

**City of St. Joseph, Missouri**  
**Facilities Plan**

**Technical Memorandum No. TM-CSO-3a**  
**Phase IA CSO Control Recommended**  
**Improvements Model**



**By**



Work Order No. 09-001  
B&V Project 163509

June 18, 2009

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## Phase IA CSO Control Recommended Improvements Model

### 1.0 Executive Summary

The purpose of the Combined Sewer Overflow (CSO) Control Facilities Plan is to further refine the CSO Long Term Control Plan (LTCP) and provide more design information for the recommended facilities and improvements. As part of the LTCP, the typical year CSO volume and potential combined sewer system (CSS) improvements were evaluated using a mathematical model. The CSS model was developed and calibrated using the one-dimensional, unsteady state hydrology and hydraulics computer model, XP-SWMM.

Using this model, the existing annual average combined sewage volume is 4.7 billion gallons, and of that volume, 4.1 billion gallons leave the CSS as combined sewer overflow. As required by the Missouri Department of Natural Resources (MDNR) and the United States Environmental Protection Agency (USEPA), facility upgrades and additions are required to reduce the frequency and volume of CSOs. Specifically, the goal of the modified Phase IA improvements, derived from the Phase I controls presented in the LTCP, is to provide the most effective CSO control with the least amount of capital expense (i.e., most cost effective). The modified Phase IA improvements consist of constructing the Blacksnake and Whitehead stormwater separation conduits, increasing the conveyance at the Whitehead Pump Station to 80 million gallons per day (mgd), increasing the treatment capacity at the existing Water Protection Facility (WPF) headworks to 88 mgd, providing 61 mgd high rate treatment (HRT) and disinfection facilities, and completing partial sewer separation in the Roy's Branch basin (currently underway).

In a typical year, the proposed Blacksnake and Whitehead stormwater separation conduits will reduce the annual volume of combined sewage overflow by 1.59 billion gallons. Increasing the conveyance capacity at the Whitehead Pump Station, increasing the treatment capacity of the existing WPF headworks to 88 mgd, and providing HRT and disinfection facilities will reduce CSO volume by an additional 0.62 billion gallons annually. Finally, completing the Roy's Branch partial sewer separation project

(currently underway) will reduce CSO volume by an additional 0.23 billion gallons annually. The Phase IA CSS model results indicate that the overall CSO volume will be reduced by 2.4 billion gallons annually from approximately 4.1 billion gallons at existing conditions to 1.7 billion gallons at the completion of the Phase IA improvements. The existing CSS system is estimated to capture approximately 12 percent of the combined sewage. By incorporation of the modified Phase IA improvements, a combined sewage volumetric capture of approximately 60 percent is anticipated.

## **2.0 Purpose of Technical Memorandum**

The purpose of this technical memorandum is to determine the CSO volume from the existing collection system and compare this with the CSO volume predicted with the proposed Phase IA CSO control improvements.

The information presented in this technical memorandum has been modified from the original scope of work requirements. The original intent of this memorandum was to present updates to all of the CSO control facilities presented in the LTCP. However, due to feedback and guidance received from MDNR and the USEPA after completion of the LTCP, the purpose of the memorandum was shifted to focus on a revised set of improvements that will achieve the best water quality benefits for the cost, Phase IA. A subsequent technical memorandum will be prepared at a later date that will present the Phase IB, Phase II, and Phase III components of the CSO control improvements.

## **3.0 Introduction**

The City of St. Joseph, Missouri (City) is developing a Facilities Plan for CSO control improvements that will be required by the USEPA as part of the existing LTCP. As part of the CSS evaluation for the LTCP, Black & Veatch developed a hydrologic and hydraulic model of the CSS. The model was used for evaluating potential improvements to reduce the volume of CSO from the CSS. The model encompasses the area of the City that is serviced by combined sewers, which is approximately the western half of the City.

In TM-CSO-2 – CSS Model Calibration and Existing Conditions, additional model calibration was documented. The updated model was used to determine the

existing conditions CSO volume. As part of recent discussions between the City and the USEPA, the financial capability assessment has determined that the City can only implement a limited number of the system improvements during the next 20 years to reduce CSO volume. This memorandum documents existing conditions CSO volume and recommended system improvements for a modified Phase IA that provide the City the most cost effective CSO controls.

#### 4.0 Confirmation of Land Use for Phase IA CSO Control Recommended Improvements Model

The CSS model developed for St. Joseph was derived from the Comprehensive Stormwater Management Plan hydrology and hydraulics model created for the City in the late 1990s. This model used future land use conditions to estimate the runoff flows into the CSS. Sewer interceptors and pump stations were added to the stormwater model to simulate the CSS for the development of LTCP solution alternatives. Using rain and flow data collected in 2007 and 2008, the model hydrology was calibrated to represent the monitored data (TM-CSO-2, Black & Veatch, 2009).

Table 1 presents the population projections for 2010 and 2030 that were derived from City experience and traffic analysis zone (TAZ) data provided by the City (TM-WW-1, Black & Veatch, 2009).

<b>Table 1</b>		
<b>Population Projections for 2010 and 2030</b>		
<b>Service Area</b>	<b>Population</b>	
	<b>2010</b>	<b>2030</b>
Westside	63,900	66,700
Eastside	13,400	17,400
<i>Total</i>	<i>77,300</i>	<i>84,000</i>

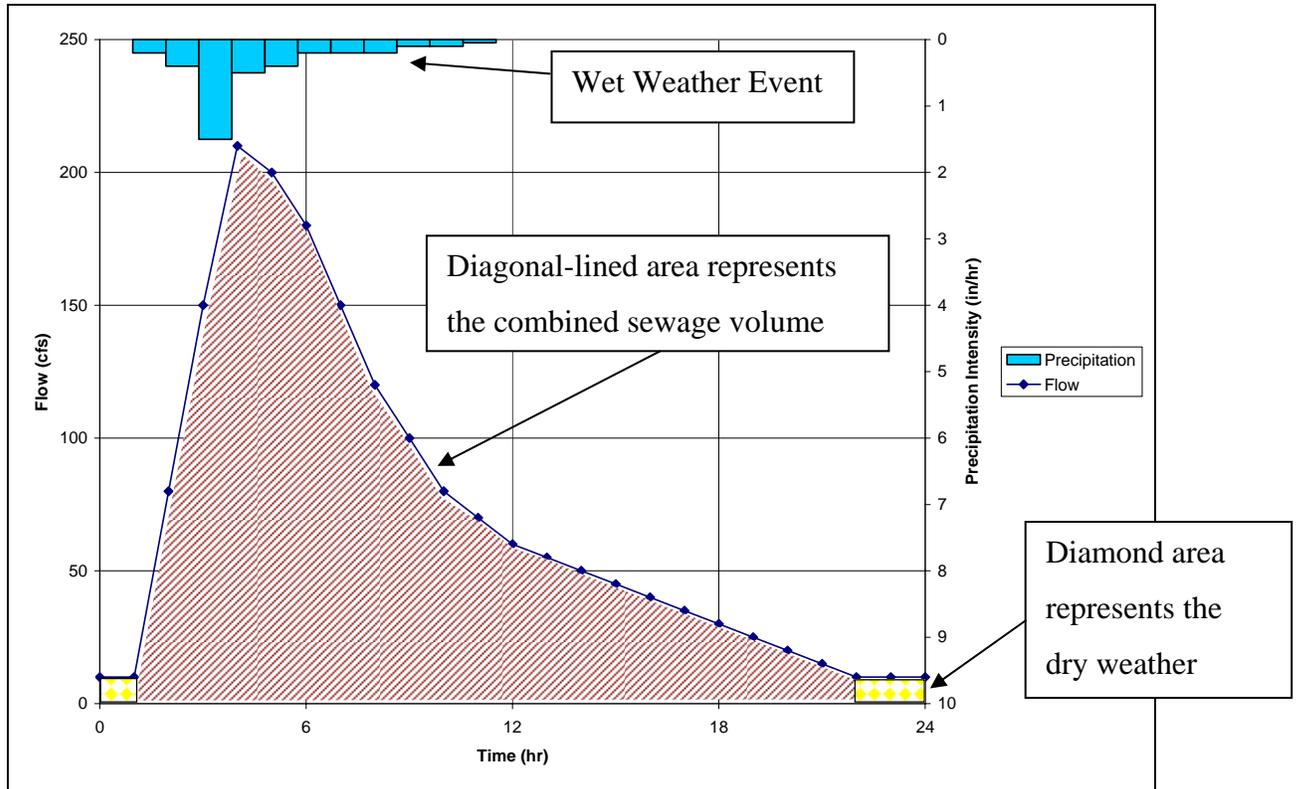
As can be seen in Table 1, a modest increase in population of the City of 2,800 residents (4.3 percent greater than the 2010 projection) is projected in the Westside service area (CSS service area) over the next 20 years. Based upon this information, the existing conditions CSS model should closely represent the conditions 20 years from

today, which is the approximate program timeline being discussed with MDNR and USEPA for the Phase IA controls. Therefore, the calibrated model was used to estimate the existing conditions and Phase IA CSO volume.

The largest contributing factor to peak flows and runoff volumes into the CSS is impervious areas that lack stormwater inflow controls. If the impervious area upstream of the CSS increases from development, then the increased peak flow and runoff volume may require larger CSO control projects. To combat this effect, the City currently has stormwater ordinances in place to maintain peak stormwater runoff flows at pre-development levels even after development has occurred. Therefore, from a peak flow perspective, the existing conditions flows should be similar to future flows no matter how the City develops.

## **5.0 Typical Year Combined Sewage Estimation**

Combined sewage consists of sanitary flows that combine with stormwater runoff during precipitation events. Figure 1 presents a typical hydrograph (i.e., flow versus time) in a CSS in response to a wet weather precipitation event. Initially, the flow in a combined sewer is relatively constant during dry weather. As the rainfall begins, the stormwater runoff increases with the precipitation, and as the precipitation begins to taper off, the stormwater runoff decreases. In some sewer systems, the elevated flow conditions within the sewer can continue for an extended period of time as groundwater, recharged from the rain event, infiltrates into the sewer system. The highlighted region (i.e., diagonal lines) in Figure 1 indicates the combined sewage volume produced during a wet-weather event.



**Figure 1 – Combined Sewage Determination from Runoff Hydrograph**

To calculate the combined sewage volume for a “typical year” requires an approximation of the typical year rainfall. The typical year rainfall is derived from the long-term rainfall patterns for a given community. The typical year rainfall can be presented either as a continuous, year long, rainfall hyetograph or presented by a series of design events. For this study, due to the proximity of St. Joseph to Kansas City, the eight statistically-determined design rainfall events from the City of Kansas City, Missouri LTCP were used to determine the “typical year” combined sewage volume in St. Joseph. Each rain event is simulated using the CSS model to determine the combined sewage and CSO volumes. The total combined sewage volume is the sum of the combined sewage volume to each diversion structure whereas the total combined sewage overflow volume is the sum of the combined sewage overflow volume leaving each diversion structure to a receiving water body during a rain event (for St. Joseph, the water body is the Missouri River).

Using the combined sewage and the combined sewage overflow volumes for each rainfall event, the calculation detailed in Section 6.0 of TM-CSO-2 is performed to determine the “typical year” combined sewage and CSO volumes. The percentage of the “typical year” combined sewage that does not become combined sewage overflow is the volumetric percent capture. For example, if 2 million gallons (MG) of combined sewage is produced by a basin, but only 0.5 MG of combined sewage overflows, then the volumetric percent capture of the basin would be 75 percent.

## **6.0 Existing and Phase IA CSS Typical Year CSO Volumes and Percent Capture**

Using the updated CSS model to simulate the “typical year” rainfall events, the calculated annual typical year combined sewage volume produced during wet weather events is 4.7 billion gallons and the annual combined sewer overflow volume is 4.1 billion gallons. Therefore, the existing volumetric capture of combined sewage in the existing CSS system is approximately 12 percent. Under the presumptive approach of the CSO control policy, a community is presumed to meet water quality standards if 85 percent of the combined sewage volume is captured. As presented in the 2008 LTCP Update, the cost of achieving 85 percent volumetric capture is prohibitive to the City within a 20-year time frame.

Based on the very high burden indicated in the Financial Capability Analysis for St. Joseph, MDNR and EPA requested that the City determine a selection of projects based upon the LTCP Phase I which provide the greatest control of CSO for the least amount of cost (i.e., most cost effective). From the complete list of recommended projects in the 2008 LTCP Update, the following projects were determined to provide the most cost-effective volumetric control of combined sewage (estimated control based on modeling results):

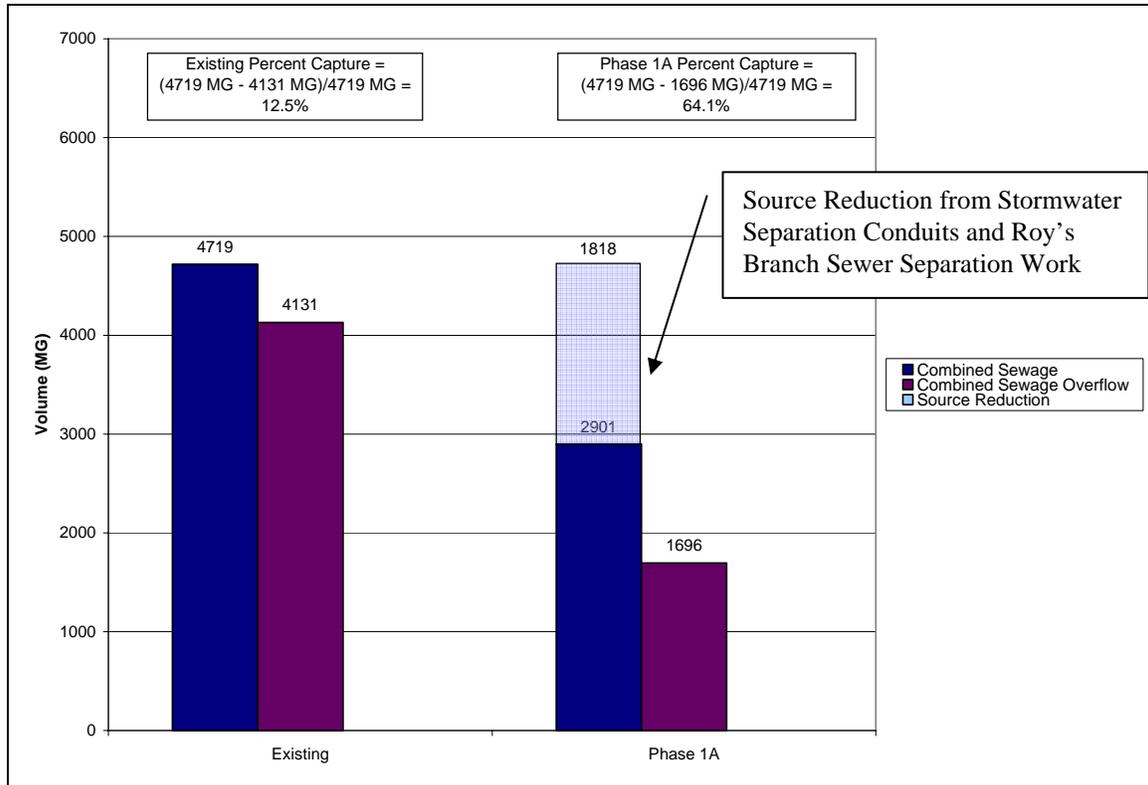
- Blacksnake and Whitehead stormwater separation conduits (estimated annual reduction in CSO: 1.59 billion gallons)
- Increasing conveyance capacity at the Whitehead Pump Station to 80 mgd, increasing treatment capacity at the existing WPF headworks to 88 mgd,

and providing 61 mgd high rate treatment and disinfection facilities (estimated annual reduction in CSO: 0.62 billion gallons)

- Roy's Branch partial sewer separation (in progress) (estimated annual reduction in CSO: 0.23 billion gallons)

Other subsequent technical memorandums will detail the costs of the modified Phase IA CSO control projects and provide more detailed descriptions of the projects required to separate stormwater and increase the conveyance and treatment of combined sewage in the CSS.

To estimate the effectiveness of the modified Phase IA improvements, the aforementioned projects were incorporated within the existing CSS model to create the modified Phase IA CSS model. Model simulations for the "typical year" events were performed and the combined sewage volumes were determined. From the model results and typical year calculations, the CSS combined sewage volume was determined to be 2.9 billion gallons whereas the combined sewer overflow volume was determined to be 1.7 billion gallons. Using the existing combined sewage volume (4.7 billion gallons) as the basis for determining volumetric percent capture, the modified Phase IA improvements achieve a volumetric percent capture of greater than 60 percent. Detailed flow and volume calculation sheets for each CSO outfall and the CSS basin summary sheet are provided in Appendix A. Figure 2 graphically presents the volumetric percent capture of the existing CSS versus Phase IA model simulations.



**Figure 2 – Annual Volumetric Capture: Existing CSS versus Phase IA CSO Control**

## 7.0 Conclusions and Recommendations

The existing combined sewage annual average volume as determined by the CSS model is 4.7 billion gallons, and of that volume, 4.1 billion gallons leave the CSS as CSO. The proposed Blacksnake and Whitehead stormwater separation conduits will reduce the annual volume of combined sewage overflow by 1.59 billion gallons for a typical year. Increasing the conveyance capacity of the Whitehead Pump Station and the treatment capacity at the existing WPF headworks will reduce CSO volume by an additional 0.62 billion gallons annually. Finally, the Roy's Branch partial sewer separation project (underway) will reduce CSO volume by an additional 0.23 billion gallons annually. The modified Phase IA CSS model results indicate that the overall CSO volume will be reduced to approximately 1.7 billion gallons annually, down approximately 2.4 billion gallons from the existing conditions estimate of 4.1 billion gallons.

The existing CSS system is estimated to capture approximately 12 percent of the combined sewage. By incorporation of the Phase IA improvements, a volumetric capture of approximately 60 percent is expected. A subsequent technical memorandum, TM-CSO-3b – Phase IA CSO Control Water Quality Model, will present the water quality benefits of the modified Phase IA improvements. The Phase IA improvements are viewed as the most cost effective controls to reduce overflows from the City’s CSS.

## **8.0 References**

1. Black & Veatch Corporation, TM-CSO-2 – CSS Model Calibration and Existing Conditions, 2009.
2. Black & Veatch Corporation, TM-WW-1 – Existing Conveyance and Water Protection Facility Assessment, 2009.

## **Appendix A**

# **Detailed Flow and Volume Combined Sewage Calculations**

# **Existing Conditions Flow and Volume Combined Sewage Calculations**

St. Joseph, MO

Combined Sewer System  
 Diversion Structure Discharge Characteristics  
 Basin Summary

Basin:  
 Diversion Structure No.:  
 Design Condition/Alt.:  
 Average Dry Weather Flow (ADWF), mgd:

**St. Joseph CSO**  
**All**  
**Existing**  
**17.417**

Rainfall Characteristics						Summary Data during Precipitation Events			
Design Storm ID	Storm Depth (inches)	Peak Hour Intensity (in/hr)	Storm Duration (hours)	Times Equalled or Exceeded in Design Year	No. of Events in Range During Design Year	Design Storm Summary		Estimated Annual Totals	
						Total Volume to Diversion Structures (mg)	Total Overflow Volume (mg)	Total Volume to Diversion Structures (mg)	Total Overflow Volume (mg)
None	0.00	0.00	0.00	78	42	0.00	0.00		
A	0.29	0.20	6.00	36	18	20.33	14.12	426.93	296.52
B	0.51	0.26	8.75	18	6	46.55	37.23	601.92	462.15
C	0.86	0.58	12.25	12	6	87.14	77.80	401.07	345.09
D	1.41	0.75	16.75	6	2	192.69	171.99	839.49	749.37
E	1.82	0.87	19.75	4	1	297.62	273.00	490.31	444.99
F	2.00	0.95	21.00	3	1	351.64	325.42	324.63	299.21
G	2.37	1.06	23.75	2	1	474.82	441.85	413.23	383.64
H	2.88	1.25	26.75	1	1	656.03	619.57	565.43	530.71
<b>Totals</b>					<b>78</b>			<b>656.03</b>	<b>619.57</b>
Long-Term Mean Annual Rainfall (inches)					36.5				
Long-Term Median Annual Rainfall (inches)					35.0				
Total Rainfall Depth Represented Above (inches)					37.04				
<b>Estimated Total Annual Inflow to Diversion Structures (mg)</b>						<b>10457.72</b>			
<b>Estimated Annual Volume Retained in System (mg)</b>						<b>6558.41</b>			
<b>ESTIMATED BASIN-WIDE ANNUAL CAPTURE DURING PRECIPITATION EVENTS</b>								<b>12%</b>	







Basin: **St. Joseph CSO**  
 Diversion Structure No.: **SBS-33**  
 Discharges to Outfall No.: **SBS-RIVER**  
 Design Condition/Alt.: **Existing**

Or to: [redacted]

At: [redacted]

Average Dry Weather Flow (mgd):

**1.2 (ADWF)**

Design Storm ID	Rainfall Characteristics					Total Design Storm Flow to Diversion Structure			Overflow Characteristics			Design Year Summary for All Events in Range		
	Storm Depth (inches)	Peak Hour Intensity (in/hr)	Storm Duration (hours)	Times Equalled or Exceeded in Design Year	No. of Events in Range During Design Year	Runoff Event Time Base (hours)	Total Volume to Diversion Structure (mg)	Peak Rate of Flow to Diversion Str. (mgd)	Overflow Volume (mg)	Peak Overflow Rate (mgd)	Duration of Overflow (hours)	Mean Runoff Event Duration (hours)	Total Volume to Diversion Structure (mg)	Overflow Volume (mg)
None	0.00	0.00	0.00	78	42	0.00	0.000	0.00	0.00	0.000	0.00			
A	0.29	0.20	6.00	36	18	4.50	0.67	11.80	0.34	9.01	4.25	2.25	14.07	7.14
B	0.51	0.26	8.75	18	6	6.92	1.55	20.86	0.97	18.45	6.50	5.71	19.98	11.79
C	0.86	0.58	12.25	12	6	10.58	2.58	42.50	2.08	39.60	10.08	8.75	12.39	9.15
D	1.41	0.75	16.75	6	6	15.50	5.87	66.53	4.48	65.02	14.42	13.04	25.35	19.68
E	1.82	0.87	19.75	4	2	18.50	8.62	79.73	7.00	78.96	17.92	17.00	14.49	11.48
F	2.00	0.95	21.00	3	1	19.83	10.03	107.95	8.39	108.87	19.25	19.17	9.33	7.70
G	2.37	1.06	23.75	2	1	22.58	13.39	134.33	11.31	136.13	21.92	21.21	11.71	9.85
H	2.88	1.25	26.75	1	1	25.50	18.01	198.52	15.75	204.86	25.17	24.04	15.70	13.53
					78							25.50	18.01	15.75
												141.03	106.07	
Estimated Annual Time During Runoff Events (hours)												452		
Estimated Annual Time Between Runoff Events												8,308		
Estimated Annual Inflow at ADWF Between Runoff Events (mg)												415.4041667		
<b>Estimated Total Annual Inflow to Diversion Structure (mg)</b>												<b>556.43</b>		
<b>Estimated Annual Volume Retained in System (mg)</b>												<b>450.36</b>		
<b>ESTIMATED ANNUAL CAPTURE DURING PRECIPITATION EVENTS</b>												<b>25%</b>		
<b>ESTIMATED OVERALL CAPTURE</b>												<b>81%</b>		

Combined Sewer System  
 Diversion Structure Discharge Characteristics  
 Messanie

Basin: **St. Joseph CSO**  
 Diversion Structure No.: **9-75**  
 Discharges to Outfall No.: **9-RIVER**  
 Design Condition/Alt.: **Existing**  
 Average Dry Weather Flow (mgd): **0.1 (ADWF)**

Or to: [REDACTED]

At: [REDACTED]

Design Storm ID	Rainfall Characteristics					Total Design Storm Flow to Diversion Structure			Overflow Characteristics			Design Year Summary for All Events in Range		
	Storm Depth (inches)	Peak Hour Intensity (in/hr)	Storm Duration (hours)	Times Equalled or Exceeded in Design Year	No. of Events in Range During Design Year	Runoff Event Time Base (hours)	Total Volume to Diversion Structure (mg)	Peak Rate of Flow to Diversion Str. (mgd)	Overflow Volume (mg)	Peak Overflow Rate (mgd)	Duration of Overflow (hours)	Mean Runoff Event Duration (hours)	Total Volume to Diversion Structure (mg)	Overflow Volume (mg)
None	0.00	0.00	0.00	78	42	0.00	0.000	0.00	0.00	0.000	0.00			
A	0.29	0.20	6.00	36	18	5.00	0.20	3.66	0.20	3.05	3.83	2.50	4.20	4.20
B	0.51	0.26	8.75	18	6	7.92	0.45	6.49	0.51	7.57	6.00	6.46	5.85	6.39
C	0.86	0.58	12.25	12	6	11.67	0.83	14.34	1.02	15.83	9.58	9.79	3.84	4.59
D	1.41	0.75	16.75	6	6	16.50	1.63	21.01	1.98	23.42	14.58	14.08	7.38	9.00
E	1.82	0.87	19.75	4	2	19.58	2.20	25.58	2.77	30.14	17.33	18.04	3.83	4.75
F	2.00	0.95	21.00	3	1	20.92	2.47	29.40	3.07	32.50	19.00	20.25	2.34	2.92
G	2.37	1.06	23.75	2	1	23.67	3.06	33.38	3.76	36.77	22.33	22.29	2.77	3.42
H	2.88	1.25	26.75	1	1	26.58	3.83	41.27	4.71	45.32	25.50	25.13	3.45	4.24
					1							26.58	3.83	4.71
					78								37.48	44.21
Estimated Annual Time During Runoff Events (hours)												495		
Estimated Annual Time Between Runoff Events												8,265		
Estimated Annual Inflow at ADWF Between Runoff Events (mg)												41.32583333		
<b>Estimated Total Annual Inflow to Diversion Structure (mg)</b>												<b>78.80</b>		
<b>Estimated Annual Volume Retained in System (mg)</b>												<b>34.59</b>		
<b>ESTIMATED ANNUAL CAPTURE DURING PRECIPITATION EVENTS</b>														-18%
<b>ESTIMATED OVERALL CAPTURE</b>														44%





Combined Sewer System  
 Diversion Structure Discharge Characteristics  
 Mitchell

Basin: **St. Joseph CSO**  
 Diversion Structure No.: **N7**  
 Discharges to Outfall No.: **BDCS-RIVER**  
 Design Condition/Alt.: **Existing**

Or to: [redacted]

At: [redacted]

Average Dry Weather Flow (mgd):

**4.7 (ADWF)**

Design Storm ID	Rainfall Characteristics					Total Design Storm Flow to Diversion Structure			Overflow Characteristics			Design Year Summary for All Events in Range		
	Storm Depth (inches)	Peak Hour Intensity (in/hr)	Storm Duration (hours)	Times Equalled or Exceeded in Design Year	No. of Events in Range During Design Year	Runoff Event Time Base (hours)	Total Volume to Diversion Structure (mg)	Peak Rate of Flow to Diversion Str. (mgd)	Overflow Volume (mg)	Peak Overflow Rate (mgd)	Duration of Overflow (hours)	Mean Runoff Event Duration (hours)	Total Volume to Diversion Structure (mg)	Overflow Volume (mg)
None	0.00	0.00	0.00	78	42	0.00	0.000	0.00	0.00	0.000	0.00			
A	0.29	0.20	6.00	36	18	5.17	2.97	42.95	5.25	60.93	5.00	2.58	62.37	110.25
B	0.51	0.26	8.75	18	6	7.33	6.90	88.02	10.84	108.48	7.08	6.25	88.83	144.81
C	0.86	0.58	12.25	12	6	10.92	13.01	160.94	20.03	180.56	10.17	9.13	59.73	92.61
D	1.41	0.75	16.75	6	2	15.92	27.61	276.59	38.22	297.24	14.83	13.42	121.86	174.75
E	1.82	0.87	19.75	4	1	18.92	42.11	342.52	55.52	363.82	17.92	17.42	69.72	93.74
F	2.00	0.95	21.00	3	1	20.25	49.64	432.26	64.23	454.76	19.33	19.58	45.88	59.88
G	2.37	1.06	23.75	2	1	23.08	67.60	583.20	83.36	604.68	22.17	21.67	58.62	73.80
H	2.88	1.25	26.75	1	1	26.08	93.06	910.82	111.68	932.50	25.50	24.58	80.33	97.52
					78							26.08	93.06	111.68
												680.40	959.03	
Estimated Annual Time During Runoff Events (hours)												483		
Estimated Annual Time Between Runoff Events												8,277		
Estimated Annual Inflow at ADWF Between Runoff Events (mg)												1620.9125		
<b>Estimated Total Annual Inflow to Diversion Structure (mg)</b>												<b>2301.31</b>		
<b>Estimated Annual Volume Retained in System (mg)</b>												<b>1342.28</b>		
<b>ESTIMATED ANNUAL CAPTURE DURING PRECIPITATION EVENTS</b>													<b>-41%</b>	
<b>ESTIMATED OVERALL CAPTURE</b>													<b>58%</b>	





Combined Sewer System  
 Diversion Structure Discharge Characteristics  
 Hickory

Basin: **St. Joseph CSO**  
 Diversion Structure No.: **33-1**  
 Discharges to Outfall No.: **33-RIVER**  
 Design Condition/Alt.: **Existing**

Or to: [Redacted]

At: [Redacted]

Average Dry Weather Flow (mgd):

**0.3 (ADWF)**

Design Storm ID	Rainfall Characteristics					Total Design Storm Flow to Diversion Structure			Overflow Characteristics			Design Year Summary for All Events in Range		
	Storm Depth (inches)	Peak Hour Intensity (in/hr)	Storm Duration (hours)	Times Equalled or Exceeded in Design Year	No. of Events in Range During Design Year	Runoff Event Time Base (hours)	Total Volume to Diversion Structure (mg)	Peak Rate of Flow to Diversion Str. (mgd)	Overflow Volume (mg)	Peak Overflow Rate (mgd)	Duration of Overflow (hours)	Mean Runoff Event Duration (hours)	Total Volume to Diversion Structure (mg)	Overflow Volume (mg)
None	0.00	0.00	0.00	78	42	0.00	0.000	0.00	0.00	0.000	0.00			
A	0.29	0.20	6.00	36	18	4.25	0.18	4.14	0.26	4.62	7.67	2.13	3.78	5.46
B	0.51	0.26	8.75	18	6	6.67	0.49	7.43	0.62	8.47	9.92	5.46	6.03	7.92
C	0.86	0.58	12.25	12	6	10.17	0.87	15.54	1.23	16.45	13.33	8.42	4.08	5.55
D	1.41	0.75	16.75	6	6	15.25	1.92	23.98	2.36	25.27	18.50	12.71	8.37	10.77
E	1.82	0.87	19.75	4	2	18.17	2.75	28.30	3.35	29.85	21.50	16.71	4.67	5.71
F	2.00	0.95	21.00	3	1	19.58	3.17	33.83	3.82	35.03	23.25	18.88	2.96	3.59
G	2.37	1.06	23.75	2	1	22.42	4.12	40.40	4.82	42.03	26.00	21.00	3.65	4.32
H	2.88	1.25	26.75	1	1	25.33	5.41	56.56	6.27	58.20	26.33	23.88	4.77	5.55
					1							25.33	5.41	6.27
					78								43.71	55.13
Estimated Annual Time During Runoff Events (hours)												437		
Estimated Annual Time Between Runoff Events												8,323		
Estimated Annual Inflow at ADWF Between Runoff Events (mg)												93.6365625		
<b>Estimated Total Annual Inflow to Diversion Structure (mg)</b>												<b>137.35</b>		
<b>Estimated Annual Volume Retained in System (mg)</b>												<b>82.22</b>		
<b>ESTIMATED ANNUAL CAPTURE DURING PRECIPITATION EVENTS</b>														-26%
<b>ESTIMATED OVERALL CAPTURE</b>														<b>60%</b>

Combined Sewer System  
 Diversion Structure Discharge Characteristics  
 Whitehead

Basin: **St. Joseph CSO**  
 Diversion Structure No.: **WMS-19**  
 Discharges to Outfall No.: **WMS-RIVER**  
 Design Condition/Alt.: **Existing**  
 Average Dry Weather Flow (mgd): **2.8 (ADWF)**

Or to: [REDACTED]

At: [REDACTED]

Design Storm ID	Rainfall Characteristics					Total Design Storm Flow to Diversion Structure			Overflow Characteristics			Design Year Summary for All Events in Range		
	Storm Depth (inches)	Peak Hour Intensity (in/hr)	Storm Duration (hours)	Times Equalled or Exceeded in Design Year	No. of Events in Range During Design Year	Runoff Event Time Base (hours)	Total Volume to Diversion Structure (mg)	Peak Rate of Flow to Diversion Str. (mgd)	Overflow Volume (mg)	Peak Overflow Rate (mgd)	Duration of Overflow (hours)	Mean Runoff Event Duration (hours)	Total Volume to Diversion Structure (mg)	Overflow Volume (mg)
None	0.00	0.00	0.00	78	42	0.00	0.000	0.00	0.00	0.000	0.00	3.38	204.12	120.54
A	0.29	0.20	6.00	36	18	6.75	9.72	115.27	5.74	91.35	12.00	8.00	291.87	202.86
B	0.51	0.26	8.75	18	6	9.25	22.71	234.58	16.80	209.86	14.08	11.13	200.13	158.61
C	0.86	0.58	12.25	12	6	13.00	44.00	435.21	36.07	408.75	17.50	15.75	398.28	333.21
D	1.41	0.75	16.75	6	2	18.50	88.76	772.44	75.00	743.96	22.50	20.04	220.71	190.27
E	1.82	0.87	19.75	4	1	21.58	131.95	1004.16	115.27	975.46	25.58	22.25	142.80	125.47
F	2.00	0.95	21.00	3	1	22.92	153.65	1196.98	135.66	1168.53	25.83	24.33	177.97	158.28
G	2.37	1.06	23.75	2	1	25.75	202.29	1498.56	180.90	1462.24	26.00	26.92	238.50	215.54
H	2.88	1.25	26.75	1	1	28.08	274.70	2144.85	250.18	2099.18	26.17	28.08	274.70	250.18
					<b>78</b>								<b>2149.08</b>	<b>1754.96</b>
Estimated Annual Time During Runoff Events (hours)											589			
Estimated Annual Time Between Runoff Events											8,171			
Estimated Annual Inflow at ADWF Between Runoff Events (mg)											953,322,222			
<b>Estimated Total Annual Inflow to Diversion Structure (mg)</b>											<b>3102.40</b>			
<b>Estimated Annual Volume Retained in System (mg)</b>											<b>1347.44</b>			
<b>ESTIMATED ANNUAL CAPTURE DURING PRECIPITATION EVENTS</b>											<b>18%</b>			
<b>ESTIMATED OVERALL CAPTURE</b>											<b>43%</b>			

Combined Sewer System  
 Diversion Structure Discharge Characteristics  
 MOAV

Basin: **St. Joseph CSO**  
 Diversion Structure No.: **[REDACTED]**  
 Discharges to Outfall No.: **[REDACTED]**  
 Design Condition/Alt.: **Existing**  
 Average Dry Weather Flow (mgd): **2.1 (ADWF)**

Or to: **[REDACTED]** At: **[REDACTED]**

Design Storm ID	Rainfall Characteristics					Total Design Storm Flow to Diversion Structure			Overflow Characteristics			Design Year Summary for All Events in Range		
	Storm Depth (inches)	Peak Hour Intensity (in/hr)	Storm Duration (hours)	Times Equalled or Exceeded in Design Year	No. of Events in Range During Design Year	Runoff Event Time Base (hours)	Total Volume to Diversion Structure (mg)	Peak Rate of Flow to Diversion Str. (mgd)	Overflow Volume (mg)	Peak Overflow Rate (mgd)	Duration of Overflow (hours)	Mean Runoff Event Duration (hours)	Total Volume to Diversion Structure (mg)	Overflow Volume (mg)
None	0.00	0.00	0.00	78	42	0.00	0.000	0.00	0.00	0.000	0.00	3.21	33.81	9.24
A	0.29	0.20	6.00	36	18	6.42	1.61	22.40	0.44	14.22	3.17	7.50	46.17	18.54
B	0.51	0.26	8.75	18	6	8.58	3.52	41.94	1.62	33.75	4.67	10.83	28.95	15.87
C	0.86	0.58	12.25	12	6	13.08	6.13	81.34	3.67	72.81	8.50	15.54	55.02	32.94
D	1.41	0.75	16.75	6	2	18.00	12.21	126.35	7.31	117.32	12.50	19.54	28.72	17.80
E	1.82	0.87	19.75	4	1	21.08	16.51	149.00	10.49	139.98	15.00	21.75	17.53	11.31
F	2.00	0.95	21.00	3	1	22.42	18.54	170.63	12.13	161.30	16.92	23.83	20.93	13.82
G	2.37	1.06	23.75	2	1	25.25	23.32	196.10	15.51	187.13	19.08	26.50	26.25	17.97
H	2.88	1.25	26.75	1	1	27.75	29.18	251.85	20.43	242.22	22.17	27.75	29.18	20.43
					78								286.56	157.92
											Estimated Annual Time During Runoff Events (hours)	567		
											Estimated Annual Time Between Runoff Events	8,193		
											Estimated Annual Inflow at ADWF Between Runoff Events (mg)	716,894,7917		
											Estimated Total Annual Inflow to Diversion Structure (mg)	1003.45		
											Estimated Annual Volume Retained in System (mg)	845.53		
											<b>ESTIMATED ANNUAL CAPTURE DURING PRECIPITATION EVENTS</b>		45%	
											<b>ESTIMATED OVERALL CAPTURE</b>		84%	

Basin: **St. Joseph CSO**  
 Diversion Structure No.: **BNB-24**  
 Discharges to Outfall No.: **BNB-28**  
 Design Condition/Alt.: **Existing**  
 Average Dry Weather Flow (mgd): **1.3 (ADWF)**

Design Storm ID	Rainfall Characteristics					Total Design Storm Flow to Diversion Structure			Overflow Characteristics			Design Year Summary for All Events in Range		
	Storm Depth (inches)	Peak Hour Intensity (in/hr)	Storm Duration (hours)	Times Equalled or Exceeded in Design Year	No. of Events in Range During Design Year	Runoff Event Time Base (hours)	Total Volume to Diversion Structure (mg)	Peak Rate of Flow to Diversion Str. (mgd)	Overflow Volume (mg)	Peak Overflow Rate (mgd)	Duration of Overflow (hours)	Mean Runoff Event Duration (hours)	Total Volume to Diversion Structure (mg)	Overflow Volume (mg)
None	0.00	0.00	0.00	78	42	0.00	0.000	0.00	0.00	0.000	0.00	3.71	13.44	0.00
A	0.29	0.20	6.00	36	18	7.42	0.64	4.15	0.00	0.00	0.00	9.54	18.45	2.16
B	0.51	0.26	8.75	18	6	11.67	1.41	11.54	0.24	6.38	1.83	12.79	11.37	3.99
C	0.86	0.58	12.25	12	6	13.92	2.38	21.57	1.09	16.31	6.50	16.46	41.88	29.64
D	1.41	0.75	16.75	6	2	19.00	11.58	85.80	8.79	80.76	10.33	20.54	32.85	26.70
E	1.82	0.87	19.75	4	1	22.08	21.27	155.05	17.91	149.83	12.42	22.75	23.75	20.28
F	2.00	0.95	21.00	3	1	23.42	26.23	214.92	22.64	207.72	13.42	24.83	31.79	27.79
G	2.37	1.06	23.75	2	1	26.25	37.34	323.31	32.93	317.29	15.33	26.92	45.08	40.41
H	2.88	1.25	26.75	1	1	27.58	52.81	508.42	47.88	500.32	17.33	27.58	52.81	47.88
					78							27.58	52.81	47.88
											271.41	198.84		
											Estimated Annual Time During Runoff Events (hours)	646		
											Estimated Annual Time Between Runoff Events	8,114		
											Estimated Annual Inflow at ADWF Between Runoff Events (mg)	425,97625		
											Estimated Total Annual Inflow to Diversion Structure (mg)	697.39		
											Estimated Annual Volume Retained in System (mg)	498.55		
											ESTIMATED ANNUAL CAPTURE DURING PRECIPITATION EVENTS	27%		
											ESTIMATED OVERALL CAPTURE	71%		

# **Phase 1A Flow and Volume Combined Sewage Calculations**

St. Joseph, MO

Combined Sewer System  
 Diversion Structure Discharge Characteristics  
 Basin Summary

Basin:  
 Diversion Structure No.:  
 Design Condition/Alt.:  
 Average Dry Weather Flow (ADWF), mgd:

**St. Joseph CSO**  
**All**  
**Phase 1A**  
**17.417**

Rainfall Characteristics						Summary Data during Precipitation Events			
Design Storm ID	Storm Depth (inches)	Peak Hour Intensity (in/hr)	Storm Duration (hours)	Times Equalled or Exceeded in Design Year	No. of Events in Range During Design Year	Design Storm Summary		Estimated Annual Totals	
						Total Volume to Diversion Structures (mg)	Total Overflow Volume (mg)	Total Volume to Diversion Structures (mg)	Total Overflow Volume (mg)
None	0.00	0.00	0.00	78	42	0.00	0.00	252.21	51.24
A	0.29	0.20	6.00	36	18	12.01	2.44	380.61	121.23
B	0.51	0.26	8.75	18	6	30.28	11.03	248.13	116.19
C	0.86	0.58	12.25	12	6	52.43	27.70	500.76	288.84
D	1.41	0.75	16.75	6	2	114.49	68.58	288.05	183.98
E	1.82	0.87	19.75	4	1	173.56	115.40	189.61	128.97
F	2.00	0.95	21.00	3	1	205.65	142.53	247.55	177.63
G	2.37	1.06	23.75	2	1	289.44	212.73	361.05	280.07
H	2.88	1.25	26.75	1	1	432.66	347.41	432.66	347.41
<b>Totals</b>					<b>78</b>			<b>2900.62</b>	<b>1695.56</b>
Long-Term Mean Annual Rainfall (inches)					36.5				
Long-Term Median Annual Rainfall (inches)					35.0				
Total Rainfall Depth Represented Above (inches)					37.04				
<b>Estimated Total Annual Inflow to Diversion Structures (mg)</b>						<b>8888.86</b>			
<b>Estimated Annual Volume Retained in System (mg)</b>						<b>7193.30</b>			
<b>ESTIMATED BASIN-WIDE ANNUAL CAPTURE DURING PRECIPITATION EVENTS</b>						<b>42%</b>			
<b>ESTIMATED BASIN-WIDE OVERALL CAPTURE</b>						<b>81%</b>			







Basin: **St. Joseph CSO**  
 Diversion Structure No.: **SBS-33**  
 Discharges to Outfall No.: **Phase 1A**  
 Design Condition/Alt.: **Phase 1A**

Or to: [Redacted]

At: [Redacted]

Average Dry Weather Flow (mgd):

**1.2 (ADWF)**

Design Storm ID	Rainfall Characteristics					Total Design Storm Flow to Diversion Structure			Overflow Characteristics			Design Year Summary for All Events in Range		
	Storm Depth (inches)	Peak Hour Intensity (in/hr)	Storm Duration (hours)	Times Equalled or Exceeded in Design Year	No. of Events in Range During Design Year	Runoff Event Time Base (hours)	Total Volume to Diversion Structure (mg)	Peak Rate of Flow to Diversion Str. (mgd)	Overflow Volume (mg)	Peak Overflow Rate (mgd)	Duration of Overflow (hours)	Mean Runoff Event Duration (hours)	Total Volume to Diversion Structure (mg)	Overflow Volume (mg)
None	0.00	0.00	0.00	78	42	0.00	0.000	0.00	0.00	0.000	0.00			
A	0.29	0.20	6.00	36	18	4.50	0.67	11.80	0.10	4.03	2.08	2.25	14.07	2.10
B	0.51	0.26	8.75	18	6	7.00	1.56	20.86	0.42	11.16	3.08	5.75	20.07	4.68
C	0.86	0.58	12.25	12	6	10.50	2.58	42.46	1.09	30.52	5.42	8.75	12.42	4.53
D	1.41	0.75	16.75	6	2	15.50	5.86	66.53	2.51	54.51	11.33	13.00	25.32	10.80
E	1.82	0.87	19.75	4	1	18.50	8.62	79.73	4.11	66.15	14.50	17.00	14.48	6.62
F	2.00	0.95	21.00	3	1	19.83	10.06	109.58	4.98	86.81	15.83	19.17	9.34	4.55
G	2.37	1.06	23.75	2	1	22.58	13.39	134.21	7.34	123.36	18.42	21.21	11.73	6.16
H	2.88	1.25	26.75	1	1	25.50	18.01	198.53	10.92	190.60	21.67	24.04	15.70	9.13
					78							25.50	18.01	10.92
												141.14	59.49	
Estimated Annual Time During Runoff Events (hours)												452		
Estimated Annual Time Between Runoff Events												8,308		
Estimated Annual Inflow at ADWF Between Runoff Events (mg)												415.3791667		
<b>Estimated Total Annual Inflow to Diversion Structure (mg)</b>												<b>556.51</b>		
<b>Estimated Annual Volume Retained in System (mg)</b>												<b>497.03</b>		
<b>ESTIMATED ANNUAL CAPTURE DURING PRECIPITATION EVENTS</b>												<b>58%</b>		
<b>ESTIMATED OVERALL CAPTURE</b>												<b>89%</b>		

Basin: **St. Joseph CSO**  
 Diversion Structure No.: **9-75**  
 Discharges to Outfall No.: **Phase 1A**  
 Design Condition/Alt.: **Phase 1A**

Or to: [redacted]

At: [redacted]

Average Dry Weather Flow (mgd):

**0.1 (ADWF)**

Design Storm ID	Rainfall Characteristics					Total Design Storm Flow to Diversion Structure			Overflow Characteristics			Design Year Summary for All Events in Range		
	Storm Depth (inches)	Peak Hour Intensity (in/hr)	Storm Duration (hours)	Times Equalled or Exceeded in Design Year	No. of Events in Range During Design Year	Runoff Event Time Base (hours)	Total Volume to Diversion Structure (mg)	Peak Rate of Flow to Diversion Str. (mgd)	Overflow Volume (mg)	Peak Overflow Rate (mgd)	Duration of Overflow (hours)	Mean Runoff Event Duration (hours)	Total Volume to Diversion Structure (mg)	Overflow Volume (mg)
None	0.00	0.00	0.00	78	42	0.00	0.000	0.00	0.00	0.000	0.00			
A	0.29	0.20	6.00	36	18	5.00	0.20	3.66	0.00	0.06	0.92	2.50	4.20	0.00
B	0.51	0.26	8.75	18	6	7.92	0.45	6.49	0.04	1.83	1.58	6.46	5.85	0.36
C	0.86	0.58	12.25	12	6	11.67	0.83	14.34	0.31	10.28	2.25	9.79	3.84	1.05
D	1.41	0.75	16.75	6	2	16.50	1.63	21.01	1.03	25.96	2.75	14.08	7.38	4.02
E	1.82	0.87	19.75	4	1	19.58	2.20	25.58	1.60	33.53	3.75	18.04	3.83	2.63
F	2.00	0.95	21.00	3	1	20.92	2.47	29.39	1.94	38.48	4.08	20.25	2.34	1.77
G	2.37	1.06	23.75	2	1	23.67	3.06	33.36	2.56	43.54	5.33	22.29	2.77	2.25
H	2.88	1.25	26.75	1	1	26.58	3.83	41.27	3.34	54.92	7.17	25.13	3.45	2.95
					78							26.58	3.83	3.34
												37.48	18.37	
Estimated Annual Time During Runoff Events (hours)												495		
Estimated Annual Time Between Runoff Events												8,265		
Estimated Annual Inflow at ADWF Between Runoff Events (mg)												41.32583333		
<b>Estimated Total Annual Inflow to Diversion Structure (mg)</b>												<b>78.80</b>		
<b>Estimated Annual Volume Retained in System (mg)</b>												<b>60.43</b>		
<b>ESTIMATED ANNUAL CAPTURE DURING PRECIPITATION EVENTS</b>													<b>51%</b>	
<b>ESTIMATED OVERALL CAPTURE</b>													<b>77%</b>	

Combined Sewer System  
 Diversion Structure Discharge Characteristics  
 Patee

Basin: **St. Joseph CSO**  
 Diversion Structure No.: **9-76**  
 Discharges to Outfall No.: **Phase 1A**  
 Design Condition/Alt.: **Phase 1A**

Or to: [Redacted]

At: [Redacted]

Average Dry Weather Flow (mgd):

**0.1 (ADWF)**

Design Storm ID	Rainfall Characteristics					Total Design Storm Flow to Diversion Structure			Overflow Characteristics			Design Year Summary for All Events in Range		
	Storm Depth (inches)	Peak Hour Intensity (in/hr)	Storm Duration (hours)	Times Equalled or Exceeded in Design Year	No. of Events in Range During Design Year	Runoff Event Time Base (hours)	Total Volume to Diversion Structure (mg)	Peak Rate of Flow to Diversion Str. (mgd)	Overflow Volume (mg)	Peak Overflow Rate (mgd)	Duration of Overflow (hours)	Mean Runoff Event Duration (hours)	Total Volume to Diversion Structure (mg)	Overflow Volume (mg)
None	0.00	0.00	0.00	78	42	0.00	0.000	0.00	0.00	0.000	0.00			
A	0.29	0.20	6.00	36	18	4.50	0.12	2.38	0.01	0.36	1.08	2.25	2.52	0.21
B	0.51	0.26	8.75	18	6	7.00	0.29	4.33	0.39	9.57	2.50	5.75	3.69	3.60
C	0.86	0.58	12.25	12	6	10.67	0.53	9.62	0.88	14.80	3.50	8.83	2.46	3.81
D	1.41	0.75	16.75	6	2	15.75	1.07	13.94	1.54	21.45	5.42	13.21	4.80	7.26
E	1.82	0.87	19.75	4	1	18.83	1.50	16.38	2.47	24.70	8.50	17.29	2.57	4.01
F	2.00	0.95	21.00	3	1	20.17	1.72	19.34	2.89	28.04	9.17	19.50	1.61	2.68
G	2.37	1.06	23.75	2	1	22.92	2.19	22.73	3.81	31.79	11.42	21.54	1.96	3.35
H	2.88	1.25	26.75	1	1	25.83	2.85	30.63	5.18	40.84	15.08	24.38	2.52	4.50
					78							25.83	2.85	5.18
												24.98	34.60	
Estimated Annual Time During Runoff Events (hours)												456		
Estimated Annual Time Between Runoff Events												8,304		
Estimated Annual Inflow at ADWF Between Runoff Events (mg)												27.67972222		
<b>Estimated Total Annual Inflow to Diversion Structure (mg)</b>												<b>52.65</b>		
<b>Estimated Annual Volume Retained in System (mg)</b>												<b>18.06</b>		
<b>ESTIMATED ANNUAL CAPTURE DURING PRECIPITATION EVENTS</b>													<b>-39%</b>	
<b>ESTIMATED OVERALL CAPTURE</b>													<b>34%</b>	



Basin: **St. Joseph CSO**  
 Diversion Structure No.: **N7**  
 Discharges to Outfall No.: **Phase 1A**  
 Design Condition/Alt.: **Phase 1A**

Or to: [Redacted]

At: [Redacted]

Average Dry Weather Flow (mgd):

**4.7 (ADWF)**

Design Storm ID	Rainfall Characteristics					Total Design Storm Flow to Diversion Structure			Overflow Characteristics			Design Year Summary for All Events in Range		
	Storm Depth (inches)	Peak Hour Intensity (in/hr)	Storm Duration (hours)	Times Equalled or Exceeded in Design Year	No. of Events in Range During Design Year	Runoff Event Time Base (hours)	Total Volume to Diversion Structure (mg)	Peak Rate of Flow to Diversion Str. (mgd)	Overflow Volume (mg)	Peak Overflow Rate (mgd)	Duration of Overflow (hours)	Mean Runoff Event Duration (hours)	Total Volume to Diversion Structure (mg)	Overflow Volume (mg)
None	0.00	0.00	0.00	78	42	0.00	0.000	0.00	0.00	0.000	0.00			
A	0.29	0.20	6.00	36	18	5.08	2.95	44.52	0.62	19.59	1.75	2.54	61.95	13.02
B	0.51	0.26	8.75	18	6	7.33	6.90	88.02	2.90	73.14	2.92	6.21	88.65	31.68
C	0.86	0.58	12.25	12	6	10.92	12.99	161.05	7.46	152.87	4.92	9.13	59.67	31.08
D	1.41	0.75	16.75	6	2	15.92	27.63	276.59	17.18	272.82	11.00	13.42	121.86	73.92
E	1.82	0.87	19.75	4	1	18.92	42.11	342.55	28.70	339.61	14.17	17.42	69.74	45.88
F	2.00	0.95	21.00	3	1	20.25	49.64	432.32	35.07	427.68	15.42	19.58	45.88	31.89
G	2.37	1.06	23.75	2	1	23.08	67.60	583.23	49.96	573.86	18.08	21.67	58.62	42.52
H	2.88	1.25	26.75	1	1	26.08	93.06	910.98	72.85	895.13	21.08	24.58	80.33	61.41
					78							26.08	93.06	72.85
												679.76	404.24	
Estimated Annual Time During Runoff Events (hours)												481		
Estimated Annual Time Between Runoff Events												8,280		
Estimated Annual Inflow at ADWF Between Runoff Events (mg)												1621.402083		
<b>Estimated Total Annual Inflow to Diversion Structure (mg)</b>												<b>2301.16</b>		
<b>Estimated Annual Volume Retained in System (mg)</b>												<b>1896.92</b>		
<b>ESTIMATED ANNUAL CAPTURE DURING PRECIPITATION EVENTS</b>												<b>41%</b>		
<b>ESTIMATED OVERALL CAPTURE</b>												<b>82%</b>		

Combined Sewer System  
 Diversion Structure Discharge Characteristics  
 Duncan

Basin: **St. Joseph CSO**  
 Diversion Structure No.: **83-18**  
 Discharges to Outfall No.: **Phase 1A**  
 Design Condition/Alt.: **Phase 1A**

Or to: [redacted]

At: [redacted]

Average Dry Weather Flow (mgd): **0.0 (ADWF)**

Design Storm ID	Rainfall Characteristics					Total Design Storm Flow to Diversion Structure			Overflow Characteristics			Design Year Summary for All Events in Range		
	Storm Depth (inches)	Peak Hour Intensity (in/hr)	Storm Duration (hours)	Times Equalled or Exceeded in Design Year	No. of Events in Range During Design Year	Runoff Event Time Base (hours)	Total Volume to Diversion Structure (mg)	Peak Rate of Flow to Diversion Str. (mgd)	Overflow Volume (mg)	Peak Overflow Rate (mgd)	Duration of Overflow (hours)	Mean Runoff Event Duration (hours)	Total Volume to Diversion Structure (mg)	Overflow Volume (mg)
None	0.00	0.00	0.00	78	42	0.00	0.000	0.00	0.00	0.000	0.00			
A	0.29	0.20	6.00	36	18	4.00	0.04	1.58	0.00	0.00	0.00	2.00	0.84	0.00
B	0.51	0.26	8.75	18	6	6.33	0.15	2.89	0.01	0.49	1.67	5.17	1.71	0.09
C	0.86	0.58	12.25	12	6	9.83	0.33	6.52	0.06	3.35	2.25	8.08	1.44	0.21
D	1.41	0.75	16.75	6	2	14.67	0.64	9.35	0.19	5.78	2.33	12.25	2.91	0.75
E	1.82	0.87	19.75	4	1	17.75	0.89	10.98	0.29	7.56	2.67	16.21	1.53	0.48
F	2.00	0.95	21.00	3	1	19.08	1.00	12.46	0.36	9.61	2.92	18.42	0.95	0.33
G	2.37	1.06	23.75	2	1	22.00	1.23	14.10	0.56	11.77	3.17	20.54	1.12	0.46
H	2.88	1.25	26.75	1	1	24.92	1.55	17.43	0.80	16.62	3.17	23.46	1.39	0.68
					78							24.92	1.55	0.80
												13.43	3.80	
Estimated Annual Time During Runoff Events (hours)												419		
Estimated Annual Time Between Runoff Events												8,341		
Estimated Annual Inflow at ADWF Between Runoff Events (mg)												1.390208333		
<b>Estimated Total Annual Inflow to Diversion Structure (mg)</b>												<b>14.82</b>		
<b>Estimated Annual Volume Retained in System (mg)</b>												<b>11.03</b>		
<b>ESTIMATED ANNUAL CAPTURE DURING PRECIPITATION EVENTS</b>												<b>72%</b>		
<b>ESTIMATED OVERALL CAPTURE</b>												<b>74%</b>		



Combined Sewer System  
 Diversion Structure Discharge Characteristics  
 Hickory

Basin: **St. Joseph CSO**  
 Diversion Structure No.: **33-1**  
 Discharges to Outfall No.: **Phase 1A**  
 Design Condition/Alt.: **Phase 1A**

Or to: [redacted]

At: [redacted]

Average Dry Weather Flow (mgd): **0.3 (ADWF)**

Design Storm ID	Rainfall Characteristics					Total Design Storm Flow to Diversion Structure			Overflow Characteristics			Design Year Summary for All Events in Range		
	Storm Depth (inches)	Peak Hour Intensity (in/hr)	Storm Duration (hours)	Times Equalled or Exceeded in Design Year	No. of Events in Range During Design Year	Runoff Event Time Base (hours)	Total Volume to Diversion Structure (mg)	Peak Rate of Flow to Diversion Str. (mgd)	Overflow Volume (mg)	Peak Overflow Rate (mgd)	Duration of Overflow (hours)	Mean Runoff Event Duration (hours)	Total Volume to Diversion Structure (mg)	Overflow Volume (mg)
None	0.00	0.00	0.00	78	42	0.00	0.000	0.00	0.00	0.000	0.00			
A	0.29	0.20	6.00	36	18	4.17	0.18	4.14	0.00	0.10	4.42	2.08	3.78	0.00
B	0.51	0.26	8.75	18	6	6.67	0.49	7.43	0.05	1.84	5.33	5.42	6.03	0.45
C	0.86	0.58	12.25	12	6	10.17	0.86	15.54	0.25	9.17	6.00	8.42	4.05	0.90
D	1.41	0.75	16.75	6	6	15.17	1.92	23.98	0.63	16.33	6.67	12.67	8.34	2.64
E	1.82	0.87	19.75	4	2	18.17	2.75	28.30	0.95	20.44	8.08	16.67	4.67	1.58
F	2.00	0.95	21.00	3	1	19.50	3.16	33.81	1.16	25.20	8.83	18.83	2.96	1.06
G	2.37	1.06	23.75	2	1	22.42	4.12	40.36	1.73	35.73	11.17	20.96	3.64	1.45
H	2.88	1.25	26.75	1	1	25.33	5.41	56.52	2.74	58.29	15.50	23.88	4.77	2.24
					78							25.33	5.41	2.74
												43.64	13.05	
Estimated Annual Time During Runoff Events (hours)												434		
Estimated Annual Time Between Runoff Events												8,326		
Estimated Annual Inflow at ADWF Between Runoff Events (mg)												93.669375		
<b>Estimated Total Annual Inflow to Diversion Structure (mg)</b>												<b>137.31</b>		
<b>Estimated Annual Volume Retained in System (mg)</b>												<b>124.26</b>		
<b>ESTIMATED ANNUAL CAPTURE DURING PRECIPITATION EVENTS</b>												<b>70%</b>		
<b>ESTIMATED OVERALL CAPTURE</b>												<b>90%</b>		





Basin: **St. Joseph CSO**  
 Diversion Structure No.: **BNB-24**  
 Discharges to Outfall No.: **Phase 1A** Or to: **[REDACTED]** At: **[REDACTED]**  
 Design Condition/Aft.: **Phase 1A**  
 Average Dry Weather Flow (mgd): **[REDACTED]** 1.3 (ADWF)

Design Storm ID	Rainfall Characteristics					Total Design Storm Flow to Diversion Structure			Overflow Characteristics			Design Year Summary for All Events in Range		
	Storm Depth (inches)	Peak Hour Intensity (in/hr)	Storm Duration (hours)	Times Equalled or Exceeded in Design Year	No. of Events in Range During Design Year	Runoff Event Time Base (hours)	Total Volume to Diversion Structure (mg)	Peak Rate of Flow to Diversion Str. (mgd)	Overflow Volume (mg)	Peak Overflow Rate (mgd)	Duration of Overflow (hours)	Mean Runoff Event Duration (hours)	Total Volume to Diversion Structure (mg)	Overflow Volume (mg)
None	0.00	0.00	0.00	78	42	0.00	0.000	0.00	0.00	0.000	0.00			
A	0.29	0.20	6.00	36	18	7.33	0.63	4.14	0.00	0.00	0.00	3.67	13.23	0.00
B	0.51	0.26	8.75	18	6	11.67	1.40	11.53	0.24	6.38	1.83	9.50	18.27	2.16
C	0.86	0.58	12.25	12	6	13.83	2.37	21.51	1.08	16.32	6.50	12.75	11.31	3.96
D	1.41	0.75	16.75	6	2	18.92	11.57	85.77	8.79	80.78	10.33	16.38	41.82	29.61
E	1.82	0.87	19.75	4	1	22.00	21.25	155.04	17.90	149.83	12.42	20.46	32.82	26.69
F	2.00	0.95	21.00	3	1	23.33	26.21	215.04	22.63	207.66	13.42	22.67	23.73	20.27
G	2.37	1.06	23.75	2	1	26.08	37.31	323.27	32.94	317.41	15.25	24.71	31.76	27.79
H	2.88	1.25	26.75	1	1	27.50	52.80	508.42	47.88	500.31	17.33	26.79	45.06	40.41
					78							27.50	52.80	47.88
												270.80	198.76	
												Estimated Annual Time During Runoff Events (hours)	642	
												Estimated Annual Time Between Runoff Events	8,118	
												Estimated Annual Inflow at ADWF Between Runoff Events (mg)	426,1775	
												Estimated Total Annual Inflow to Diversion Structure (mg)	696.97	
												Estimated Annual Volume Retained in System (mg)	498.21	
												ESTIMATED ANNUAL CAPTURE DURING PRECIPITATION EVENTS	27%	
												ESTIMATED OVERALL CAPTURE	71%	