0	0	0
44	9/21/15 7:44 PM	M-22C	0.80	Chimney	Brickwork	Missing Mortar	Small	MMS	2.00					Yes		12	12		2	0	4	0
45	9/21/15 7:44 PM	M-22C	3.00	Cone	Deposits	Ingress	Fine silt/sand	DNF					5	Yes		12	12		0	2	0	2
46	9/21/15 7:45 PM	M-22C	15.00	Pipes	Deposits	Attached	Ragging	DAR					5	No		6	12		0	2	0	2
47	9/21/15 7:45 PM	M-22C	12.00	Wall	Surface Damage	Aggregate Visible	Chemical	SAVC	2.00					Yes		12	12		3	0	6	0
48	9/21/15 7:48 PM	M-25A	2.20	Cone	Infiltration	Stain	Joint	ISJ						Yes		12	12		0	0	0	0
49	9/21/15 7:49 PM	M-25A	7.00	Wall	Obstacles and Obstructions	Other Objects		OBZ					5	No		12		garbage, coffee cups	0	2	0	2
50	9/21/15 7:49 PM	M-25A	8.00	Pipes	Deposits	Attached	Grease	DAGS					10	No		6	12		0	2	0	2
51	9/21/15 7:52 PM	M-25B	0.80	Chimney	Infiltration	Stain	Joint	ISJ						Yes		3	9		0	0	0	0
52	9/21/15 7:53 PM	M-25B	11.00	Wall	Surface Damage	Roughness Increased	Chemical	SRIC						Yes	Yes	12	12		1	0	1	0
53	9/21/15 7:53 PM	M-25B	17.00	Pipes	Deposits	Attached	Grease	DAGS					15	No		12	12		0	3	0	3
54	9/21/15 7:57 PM	M-25C	0.80	Chimney	Infiltration	Stain	Joint	ISJ						Yes		12	12		0	0	0	0
55	9/21/15 7:58 PM	M-25C	3.00	Wall	Deposits	Attached	Encrustation	DAE					5	Yes		6			0	2	0	2
56	9/21/15 7:59 PM	M-25C	14.00	Wall	Infiltration	Stain	Barrel	ISB						No		3	5		0	0	0	0
57	9/21/15 8:03 PM	RVI 15-1A	0.80	Chimney	Infiltration	Stain	Joint	ISJ						Yes		12	12		0	0	0	0
58	9/21/15 8:04 PM	RVI 15-1A	4.00	Wall	Surface Damage	Roughness Increased	Chemical	SRIC						Yes	Yes	12	12		1	0	1	0
59	9/21/15 8:05 PM	RVI 15-1A	6.00	Wall	Deposits	Attached	Encrustation	DAE					5	No		7			0	2	0	2
60	9/21/15 8:06 PM	RVI 15-1A	5.50	Wall	Deposits	Attached	Encrustation	DAE					5	No		3	4		0	2	0	2
61	9/21/15 8:06 PM	RVI 15-1A	7.00	Pipes	Deposits	Attached	Ragging	DAR					5	No		11	1		0	2	0	2
62	9/21/15 8:15 PM	U-2	0.70	Chimney	Roots	Fine	Joint	RFJ						Yes		12	12	Upstream Access Point	0	1	0	1
63	9/21/15 8:16 PM	U-2	0.70	Chimney	Brickwork	Missing Mortar	Small	MMS	1.00					Yes		12	12	Upstream Access Point	2	0	2	0
64	9/21/15 8:17 PM	U-2	4.00	Pipes	Deposits	Attached	Ragging	DAR					5	No		5		Upstream Access Point	0	2	0	2
65	9/21/15 8:18 PM	U-2	4.00	Pipes	Deposits	Attached	Ragging	DAR					5	No		7		Upstream Access Point	0	2	0	2
66	9/21/15 8:19 PM	U-2	0.70	Chimney	Infiltration	Stain	Joint	ISJ						Yes		12	12	Downstream Access Point	0	0	0	0
67	9/21/15 8:20 PM	U-2	3.00	Wall	Surface Damage	Aggregate Projecting	Chemical	SAPC	3.00					Yes	Yes	12	12	Downstream Access Point	3	0	9	0
68	9/21/15 8:20 PM	U-2	7.00	Wall	Surface Damage	Aggregate Visible	Mechanical	SAVM						Yes		2	4	Downstream Access Point	3	0	3	0
69	9/21/15 8:22 PM	U-6	0.70	Chimney	Brickwork	Missing Mortar	Small	MMS						Yes		12	12	Old Regulator	2	0	2	0
70	9/21/15 8:22 PM	U-6	8.00	Wall	Surface Damage	Aggregate Visible	Chemical	SAVC	3.00					Yes	Yes	12	12	Old Regulator	3	0	9	0
71	9/21/15 8:25 PM	U-7	1.20	Wall	Infiltration	Stain	Joint	ISJ						Yes		2	8	Upstream Access Point	0	0	0	0
72	9/21/15 8:26 PM	U-7	11.00	Bench	Deposits	Settled	Fine silt/sand	DSF					5	No		12	6	Upstream Access Point	0	2	0	2
73	9/21/15 8:28 PM	U-8	16.00	Bench	Deposits	Attached	Ragging	DAR					5	No		12	12		0	2	0	2
74	9/21/15 8:29 PM	U-11	0.80	Chimney	Brickwork	Missing Mortar	Small	MMS	1.20					Yes		12	12		2	0	4	0
75	9/21/15 8:30 PM	U-11	11.00	Pipes	Deposits	Attached	Ragging	DAR					5	No	Yes	9		hanging from step	0	2	0	2
76	9/21/15 8:31 PM	U-11	11.00	Pipes	Deposits	Attached	Encrustation	DAE					5	Yes		12		inside pipe at joint	0	2	0	2
77	9/21/15 8:31 PM	U-11	10.00	Wall	Surface Damage	Roughness Increased	Chemical	SRIC						Yes		12	12		1	0	1	0

Attachment 2 - Structure Ratings Table

	Structural									O & M									OVERALL								
	Structure Grade Scores									Structure Grade Scores									Structure Grade Scores								
Structure ID	Grade 1	Grade 2	Grade 3	Grade 4	Grade 5	Structure Grade Score	Structure Rating	Quick Rating	Structure Ratings Index	Grade 1	Grade 2	Grade 3	Grade 4	Grade 5	Structure Grade Score	Structure Rating	Quick Rating	Structure Ratings Index	Grade 1	Grade 2	Grade 3	Grade 4	Grade 5	Structure Grade Score	Structure Rating	Quick Rating	Structure Ratings Index
JC 2-38	0	0	6	0	0	6	18	3600	3.000	0	2	0	0	0	2	4	2200	2.000	0	2	6	0	0	8	22	3622	2.750
G-1A	0	0	0	0	0	0	0	0000	0.000	0	16	1	0	0	17	35	312B	2.059	0	16	1	0	0	17	35	312B	2.059
G-1B	0	0	1	0	0	1	3	3100	3.000	0	11	1	0	0	12	25	312A	2.083	0	11	2	0	0	13	28	322A	2.154
JC 2-8A	0	0	1	0	0	1	3	3100	3.000	0	1	0	0	0	1	2	2100	2.000	0	1	1	0	0	2	5	3121	2.500
JC 3-37A	0	0	3	0	1	4	14	5133	3.500	0	0	0	0	0	0	0	0000	0.000	0	0	3	0	1	4	14	5133	3.500
JC 3-37B	0	0	2	0	0	2	6	3200	3.000	0	0	0	0	0	0	0	0000	0.000	0	0	2	0	0	2	6	3200	3.000
JC 27	0	1	1	0	0	2	5	3121	2.500	0	1	0	0	0	1	2	2100	2.000	0	2	1	0	0	3	7	3122	2.333
M-20A	0	0	5	0	0	5	15	3500	3.000	0	0	1	0	0	1	3	3100	3.000	0	0	6	0	0	6	18	3600	3.000
M-20B	0	0	6	0	0	6	18	3600	3.000	0	0	1	0	0	1	3	3100	3.000	0	0	7	0	0	7	21	3700	3.000
M-21A	0	0	7	0	0	7	21	3700	3.000	0	0	0	0	0	0	0	0000	0.000	0	0	7	0	0	7	21	3700	3.000
M-21B	2	0	1	0	0	3	5	3112	1.667	0	0	0	0	0	0	0	0000	0.000	2	0	1	0	0	3	5	3112	1.667
M-21C	0	0	1	0	0	1	3	3100	3.000	0	1	0	0	0	1	2	2100	2.000	0	1	1	0	0	2	5	3121	2.500
M-21D	0	0	0	0	0	0	0	0000	0.000	0	1	0	0	0	1	2	2100	2.000	0	1	0	0	0	1	2	2100	2.000
M-22A	0	2	0	0	0	2	4	2200	2.000	0	1	0	0	0	1	2	2100	2.000	0	3	0	0	0	3	6	2300	2.000
M-22B	1	2	0	0	0	3	5	2211	1.667	0	1	0	0	0	1	2	2100	2.000	1	3	0	0	0	4	7	2311	1.750
M-22C	0	2	2	0	0	4	10	3222	2.500	0	2	0	0	0	2	4	2200	2.000	0	4	2	0	0	6	14	3224	2.333
M-25A	0	0	0	0	0	0	0	0000	0.000	0	2	0	0	0	2	4	2200	2.000	0	2	0	0	0	2	4	2200	2.000
M-25B	1	0	0	0	0	1	1	1100	1.000	0	0	1	0	0	1	3	3100	3.000	1	0	1	0	0	2	4	3111	2.000
M-25C	0	0	0	0	0	0	0	0000	0.000	0	1	0	0	0	1	2	2100	2.000	0	1	0	0	0	1	2	2100	2.000
RVI 15-1A	1	0	0	0	0	1	1	1100	1.000	0	3	0	0	0	3	6	2300	2.000	1	3	0	0	0	4	7	2311	1.750
U-2	0	1	4	0	0	5	14	3421	2.800	1	2	0	0	0	3	5	2211	1.667	1	3	4	0	0	8	19	3423	2.375
U-6	0	1	3	0	0	4	11	3321	2.750	0	0	0	0	0	0	0	0000	0.000	0	1	3	0	0	4	11	3321	2.750
U-7	0	0	0	0	0	0	0	0000	0.000	0	1	0	0	0	1	2	2100	2.000	0	1	0	0	0	1	2	2100	2.000
U-8	0	0	0	0	0	0	0	0000	0.000	0	1	0	0	0	1	2	2100	2.000	0	1	0	0	0	1	2	2100	2.000
U-11	1	2	0	0	0	3	5	2211	1.667	0	2	0	0	0	2	4	2200	2.000	1	4	0	0	0	5	9	2411	1.800