



INTEGRATED WET WEATHER IMPROVEMENT PLAN

PHASE 1

BINDER 3

☐ Attachments

- C. Pollutant Model Technical Memorandum
- D. ACTIFO and BIOACTIFLO Pilot Study
- E. High Rate Treatment Basis of Design
- F. Source Control Pilot Study Supporting Documents
- G. Modeling Methods Technical Memorandum
- H. Public Input Documents
- I. Modeling Public Preferences at Catchment-scale Technical Memorandum

City of Lakewood, Ohio

September 1, 2016

Attachment C
Pollutant Model Technical Memorandum

D R A F T

June 30, 2016

City of Lakewood

**Integrated Wet Weather Improvement Plan
Characterization of Pollutant Loads
Technical Memorandum**

June 2016

EXECUTIVE SUMMARY

Lakewood's NPDES permit requires "*adequate characterization*" of the sewer system to allow for "*volume and frequency of sewage discharges as well as pollutant concentrations/loads discharged.*" The volume and frequency of sewage discharges was submitted in a Technical Memorandum in June 2014 to both the Ohio EPA and the USEPA Region 5. Pollutant characterization was done by modeling pollutants as an enhancement to its Storm Water Management Model (SWMM) hydrologic model developed for the hydraulic characterization. The objective of modeling pollutants is to characterize their concentrations in:

1. Untreated Overflows
2. Wastewater Treatment Plant (WWTP) influent on dry and wet days

This characterization will enable comparison of long term control alternatives to provide the most cost-effective improvement to the water quality of Lake Erie.

Pollutants added to the SWMM model include total suspended solids (TSS), carbonaceous biological oxygen demand (CBOD), total phosphorous (TP), and *Escherichia coli* (*E. coli*) bacteria. Typical concentrations of these pollutants in sewage were calculated from five years of WWTP Discharge Monitoring Reports. Pollutants in stormwater runoff were modeled using SWMM's buildup and washoff equations. The SWMM pollutant equations were calibrated with data from five samplers with attached flow meters. Details of the process to set up the model and calibrate it are described within this report.

After setting up and calibrating the model parameters to calculate pollutant loadings, SWMM was run with a typical year of rainfall. Output from the typical year analysis serves as the basis for calculating pollutant reductions of future improvements. The following table shows the amount of flow and pollutants in a typical year currently treated by the Lakewood WWTP and Northeast Ohio Regional Sewer District and the amount of untreated flow discharged through the City's outfalls. In addition to the total flows treated and discharged, the table also shows the percentages of flow and pollutants captured for treatment by the collection system during precipitation events on a system-wide annual average basis (wet weather capture).

City of Lakewood					
SWMM Typical Year Flow and Pollutant Loadings					
	Flow (MGal)	CBOD (lbs)	<i>E. coli</i> (cfu)	TP (lbs)	TSS (lbs)
WWTP Influent	2,787	1,843,662	2.06E+18	70,000	2,747,213
To NEORSD	398	27,142	3.04E+16	1,030	40,469
Lakewood Outfalls	577	30,720	2.30E+16	1,129	56,356
Total Quantity Treated	3,185	1,870,804	2.09E+18	71,030	2,787,682
Percentage of Total Flow Captured for Treatment	83.2%	98.2%	98.8%	98.3%	97.8%
Percentage of Wet Weather Flow Captured for Treatment	73.1%	94.3%	96.0%	94.4%	93.2%

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CHAPTER 1 – INTRODUCTION

1.1 OBJECTIVE

After submittal of the Lakewood Storm Water Management Model (SWMM) to the United States Environmental Protection Agency (USEPA), the City of Lakewood (City) began work to add pollutant loadings to the model. Pollutants added to the model include total suspended solids (TSS), carbonaceous biological oxygen demand (CBOD), total phosphorous (TP), and *Escherichia coli* (*E. coli*) bacteria. The objective of modeling pollutants is to characterize their concentrations in:

1. Untreated Overflows
2. Wastewater Treatment Plant (WWTP) influent on dry and wet days

This characterization will enable comparison of wet weather improvement alternatives to provide the most cost-effective improvement to the water quality of Lake Erie.

1.2 POLLUTANT SOURCES

SWMM has the following six methods to add pollutants to the hydrologic model:

1. Dry Weather Flow (DWF) – In the Lakewood hydrologic model, SWMM's DWF parameter was used to model daily input of normal sewage flow. Average concentrations of pollutants in sewage are input values for all DWF. The DWF flows are multiplied by these concentrations to calculate pollutant loadings into junction nodes.
2. Rainfall Dependent Infiltration and Inflow (RDII) – Average concentrations of pollutants in RDII are input values applied to all RDII. The RDII flows are multiplied by these concentrations to calculate pollutant loadings into junction nodes.
3. Subcatchment Runoff – Pollutants are deposited and accumulate on subcatchment land during dry weather. These pollutants are then washed off the land during wet weather. SWMM has four equations available to calculate buildup and three equations available to calculate washoff. These equations are developed for different land use types (i.e. residential, commercial, industrial, etc.). In the Lakewood pollutant model, subcatchment buildup/runoff parameters are calibrated using flow meter and sampling data for four types of land use:
 - a. Low-Density Residential
 - b. Medium-Density Residential
 - c. High-Density Residential
 - d. Commercial/Industrial

A fifth type of land use, Open Space, uses 50% of the calibrated Medium Density Residential values.

4. Rainfall – Average concentrations of pollutants in rainfall are available in SWMM. If used, the rainfall volumes are multiplied by these values. In sewer studies, such concentrations are generally not significant compared to other sources. For the Lakewood model, rainfall pollutants were considered to be included in the Subcatchment Runoff and RDII values.
5. Direct Flow - In the Lakewood model, SWMM's Direct Flow parameter was used in the hydrologic model to represent dry weather infiltration of groundwater. Concentrations of pollutants in groundwater are generally not significant compared to sewage. For the Lakewood pollutant model, Direct Flow pollutants were considered to be included in the DWF values.
6. Groundwater – The use of Aquifers and Groundwater equations are an alternative method of modeling pipe joint infiltration in the hydrologic model. Average concentrations of pollutants in Groundwater are data input values. The Groundwater flows are multiplied by these values. For the Lakewood model, the Groundwater function was not used in lieu of Direct Flow. If it had been used, pollutant concentrations would be considered not significant compared to sewage, and therefore included in the sewage values.

This report details the development of the pollutant model using pollutants in sewage, RDII and subcatchment runoff.

1.3 ORGANIZATION OF THIS REPORT

Chapters 2 through 4 describe the analysis used to develop pollutant parameters. Chapter 2 analyzes DWF parameters. Chapter 3 analyzes RDII parameters. Chapter 4 analyzes Subcatchment buildup and washoff parameters.

Chapter 5 analyzes dry weather sewage flow. It describes the development of the diurnal sewage flow pattern, and it presents the results of sampling and testing for *E. coli*.

Chapter 6 analyzes a typical year of rainfall and calculates pollutant loadings to the WWTP. It also presents the quantity of pollutants discharged to NEORSD and to Lake Erie from Lakewood outfalls.

CHAPTER 2 – DRY WEATHER FLOW POLLUTANTS

2.1 INTRODUCTION

Dry weather flow has two components: sewage and groundwater. Sewage is highly polluted while groundwater is much cleaner. Sewage is composed of human waste and household wastes. It has high concentrations of the pollutants being modeled: CBOD, *E. coli*, TP and TSS. Groundwater originates with rainfall that soaks into pervious areas, and percolates down to the water table. Within the water table, the rainfall slowly flows laterally through the soil and into defective sewer pipes and manholes (sewer studies term this groundwater infiltration as opposed to the surface infiltration term used by hydrologists). As the rain water soaks into the ground, the soil filters out solids. As it travels through the soil, vegetation absorbs nutrients and biological action breaks down bacteria that were picked up on the surface. Usually, within twenty feet of the surface, the water is significantly cleaner. As a result of these actions, the groundwater that infiltrates into the sewers is much cleaner than the sewage portion of the dry weather flow. For the model, pollutant loadings are applied to the sewage portion of dry weather flow and include any pollutants that might be in groundwater.

On a year round basis, the daily flow rate of sewage is more consistent than groundwater. In the clay soils of Lakewood, the sewer trenches act as French drains and control the water table. In the spring, groundwater infiltration rates are higher as snow melt and spring rains raise the water table. In the summer and fall, the water table falls and flow rates decrease as vegetation and evaporation assimilate a significant portion of the rainfall. Groundwater flow rates vary seasonally; however, dry day pollutant loadings at the WWTP are fairly consistent from month to month. This consistency is another justification for assigning pollutants to sewage only.

For the Lakewood model, the groundwater and sewage are both hydraulically entered at junction nodes. Sewage is hydraulically entered using the “DWF” parameter. Groundwater is hydraulically entered using SWMM’s “Direct” parameter. Pollutants are introduced into the model as concentrations within DWF. These concentrations are calculated from the influent data as measured and reported by the WWTP.

2.2 SEWAGE FLOW CALCULATIONS

The portion of the WWTP flow attributable to sewage was calculated from water billing records. Monthly billed water consumption for the years from 1998 to 2010 was entered into a spreadsheet. Figure 2-1 is a graph of the average monthly water usage billings. The graph does not add non-billed water (i.e. fire stations and City Hall) and does not subtract normal water usage not returned to the sewer (i.e. cooking, home humidifiers, etc. – these tend to cancel each other out). There is a noticeable increase in summer months due to non-sewage generating water consumption (i.e. car and house washing, lawn and garden sprinkling, etc.). Excluding the extraordinary summer water demand, the average daily consumption for the 13 years was calculated to be 4.409 MGD. However, Lakewood has experienced a drop in water consumption. The reason for the drop in consumption is beyond the scope of this study;

however it may be due to rising water rates, water conservation practices, declining population, and/or economic impacts. Figure 2-2 is a graph of total yearly water billings (excluding the extraordinary summer water demand). An Excel trendline was applied to the values. The equation for the trendline was used to calculate a water consumption of 3.693 MGD for 2011. This 3.693 MGD value is comparable to the average daily consumption of 3.256 MGD billed from September 2010 to May 2011.

The model has some flow that is not tributary to the Lakewood WWTP. A portion of southwest Lakewood discharges to Northeast Ohio Regional Sewer District (NEORS) near Riverside Drive @ Fischer Road. A portion of southeast Lakewood discharges to NEORS at the intersection of Berea Road with West 117th Street. During wet weather, a third area on the east side of Lakewood discharges to NEORS on West 117th Street near Edgewater Drive. These three locations discharge a total of 0.165 MGD of sewage to NEORS. An additional flow of 0.060 MGD has been found as illicit connections to the sewers (since rectified). These flows are not tributary to the WWTP, and they reduce average daily influent flow to 3.031 MGD.

$$3.256 \text{ MGD} - (0.165 + 0.060) \text{ MGD} = 3.031 \text{ MGD}$$

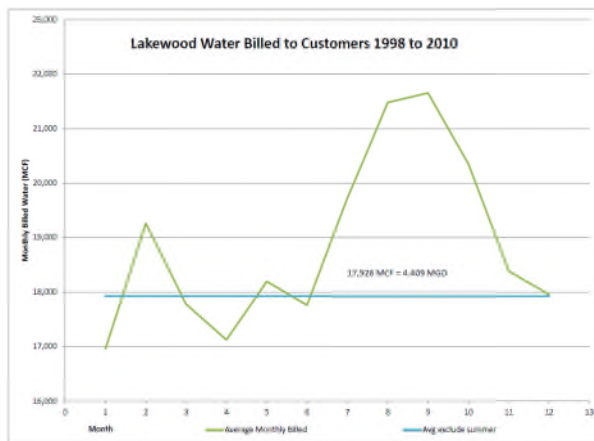


Figure 2-1 Average Monthly Water Usage Billed (MCF – 1,000 cubic feet)

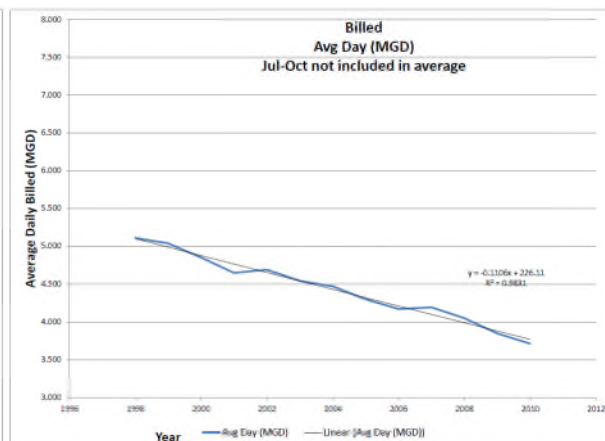


Figure 2-2 Yearly Water Billings (MGD – million gallons per day)

2.3 SEWAGE LOADINGS – CBOD, TP AND TSS

Daily wastewater treatment plant (WWTP) influent concentrations of CBOD, TP and TSS were entered into a spreadsheet from data reported in the monthly DMRs. The data for years 2010 to 2014 were input. All the days had flow and rainfall data. The WWTP generally measured concentrations of TSS five days a week, CBOD four days a week and TP two days a week. These influent flows and concentrations were used to calculate the daily influent loadings within the spreadsheet.

The data was sorted from lowest to highest flow to determine dry and wet day conditions.

- Dry day flow is composed of sewage and groundwater with all the pollutants coming from the sewage. A review of the rain and flow data indicated that flows rose after rainfall and sometimes stayed elevated on following days. Flows were also elevated in winter and spring due to snow melt. After removing days with rainfall and the subsequent wet days, the spreadsheet data was sorted by flow and examined to determine a flow that could confidently be considered as dry weather. After excluding possible snow melt values that occurred in winter months, the examination found that non-rain affected flows were generally less than 5.7 MGD. As a result, spreadsheet data were classified as dry day values when the total flow was 5.7 MGD or less.
- Wet day flow is composed of sewage, groundwater and rainfall dependent infiltration and inflow (RDII). Since rainfall is needed to wash off pollutants into RDII, the daily values were classified as wet days when rainfall was recorded.
- Days with greater than 5.7 MG but no rainfall were classified as in-between days and not used for dry weather pollutant concentrations.

Pollutant loadings were calculated for the dry days that were sampled. The spreadsheet totaled the loadings for the five years of DMR data and counted the number of days that were tested. Sewage concentrations were calculated as the total loadings divided by the total volume of sewage flow. With parts per million (ppm) being equivalent to milligrams per liter (mg/l), the general form of the equation is:

$$(\text{Total lbs} / (8.34 \text{ lb/gal})) / (3.031 \text{ MG/day} \times \text{number of days sampled}) = \text{concentration (mg/l)}$$

The average concentrations of these pollutants in Lakewood sewage are shown in Table 2-1.

2.4 SEWAGE CONCENTRATIONS – *E. COLI*

E. coli is not sampled in the influent flow to the WWTP. The *E. coli* concentration shown in Table 2-1 is based on concentrations calculated in Appendix B – Sampler E.

Table 2-1 City of Lakewood Yearly WWTP Influent Sewage Loads and Concentrations on Dry Days, 2010-2014				
Pollutant	CBOD	<i>E. coli</i>	TP	TSS
Pollutant Concentration Calculations				
Total loading (lbs)	2,028,004	n/a	40,808	3,880,474
Number of days sampled	454	n/a	240	589
Sewage volume (MG)	1376	n/a	727	1785
Sewage concentration (mg or cfu)/l	177	4.43x10 ⁸	6.73	261

2.5 YEARLY SEWAGE POLLUTANT LOADINGS

The sewage concentrations of pollutants were used to calculate total yearly loadings from sewage. These yearly pollutant loadings to the WWTP are based on the current 3.031 MGD of sewage reaching the WWTP. The general form of the yearly loading equation is as follows:

$$(3.031 \text{ MG/day}) \times (365 \text{ days/year}) \times (\text{concentration mg/l}) \times (8.34 \text{ lb/gal}) = \text{Total lbs/year}$$

These yearly loadings in Lakewood sewage are shown in Table 2-2. The yearly *E. coli* loading is also based calculations in Appendix B – Sampler E.

Table 2-2 City of Lakewood Yearly WWTP Influent Sewage Loadings				
Pollutant	CBOD	<i>E. coli</i>	TP	TSS
	(lbs)	(cfu)	(lbs)	(lbs)
Yearly sewage loading (lbs or cfu)	1,630,000	1.09x10 ¹⁸	62,100	2,405,000

The values in Table 2-2 are less than the total typical year values shown in the Executive Summary because they are only the sewage portion of the total yearly loadings.

CHAPTER 3 – RAINFALL DEPENDENT INFILTRATION AND INFLOW POLLUTANTS

3.1 INTRODUCTION

Rainfall Dependent Infiltration and Inflow (RDII) is flow that quickly enters a sewer collection system when rainfall occurs. In areas with older sewers, RDII may infiltrate into defective sewer joints. Roof downspouts are modeled as RDII if they are directly connected to the sewer. In the Lakewood SWMM model, the RDII flow is introduced into the sewer at junction nodes. Hydraulically, RDII is introduced as an additional equation separate from Direct Flow and DWF. The RDII represents runoff from roofs and leaking joints that are directly or indirectly connected to the sewer.

Since RDII is associated with runoff, it picks up pollutants as it flows down the roofs. These pollutants are introduced into the SWMM model as average concentrations in RDII. These average concentrations are applied to the RDII throughout the runoff period. Pollutant concentrations are applied to all RDII sources regardless of the type of land use. The values for RDII concentrations are calculated from WWTP DMRs and flow sampling.

3.2 CBOD, TP AND TSS

The same five years (2010 to 2014) of Lakewood WWTP DMRs were analyzed to determine the values of CBOD, TP and TSS in the wastewater on wet days. The wet days were considered to be any day with rainfall. Influent pollutant loadings were calculated using influent flows and concentrations. The RDII pollutant loadings were the net increase in the pollutant loadings after subtracting the portion that comes from sewage. The RDII concentrations are calculated by dividing this net increase in pollutant loading by the net increase in flow volume and then converting to milligrams per liter (mg/l). The general equation for calculating the concentrations is as follows:

$$\text{concentration} = \frac{(\text{Total Wet Weather Pounds} - \text{Pounds of Dry Weather Portion}) \div 8.34 \text{ lb/gal}}{\text{Total wet weather flow (MG)} - \text{Dry Weather Flow Portion (MG)}}$$

The concentration units in the above equation are gallons per million gallons (gal/MG) which is equivalent to parts per million (ppm) or milligrams per liter (mg/l).

Because of the different frequencies of influent pollutant sampling, the number of wet days had to be counted separately for each pollutant to calculate the associated DWF pounds and DWF volume. Table 3-1 lists the wet day volumes and loadings for the five years of DMR data.

Table 3-1
Lakewood Wet Day Influent Pollutants

Year	CBOD			TP			TSS		
	Wet Day Load (lbs)	Wet Day Flow (MG)	Number of Wet Days	Wet Day Load (lbs)	Wet Day Flow (MG)	Number of Wet Days	Wet Day Load (lbs)	Wet Day Flow (MG)	Number of Wet Days
2010	390,477	760	78	8,251	469	43	710,468	949	95
2011	523,538	1,429	88	9,256	716	43	1,152,581	1,733	110
2012	322,216	765	65	6,680	431	37	774,028	966	85
2013	360,255	779	66	6,879	387	35	756,916	949	82
2014	508,883	870	86	10,743	467	44	851,604	1,033	104
Total	2,105,369	4,603	383	41,809	2,470	202	4,245,597	5,630	476
DWF	1,710,849	1,161		34,347	612		3,136,003	1,443	
Net	394,520	3,442		7,462	1,858		1,109,594	4,187	
Concentration(mg/l)		13.7		0.48			31.8		

3.3 *E. COLI*

The concentration of *E. coli* in runoff from medium density residential land (see Appendix B – Sampler D) is used for *E. coli* in RDII. The Sampler D flow weighted average value of 4.53×10^5 cfu per 100 ml is used for the SWMM RDII input value 4.53×10^6 cfu/liter.

3.4 COMPARISON TO NSQD VALUES

The calculated pollutant concentrations were compared to average values in the University of Alabama's National Stormwater Quality Database (NSQD), Version 4.02, (March 17, 2015). The NSQD average BOD5 value for stormwater is 12 mg/l. Other studies have found that BOD values average 16% higher than CBOD values. The CBOD value in the model is 32% higher ($13.7 \times 1.16 \div 12 \times 100 = 32\%$) compared to NSQD. The *E. coli* value of 453,000 cfu/100ml is 56 times higher than the NSQD average of 8,033 cfu/100ml. The higher *E. coli* concentration may be due to higher density housing and associated higher pet waste buildup as compared to the NSQD study. Since similar high *E. coli* concentrations were measured in the other sampled locations, its value was considered appropriate. The Total Phosphorous concentration of 0.48 mg/l is comparable compared to the NSQD average Total Phosphorous concentration for stormwater of 0.42 mg/l. The TSS concentration of 31.8 mg/l is significantly lower compared to the NSQD TSS concentration for stormwater of 134 mg/l. Although there are differences between NSQD and RDII calculated values, the calculated concentrations were used in the SWMM model as initial values when calibrating the model to a typical year of rainfall.

CHAPTER 4 – SUBCATCHMENT RUNOFF POLLUTANTS

4.1 INTRODUCTION

In SWMM, surface water is modeled as runoff from pervious and impervious surfaces within a defined area known as a subcatchment. Hydrologic flow rates are calculated and merged together in the hydraulic model of the collection system. The input parameters used to calculate the volume of runoff do not consider the pollutants on the surface of the land

As water runs off the surfaces in the subcatchment, it picks up pollutants. Different land uses have different amounts of pollutants building up on the ground between storms. For example, a fast food parking lot collects CBOD (from food litter) and bacteria (from scavenger birds) but little TSS from disturbed ground. Residential properties have TSS from ground disturbing activities and bacteria from pet waste. SWMM allows for different pollutant buildup rates depending on the land use. When it rains these pollutants are washed off into the sewer system and flow to the WWTP. SWMM allows for different washoff rates depending on the land use and type of pollutant.

This chapter details the development of the pollutant buildup and washoff equations for the Lakewood SWMM model. Flow meters and samplers were used to measure the runoff rates and pollutant concentrations in the sewers from four subcatchments which represented different land uses. Washoff loadings were calculated from the flow data and pollutant analysis of the samples. Buildup and washoff equations were chosen from SWMM's available options. Finally, a trial and error method was used to develop the appropriate coefficients to use in the buildup and washoff equations.

4.2 LAND USE CALCULATIONS

Lakewood's pollutants are modeled in the following five types of land use (% is of total land in the Lakewood SWMM model).

1. 20% Low-density residential – Single and two-family residential properties with land area greater than $\frac{1}{4}$ acre in size.
2. 60% Medium-density residential – Single and two-family residential properties with land area less than $\frac{1}{4}$ acre in size.
3. 5 % High-density residential – Properties classified as apartments.
4. 10% Commercial/Industrial – Properties with large impervious areas. In addition to commercially and industrially used properties, this group also includes properties listed as institutional (municipal, schools and churches), highway, and active recreation areas.
5. 5% Open Space – Properties with large pervious areas. This group includes the following types of land uses broken down by percentage of total open space
 - a. passive green space 78%
 - b. railroads 13%
 - c. utility 9%

Several subcatchments outside Lakewood were included for the hydraulic portion of the model only. These subcatchments are tributary to NEORSD's Northwest Interceptor sewer which carries some of the pollutants from the three connection points described in Section 2.2. No pollutants are calculated for the non-Lakewood flow into the interceptor.

For each Lakewood subcatchment in the model, a percentage was calculated for each type of land use. The Cuyahoga County Auditor's database of Lakewood properties was downloaded and sorted by land use. For one and two family residential properties, the data was further sorted by lot size. Several lot sizes were examined to determine a break point between low-density and medium-density residential land. A break point of $\frac{1}{4}$ acre resulted in 75% of the residential land being medium-density and the remaining 25% being low-density. GIS was used to assign the properties to their respective land use designations. Thiessen polygon capability was used to extend the property lines to the center of the street. The revised acreages were totaled for each type of land use within each subcatchment. Appendix A is a summary table with the acreage of each subcatchment and the percentage of each land use type within the subcatchment. The final step was to enter the fractional value of each type of land use into the model.

4.3 SUBCATCHMENT RUNOFF MEASUREMENTS

Five flow meter/samplers were used to collect pollutant loadings from the different land uses. The samplers were configured to take up to eight discrete samples when activated by a flow depth sensor. The flow meters measured the flow in the sewers and also recorded the time each sample was taken. The meter/ samplers were in the sewers from July 17, 2015 to September 30, 2015.

4.3.1 SAMPLER AND FLOW METER LOCATIONS

Aerial photographs and local knowledge were used to select representative subcatchments for four different land uses. The Lakewood sewer maps were then used to refine the selection to choose areas that had a good meter/sampling locations carrying the runoff out of the subcatchments. A fifth meter was placed in a sewer to collect sewage samples from a medium-density residential area to develop a diurnal flow pattern and to measure *E. coli* concentrations in sewage. The locations chosen for the meter/samplers are shown in the following aerial photos (Figures 4-1 to 4-5).



Figure 4-1	Land Use Description	Diameter (inches)	Model ID	Location
Site A	Low-density Residential	30	002T3741	Lake, west of intersection with Clifton & Forest

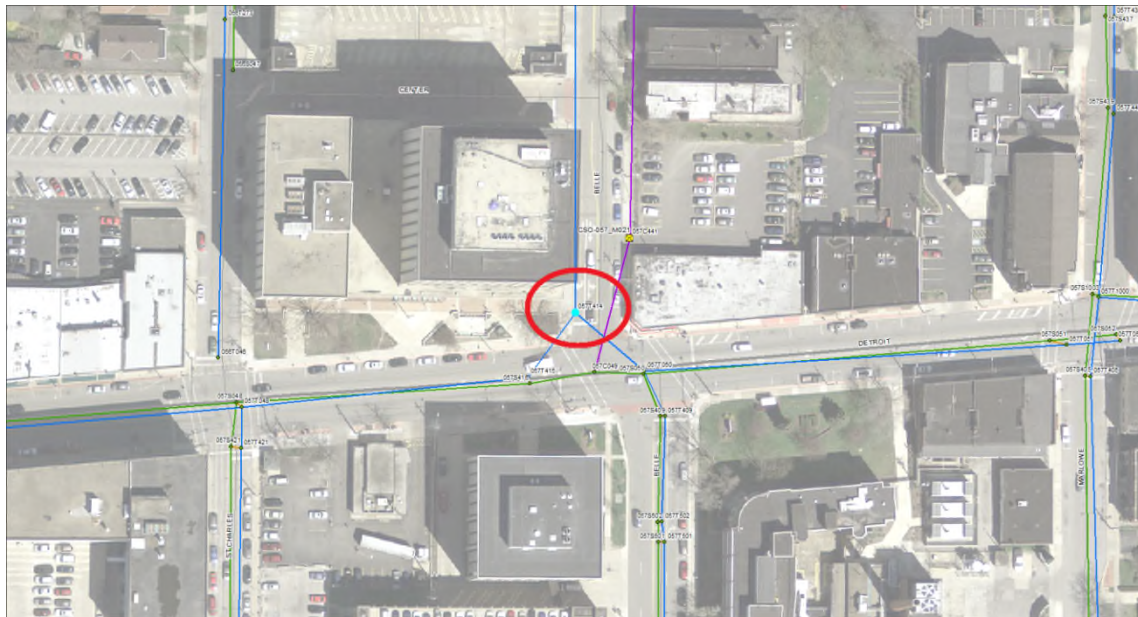


Figure 4-2	Land Use Description	Diameter (inches)	Model ID	Location
Site B	Commercial	60	057T414	Intersection of Detroit & Belle



Figure 4-3	Land Use Description	Diameter (inches)	Model ID	Location
Site C	High-density Residential	48	059T4120	Edgewater, west of W.117 th St.



Figure 4-4	Land Use Description	Diameter (inches)	Model ID	Location
Site D	Medium-density Residential	36	052T074	Hilliard & Eldred



Figure 4-5	Land Use Description	Size (inches)	Model ID	Location
Site E	Medium-density Residential	10	052S075	Hilliard & Eldred

The flow meters associated with the samplers recorded flow rates which were used to calculate pollutant loadings. The flow rates were calculated as area of flow (based on depth) times the velocity of flow (using ultrasonic Doppler technology). CT performed a QA/QC analysis of the flow data (described below) prior to calculating pollutant loadings.

4.3.2 QA/QC OF DEPTH READINGS

There are several potential problems with depth readings. First, depth sensors sometimes send an anomalous value to memory (i.e. a single 5-minute reading that jumps from normal depth to a very high value then back to normal depth). These depths are replaced with the average of the before and after readings. Second, the sensor may experience hysteresis (where after a rain event the normal depth is consistently higher or lower). These depth values are adjusted by a constant value that adjusts the post event water levels to prior values. Third, the depth sensors can experience drift (where the normal levels slowly increase or decrease from actual values). These depth values are adjusted by applying a uniformly increasing or decreasing value that is based on observed actual depths during site visits. After correcting the meter depth values, the data is ready for the velocity QA/QC procedures.

4.3.3 QA/QC OF VELOCITY READINGS

There are several potential problems with velocity readings in sewers. First, velocity sensors do not always record a velocity due to the relative clearness of the water (not enough particles to reflect back an ultrasonic signal). Second, the turbulence of the flow sometimes causes the velocity sensors to record a negative value. Third, at low depths, the velocity sensor does not pick up an accurate value. Fourth, in any large set of depth-velocity data points there are some velocity values outside the normal range (outliers). Fifth, the velocity sensor is sometimes blinded by debris. These problems are fixed by the QA/QC analysis described below.

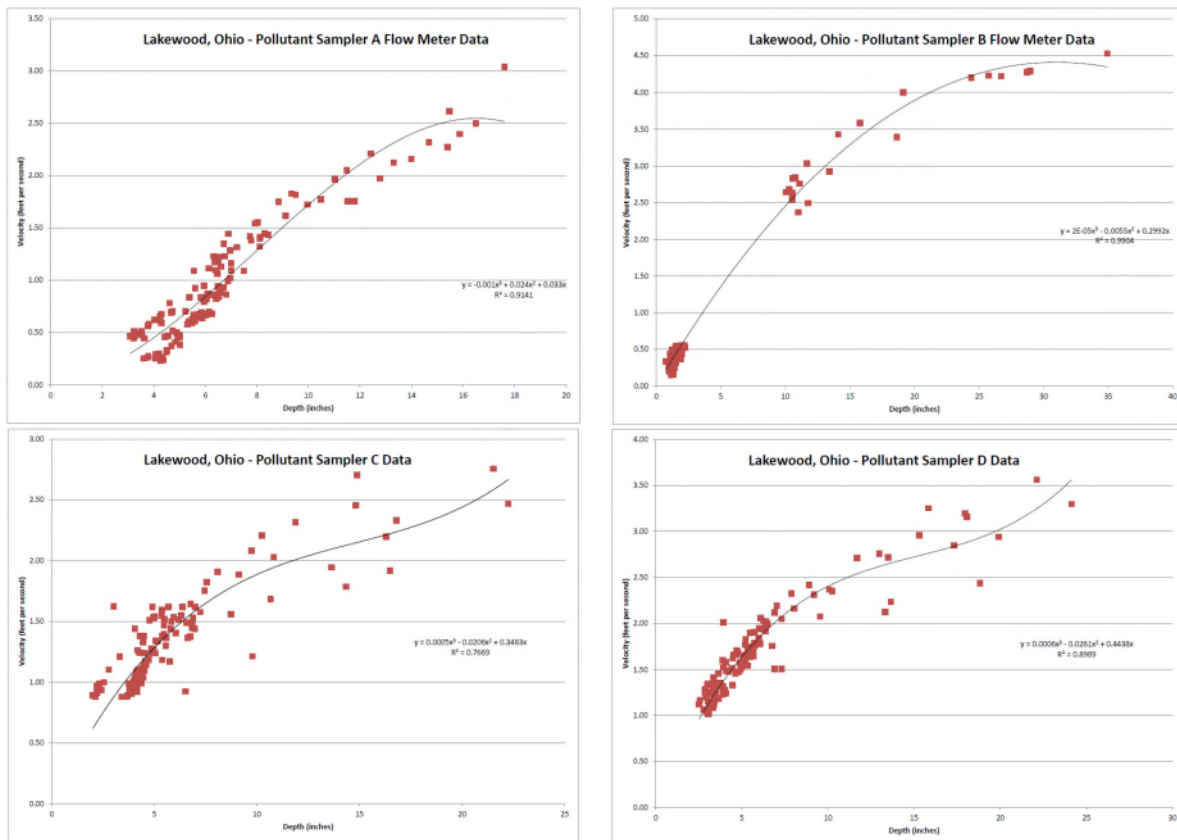
The QA/QC of velocity uses an Excel spreadsheet to correct velocity problems. First, the raw date/time, adjusted depth, raw velocity and raw flow data are entered into the spreadsheet. The data is then sorted by depth to capture all readings where there was flow in the sewer. Zero depth readings that have a velocity are temporarily set aside. Depth readings that have negative velocities are also temporarily set aside. Readings that have depth and velocity are placed in an Excel scattergraph. A preliminary polynomial equation is fit to these points using the Excel trendline function and forcing a 0,0 intercept. Outlier readings are removed from the dataset as are the many readings with very low depths or velocities. Outliers were determined by visually inspecting the plotted data and removing extremes, defined as data points that were more than 50% off the trendline. A final scattergraph and third order trendline is prepared from the remaining points in the dataset. The equation for the trendline is then used to calculate velocities for depth data that did not have a velocity. Points with negative velocities are examined relative to the context of other data points at that time. If the negative velocity appears to be an anomaly, the equation is used to calculate a positive value. Finally, the equation is reversed to calculate depths for data points that have a velocity and no depth.

Table 4-1 is a summary of the number of data points taken by the flow meters at the sampler locations.

Table 4-1					
Lakewood Samplers – Categories of Flow Meter Data					
Sampler with Flow Meter	Number of Readings				
	Depth with Zero Velocity	Velocity with Zero Depth	Depth with Negative Velocities	Readings used for Preliminary Scattergraph	Readings used for Final Scattergraph
A	2143	0	10	258	143
B	1893	0	0	295	118
C	3963	1	16	771	226
D	256	0	71	205	125
E	504	11	2	821	9

4.3.4 TRENDLINE EQUATIONS

The scattergraphs for Samplers A through D are shown below:



The trendline equations for velocity based on depth in the above scattergraphs are:

- Meter A - Velocity = $-0.00100 \text{ depth}^3 + 0.0240 \text{ depth}^2 + 0.0330 \text{ depth}$
- Meter B - Velocity = $+0.00002 \text{ depth}^3 - 0.0055 \text{ depth}^2 + 0.2992 \text{ depth}$
- Meter C - Velocity = $+0.00050 \text{ depth}^3 - 0.0206 \text{ depth}^2 + 0.3483 \text{ depth}$
- Meter D - Velocity = $+0.00060 \text{ depth}^3 - 0.0261 \text{ depth}^2 + 0.4438 \text{ depth}$
- Meter E - Insufficient number of points to confidently prepare a trendline

The above equations were used to calculate velocities for the zero values and the temporarily ignored readings.

4.4 SWMM CHANGES FOR POLLUTANT CALIBRATION

Several changes were made to simplify the SWMM model and decrease run times for pollutant calibration.

1. Prepared rainfall and climate files for sampling time period. Downloaded rainfall data in 5-minute increments to better model short duration high intensity periods of rainfall.

2. Ran the model for the sampling time period and downloaded flow and depth time series for the manholes downstream of the samplers. Converted the manholes downstream of the sampler locations to outfalls and applied the time series to the outfall to match flow depths to the full model.
3. Stripped out subcatchments, conduits, outfalls and nodes not contributing to a flow meter.
4. Ran the stripped down model for the time period. This reduced the runtime from 3 hours to 75 seconds.
5. Converted link 057T547_057T547A from a vortex valve to a 12-inch orifice. This decreased the flow routing continuity error from -52% to -0.03%.

Additional changes were made to the subcatchments tributary to the sampler/meters. These changes and additional notes specific to the sampled areas are described in the following subsections. The parameter names as used by SWMM are shown in italics.

4.4.1 METER SITE A

Initially, Site A runoff volume in SWMM was 30% of the metered volume. This was due to some subcatchment settings which reduced the runoff to the sewers. To better compare SWMM pollutant loadings to metered and sampled loadings, the following adjustments were made to the subcatchment data:

1. Doubled the subcatchment width to cut the flow path length in half. This better models a subcatchment with a street in the middle and runoff coming in from both sides.
2. % *Routed* (to pervious) decreased from 50% to 30% (this is a reduction in the amount of sidewalks, patios, driveways, etc.) that drain onto grassy areas.
3. % *Zero Impervious* increased from 50% to 80% (this is the percentage that does not have puddles after the rain event).
4. Moved the outlet of subcatchment S002T3741 from 002T3741 to 002T3740 to include its runoff with the sample/metered data.

4.4.2 METER SITE B

Site B is a mixture of commercial and medium density residential subcatchments. There are five commercial subcatchments, three mixed commercial/medium-density residential, and six medium-density residential subcatchments tributary to the sampler/meter. Site D was calibrated first and its buildup and washoff parameters used for the residential portions of the subcatchments. The remaining pollutant loadings were then used to develop the commercial parameter values.

Initially, Site B had more runoff in SWMM compared to the metered data. The model had a high percentage of the commercial area connected to the sewer as RDII. The commercial subcatchments also had the impervious area with a high percentage flowing onto pervious land. Changes to the model include:

1. For the commercial subcatchments:
 - a. Changed the rain gauge for subcatchments S057T047 and S057T048 from RG_Lincoln to RG_Fire_1. This is the rain gauge for all the other subcatchments in area B.
 - b. Changed the % *Routed* from pervious to *Outlet*. This directs impervious runoff directly into the sewer instead of onto grass.
 - c. Doubled the ground slope to create steeper rising and falling hydrograph limbs.
2. For the medium density subcatchments:
 - a. Decreased % *Impervious* of each subcatchment by 7%.
 - b. Doubled the ground slope to create steeper rising and falling hydrograph limbs.

4.4.3 METER SITE C

Initially, Site C had no runoff in SWMM for any rainfall less than 1-year storm. Consequently, there was no runoff in the model during the metering/sampling period. Since the flow meter measured wet weather flow increases, subcatchment parameter changes were made to the model. These changes include:

1. % *Impervious* increased from 40% to 60% to reflect more parking area and the high density large buildings.
2. % *Zero Impervious* increased from 25% to 50% to reflect fewer puddles on roofs and parking areas
3. *D Store Impervious* (the depth of puddles in impervious areas) decreased from 0.137 inches to 0.070 inches to reflect shallower puddles.
4. % *Routed* (flow routed from impervious area to pervious area) decreased from 100% to 25% to reflect drainage systems for the parking areas and roofs.

4.4.4 METER SITE D

Initially, Site D had more runoff in SWMM compared to the metered data. The model had an average 23% of the impervious area connected to the sewer as RDII. This would include mostly roofs and other sources that do not flow onto pervious areas. The remaining impervious area needed to have a higher percentage flowing onto pervious land. Changes to the model include:

1. Decreased % *Impervious* from 70% to 37%
2. Increase % *Routed* (impervious to pervious) from 20% to 50%
3. Increased % *Impervious* with no storage from 55% to 75%

4.5 POLLUTANT BUILDUP AND WASHOFF IN SUBCATCHMENTS

Pollutants accumulate on the ground until rainfall washes them off and into the collection system. In the Lakewood SWMM model, the buildup accumulations are measured in pounds per acre, and washoff is also calculated in pounds per acre but then converted to a concentration in the runoff. Development of buildup and washoff equations is detailed in the following sections.

4.5.1 POLLUTANT BUILDUP EQUATION

Four options are available in SWMM to model pollutant buildup¹. One option would use a time series if actual buildup data were available. This option was eliminated because there were no measurements available of buildup over time for the four types of land use. Three other options are buildup equations that are graphed in Figures 4-6 to 4-8.

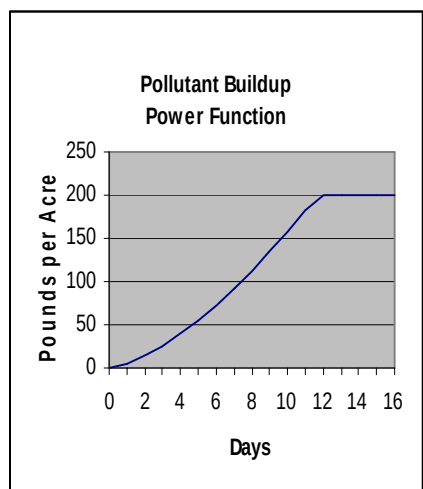


Figure 4-6 Power Function

Power Function - pollutants build up slowly at first, then more rapidly after a few days to a maximum value.

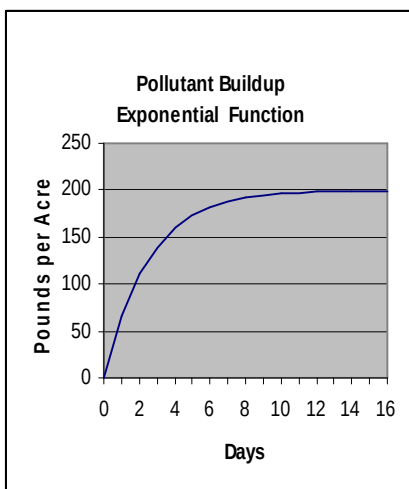


Figure 4-7 Exponential Function

Exponential Function – pollutants build up very rapidly in the first few days, then the buildup slows down to a maximum value

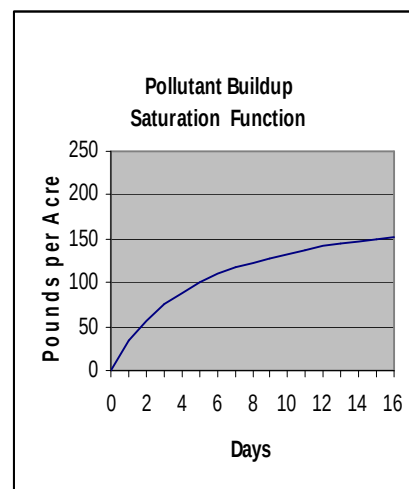


Figure 4-8 Saturation Function

Saturation Function –pollutant buildup is initially more rapid, then it tapers as the quantity approaches a maximum value.

All three equations were evaluated for each pollutant in the model. In Lakewood's residential areas, the pollutants accumulate from wildlife deposits, pet deposits, residential activity (lawn cutting and gardening), construction activity, and windblown dust and debris. Eventually, residents will take action to reduce the amount of pollutants on their property, thus there should be a maximum value. The buildup is fairly steady, and the saturation function was chosen to represent buildup of the pollutants in the model.

In the SWMM manual, the general form of the saturation equation is:

$$\text{Buildup (lbs per acre)} = C1 \text{ (lbs per acre)} * \text{Days} / (C2 + \text{Days})$$

¹ Lewis A. Rossman, Storm Water Management Model, User's Manual Version 5.1 - Hydrology, EPA/600/R-14/413b, US EPA Office of Research and Development, (September 2015), pp. 65-66.

The constant C1 is the maximum possible buildup and C2 is the number of days to reach half the value. Initial maximum values were calculated from the quantity of pollutants washed off and sampled. The number of days to half saturation was determined by trial and error in conjunction with development of the washoff equation.

4.5.2 POLLUTANT WASHOFF EQUATION

Rainfall washes the remaining pollutants off the ground and into the collection system. The SWMM manual provides three (3) equations² to model rain induced pollutant washoff. All three algorithms will track the quantity of pollutants washed off until no more are remaining on the ground.

1. Event Mean Concentration - washoff is proportional to runoff. The concentration of pollutants in the washoff does not change. The sampling data does not support this method. First flush (high concentrations) were observed in the data set.
2. Rating Curve - washoff is proportional to runoff raised to a power. A more intense rain will wash pollutants off faster. This equation does not account for the quantity of pollutants on the ground.
3. Exponential – washoff is proportional to the product of runoff raised to a power and to the amount of buildup remaining. Not only will a more intense rain wash pollutants off faster, but if there are more pollutants on the ground, there will be more in the washoff. This equation was selected as intuitively being more representative of the actual washoff process.

In the SWMM manual, the form of the exponential washoff equation is

$$\text{Washoff} = C1 * \text{runoff rate (inches/hour)}^{C2} * \text{pollutant buildup (lbs)}$$

The C1 and C2 constants in this equation are different from those in the buildup equation. By trial and error and in conjunction with the buildup equations, the final values for these C1 and C2 constants were determined for the four pollutants (refer to Table 4-3).

4.5.3 STREET SWEEPING

SWMM uses street sweeping to remove pollutants once they are on the ground. SWMM's street sweeping routine removes a portion of these pollutants based on the frequency and extent of the sweeping (SWMM parameter names are shown in italics). Lakewood generally sweeps the main arterials every two weeks and residential streets every four weeks (the line labeled *Interval* in Table 4-2). The commercial and high-density land uses are generally located on arterial streets, and low-density and medium-density housing are mostly located on the residential streets. The sweeping season runs from late spring after the snow season until fall when the city switches to leaf pickup.

² Lewis A. Rossman, Storm Water Management Model, User's Manual Version 5.1 - Hydrology, EPA/600/R-14/413b, US EPA Office of Research and Development, (September 2015), pp. 66-67.

Lakewood had 500 cubic yards of sweepings in 2013 and 750 cubic yards in 2014. At 1.3 tons per cubic yard of sweepings³, the weights for the two years are 650 and 975 tons respectively. Based on an average moisture content of 11%,⁴ and converting from tons to pounds, the dry weight of the sweepings is 1,160,000 and 1,740,000 pounds in 2013 and 2014 respectively. These values will be compared to SWMM calculated values in the output report file for a typical year.

The following calculations determined street sweeping parameters for the four land uses in the Lakewood SWMM model pollutant calibration areas. The length of the streets multiplied by their width is the acreage available to sweepers. This acreage divided by the total subcatchments acreage is the fraction available to sweepers (the line labeled *Availability* in Table 4-2). Sweeping was set to be 90% effective (the line labeled *Cleaning Effic.* in Table 4-2) in removing the buildup of pollutants from the *Availability* area. Table 4-2 lists the data used to calculate the street sweeping parameters. The area tributary to Sampler B is a mixture of commercial and residential properties – for the Table 4-2 commercial land use column, only the commercial properties were used for the calculations.

Table 4-2 City of Lakewood SWMM Street Sweeping Data				
	Low-Density Residential	Commercial	High-Density Residential	Medium-Density Residential
Sweeping Season	4/15 to 10/15	4/15 to 10/15	4/15 to 10/15	4/15 to 10/15
<i>Interval</i> (days)	28	14	14	28
Meter/Sampler ID	A	B	C	D
Total area (acres)	25.78	23.97	30.1	44.56
Street area (acres)	3.02	4.13	1.81	3.96
<i>Availability</i>	0.12	0.18	0.06	0.09
<i>Cleaning Effic.</i>	90%	90%	90%	90%

With these parameters, SWMM calculated 1,200 pounds of pollutants being removed by street sweeping in the typical year analysis. This poundage is less than the total reported by Lakewood because their sweepings include gross solids (litter and other solid waste) that are not included in the model. Because this SWMM calculated value is less than the City's historical experience, the 90% efficiency of sweeping was not changed.

³ University of Massachusetts, Boston, *Case study: Saving Money through Alternative Disposal of Street Sweeping Debris*, Town of Natick, Massachusetts, (June 2, 2019), http://www.umb.edu/editor_uploads/images/centers_institutes/center_collins_mgmt/Casestudy-StreetSweepingDebrisManagement.06.02.09.pdf

⁴ Sukalyan Sengupta, et.al., *Processing and Reuse of Street Sweepings and Catch Basin Cleanings*, University of Massachusetts, Dartmouth, Street Sweeping (On Site), (July 9, 2007), http://www.trb-adc60.org/downloads/S.%20Sengupta%20_%20K.%20Leach.pdf

4.6 CALIBRATING BUILDUP AND WASHOFF COEFFICIENTS

The previous sections detail the process of developing the buildup and runoff equations. The equations for pollutants in subcatchment runoff were calibrated by graphing the SWMM pollutant loadings with the measured loadings from the sampling data. The final coefficient values are presented in Table 4-3 and the calibration graphs are in Appendix C. The acreage listed in Table 4-3 is the percentage of land that can be swept (streets) from Table 4-2.

Table 4-3				
SWMM Buildup and Washoff Coefficients				
	CBOD	<i>E. coli</i>	TP	TSS
Area A – Low-density Residential: Sweep 28 days, 90% efficiency, 12% of the acreage				
Buildup Equation	Saturation	Saturation	Saturation	Saturation
Max per acre – C1	3.25	6.9×10^{11}	0.13	26
Days to ½ - C2	10	10	14	10
Washoff Equation	Exponential	Exponential	Exponential	Exponential
Coefficient – C1	6	10	5	5
Exponent – C2	0.5	0.5	0.5	0.5
Area B – Commercial/Industrial: Sweep 14 days, 90% efficiency, 18% of the acreage				
Buildup Equation	Saturation	Saturation	Saturation	Saturation
Max per acre – C1	6.10	1.4×10^{12}	0.15	13.7
Days to ½ - C2	10	6	14	10
Washoff Equation	Exponential	Exponential	Exponential	Exponential
Coefficient – C1	6	10	5	5
Exponent – C2	0.5	0.5	0.5	0.5
Area C – High-density Residential: Sweep 14 days, 90% efficiency, 6% of the acreage				
Buildup Equation	Saturation	Saturation	Saturation	Saturation
Max per acre – C1	0.79	1.41×10^{11}	0.051	15.1
Days to ½ - C2	10	10	14	10
Washoff Equation	Exponential	Exponential	Exponential	Exponential
Coefficient – C1	6	10	5	5
Exponent – C2	0.5	0.5	0.5	0.5
Area D – Medium-density Residential: Sweep 28 day, 90% efficiency, 9% of the acreage				
Buildup Equation	Saturation	Saturation	Saturation	Saturation
Max per acre – C1	0.70	2.5×10^{10}	0.03	9.6
Days to ½ - C2	10	10	14	10
Washoff Equation	Exponential	Exponential	Exponential	Exponential
Coefficient – C1	6	10	5	7
Exponent – C2	0.5	0.5	0.5	0.5

The additional land use type, Open Space, did not have calibrated buildup and washoff equations. No sampling was performed to calibrate Open Space pollutant equations – ½ the Medium-density Residential values were used to provide for surface pollution from wildlife and passive recreation.

Table 4-3 (Continued)				
SWMM Buildup and Washoff Coefficients				
	CBOD	<i>E. coli</i>	TP	TSS
Open Space: Sweep 0 days, 0% efficiency, 0% of the acreage				
Buildup Equation	Saturation	Saturation	Saturation	Saturation
Max per acre – C1	0.35	1.25x10 ¹⁰	0.015	4.8
Days to ½ - C2	10	10	14	10
Washoff Equation	Exponential	Exponential	Exponential	Exponential
Coefficient – C1	6	10	5	5
Exponent – C2	0.5	0.5	0.5	0.5

CHAPTER 5 – SEWAGE FLOW ANALYSIS

5.1 INTRODUCTION

Meter Site E was a sewage sampling and metering site. The metering and sampling at this location had two purposes:

1. Measure *E. coli* concentrations in the incoming residential sewage.
2. Establish a diurnal flow pattern for dry days.

This chapter details the analysis of the flow metering and sampling data.

5.2 *E. COLI* CONCENTRATIONS

Sampler E was used to measure the dry weather pollutant concentrations in sewage. These samples were important to acquire data because *E. coli* is not a tested WWTP influent parameter. The sampler was programmed to collect discrete samples at 1 to 2 hour intervals. The 1-hour intervals were set for the higher flow periods of morning and evening, and the 2-hour interval for the middle of the day and middle of the night. The sampler was installed at 10:15 a.m. on July 27, 2015. Lakewood sewer crew collected the samples at 10:15AM on July 28, 2015 and delivered them to an outside laboratory for analysis. Seventeen samples were drawn into separate bottles. Middle of the night sample numbers 11, 12, and 13 all had minimal amounts of water, so they were combined and labeled as E11.

The fifteen samples were cultured and *E. coli* colonies counted. The *E. coli* values were placed in a spreadsheet and averaged three ways. The results are as follows:

1. 3.51×10^7 cfu/deciliter – a straight average of the 15 values.
2. 3.66×10^7 cfu/deciliter – a weighted average wherein the concentration was multiplied by the flow rate at that time with the sum divided by the total flow.
3. 2.6×10^7 cfu/deciliter - the geometric mean of the 15 values.

Although the EPA uses a geometric mean for water quality monitoring at public beaches, the weighted average was used for the SWMM model as being more conservative. This weighted average was divided by the sewage fraction of the total flow (82.7%) to calculate the SWMM input value of 4.43×10^8 cfu/l.

The average daily sewage flow of 3.031 MGD was multiplied by the concentration and conversion factors to calculate a total yearly cfu loading currently reaching the WWTP in the sewage portion of the influent. The concentration and yearly loading are shown in Table 2-2.

5.3 DIURNAL FLOW PATTERN

As shown in Table 4-1, the flow meter did not work well during the original metering period in July through September (only 9 readings were available for the final scattergraph). The location was metered again from October 13, 2015 to October 20, 2015 to obtain sewage flow data on dry days. Two dry days, October 17 and October 18 were graphed in the spreadsheet, and shown as Figure 5-1. The metered depths and velocities are shown as the two jagged lines on the upper and lower portion of the graph. Smoother lines were made for depth, velocity and flow by calculating a 35-minute moving average of the metered values. This graph shows a classic diurnal sewage flow pattern. This data was used to create the diurnal hourly flow pattern for sewage in the SWMM pollutant calibration model for Meter Site E.

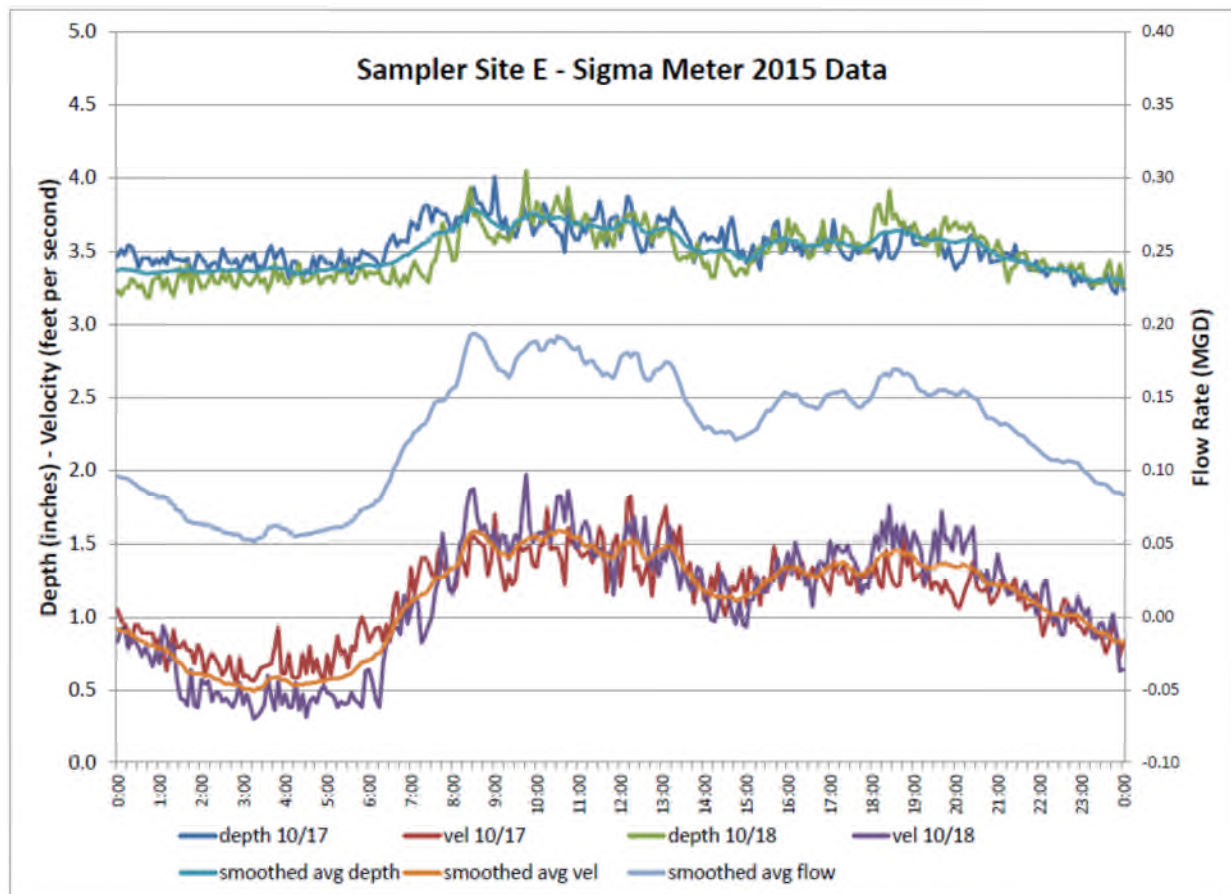


Figure 5-1 Diurnal Flow Pattern

The diurnal flow pattern was converted to the hourly sewage flow pattern shown in Table 5-1. This pattern was used in the pollutant calibration model to vary the sewage flows during the day.

The calculations to achieve the hourly sewage flow pattern are as follows:

1. The hourly flows for the 17th and 18th were averaged.
2. The infiltration rate of 0.011 MGD was subtracted from each average. (See the bottom of Appendix B – Sampler E, total flow 0.062 MGD – sewage flow 0.051 MGD.)
3. The daily flow of 0.115 MGD is the average of the 24 hourly averages
4. The hourly fraction of the daily flow is each (hourly average – infiltration) ÷ daily flow
5. The average of the hourly fractions is 1.000 which shows that they are normalized.

Table 5-1 Hourly Sewage Flow Pattern			
Hour	Hourly Average Flow Rate (MGD)	Hourly Average – Infiltration (MGD)	Hourly Fraction Of Daily Flow
0:00	0.098	0.087	0.754
1:00	0.082	0.071	0.611
2:00	0.064	0.053	0.455
3:00	0.053	0.042	0.364
4:00	0.060	0.049	0.425
5:00	0.060	0.049	0.425
6:00	0.075	0.064	0.555
7:00	0.122	0.111	0.958
8:00	0.156	0.145	1.257
9:00	0.174	0.163	1.413
10:00	0.189	0.178	1.538
11:00	0.185	0.174	1.504
12:00	0.178	0.167	1.443
13:00	0.171	0.160	1.387
14:00	0.128	0.117	1.014
15:00	0.124	0.113	0.979
16:00	0.153	0.142	1.226
17:00	0.153	0.142	1.226
18:00	0.151	0.140	1.213
19:00	0.163	0.152	1.313
20:00	0.152	0.141	1.218
21:00	0.133	0.122	1.057
22:00	0.113	0.102	0.884
23:00	0.101	0.090	0.780
Daily Flow>		0.115	
Average Hourly Factors>			1.000

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CHAPTER 6 – TYPICAL YEAR POLLUTANT LOADINGS

6.1 INTRODUCTION

The Lakewood SWMM model was run to simulate flows and pollutant loadings in a typical year. The purpose of the run was to establish a baseline to compare the effectiveness of improvements to the WWTP and collection system on Lake Erie water quality.

6.2 TYPICAL YEAR RAINFALL AND CLIMATOLOGY

The model used the typical year of rainfall as submitted to U.S. EPA. The basis for the typical year was 1977 rainfall at Hopkins Airport because of the size and number of storms during that year. That year had 35.48 total inches of rain, to which 2.04 inches were added to reflect recent increases in yearly rainfall. The typical year used in the model has 37.52 inches of rainfall. The rain events include:

1. No storm events greater than a 1-year storm
2. A 1-year 1-hour storm
3. A 6-month 1-hour storm
4. A 4-month 1-hour storm
5. A 3-month 1-hour storm
6. Remaining storms are less than a 3-month storm

Rainfall is broken down into 15 minute increments to enable the model to calculate peak flow rates from smaller subcatchments that have short times of concentration.

In addition to rainfall, a climatology input file was prepared. This climatology file uses data from 1977 to match wet weather days. The climate file contains daily values for:

1. High Temperature
2. Low Temperature
3. Wind Speed

SWMM uses daily high and low temperatures to differentiate between rain and snow. It uses wind speed in its snow melt calculations. SWMM also uses the temperatures to calculate evaporation rates throughout the year. All these daily values are in the climate file.

6.3 POLLUTANT MODELING

The Lakewood model was enhanced to include SWMM capabilities of modeling pollutant loads. Typical DWF and RDII concentrations as calculated in Chapters 2 and 3 were assigned to the four modeled pollutants. Buildup and washoff coefficients as calculated in Chapter 4 were assigned to the four pollutants for the five types of land use.

6.4 AVERAGE YEARLY WWTP FLOWS AND LOADINGS

Table 6-1 lists the yearly rainfall, and WWTP influent flow and pollutant loadings from 2010 to 2014. The total flow values are as reported in the DMRs. Daily pollutant loadings are calculated from DMR influent concentrations. Because pollutants are not sampled every day, the yearly loadings are extrapolated values based on the number days that influent concentration was sampled. The days not tested are assumed to contain a similar proportion of wet and dry weather as the days tested. The general equation for extrapolating loadings is as follows:

$$\text{Measured lbs} / \text{Number of days tested} \times 365 \text{ days/year} = \text{Extrapolated lbs/year}$$

The 5-year average pollutant loadings are shown at the bottom of Table 6-1. Since influent *E. coli* is not measured, there is no data for that column. The average values are also shown excluding year 2011 because of its extremely high total rainfall.

Table 6-1 Lakewood WWTP - Yearly Influent to WWTP (2010-2014)						
Year	Rainfall (inches)	Total Flow (MG)	CBOD Extrapolated (lbs)	<i>E. coli</i> (cfu)	TP Extrapolated (lbs)	TSS Extrapolated (lbs)
2010	30.42	2,520	1,699,793	n/a	64,191	2,323,305
2011	60.95	3,793	1,745,619	n/a	65,368	2,834,474
2012	37.65	2,570	1,590,437	n/a	63,509	2,638,742
2013	34.02	2,721	1,793,740	n/a	68,452	2,839,658
2014	34.51	2,730	1,956,179	n/a	71,687	2,653,134
Average	39.51	2,867	1,757,154	n/a	66,641	2,657,863
Exclude 2011	34.15	2,635	1,760,037	n/a	66,960	2,613,710

The 4-year average pollutant loadings to the WWTP (excluding year 2011) are similar to the 5-year average loadings. This indicates the increased total flow for 2011 is composed of relatively clean groundwater and diluted runoff (the pollutants having already been washed off).

6.5 SWMM TYPICAL YEAR MODEL FLOW PATTERNS

The spreadsheet used to calculate average yearly loadings was expanded to calculate monthly sewage, monthly infiltration and daily flow patterns. For the years 2010 to 2014, the dry day sewage portion of the flow was averaged by month and by weekday. The water consumption spreadsheet calculated the monthly sewage portion of the flows. The monthly dry weather infiltration was calculated by subtracting the sewage portion of the flows from monthly averages. Table 6-2 shows the average monthly sewage flows and their ratio to the yearly average. Table 6-3 shows the average monthly infiltrations and their ratio to the yearly average. Table 6-4 shows the dry day daily sewage variations and their ratio to the weekly average. These ratios were input into the SWMM program as monthly and daily time patterns.

Table 6-2 Lakewood WWTP Monthly Sewage Discharge Pattern		
Month	5-Year Average Dry Day Sewage (MGD)	Monthly Fraction of Yearly Average Sewage
January	3.255	1.074
February	3.007	0.992
March	2.895	0.955
April	3.076	1.015
May	3.004	0.991
June	3.031	1.000
July	3.031	1.000
August	3.031	1.000
September	3.031	1.000
October	3.107	1.025
November	3.037	1.002
December	2.867	0.946
Monthly Average	3.031	1.000

Table 6-3 Lakewood WWTP Monthly Infiltration Pattern		
Month	5-Year Average Dry Day Infiltration (MGD)	Monthly Fraction of Yearly Average Infiltration
January	1.645	0.902
February	2.031	1.114
March	2.443	1.340
April	2.123	1.165
May	1.946	1.068
June	2.048	1.123
July	1.780	0.977
August	1.548	0.849
September	1.237	0.678
October	1.410	0.773
November	1.664	0.913
December	2.001	1.098
Monthly Average	1.823	1.000

Table 6-4 Lakewood WWTP Daily Sewage Flow Pattern		
	5-Year Average Dry Day Flow (MGD)	Daily Fraction Of Average Flow
Sunday	4.804	1.040
Monday	4.683	1.012
Tuesday	4.668	0.990
Wednesday	4.624	0.996
Thursday	4.653	0.997
Friday	4.663	0.985
Saturday	4.678	0.980
Daily Average	4.682	1.000

For the 2011 calibrated SWMM model, diurnal sewage flow patterns were developed from the 2011 flow metering data. Hourly flow data on dry days were entered into a spreadsheet. Multiple weekdays and weekend days were selected and the hourly flows were averaged to

determine diurnal weekday and weekend patterns for each flow meter. Seventeen of these individual meter flow patterns were aggregated to develop citywide diurnal flow patterns for the typical year pollutant model. Table 6-5 presents the weekday pattern and Table 6-6 presents the weekend pattern. The weekday pattern is typical in that flow peaks at 08:00 (8:00 a.m.) and again at 21:00 (9:00 p.m.). The weekend pattern has a later morning flow peak at 11:00 a.m. and no definitive evening peak.

Table 6-5 Lakewood Metered Sewage Weekday Hourly Discharge Pattern		
Hour	18-Meter Average Hourly Sewage (MGD)	Hourly Fraction of Average Daily Sewage
0:00	0.908	0.902
1:00	0.794	0.789
2:00	0.690	0.686
3:00	0.629	0.625
4:00	0.623	0.620
5:00	0.677	0.673
6:00	0.884	0.878
7:00	1.253	1.245
8:00	1.323	1.315
9:00	1.168	1.161
10:00	1.183	1.176
11:00	1.089	1.082
12:00	1.047	1.040
13:00	1.055	1.048
14:00	1.040	1.034
15:00	0.991	0.985
16:00	1.032	1.025
17:00	1.046	1.039
18:00	1.107	1.100
19:00	1.153	1.146
20:00	1.153	1.146
21:00	1.168	1.160
22:00	1.128	1.121
23:00	1.011	1.004
Weekday Average	1.006	1.000

Table 6-6 Lakewood Metered Sewage Weekend Hourly Discharge Pattern		
Month	18-Meter Average Hourly Sewage (MGD)	Hourly Fraction of Average Daily Sewage
0:00	0.922	0.928
1:00	0.781	0.786
2:00	0.652	0.656
3:00	0.642	0.646
4:00	0.614	0.618
5:00	0.586	0.590
6:00	0.665	0.669
7:00	0.793	0.798
8:00	0.998	1.004
9:00	1.209	1.217
10:00	1.245	1.253
11:00	1.367	1.375
12:00	1.342	1.350
13:00	1.306	1.313
14:00	1.204	1.212
15:00	1.164	1.171
16:00	1.118	1.125
17:00	1.081	1.088
18:00	1.074	1.081
19:00	1.032	1.038
20:00	1.053	1.060
21:00	1.054	1.061
22:00	0.977	0.983
23:00	0.972	0.978
Weekend Average	0.994	1.000

6.6 SWMM TYPICAL YEAR RESULTS

Lakewood has its WWTP outfall and 33 sewer outfalls. In addition to these outfalls, 13% of Lakewood's combined sewage is discharged to the Northeast Ohio Regional Sewer District (NEORS). These outfalls discharge pollutants from overflows within the collection system. For the typical year of rainfall, PCSWMM calculates the total flow volume and pollutant quantity discharged at each outfall. The Lakewood model was run for the conditions:

1. Typical Year rainfall = 37.52 inches
2. Average dry day flow = 6.283 MGD
3. Evaporation turned on.
4. Ponding allowed at surcharged manholes

The 6.283 MGD average dry day flow is composed of 3.693 MGD sewage and 2.590 MGD infiltration. Table 6-7 lists the resulting discharges for this scenario. The calculated values are divided into three groups: the loadings influent to the WWTP, the portion of Lakewood's sewage and runoff that flows to NEORS, and the total of all Lakewood outfalls.

Table 6-7 City of Lakewood SWMM Calculated Flows and Loadings					
	Flow (MG)	CBOD (lbs)	<i>E. coli</i> (cfu)	TP (lbs)	TSS (lbs)
Typical Year Scenario					
WWTP Influent	2,787	1,843,662	2.06E+18	70,000	2,747,213
To NEORS	398	27,142	3.04E+16	1,030	40,469
Lakewood outfalls	577	30,720	2.30E+16	1,129	56,356
Total Generated	3,762	1,901,524	2.12E+18	72,159	2,844,038

For this scenario, Table 6-8 shows the typical year flows to each individual outfall, the WWTP, and to the NEORS connection points described in Section 2.2. For outfall 052NEORS (which is outside the Lakewood corporate limits), Table 6-8 shows only the Lakewood generated flow and pollutant values.

Table 6-8
Lakewood Sewer Outfalls
SWMM Typical Year Flows and Loadings

SWMM Model Outfall ID	Flow (MG)	CBOD (lbs)	<i>E. coli</i> (cfu)	TP (lbs)	TSS (lbs)
Lakewood Outfalls					
002LEWS1070	15.249	1,380.4	1.03E+15	50.8	2,529.9
002LEWS1195	6.354	492.0	4.75E+14	18.4	820.9
002LEWS1210	0.086	0.1	9.77E+09	0.0	0.6
002LEWS1215	0.891	1.3	2.55E+11	0.0	11.2
002LEWS1220	0.088	2.6	2.88E+12	0.1	3.9
002LEWS1230	0.400	0.2	5.27E+09	0.0	2.1
002LEWS1285	0.000	0.0	0.00E+00	0.0	0.0
002LEWS1295	14.125	111.2	1.14E+14	4.2	254.9
002RRES1145	53.356	1,063.1	7.71E+14	38.8	2,042.3
002RRES1150	0.000	0.0	0.00E+00	0.0	0.0
002SRRES1065	2.058	1.7	3.14E+11	0.1	14.8
052NEORS	1.829	1.3	2.65E+11	0.0	10.0
052RRES1160	173.514	10,734.7	7.66E+15	393.6	19,893.5
052RRES1165B	0.410	0.5	1.27E+11	0.0	1.4
052RRES1180	1.878	13.6	4.62E+12	0.5	31.1
052RRES1185	4.638	14.3	4.72E+12	0.3	32.6
052RRES1215	3.692	2.5	5.53E+11	0.1	13.8
052T01	0.742	0.3	5.30E+10	0.0	2.7
053RRWS1200	3.229	345.0	2.62E+14	12.7	620.6
054RRES1140	16.335	55.8	2.13E+13	1.9	140.8
055LEWS1225	1.850	6.5	5.55E+12	0.2	14.0
056LEWS1140	25.700	655.4	5.25E+14	24.2	1,189.1
056LEWS1145	3.323	85.9	7.82E+13	3.2	149.4
056LEWS1180	12.498	938.7	6.53E+14	34.4	1,742.4
057LEWS1130	15.417	56.2	2.49E+13	1.8	149.7
057LEWS1135	2.366	244.9	1.60E+14	8.9	464.7
058LEWS1110	1.856	34.3	1.45E+13	1.2	76.1
059ALEWS1040	123.668	10,218.2	7.74E+15	376.0	18,557.8
059LEWS1005	0.232	0.2	4.05E+10	0.0	3.5
059LEWS1035	59.232	2,482.9	2.61E+15	93.5	3,912.6
059LEWS1045	5.544	628.8	2.99E+14	22.6	1,282.0
059LEWS1050	1.448	3.6	7.43E+11	0.1	29.2
059LEWS1055_1060	23.366	1,017.7	4.67E+14	36.5	2,130.8
CSO002	1.920	126.2	9.68E+13	4.7	227.4
WWTP Influent					
053WWTP	93.991	81,177.9	9.12E+16	3,083.2	120,597.6
WWTP	2,692.646	1,762,483.6	1.97E+18	66,916.3	2,626,615.5
NEORS Influent					
059C33	293.441	1.0	2.12E+16	709.4	27,577.4
059C4	92.410	1,924.2	2.16E+15	73.0	2,912.7
Southwest Lakewood	12.170	6,540.8	7.05E+15	247.5	9,979.3

6.7 COMPARISON OF SWMM TYPICAL YEAR TO AVERAGE WWTP INFLUENT FLOWS

One validation check of the calibrated SWMM model is to compare its output to the Lakewood WWTP influent flow quantities. Table 6-9 shows this comparison. SWMM Typical-year Influent values are from Table 6-7 Average Typical Year Scenario. The 4-yr DMR Influent values are from Table 6-1 and based on the average yearly WWTP influent flow and loadings as calculated from DMR data. Table 6-9 shows SWMM influent flow to be 10% higher than the DMR data, which is due to the higher total rainfall. SWMM's pollutant loadings are also higher than the DMR data due to extra RDII having constant pollutant concentrations. SWMM's yearly WWTP influent *E. coli* loading (2.06E+18cfu from Table 6-7) is not shown in Table 6-9 because there are no measured influent concentrations in the DMR data.

Table 6-9 City of Lakewood SWMM versus WWTP DMR Influent Flows and Loadings					
	Total Rainfall (inches)	Flow (MG)	CBOD (lbs)	TP (lbs)	TSS (lbs)
SWMM Typical-year Influent	37.52	2,787	1,843,662	70,000	2,747,213
4-yr DMR Influent	34.15	2,635	1,760,037	66,960	2,613,710
SWMM to DMR Ratio	110%	106%	105%	105%	105%

6.8 POLLUTANT CAPTURE PERCENTAGES

The percentage of pollutants captured is a value that can be used to evaluate WWTP and collection system improvement alternatives. One version of this number is percentage capture of typical year total pollutant loadings. Another version is percentage capture of typical year wet weather pollutant loadings. These two values are described in the following sections.

6.8.1 TYPICAL YEAR CAPTURE PERCENTAGE OF TOTAL POLLUTANT LOADINGS

These values combined with the WWTP's effectiveness in removing pollutants can be used to calculate the total pollutant loadings discharged to Lake Erie. Improvement alternatives can be analyzed to determine their ability to further reduce pollutants. A cost benefit ratio (\$ per additional pound of pollutant removed) for each alternative can then be calculated to determine a relative ranking of system improvement alternatives. (Cost benefit ratios are not a part of the pollutant model; however, the data for typical year total pollutant loadings are presented herein as the baseline for comparisons.)

The values to calculate typical year capture percentages have previously been calculated. Table 6-7 lists the typical year flows to the WWTP influent and to NEORSD. These treated flows are summed in Table 6-10. Added to that sum is the total flow and loadings discharged at the Lakewood outfalls to give the total Lakewood generated flows and

loadings. The treated values divided by the total generated values gives the percentage of flows and pollutants treated.

Table 6-10 City of Lakewood Typical Year Total Pollutant Loading Treatment Percentages					
	Flow (MG)	CBOD (lbs)	<i>E. Coli</i> (lbs)	TP (lbs)	TSS (lbs)
WWTP+NEORSD Treated	3,525	1,924,515	2.16E+18	73,072	2,866,695
Total Lakewood Generated	4,236	1,959,339	2.18E+18	74,354	2,929,993
Capture Percentage	83.2%	98.2%	98.8%	98.3%	97.8%

6.8.2 WET WEATHER POLLUTANT CAPTURE PERCENTAGE

This value is the pollutant loading to Rocky River and Lake Erie during wet weather. Collection system improvement alternatives can be analyzed to determine their ability to capture pollutants for treatment by NEORSD or the WWTP. A cost benefit ratio (\$ per additional pound of pollutant captured) for each alternative can then be calculated to determine a relative ranking of collection system improvement alternatives.

The values to calculate typical year wet weather capture percentages are based on output from the SWMM model. The model was run for the typical year with rainfall turned on, and then run again with rainfall turned off (dry weather). The dry weather flow is the sewage portion of the wet weather flow for a given time slot. Flow rate and pollutant concentrations were downloaded from the WWTP and NEORSD capture points. This data was entered into an excel spreadsheet in 15-minute time slots. A wet weather event was considered to have started when both of the following two conditions were met:

1. Precipitation had occurred within the previous two hours
2. Total typical year captured flow rate exceeded total dry weather flow rate for the corresponding time slot by at least 0.4 MGD. (After some wet weather events the wet minus dry flow rate difference takes some time to stabilize. The wet minus dry difference was -0.387 MGD at its lowest. To eliminate error caused by this flow rate instability at the end of a wet weather event, the value of 0.4 MGD was chosen as the cut-off point for the storm.)

The wet weather event was considered to have ended when typical year captured flow rate returned to within 0.4 MGD of dry weather flow rate for the corresponding time slot. These two conditions resulted in 150 wet weather events on 118 wet days (a new day was not counted if the event spanned midnight, but was counted if the event lasted more than 24 hours).

For each wet weather time slot, treated pollutant loadings were calculated for the specific wet weather flow volume and pollutant concentration. The sum of all the time slots is the total treated wet weather flow and loadings.

The sum of these treated flows is shown in the first line of Table 6-11. The second line shows the total flow and loadings discharged at the Lakewood outfalls. The sum of these two values is the total Lakewood generated wet weather flows and loadings. The captured values divided by the total generated values gives the percentage of flows and pollutants captured.

Table 6-11 City of Lakewood Typical Year Wet Weather Pollutant Loading Treatment Percentages					
	Flow (MG)	CBOD (lbs)	<i>E. Coli</i> (lbs)	TP (lbs)	TSS (lbs)
WWTP+NEORSD Treated	1,541	497,408	5.35E+17	18,813	761,643
Discharge to Lakewood Outfall	568	30,208	2.24E+16	1,110	55,601
Total Lakewood Wet Weather	2,109	527,616	5.57E+17	19,922	817,243
Wet Weather Capture Percentage	73.1%	94.3%	96.0%	94.4%	93.2%

6.9 RECOMMENDED FURTHER ACTION

Further pollutant calibration is not proposed at this time, because the historical DMR data is not tied to rainfall intensity. Instead, the following actions should be incorporated to keep the pollutant model updated:

1. Run the pollutant model with future actual rainfall intensities. Compare SWMM loadings to the WWTP DMR loadings.
2. Continue to monitor water consumption. With increased use of water saving devices, future sewage flow volumes may continue to decrease.
3. Monitor population trends. Although flow volumes may decrease, if population remains constant pollutant loadings from sewage will remain constant. As a result, influent concentrations will increase. Since SWMM uses influent concentrations for sewage, this monitoring will be necessary to possibly adjust sewage concentrations.
4. Use overflow monitoring to refine SWMM input parameters. Since these overflows discharge to Lake Erie and Rocky River, comparing the model's calculated values to these metered values will be important to confirm the characterization of the collection system.

With the current pollutant model, a plan of improvements to the treatment plant and collection system can be developed to cost-effectively improve the water quality of Lake Erie and Rocky River. Future updates to the pollutant model can confirm whether Lakewood is remaining on the best course of improvements, or if alternative plans should be considered.

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APPENDIX A

LAND USE PERCENTAGES

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APPENDIX A – LAND USE PERCENTAGES

A.1 Introduction

The SWMM model was developed to calculate pollutants from runoff from the following five types of land use:

1. Low-density residential – Single and two-family residential properties with land area greater than $\frac{1}{4}$ acre in size.
2. Medium-density residential – Single and two-family residential properties with land area less than $\frac{1}{4}$ acre in size.
3. High-density residential – Properties classified as apartments.
4. Commercial/Industrial – Properties with large impervious areas. In addition to commercially and industrially used properties, this group also includes properties listed as institutional (municipal, schools and churches), highway, and active recreation areas.
5. Open Space – Properties with large pervious areas. This group includes the following types of land uses broken down by percentage of total open space
 - a. passive green space 78%
 - b. railroads 13%
 - c. utility 9%

For each Lakewood subcatchment in the model, a percentage was calculated for each type of land use within that subcatchment. The Cuyahoga County Auditor's database of Lakewood properties was downloaded and sorted by land use. For one and two family residential properties, the data was further sorted by lot size. Lot sizes were examined to determine a break point between low-density and medium-density residential land. A break point of $\frac{1}{4}$ acre resulted in 75% of the residential land being medium-density and the remaining 25% being low-density. GIS was used to assign the properties to their respective land use designations. Thiessen polygon capability was used to extend the property lines to the center of the street. The revised acreages were totaled for each type of land use within each subcatchment. This appendix lists all the subcatchments within the model, their acreages and the percentage of the acreage classified to each of the five land uses.

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Subcatchment Name	Tributary To Node	Area (acres)	Low Density Residential	Medium Density Residential	High Density Residential	Commercial	Open Space
S002C026A	002C026A	1.192		88.5%		11.5%	
S002C029A	002C029A	3.310		79.2%		20.8%	
S002C039A	002C039A	2.322		93.7%		6.3%	
S002C124	002C124	2.155	88.9%	11.1%			
S002C1421	002C1421	3.803	85.1%	14.9%			
S002C169	002T169	0.806	22.5%	77.5%			
S002C170	002C170	1.012		100.0%			
S002C179	002C179	0.953		100.0%			
S002C181	002C181	0.427		100.0%			
S002C185	002C185	0.774	0.1%	99.9%			
S002C187	002C187	1.338	53.2%	43.3%		3.5%	
S002C189	002C189	1.371	59.6%	40.4%			
S002C191	002C191	1.099		100.0%			
S002C192	002C192	1.275		100.0%			
S002C193	002C193	2.536	58.2%	41.8%			
S002C195	002C195	1.704	17.8%	82.2%			
S002C198	002C198	3.201	84.9%	15.1%			
S002C210	002C210	0.788	11.4%	88.6%			
S002C214	002C214	2.022	96.6%	3.4%			
S002C219	002C219	1.993	16.2%	83.8%			
S002C238A	002C238A	2.485	16.8%	83.2%			
S002C240A	002C240A	2.572	37.5%	62.5%			
S002C241	002C241	1.899	14.0%	86.0%			
S002C255	002C255	0.820	33.6%	65.6%			0.8%
S002C260	002C260	3.135	25.6%	58.0%	16.4%		
S002C3646	002C3646	5.516		94.8%		5.2%	
S002C3648	002C3648	5.131		100.0%			
S002C3651	002C3651	6.518		100.0%			
S002C3691	002C3691	2.533		91.5%		8.5%	
S002C3693	002C3693	4.352		100.0%			
S002C3695	002C3695	7.027		100.0%			
S002C3697	002C3697	1.541		77.4%		22.6%	
S002C3804	002C3804	1.840	66.5%	33.5%			
S002C3895	002C3895	1.236	15.1%	84.9%			
S002C3897	002C3897	2.463	12.5%	87.5%			
S002C3906	002C3906	3.357	62.3%	37.7%			
S002C3941	002C3941	2.152	62.6%	37.4%			
S002C3943	002C3943	3.137	90.7%	9.3%			
S002C3945	002C3945	1.043		93.1%		6.9%	
S002C3946	002C3946	1.002		100.0%			
S002C3947	002C3947	1.392		80.7%			19.3%
S002C3948	002C3948	1.292		100.0%			
S002C3949	002C3949	1.498		100.0%			

**CITY OF LAKEWOOD
INTEGRATED WET WEATHER IMPROVEMENT PLAN**

**CHARACTERIZATION OF POLLUTANT LOADS
TECHNICAL MEMORANDUM**

Subcatchment Name	Tributary To Node	Area (acres)	Low Density Residential	Medium Density Residential	High Density Residential	Commercial	Open Space
S002C3951	002C3951	0.877		100.0%			
S002C4049	002C4049	1.371			83.0%	17.0%	
S002C4418	002C4418	0.612		33.9%	34.7%	31.4%	
S002C4422	002C4422	2.223	15.6%	84.4%			
S002C4433	002C4433	5.578	1.9%	98.1%			
S002C9980	002C9980	1.080		100.0%			
S002S252	002S252	2.387	4.0%	6.6%	3.5%	12.8%	73.2%
S002S4066	002S4066	1.968		100.0%			
S002S4425	002S4425	1.225				100.0%	
S002S4426	002S4426	1.335	17.8%	3.0%		79.2%	
S002T015	002T015	7.522		95.9%		4.1%	
S002T017	002T017	4.358		86.8%		13.2%	
S002T019	002T019	5.134		100.0%			
S002T021	002T021	2.832		100.0%			
S002T024	002T024	0.912				100.0%	
S002T026	002T026	2.350			42.5%	57.5%	
S002T027	002T027	2.366			0.2%	99.8%	
S002T028	002T028	0.779				100.0%	
S002T029	002T029	2.970		3.7%	55.7%	40.6%	
S002T030	002T030	2.638		1.6%	13.6%	84.8%	
S002T031	002T031	1.818		11.7%	0.1%	88.3%	
S002T032	002T032	1.860		0.2%		99.8%	
S002T035	002T035	2.056		93.4%		6.6%	
S002T036	002T036	6.093		0.9%		99.0%	
S002T038	002T038	1.440		4.9%		95.1%	
S002T039	002T039	1.865		0.2%		99.8%	
S002T040	002T040	2.310		1.6%		98.4%	
S002T041	002T041	1.005		0.3%		99.7%	
S002T043	002T043	1.086		0.1%	1.0%	98.9%	
S002T044	002T044	1.406		4.3%	0.9%	94.8%	
S002T046	002T046	1.296			25.8%	74.2%	
S002T048	002T048	1.383				100.0%	
S002T049	002T049	3.693		32.7%		67.3%	
S002T053	002T053	1.386		100.0%			
S002T054	002T054	1.392		100.0%			
S002T055	002T055	1.253		100.0%			
S002T056	002T056	0.996	53.2%	46.8%			
S002T057	002T057	1.210	81.3%	18.5%			0.1%
S002T070	002T070	2.898		38.0%	45.2%	16.7%	
S002T075	002T075	3.577	20.9%	76.8%	2.3%		
S002T078	002T078	1.127		88.2%	11.8%		
S002T080	002T080	2.328		99.9%			0.1%
S002T082	002T082	2.342		100.0%			
S002T084	002T084	2.392		44.2%	25.3%	30.5%	
S002T090	002T090	2.749		22.3%	2.3%	75.4%	

CITY OF LAKEWOOD
INTEGRATED WET WEATHER IMPROVEMENT PLAN

CHARACTERIZATION OF POLLUTANT LOADS
TECHNICAL MEMORANDUM

Subcatchment Name	Tributary To Node	Area (acres)	Low Density Residential	Medium Density Residential	High Density Residential	Commercial	Open Space
S002T092	002T092	1.571			12.7%	87.3%	
S002T094	002T094	1.024			97.4%	2.6%	
S002T103	002T103	1.711	100.0%				
S002T106	002T106	2.977	100.0%				
S002T107	002T107	2.593	100.0%				
S002T110	002T110	2.902	47.6%	46.3%		6.1%	
S002T1102	002T1102	1.441		80.4%		19.6%	
S002T114	002T114	4.607	87.8%	12.2%			
S002T116	002T116	1.498	78.4%	21.6%			
S002T1201	002T1201	3.017	75.6%	24.4%			
S002T123	002T123	4.319	18.4%	81.6%			
S002T1301	002T1301	2.599	49.5%	50.5%			
S002T1303	002T1303	4.228	18.4%	81.6%			
S002T1306	002T1306	3.770	80.7%	19.3%			
S002T1308	002T1308	1.511	100.0%				
S002T131	002T131	2.409	29.5%	70.5%			
S002T1313	002T1313	3.693	99.7%	0.3%			
S002T1318	002T1318	1.383	78.0%	22.0%			
S002T1319	002T1319	2.403	99.7%	0.3%			
S002T132	002T132	2.223		59.0%	12.4%	28.6%	
S002T1322	002T1322	1.347	98.5%	1.5%			
S002T1322A	002T1322	0.169	100.0%				
S002T1324	002T1324	1.079	16.9%	83.1%			
S002T1326	002T1326	1.058	99.3%	0.7%			
S002T1328	002T1328	1.326	59.4%	40.6%			
S002T1330	002T1330	1.820	0.5%	99.5%			
S002T138	002T138	1.357		100.0%			
S002T139	002T139	2.630	0.1%	62.4%	20.4%		17.2%
S002T1403	002T1403	3.678	87.0%	13.0%			
S002T1408	002T1408	2.422	27.2%	72.7%	0.1%		
S002T141	002T141	2.320	10.9%	67.3%			21.8%
S002T1410	002T1410	1.424	48.1%	51.9%			
S002T1417	002T1417	1.972	1.4%	63.8%	34.8%		
S002T1419	002T1419	2.837		100.0%			
S002T1423	002T1423	2.487	81.1%	18.9%			
S002T1429	002T1429	1.090	25.8%	74.2%			
S002T143	002T143	4.140	1.0%	98.9%		0.1%	
S002T1431	002T1431	2.219	60.1%	39.9%			
S002T145	002T145	1.248		100.0%			
S002T147	002T147	0.866		96.3%	3.7%		
S002T166	002T166	1.777	11.5%	88.5%			
S002T173	002T173	1.077	26.2%	73.8%			
S002T175	002T175	1.246	43.2%	56.8%			
S002T184	002T184	1.247	0.2%	99.8%			
S002T184A	002T184	1.918		100.0%			

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S002T186	002T186	1.064	6.3%	29.4%		64.3%	
S002T196	002T196	0.675	18.0%	82.0%			
S002T2000	002T2000	1.198	24.6%	75.4%			
S002T205	002T205	0.403	45.9%	54.1%			
S002T207	002T207	2.346	94.6%	5.4%			
S002T2106	002T2106	5.403	12.4%	87.6%			
S002T2107	002T2107	4.616		100.0%			
S002T2109	002T2109	3.721		100.0%			
S002T2115	002T2115	0.992				100.0%	
S002T2122	002T2122	5.354		100.0%			
S002T2124	002T2124	2.445		100.0%			
S002T2126	002T2126	2.564		100.0%			
S002T2131	002T2131	1.468		37.9%		62.1%	
S002T2149	002T2149	2.381		65.9%	10.4%	23.7%	
S002T2151	002T2151	2.956		100.0%			
S002T2154	002T2154	5.113		100.0%			
S002T216	002T216	1.784	5.4%	94.6%			
S002T2162	002T2162	3.090	7.2%	37.1%		55.7%	
S002T2164	002T2164	3.547	56.6%	43.4%			
S002T2165	002T2165	3.552	45.8%	38.6%			15.6%
S002T2167	002T2167	4.506	57.0%	43.0%			
S002T2169	002T2169	6.122	49.9%	31.9%		18.2%	
S002T217	002T217	1.739	98.1%	1.9%			
S002T2173	002T2173	2.062		100.0%			
S002T230	002T230	2.169	72.2%	27.8%			
S002T236	002T236	1.175	0.7%	99.3%			
S002T242	002T242	1.276	41.6%	58.4%			
S002T251	002T251	6.133		6.0%	25.5%	68.5%	
S002T253	002T253	1.813	0.4%	37.2%	26.9%		35.5%
S002T256	002T256	0.939		83.3%			16.7%
S002T257	002T257	3.119	0.1%	1.9%		98.0%	
S002T3587	002T3587	3.452		100.0%			
S002T3589	002T3589	2.969		100.0%			
S002T3593	002T3593	3.802		100.0%			
S002T3595	002T3595	2.031		84.5%	8.0%	7.5%	
S002T3602	002T3602	2.532		75.4%	5.8%	18.8%	
S002T3603	002T3603	3.510		100.0%			
S002T3606	002T3606	2.536		100.0%			
S002T3610	002T3610	4.339		100.0%			
S002T3620	002T3620	3.527		65.7%		34.3%	
S002T3622	002T3622	5.141		100.0%			
S002T3624	002T3624	5.865		100.0%			
S002T3626	002T3626	5.211		90.6%		9.4%	
S002T3632	002T3632	7.086		96.5%	2.2%	1.3%	
S002T3637	002T3637	6.294		100.0%			

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S002T3641	002T3641	3.364		100.0%			
S002T3643	002T3643	1.574		53.1%		46.9%	
S002T3654	002T3654	2.345		92.5%	3.8%		3.8%
S002T3655	002T3655	2.685		100.0%			
S002T3656	002T3656	2.200		100.0%			
S002T3657	002T3657	2.560		100.0%			
S002T3658	002T3658	2.878		100.0%			
S002T3661	002T3661	2.914	11.5%	79.9%		8.5%	
S002T3664	002T3664	4.543		97.9%		2.1%	
S002T3667	002T3667	3.496		100.0%			
S002T3673	002T3673	5.711	4.5%	91.9%	3.6%		
S002T3675	002T3675	2.352		93.6%		6.4%	
S002T3677	002T3677	4.359		100.0%			
S002T3680	002T3680	4.872		100.0%			
S002T3689	002T3689	1.770		91.9%		8.1%	
S002T3702	002T3702	5.927		100.0%			
S002T3704	002T3704	3.364		93.2%		6.8%	
S002T3705	002T3705	0.941		15.2%	54.5%	30.2%	
S002T3728	002T3728	2.059	100.0%				
S002T3732	002T3732	3.170	64.7%	17.6%		17.7%	
S002T3735	002T3735	1.791	100.0%				
S002T3741	002T3741	4.252	94.6%	5.4%			
S002T3744	002T3744	4.406	97.9%	2.1%			
S002T3749	002T3749	0.877	100.0%				
S002T3766	002T3766	3.188	89.3%	10.7%			
S002T3770	002T3770	5.759	100.0%				
S002T3772	002T3772	1.189	77.8%	22.2%			
S002T3779	002T3779	1.835	55.7%	44.3%			
S002T3829	002T3829	4.607	91.1%	8.9%			
S002T3836	002T3836	5.142	100.0%				
S002T3840	002T3840	7.498	92.9%	7.1%			
S002T3846	002T3846	3.725	84.0%	16.0%			
S002T3848	002T3848	8.079	90.6%	9.4%			
S002T3867	002T3867	2.158	82.0%	18.0%			
S002T3869	002T3869	2.324	100.0%				
S002T3870	002T3870	3.047	79.5%	20.5%			
S002T3873	002T3873	2.991	100.0%				
S002T3875	002T3875	3.236	81.8%	18.2%			
S002T3880	002T3880	1.269	0.1%	99.9%			
S002T3883	002T3883	1.503		100.0%			
S002T3889	002T3889	1.372	1.4%	98.6%			
S002T3908	002T3908	2.512	29.2%	70.8%			
S002T3922	002T3922	1.959		82.8%	5.6%	11.6%	
S002T3923	002T3923	1.521		92.6%			7.4%
S002T3924	002T3924	1.655		82.5%			17.5%

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S002T3925	002T3925	1.368		100.0%			
S002T3926	002T3926	1.448		100.0%			
S002T3927	002T3927	1.485	14.1%	79.7%	6.2%		
S002T3929	002T3929	1.885	0.1%	50.0%		49.9%	
S002T3930	002T3930	1.319		99.9%			
S002T3932	002T3932	2.799		91.6%			8.4%
S002T3934	002T3934	2.669		100.0%			
S002T3953	002T3953	0.812	24.3%	22.6%	16.4%	36.7%	
S002T3954	002T3954	0.969		70.8%	29.2%		
S002T3955	002T3955	0.789		100.0%			
S002T3956	002T3956	0.753		71.7%			28.3%
S002T3957	002T3957	0.787		100.0%			
S002T3958	002T3958	0.782		100.0%			
S002T3959	002T3959	0.786		100.0%			
S002T3960	002T3960	0.779		100.0%			
S002T3961	002T3961	1.507		100.0%			
S002T3963	002T3963	2.025	8.5%	62.8%	19.9%	8.8%	
S002T3964	002T3964	1.149		96.7%	3.3%		
S002T3965	002T3965	1.207		36.0%	35.8%		28.2%
S002T3966	002T3966	2.233		93.9%			6.1%
S002T3967	002T3967	1.454		100.0%			
S002T3968	002T3968	1.682	14.3%	85.7%			
S002T3969	002T3969	1.902	1.0%	99.0%			
S002T3974	002T3974	1.231		64.7%	26.1%	9.2%	
S002T3979	002T3979	2.074		70.1%	15.3%		14.6%
S002T3981	002T3981	1.780		92.2%			7.8%
S002T3982	002T3982	1.424		100.0%			
S002T3984	002T3984	2.477	5.0%	95.0%			
S002T3986	002T3986	0.549		86.7%		13.3%	
S002T3987	002T3987	0.684		99.2%	0.3%	0.4%	
S002T3988	002T3988	1.762		99.9%			0.1%
S002T3990	002T3990	1.304		73.2%			26.8%
S002T3991	002T3991	1.422		100.0%			
S002T3992	002T3992	1.378		100.0%			
S002T3994	002T3994	1.862		100.0%			
S002T4002	002T4002	1.236		100.0%			
S002T4004	002T4004	0.993		100.0%			
S002T4005	002T4005	0.425		100.0%			
S002T4020	002T4020	2.381		100.0%			
S002T4022	002T4022	2.235		100.0%			
S002T4025	002T4025	2.270		94.9%	5.1%		
S002T4026	002T4026	1.206		100.0%			
S002T4028	002T4028	0.864		99.9%			0.1%
S002T4031	002T4031	1.760		56.0%		44.0%	
S002T4033	002T4033	1.797		99.0%	0.3%	0.8%	

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S002T4037	002T4037	1.584		100.0%			
S002T4043	002T4043	1.868		86.4%			13.6%
S002T4064	002T4064	1.477	27.4%	59.8%		12.8%	
S002T4065	002T4065	1.472	48.4%	51.6%			
S002T4152	002T4152	5.207	65.6%	34.4%			
S002T4157	002T4157	1.871	60.0%	40.0%			
S002T4171	002T4171	4.103	100.0%				
S002T4227	002T4227	1.695	22.4%	77.6%			
S002T4228	002T4228	2.798	3.2%	96.8%			
S002T4232	002T4232	2.359		100.0%			
S002T4233	002T4233	2.081	1.6%	98.4%			
S002T4235	002T4235	2.101	100.0%				
S002T4243	002T4243	1.256	41.3%	58.7%			
S002T4250	002T4250	4.193	68.1%	31.9%			
S002T4254	002T4254	2.311	92.6%	7.4%			
S002T4259	002T4259	1.667	31.2%	68.8%			
S002T4278	002T4278	7.253	94.8%	5.2%			
S002T4300	002T4300	1.363		19.8%	70.2%	10.0%	
S002T4301	002T4301	2.550		77.2%	16.9%	5.9%	
S002T4304	002T4304	1.002		50.9%	3.7%	45.4%	
S002T4306	002T4306	3.304		57.7%	32.7%	9.6%	
S002T4307	002T4307	3.313		100.0%			
S002T4309	002T4309	2.311		95.2%		4.8%	
S002T4315	002T4315	5.742		56.8%	18.4%	24.8%	
S002T4317	002T4317	2.528	0.9%	79.2%	19.9%		
S002T4320	002T4320	2.255	15.5%	84.1%	0.4%		
S002T4322	002T4322	1.249		100.0%			
S002T4324	002T4324	3.827		76.4%	23.6%		
S002T4394	002T4394	4.951		95.5%	4.5%		
S002T4395	002T4395	3.654		100.0%			
S002T4414	002T4414	2.922		99.4%		0.6%	
S002T4416	002T4416	0.683		2.0%	2.5%	95.5%	
S002T4424	002T4424	2.897		73.4%		26.6%	
S002T4426	002T4426	6.455		100.0%			
S002T4428	002T4428	1.745	3.5%	96.5%			
S002T4651	002T4651	1.683				100.0%	
S002T685	002T685	0.939		100.0%			
S002T725	002T725	2.578	99.5%	0.5%			
S002T767	002T767	2.418	51.5%	48.5%			
S002T9984	002T9984	0.985	79.2%	20.8%			
S002T9988	002T9988	1.440		100.0%			
S0059C015	059C015	4.912	4.7%	95.3%			
S0059T011	059T011	1.391	26.8%	46.3%	26.9%		
S0059T014	059T014	3.030	33.4%	24.2%		42.5%	
S052C1133	052C1133	0.470		100.0%			

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S052C1138	052C1138	2.590		100.0%			
S052C1143	052C1143	1.240		100.0%			
S052C1148	052C1148	1.090		100.0%			
S052C1150	052C1150	1.170		100.0%			
S052S103	052S103	0.720		9.1%		90.9%	
S052S1060	052S1060	1.430		100.0%			
S052S1072	052S1072	1.670		100.0%			
S052S1076	052S1076	3.860		22.0%		78.0%	
S052S1080	052S1080	2.950		100.0%			
S052S1081	052S1081	2.300		81.7%		18.3%	
S052S1171	052S1171	1.150	60.1%	39.9%			
S052S1173	052S1173	1.050		100.0%			
S052S1178	052S1178	1.390		100.0%			
S052S1257	052S1257	1.850		100.0%			
S052S1258	052S1258	1.720		100.0%			
S052S1259	052S1259	1.530		100.0%			
S052S1260	052S1260	1.340		100.0%			
S052S1261	052S1261	1.730		100.0%			
S052S1262	052S1262	2.370		95.6%		4.4%	
S052S1492	052S1492	1.610	98.9%	1.1%			
S052S3419	052S3419	1.460		0.7%		99.3%	
S052S4615	052S4615	1.820		57.3%		42.7%	
S052T003	052T003	2.520	77.4%	22.6%			
S052T006	052T006	2.800	0.7%		79.7%	19.7%	
S052T007	052T007	2.330		11.3%	43.7%	45.0%	
S052T008	052T008	2.900		21.8%	16.6%	61.5%	
S052T009	052T009	2.480		12.2%	40.1%	47.7%	
S052T010	052T010	3.790	7.7%	17.7%	26.0%	48.6%	
S052T011	052T011	2.010		1.2%	18.4%	59.1%	21.4%
S052T012	052T012	1.800			44.8%	55.2%	
S052T013	052T013	1.880		1.3%	27.0%	71.6%	
S052T014	052T014	1.720		0.6%		99.4%	
S052T014A	052T014	1.390		100.0%			
S052T015	052T015	1.630		1.4%		98.6%	
S052T016	052T016	1.400		15.9%		84.1%	
S052T017	052T017	2.750			28.8%	71.2%	
S052T018	052T018	1.320		100.0%			
S052T019	052T019	1.400		21.6%		78.4%	
S052T021	052T021	2.000		0.5%	28.7%	70.8%	
S052T023	052T023	4.390		4.3%		95.7%	
S052T024	052T024	3.100		1.8%	34.1%	64.2%	
S052T025	052T025	3.780		0.8%	34.0%	65.1%	
S052T026	052T026	3.680		7.0%	5.2%	87.7%	
S052T027	052T027	2.130		20.0%	33.9%	46.2%	
S052T028	052T028	2.510		1.5%	26.4%	72.1%	

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S052T029	052T029	2.120		19.4%	7.2%	73.4%	
S052T032	052T032	0.220				100.0%	
S052T036	052T036	1.400	70.0%	30.0%			
S052T037	052T037	1.910	92.1%	7.9%			
S052T039	052T039	2.180	17.7%	82.3%			
S052T040	052T040	1.870	100.0%				
S052T041	052T041	1.410	79.7%	20.3%			
S052T043	052T043	1.860	30.6%	62.5%			6.9%
S052T046	052T046	1.020		100.0%			
S052T048	052T048	1.790		100.0%			
S052T049	052T049	1.700		100.0%			
S052T050	052T050	1.200	35.1%	64.9%			
S052T051	052T051	1.360	14.0%	86.0%			
S052T052	052T052	0.950		100.0%			
S052T053	052T053	1.610	0.2%			99.8%	
S052T055	052T055	1.870		66.2%		33.8%	
S052T056	052T056	1.350	9.8%	90.2%			
S052T058	052T058	1.670	47.4%	52.6%			
S052T060	052T060	4.070	21.6%	78.4%			
S052T064	052T064	1.260	16.1%	83.9%			
S052T066	052T066	1.620	22.4%	77.6%			
S052T068	052T068	2.220	61.3%	38.7%			
S052T074	052T074	0.960	1.1%	98.9%			
S052T080	052T080	1.450	5.6%	40.4%		54.0%	
S052T081	052T081	1.110	49.2%	34.6%		16.1%	
S052T083	052T083	2.110		10.2%	35.3%	54.6%	
S052T092	052T092	0.590		11.4%		88.6%	
S052T095	052T095	1.530		87.6%		12.4%	
S052T096	052T096	1.330		91.8%		8.2%	
S052T097_2	052T097	0.760		58.8%		41.2%	
S052T098	052T098	0.970		100.0%			
S052T099	052T099	0.520		31.8%		68.2%	
S052T101	052T101	2.270	11.5%	54.0%		34.5%	
S052T102	052T102	0.980		100.0%			
S052T1047	052T1047	1.160		0.1%		99.9%	
S052T1049	052T1049	2.240		99.9%		0.1%	
S052T105	052T105	0.910		93.4%		6.6%	
S052T1050	052T1050	1.960		100.0%			
S052T1051	052T1051	2.360		100.0%			
S052T1052	052T1052	1.800		100.0%			
S052T1053	052T1053	2.230		100.0%			
S052T1054	052T1054	1.960		100.0%			
S052T1055	052T1055	1.950		100.0%			
S052T1058	052T1058	2.040		100.0%			
S052T1059	052T1059	2.130		100.0%			

**CITY OF LAKEWOOD
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**CHARACTERIZATION OF POLLUTANT LOADS
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Subcatchment Name	Tributary To Node	Area (acres)	Low Density Residential	Medium Density Residential	High Density Residential	Commercial	Open Space
S052T105A	052T105	0.420		100.0%			
S052T106	052T106	0.890		100.0%			
S052T1061	052T1061	1.210		100.0%			
S052T1062	052T1062	2.130		100.0%			
S052T1064	052T1064	2.500		100.0%			
S052T1065	052T1065	2.770		99.9%		0.1%	
S052T1068	052T1068	1.220		100.0%			
S052T1069	052T1069	2.390		100.0%			
S052T1070	052T1070	2.720		100.0%			
S052T1077	052T1077	1.340		100.0%			
S052T1078	052T1078	0.980		100.0%			
S052T1079	052T1079	0.510		100.0%			
S052T108	052T108	2.330		100.0%			
S052T1082	052T1082	3.130		100.0%			
S052T1083	052T1083	2.300		100.0%			
S052T1086	052T1086	0.970		100.0%			
S052T1087	052T1087	1.240		77.8%		22.2%	
S052T1088	052T1088	1.100		64.2%		35.8%	
S052T1089	052T1089	1.700		88.1%		11.9%	
S052T109	052T109	0.830		100.0%			
S052T1090	052T1090	1.900		100.0%			
S052T1092	052T1092	0.500		100.0%			
S052T1093	052T1093	0.400		100.0%			
S052T1094	052T1094	1.510		100.0%			
S052T1096	052T1096	2.600		100.0%			
S052T1098	052T1098	3.210		88.3%	11.4%	0.3%	
S052T110	052T110	0.920		100.0%			
S052T1101	052T1101	1.100		100.0%			
S052T1103	052T1103	1.850		100.0%			
S052T1105	052T1105	2.460		100.0%			
S052T1106	052T1106	1.970		100.0%			
S052T111	052T111	1.200		100.0%			
S052T1110	052T1110	2.330		73.0%		27.0%	
S052T1111	052T1111	2.290		100.0%			
S052T1112	052T1112	1.660		100.0%			
S052T1113	052T1113	1.880		100.0%			
S052T1115	052T1115	1.130		100.0%			
S052T1117	052T1117	2.290		100.0%			
S052T1118	052T1118	0.760		100.0%			
S052T112	052T112	0.730		100.0%			
S052T1122	052T1122	1.400		65.6%		34.4%	
S052T1124	052T1124	1.450		100.0%			
S052T1126	052T1126	2.120		100.0%			
S052T1128	052T1128	1.390		100.0%			
S052T113	052T113	0.200		100.0%			

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Subcatchment Name	Tributary To Node	Area (acres)	Low Density Residential	Medium Density Residential	High Density Residential	Commercial	Open Space
S052T1130	052T1130	1.490		75.0%	25.0%		
S052T1135	052T1135	0.910		100.0%			
S052T1137	052T1137	1.010		100.0%			
S052T114	052T114	0.890		100.0%			
S052T1141	052T1141	1.150		100.0%			
S052T1146	052T1146	0.830		100.0%			
S052T1147	052T1147	1.030		100.0%			
S052T1149	052T1149	1.370		92.1%	7.9%		
S052T114A	052T114	0.830		100.0%			
S052T1151	052T1151	1.460		100.0%			
S052T1152	052T1152	1.690		100.0%			
S052T1153	052T1153	1.720		100.0%			
S052T1156	052T1156	2.080		100.0%			
S052T1157	052T1157	2.320		100.0%			
S052T1158	052T1158	2.770		74.1%	14.7%	11.2%	
S052T1159	052T1159	2.420		100.0%			
S052T116	052T116	1.890		100.0%			
S052T1160	052T1160	2.900		100.0%			
S052T1161	052T1161	2.790		100.0%			
S052T1162	052T1162	3.370		100.0%			
S052T1163	052T1163	3.360		100.0%			
S052T1164	052T1164	2.310		100.0%			
S052T1165	052T1165	1.730		100.0%			
S052T1168	052T1168	1.830		100.0%			
S052T116A	052T116	1.410		100.0%			
S052T117	052T117	2.130		100.0%			
S052T1174	052T1174	0.670		100.0%			
S052T1176	052T1176	0.770		100.0%			
S052T1177	052T1177	1.610		100.0%			
S052T1179	052T1179	1.890		100.0%			
S052T117A	052T117	1.360		100.0%			
S052T118	052T118	0.510		100.0%			
S052T1181	052T1181	3.230		100.0%			
S052T1184	052T1184	1.950		100.0%			
S052T1187	052T1187	1.550		100.0%			
S052T1190	052T1190	1.960		100.0%			
S052T1191	052T1191	1.390		100.0%			
S052T1194	052T1194	2.450	14.2%	85.8%			
S052T1196	052T1196	3.320		100.0%			
S052T1198	052T1198	2.470		100.0%			
S052T1199	052T1199	0.930		100.0%			
S052T120	052T120	0.560		100.0%			
S052T1201	052T1201	1.340		100.0%			
S052T1203	052T1203	1.490		100.0%			
S052T1205	052T1205	2.560		100.0%			

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Subcatchment Name	Tributary To Node	Area (acres)	Low Density Residential	Medium Density Residential	High Density Residential	Commercial	Open Space
S052T1206	052T1206	0.700		100.0%			
S052T121	052T121	0.660		100.0%			
S052T1216	052T1216	1.430		100.0%			
S052T1218	052T1218	1.670		100.0%			
S052T122	052T122	1.160		100.0%			
S052T1220	052T1220	2.060	17.4%	71.8%	10.7%	0.2%	
S052T1221	052T1221	2.480		100.0%			
S052T1222	052T1222	3.720		100.0%			
S052T1223	052T1223	2.030		100.0%			
S052T1224	052T1224	3.040		100.0%			
S052T1225	052T1225	2.480		100.0%			
S052T1226	052T1226	2.230		100.0%			
S052T1228	052T1228	1.950		100.0%			
S052T123	052T123	1.000		100.0%			
S052T1230	052T1230	3.470		100.0%			
S052T1231	052T1231	2.560		100.0%			
S052T1233	052T1233	2.400		100.0%			
S052T1234	052T1234	2.220		100.0%			
S052T1235	052T1235	1.470		87.9%		12.1%	
S052T1236	052T1236	2.050		76.0%		24.0%	
S052T1237	052T1237	2.290		100.0%			
S052T1238	052T1238	1.870		100.0%			
S052T124	052T124	0.570		100.0%			
S052T1240	052T1240	1.980		100.0%			
S052T1241	052T1241	1.720		100.0%			
S052T1242	052T1242	2.400		100.0%			
S052T1243	052T1243	1.830		100.0%			
S052T1245	052T1245	1.660		100.0%			
S052T125	052T125	1.310		100.0%			
S052T126	052T126	0.570		100.0%			
S052T1263	052T1263	3.250		93.3%	6.4%	0.2%	
S052T1264	052T1264	3.010		100.0%			
S052T1265	052T1265	2.280		100.0%			
S052T1266	052T1266	1.830		100.0%			
S052T1267	052T1267	1.780		100.0%			
S052T1269	052T1269	2.300		89.3%		10.7%	
S052T127	052T127	0.940		100.0%			
S052T1270	052T1270	2.980		100.0%			
S052T1271	052T1271	2.950		100.0%			
S052T1272	052T1272	3.230	11.3%	88.7%			
S052T1273	052T1273	2.060	7.0%	63.6%		29.4%	
S052T1278	052T1278	1.910		82.0%		18.0%	
S052T1279	052T1279	1.260		99.8%		0.2%	
S052T128	052T128	1.800		100.0%			
S052T1280	052T1280	0.490		100.0%			

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Subcatchment Name	Tributary To Node	Area (acres)	Low Density Residential	Medium Density Residential	High Density Residential	Commercial	Open Space
S052T1284	052T1284	2.050		98.7%		1.3%	
S052T1285	052T1285	2.190		100.0%			
S052T1286	052T1286	2.510		100.0%			
S052T1289	052T1289	1.490		100.0%			
S052T129	052T129	0.620		100.0%			
S052T1290	052T1290	2.050		100.0%			
S052T1291	052T1291	1.950		100.0%			
S052T1294	052T1294	2.320		100.0%			
S052T1295	052T1295	2.050		100.0%			
S052T1296	052T1296	1.790		100.0%			
S052T1297	052T1297	1.420	0.1%	99.9%			
S052T1298	052T1298	2.990	27.5%	72.5%			
S052T130	052T130	1.180		100.0%			
S052T1300	052T1300	1.782		100.0%			
S052T1301	052T1301	2.069		100.0%			
S052T1302	052T1302	2.807		100.0%			
S052T1303	052T1303	3.125		100.0%			
S052T131	052T131	0.980		100.0%			
S052T132	052T132	0.550		100.0%			
S052T133	052T133	1.150		100.0%			
S052T134	052T134	1.140		0.1%	19.7%	80.2%	
S052T135	052T135	0.880		100.0%			
S052T136	052T136	0.690		99.7%		0.3%	
S052T1368	052T1368	1.400		0.2%	16.3%	83.5%	
S052T137	052T137	1.250		100.0%			
S052T138	052T138	0.820		99.8%	0.2%		
S052T139	052T139	1.080	37.2%	28.3%	19.5%	14.9%	
S052T140	052T140	0.480		100.0%			
S052T1401	052T1401	3.430		0.7%	10.4%	89.0%	
S052T1403	052T1403	1.740		0.9%	21.8%	77.3%	
S052T141	052T141	2.090		0.9%		99.1%	
S052T1410	052T1410	2.040			0.1%	99.9%	
S052T145	052T145	14.800		7.8%		92.2%	
S052T146	052T146	0.940		100.0%			
S052T1461	052T1461	2.390	71.4%	27.2%			1.5%
S052T147	052T147	2.150		100.0%			
S052T1471	052T1471	1.710	96.5%	2.6%			1.0%
S052T1478	052T1478	1.990	84.4%	13.9%			1.7%
S052T148	052T148	1.870		99.0%		1.0%	
S052T1484	052T1484	2.600	36.6%	63.4%			
S052T1488	052T1488	1.930	68.3%	31.5%			0.2%
S052T149	052T149	4.297		99.2%		0.8%	
S052T1494	052T1495	1.299	42.3%	57.7%			
S052T150	052T150	1.360		90.9%		9.1%	
S052T151	052T151	1.379		75.1%		24.9%	

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Subcatchment Name	Tributary To Node	Area (acres)	Low Density Residential	Medium Density Residential	High Density Residential	Commercial	Open Space
S052T1513	052T1513	0.854	99.4%	0.6%			
S052T1521	052T1521	1.495		100.0%			
S052T1526	052T1526	0.609		100.0%			
S052T1537	052T1537	1.735		100.0%			
S052T1538	052T1538	1.620		100.0%			
S052T1540	052T1540	0.780	0.4%	99.6%			
S052T1542	052T1542	0.980		100.0%			
S052T1543	052T1543	2.600		100.0%			
S052T1544	052T1544	2.700	0.4%	99.6%			
S052T1545	052T1545	2.230	57.8%	42.2%			
S052T1546	052T1546	2.790		100.0%			
S052T1546A	052T1546	1.870		100.0%			
S052T1548	052T1548	3.610		92.0%		8.0%	
S052T1549	052T1549	1.990		91.2%		8.8%	
S052T1559	052T1559	1.200		31.9%		68.1%	
S052T157	052T157	2.670	38.6%	59.4%			2.0%
S052T2002	052T2002	1.237	48.3%	51.6%			0.1%
S052T2004	052T2004	1.070			100.0%		
S052T2005	052T2005	10.950	0.9%	0.4%		92.8%	5.9%
S052T2007	052T2007	1.240		1.5%		98.5%	
S052T2008	052T2008	8.270		0.2%	4.4%	95.5%	
S052T3002	052T3002	1.560	41.4%	58.6%			
S052T3467	052T3467	1.830	39.4%	60.6%			
S052T3469	052T3469	1.230	37.7%	62.3%			
S052T3470	052T3470	1.370	15.0%	85.0%			
S052T3473	052T3473	1.800		100.0%			
S052T3476	052T3476	2.000		100.0%			
S052T3478	052T3478	2.000		100.0%			
S052T3481	052T3481	3.230		100.0%			
S052T3485	052T3485	2.490	34.8%	65.2%			
S052T3486	052T3486	1.660	45.4%	54.6%			
S052T3487	052T3487	1.270		100.0%			
S052T3490	052T3490	2.440		100.0%			
S052T3494	052T3494	2.500		100.0%			
S052T3495	052T3495	2.310		100.0%			
S052T3497	052T3497	3.080		94.1%	5.9%		
S052T3498	052T3498	2.030	15.9%	84.1%			
S052T3502	052T3502	5.370	61.6%	29.2%	9.2%		
S052T4403	052T4403	1.395	50.5%	49.5%			
S052T4439	052T4439	0.749	4.5%	95.5%			
S052T4440	052T4440	0.870		100.0%			
S052T4441	052T4441	1.452		100.0%			
S052T4442	052T4442	1.351		100.0%			
S052T4445	052T4445	2.243		100.0%			
S052T4446	052T4446	1.237	0.1%	99.9%			

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Subcatchment Name	Tributary To Node	Area (acres)	Low Density Residential	Medium Density Residential	High Density Residential	Commercial	Open Space
S052T4449	052T4449	0.931		100.0%			
S052T4450	052T4450	2.147		100.0%			
S052T4582	052T4582	0.750		85.1%	14.9%		
S052T4585	052T4585	1.900		89.8%	10.2%		
S052T4588	052T4588	0.960		75.1%		24.9%	
S052T4590	052T4590	1.130		100.0%			
S052T4592	052T4592	1.280		88.7%		11.3%	
S052T4593	052T4593	1.520	57.7%	22.2%		20.0%	
S052T4597	052T4597	2.700		8.6%		91.4%	
S052T4600	052T4600	1.950		65.0%		35.0%	
S052T4601	052T4601	2.050		83.0%		17.0%	
S052T4602	052T4602	1.770		100.0%			
S052T4603	052T4603	2.210		100.0%			
S052T4604	052T4604	1.370		100.0%			
S052T4605	052T4605	2.150		100.0%			
S052T4606	052T4606	3.360		100.0%			
S052T4609	052T4609	0.480		100.0%			
S052T4635	052T4635	0.850		100.0%			
S053C008	053C008	5.664		5.8%	86.0%	8.0%	0.3%
S053C009	053C010	0.688		81.6%	0.1%	18.3%	
S053C011	053C011	0.726		81.1%	18.9%		
S053C012	053C012	0.809		100.0%			
S053C013	053C013	0.353		99.7%	0.3%		
S053C3521	053C3521	0.815		94.8%		5.2%	
S053C3525	053C3525	1.247		76.1%		23.9%	
S053C3528	053C3528	1.369		57.4%		42.6%	
S053C3529	053C3529	1.232		100.0%			
S053C3544	053C3544	0.481		100.0%			
S053T014	053T014	0.523		0.7%	99.3%		
S053T015	053T015	0.256		100.0%			
S053T016	053T016	0.555		100.0%			
S053T017	053T017	1.458			57.8%	41.7%	0.5%
S053T018	053T018	1.378		0.1%	2.2%	97.8%	
S053T3507	053T3507	1.699			54.5%	45.5%	
S053T3510	053T3510	3.613			8.9%	91.1%	
S053T3513	053T3513	1.987		0.2%	56.7%	43.2%	
S053T3533	053T3533	1.770		83.0%	17.0%		
S053T3534	053T3534	1.636		58.9%	41.1%		
S053T3536	053T3536	2.928		11.2%	37.1%	51.7%	
S053T3538	053T3538	1.771		98.2%		1.8%	
S053T3539	053T3539	1.490		100.0%			
S053T3541	053T3541	0.630		100.0%			
S053T3546	053T3546	1.613		60.3%	39.7%		
S053T3547	053T3547	0.448		27.3%	63.1%	9.6%	
S053T4333	053T4333	2.044		0.2%	0.1%	99.7%	

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Subcatchment Name	Tributary To Node	Area (acres)	Low Density Residential	Medium Density Residential	High Density Residential	Commercial	Open Space
S053T4339	053T4339	1.633		0.3%	65.4%	34.3%	
S053T4340	053T4340	1.618			100.0%		
S053T4342	053T4342	1.804		0.5%	28.9%	70.6%	
S053T4343	053T4343	1.066		0.4%	25.2%	74.4%	
S055C001	055C001	1.127	11.8%	88.2%			
S055C008	055C672	5.086	46.3%	53.7%			
S055C010	055C010	3.106	11.0%	89.0%			
S055C011	055C011	1.922	14.0%	86.0%			
S055C012	055C012	1.797	0.3%	99.7%			
S055C014	055C014	1.708		100.0%			
S055C015	055C015	1.355	4.9%	78.9%	5.4%	10.8%	
S055C700	055C700	2.447	11.6%	88.4%			
S055C701	055C701	2.224		100.0%			
S055C702	055C702	2.627		81.6%			18.4%
S055C705	055C705	1.906		100.0%			
S055C706	055C706	1.603		91.9%		8.1%	
S055T005	055T005	0.615	0.2%	99.8%			
S056C013	056C013	3.444	1.4%	27.0%	71.6%		
S056C014	056C014	0.934	0.2%	99.8%			
S056C019	056C019	0.768		8.5%	91.5%		
S056C035	056C035	0.525		100.0%			
S056C117	056C117	0.757		100.0%			
S056C1300	056C1300	1.513	51.0%	49.0%			
S056C1301	056C1301	0.344		100.0%			
S056C194	056C194	3.826	7.9%	36.4%	55.7%		
S056C195	056C195	1.751	0.6%	99.2%	0.2%		
S056C280	056C280	1.321		95.8%			4.2%
S056C281	056C281	0.851		100.0%			
S056C284A	056C284A	0.519	88.0%	12.0%			
S056C285	056C285	1.806		100.0%			
S056C289	056C289	0.794		33.2%		66.8%	
S056C296	056C296	4.104		99.9%		0.1%	
S056C297	056C297	7.772		100.0%			
S056C304	056C304	2.998		100.0%			
S056C305	056C305	3.633		93.7%		6.3%	
S056C307	056C307	4.861		99.7%		0.3%	
S056C318	056C318	4.946		100.0%			
S056C320	056C320	2.758		84.9%		15.1%	
S056C325	056C325	4.479		88.9%		11.1%	
S056C490	056C490	0.443	90.4%	9.6%			
S056C557	056C557	0.779		100.0%			
S056C898	056C898	3.509	26.9%	46.2%	26.9%		
S056C899	056C899	0.546	10.3%		89.7%		
S056C912	056C912	0.737	41.4%	58.6%			
S056C913	056C913	1.017	59.1%	40.9%			

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Subcatchment Name	Tributary To Node	Area (acres)	Low Density Residential	Medium Density Residential	High Density Residential	Commercial	Open Space
S056C914	056C914	1.763	52.1%	47.9%			
S056C917	056C917	0.422		100.0%			
S056C918	056C918	0.945	86.0%	14.0%			
S056C918A	056C918	0.423		100.0%			
S056C919	056C919	0.901	66.6%	33.2%		0.2%	
S056S032	056S032	1.129		100.0%			
S056S2143	056S2143	1.598	1.7%	56.2%	42.0%		
S056S810	056S810	4.602	2.6%	71.3%		26.0%	0.1%
S056T017	056T017	3.962	15.2%	66.0%	18.8%		
S056T023	056T023	2.384		81.8%	18.2%		
S056T024	056T024	2.568		43.2%	56.8%		
S056T028	056T028	1.923		66.6%	33.4%		
S056T030	056T030	4.613		99.4%	0.6%		
S056T034	056T034	4.050		100.0%			
S056T038	056T038	3.789		17.2%		82.8%	
S056T040	056T040	4.455	11.3%	41.0%		38.1%	9.6%
S056T049	056T049	2.452		2.1%		97.9%	
S056T050	056T050	2.739				100.0%	
S056T052	056T052	1.756				100.0%	
S056T055	056T055	5.600		12.1%		87.9%	
S056T058	056T058	1.176		95.2%	4.8%		
S056T060	056T060	3.478	30.9%	69.1%			
S056T061	056T061	3.851		99.4%		0.6%	
S056T064	056T064	4.807	11.2%	74.8%	3.9%	10.1%	
S056T101	056T101	1.030	68.7%	31.3%			
S056T115	056T115	1.494		100.0%			
S056T190	056T190	2.003		76.2%	23.8%		
S056T191	056T191	3.449	2.8%	68.8%	28.4%		
S056T2133	056T2133	2.282		78.7%		21.3%	
S056T2134	056T2134	2.575		100.0%			
S056T2136	056T2136	3.176		79.6%	4.2%		16.2%
S056T2137	056T2137	2.266		100.0%			
S056T2138	056T2138	2.069	8.4%	46.5%		45.0%	
S056T2138A	056T2138	2.693		100.0%			
S056T235	056T235	1.772		89.0%			11.0%
S056T239	056T239	2.765		100.0%			
S056T253	056T253	4.638		67.1%		28.7%	4.2%
S056T264	056T264	5.643		95.8%			4.2%
S056T296	056T296	4.566	4.1%	74.4%		14.8%	6.7%
S056T299	056T299	6.715		100.0%			
S056T303	056T303	1.549		100.0%			
S056T309	056T309	3.742		0.2%		99.8%	
S056T311	056T311	2.464		24.3%	32.6%	43.0%	
S056T313	056T313	1.788		73.0%	5.0%	22.0%	
S056T331	056T331	2.316	22.8%	26.4%	50.5%	0.3%	

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S056T334	056T334	1.870	13.5%	65.9%		20.6%	
S056T335	056T335	1.325		1.4%		98.6%	
S056T540	056T540	1.436		93.6%		6.4%	
S056T541	056T541	1.534		96.6%		3.4%	
S056T542	056T542	1.023		100.0%			
S056T542A	056T542A	1.115		100.0%			
S056T543	056T543	1.340		100.0%			
S056T545	056T545	1.097		100.0%			
S056T547	056T547	1.476		100.0%			
S056T548	056T548	1.101		100.0%			
S056T550	056T550	1.481		100.0%			
S056T554	056T554	1.704		100.0%			
S056T789	056T789	7.790		95.4%			4.6%
S056T792	056T792	6.715		90.9%			9.1%
S056T793	056T793	7.976		100.0%			
S056T801	056T801	5.793	5.1%	66.5%		16.8%	11.7%
S056T804	056T804	8.008		100.0%			
S056T806	056T806	0.126		100.0%			
S056T813	056T813	1.699		79.4%			20.6%
S056T820	056T820	2.770		100.0%			
S056T837	056T837	6.131		94.6%	2.4%		3.1%
S056T895	056T895	1.297	17.6%	82.4%			
S056T897	056T897	4.276	34.2%	60.9%	4.9%		
S056T900	056T900	2.131		40.3%	59.7%		
S057C005	057C005	1.448	37.7%	62.1%	0.2%		
S057C007	057C007	3.052	30.8%	69.2%			
S057C013	057C013	2.104	14.5%	85.5%			
S057C013A	057C013A	1.394	23.8%	76.2%			
S057C015	057C015	2.134	33.4%	66.6%			
S057C018	057C018	1.538	37.4%	62.6%			
S057C020	057C020	2.397	19.4%	79.8%		0.8%	
S057C021	057C021	2.151		100.0%			
S057C022	057C022	1.136		100.0%			
S057C023	057C023	1.772		44.4%		55.6%	
S057C024	057C024	3.041	0.1%	90.8%	9.2%		
S057C025	057C025	2.500	30.8%	69.2%			
S057C278	057C278	1.940		81.7%			18.3%
S057C279	057C279	1.764	77.8%	22.2%			
S057C282	057C282	1.784	90.1%	9.9%			
S057C286	057C286	3.761	90.9%	9.1%			
S057C442	057C442	1.615		8.9%	25.2%	65.9%	
S057C443	057C443	1.168		98.8%	1.2%		
S057T009	057T009	1.987		46.7%	53.3%		
S057T010	057T010	2.756	15.3%	84.7%			
S057T014	057T014	1.877		100.0%			

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Subcatchment Name	Tributary To Node	Area (acres)	Low Density Residential	Medium Density Residential	High Density Residential	Commercial	Open Space
S057T016	057T016	2.794	2.9%	97.1%			
S057T029	057T029	2.539	2.2%	47.1%		50.6%	
S057T030	057T030	2.586		85.9%		14.1%	
S057T031	057T031	1.149		100.0%			
S057T031A	057T031	1.144		100.0%			
S057T032	057T032	1.390		100.0%			
S057T036	057T036	1.797	20.3%	28.0%	0.1%	51.6%	
S057T047	057T047	1.628		2.8%		97.2%	
S057T048	057T048	1.999				100.0%	
S057T053	057T053	1.004			8.4%	91.6%	
S057T054	057T054	0.562		0.4%	0.4%	99.2%	
S057T1000	057T1000	1.854			25.9%	74.1%	
S057T370	057T370	4.998	99.4%	0.6%			
S057T372	057T372	4.534	98.8%	1.2%			
S057T375	057T375	8.429	80.4%	19.6%			
S057T379	057T379	7.185	47.0%	29.2%	4.1%	14.5%	5.2%
S057T400	057T400	0.693		41.2%		58.8%	
S057T405	057T405	4.138		47.2%		52.8%	
S057T409	057T409	5.960		28.8%		71.2%	
S057T414	057T414	5.489				100.0%	
S057T421	057T421	4.786		22.6%		77.4%	
S057T426	057T426	3.155	0.4%	99.6%			
S057T427	057T427	3.025	0.5%	99.5%			
S057T430	057T430	2.791	0.3%	88.9%			10.8%
S057T431	057T431	5.799			83.8%	11.6%	4.6%
S057T431A	057T431	3.714		73.1%	5.0%	18.7%	3.1%
S057T448	057T448	3.768		100.0%			
S057T452	057T452	2.162	15.2%	74.6%			10.2%
S057T457	057T457	9.026		99.7%		0.2%	
S057T469	057T469	3.457		99.0%	1.0%		
S057T471	057T471	5.418		100.0%			
S057T473	057T473	5.250		100.0%			
S057T474	057T474	2.595		100.0%			
S057T475	057T475	0.775		49.8%	11.8%	38.3%	
S057T477	057T477	5.069		99.6%		0.4%	
S057T480	057T480	7.072		100.0%			
S057T481	057T481	2.904		89.5%		10.5%	
S057T485	057T485	7.732	8.5%	89.1%	1.4%	1.0%	
S057T489	057T489	10.155		100.0%			
S057T511	057T511	10.302		98.5%		1.5%	
S057T514	057T514	5.960		100.0%			
S057T517	057T517	4.249		71.2%		28.8%	
S057T535	057T535	6.334		96.6%		3.4%	
S057T539	057T539	4.570		100.0%			
S057T547	057T547	4.151		23.7%	11.1%	65.2%	

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Subcatchment Name	Tributary To Node	Area (acres)	Low Density Residential	Medium Density Residential	High Density Residential	Commercial	Open Space
S057T552	057T552	2.071				100.0%	
S057T580	057T580	2.037	16.1%	83.7%	0.2%		
S057T601	057T601	2.339		91.2%		8.8%	
S057T603	057T603	4.496		100.0%			
S057T609	057T609	3.379		91.9%			8.1%
S057T610	057T610	2.504		100.0%			
S057T611	057T611	2.644		85.4%		14.6%	
S057T612	057T612	2.109		100.0%			
S057T613	057T613	2.151		100.0%			
S057T614	057T614	4.214		89.6%			10.4%
S057T617	057T617	5.092		96.1%			3.9%
S057T618	057T618	2.755		100.0%			
S057T621	057T621	2.725		42.2%	41.9%		15.9%
S057T630	057T630	3.753		100.0%			
S057T632	057T632	2.037		100.0%			
S057T635	057T635	1.906		100.0%			
S057T636	057T636	1.938		100.0%			
S057T637	057T637	2.511		43.9%		56.1%	
S057T638	057T638	4.039		76.9%	14.9%	2.7%	5.5%
S057T657	057T657	2.443			96.4%	3.6%	
S057T739	057T739	4.766		3.0%	87.6%	6.2%	3.2%
S058C002	058C002	3.021	77.6%	22.4%			
S058C004	058C004	3.601	57.2%	42.8%			
S058C004A	058C004	3.714	55.3%	23.8%		20.9%	
S058C005	058C005	3.754	75.2%	24.8%			
S058C006	058C006	6.198	72.5%	9.2%		18.2%	
S058C008	058C008	0.684		100.0%			
S058T014	058T014	7.428	1.8%	4.8%	0.3%	83.3%	9.9%
S059AC001	059AC001	1.524	99.1%	0.9%			
S059AC001A	059AC001	0.979	98.5%	1.5%			
S059AC001B	059AC001	0.839	99.8%	0.2%			
S059AC001C	059AC001	3.333	100.0%				
S059AC001D	059AC001	2.428	81.4%	18.6%			
S059AC001E	059AC001	1.012	56.2%	43.8%			
S059AC017	059AC017	1.063			0.2%	99.8%	
S059AC046A	059AC046A	0.850		16.0%	23.8%	60.3%	
S059AC1013	059AC1013	0.538		78.9%		21.1%	
S059AC1013A	059AC1013	0.586		99.0%		1.0%	
S059AC1015	059AC1015	1.302		100.0%			
S059AC1015A	059AC1015	1.323		98.2%		1.8%	
S059AC1017	059AC1017	0.684		83.0%		17.0%	
S059AC1017A	059AC1017	0.760		72.9%		27.1%	
S059AC1017B	059AC1017	1.543		99.7%		0.3%	
S059AC1017C	059AC1017	1.540		100.0%			
S059AC1020	059AC1020	2.974		90.6%	8.2%	1.2%	

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S059AC1021	059AC1021	1.992		99.7%		0.3%	
S059AC1023	059AC1023	2.838		0.4%		99.6%	
S059AC1023A	059AC1023	3.502		67.3%		32.7%	
S059AC1034	059AC1034	2.993		92.2%	7.8%		
S059AC1310	059AC1310	0.386		99.9%			
S059AC1310A	059AC1310	0.197		43.3%	56.7%		
S059AC3001	059AC3001	1.756		59.1%	16.0%	24.8%	
S059AC3002	059AC3002	2.152	17.0%	83.0%			
S059AC3003	059AC3003	2.331	49.6%	50.4%	0.1%		
S059AC3005	059AC3005	2.246		24.6%	75.4%		
S059AC898	059AC898	1.772	17.6%	60.1%	10.3%	11.9%	
S059AC898A	059AC898	1.582	0.1%	99.9%			
S059AC899	059AC899	2.879		100.0%			
S059AC900	059AC900	2.618		100.0%			
S059AC901	059AC901	1.494	0.2%	99.8%			
S059AC902	059AC902	2.775	11.9%	88.1%			
S059AC903	059AC903	2.502		100.0%			
S059AC904	059AC904	2.270		100.0%			
S059AC905	059AC905	1.921		92.6%		7.4%	
S059AC908	059AC908	1.970		98.2%	1.8%		
S059AC909	059AC909	1.250		100.0%			
S059AC910	059AC910	3.510		100.0%			
S059AC911	059AC911	3.234	5.1%	94.9%			
S059AC912	059AC912	2.762	8.3%	91.7%			
S059AC914	059AC914	1.220		100.0%			
S059AC914A	059AC914	0.470		100.0%			
S059AC916	059AC916	0.465	18.6%	81.4%			
S059AC916A	059AC916	1.228	41.6%	58.4%			
S059AC971	059AC971	1.376		100.0%			
S059AC972	059AC972	3.350		100.0%			
S059AC975	059AC975	3.610		96.2%		3.8%	
S059AC977	059AC977	1.680		100.0%			
S059AC978	059AC978	2.170		94.1%	5.9%		
S059AS3006	059AS3006	2.133	13.6%	60.6%	25.8%		
S059AST0RE	059AST0RE	5.406		4.5%		95.5%	
S059AT003	059AT003	4.649	99.5%	0.5%			
S059AT006A	059AT006A	1.648	6.8%	93.1%		0.2%	
S059AT006AB	059AT006A	1.908	47.9%	51.6%	0.4%		
S059AT007	059AT007	1.967	29.9%	18.2%	51.9%		
S059AT012	059AT012	1.286		100.0%			
S059AT016	059AT016	2.350		17.8%	1.7%	80.5%	
S059AT018	059AT018	2.730		2.3%	15.0%	82.6%	
S059AT021	059AT021	2.710		3.5%		96.5%	
S059AT022	059AT022	2.950		0.6%	6.1%	93.3%	
S059AT024	059AT024	1.980		45.3%	0.3%	54.4%	

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S059AT025	059AT025	2.100		0.2%	23.1%	76.8%	
S059AT026	059AT026	2.750		0.3%	23.6%	76.1%	
S059AT027	059AT027	2.300	15.6%	1.8%	17.5%	65.2%	
S059AT029	059AT029	2.190	0.2%		52.0%	47.8%	
S059AT030	059AT030	1.846			28.6%	71.4%	
S059AT031	059AT031	0.966			10.5%	89.5%	
S059AT1000	059AT1000	2.150		98.6%		1.4%	
S059AT1001	059AT1001	2.580		92.6%		7.4%	
S059AT1004	059AT1004	3.829		98.9%		1.1%	
S059AT1011	059AT1011	3.729		0.2%		99.8%	
S059AT1013	059AT1013	1.848				100.0%	
S059AT1014	059AT1014	0.596		93.8%		6.2%	
S059AT1018	059AT1018	1.092		94.4%		5.6%	
S059AT1039	059AT1039	2.820		99.9%		0.1%	
S059AT1041	059AT1041	1.891		99.7%		0.3%	
S059AT1043	059AT1043	2.093		100.0%			
S059AT1046	059AT1046	1.909		100.0%			
S059AT1311	059AT1311	0.964	0.1%	27.6%	71.6%	0.7%	
S059AT876	059AT876	3.090		95.8%		4.2%	
S059AT878	059AT878	3.290		100.0%			
S059AT880	059AT880	4.070		91.3%			8.7%
S059AT884	059AT884	2.504	2.0%	70.2%		21.4%	6.3%
S059AT884A	059AT884	6.554			0.5%	99.4%	0.1%
S059AT885	059AT885	4.771	4.4%	22.7%	26.0%	46.9%	
S059AT888	059AT888	2.420		59.1%		40.9%	
S059AT891	059AT891	2.600		100.0%			
S059AT913	059AT913	1.230		100.0%			
S059AT915	059AT915	1.235	0.6%	99.4%			
S059AT920	059AT920	3.995		96.1%		3.9%	
S059AT921	059AT921	2.890		100.0%			
S059AT922	059AT922	2.890		100.0%			
S059AT924	059AT924	3.670	2.7%	97.3%			
S059AT925	059AT925	2.410	12.0%	88.0%			
S059AT926	059AT926	2.520	41.7%	58.3%			
S059AT927	059AT927	2.440	54.2%	18.0%	25.6%	2.0%	
S059AT930	059AT930	3.665		95.7%		4.3%	
S059AT932	059AT932	4.430		100.0%			
S059AT933	059AT933	3.580		100.0%			
S059AT935	059AT935	3.120	15.0%	85.0%			
S059AT936	059AT936	0.750		100.0%			
S059AT937	059AT937	2.230	17.3%	82.7%			
S059AT940	059AT940	2.940	23.1%	76.9%			
S059AT942	059AT942	1.390		100.0%			
S059AT945	059AT945	4.050		100.0%			
S059AT946	059AT946	2.900		100.0%			

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**CHARACTERIZATION OF POLLUTANT LOADS
TECHNICAL MEMORANDUM**

Subcatchment Name	Tributary To Node	Area (acres)	Low Density Residential	Medium Density Residential	High Density Residential	Commercial	Open Space
S059AT948	059AT948	4.840		56.7%		43.3%	
S059AT950	059AT950	2.010		100.0%			
S059AT956	059AT956	3.190		95.7%	4.3%		
S059AT958	059AT958	3.000		100.0%			
S059AT960	059AT960	3.640		100.0%			
S059AT962	059AT962	3.680	11.6%	88.4%			
S059AT963	059AT963	4.520	24.9%	75.1%			
S059AT969	059AT969	2.741		99.9%		0.1%	
S059AT983	059AT983	2.620		99.9%	0.1%		
S059AT984	059AT984	1.920		100.0%			
S059AT985	059AT985	1.920		100.0%			
S059AT986	059AT986	2.190		99.8%		0.2%	
S059AT987	059AT987	2.470		100.0%			
S059AT989	059AT989	2.660		100.0%			
S059AT989A	059AT989	3.280		94.5%		5.5%	
S059AT993	059AT993	11.808		29.5%		70.4%	
S059AT995	059AT995	9.400		36.9%		63.1%	
S059AT999	059AT999	3.890		99.0%		1.0%	
S059BC010	059BC010	10.877	90.4%	9.4%		0.2%	
S059BT005	059BT005	2.157	83.4%	16.6%			
S059BT011	059BT011	2.979	19.2%	52.7%		28.1%	
S059BT013	059BT013	1.160		100.0%			
S059BT745	059BT745	3.028	67.3%	32.7%			
S059BT751	059BT751	1.979	77.2%	22.8%			
S059BT753	059BT753	3.054	93.0%	7.0%			
S059C0001	059C0001	3.821		1.0%		99.0%	
S059C0004	059C0004	1.398		2.5%		97.5%	
S059C0005	059C0005	3.856	34.9%	60.7%	4.4%		
S059C0009	059C0009	2.627	33.7%	51.2%	15.1%		
S059C0011	059C0011	5.082	7.9%	0.2%	78.8%	13.1%	
S059C0015	059C0015	2.665		10.8%	89.2%		
S059C0019	059C0019	2.912			99.9%	0.1%	
S059C0026	059C0026	1.279		26.6%	73.3%	0.1%	
S059C0028	059C0028	2.274		2.5%	13.2%	84.3%	
S059C0032	059C0032	2.744		9.0%	91.0%		
S059C0035	059C0035	3.073		19.6%	79.4%	1.0%	
S059C0040	059C0040	2.266		100.0%			
S059C0043	059C0043	1.189		0.7%	60.1%	39.2%	
S059C0044	059C0044	0.963		38.2%	1.1%	60.7%	
S059C0046	059C0046	2.777		10.2%	14.1%	75.6%	0.1%
S059C0047	059C0047	2.617			1.1%	98.9%	
S059C0051	059C0051	4.876	0.7%	12.0%	7.1%	80.2%	
S059C0052	059C0052	3.192	17.2%	6.8%	0.8%	75.1%	
S059C0053	059C0053	1.790		19.9%	17.3%	62.8%	
S059C0055	059C0055	1.756		72.2%		27.8%	

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Subcatchment Name	Tributary To Node	Area (acres)	Low Density Residential	Medium Density Residential	High Density Residential	Commercial	Open Space
S059C0057	059C0057	3.734	1.6%	19.3%	33.3%	45.8%	
S059C0058	059C0058	1.788	0.1%	35.3%		64.6%	
S059C0059	059C0059	5.036		0.1%		99.9%	
S059C0061	059C0061	1.036		100.0%			
S059C0062	059C0062	0.212		97.2%	0.6%	2.2%	
S059C0063	059C0063	0.378	1.8%	48.4%	49.8%		
S059C0064	059C0064	0.968		100.0%			
S059C0065	059C0065	0.940		85.8%	14.2%		
S059C0067	059C0067	1.825		80.9%		19.1%	
S059C0068	059C0068	0.863	0.1%	96.9%	3.1%		
S059C0069	059C0069	0.885	42.3%	1.7%		56.0%	
S059C0070	059C0070	1.671		13.4%		86.5%	
S059C0072	059C0072	0.703		99.8%		0.2%	
S059C0073	059C0073	1.157		99.8%		0.2%	
S059C0073A	059C0073A	2.591			0.2%	99.8%	
S059C0074A	059C0074A	1.906		0.8%	7.4%	91.9%	
S059C0075	059C0075	2.358				100.0%	
S059C0076	059C0076	3.904		2.6%	17.9%	79.5%	
S059C0076A	059C0076A	1.977		1.1%	1.2%	97.6%	
S059C0077	059C0077	18.169		81.8%	1.2%	15.7%	1.3%
S059C0077A	059C0077A	1.795		0.4%		99.6%	
S059C0079	059C0079	1.685		0.2%	5.7%	94.1%	
S059C0079A	059C0079A	1.093		100.0%			
S059C0080	059C0080	2.229		0.8%	33.7%	65.5%	
S059C0080A	059C0080A	1.262		100.0%			
S059C0081	059C0081	1.695			22.0%	78.0%	
S059C0081A	059C0081A	1.105		100.0%			
S059C0082	059C0082	1.029		100.0%			
S059C0082A	059C0082A	1.168		100.0%			
S059C0083	059C0083	0.891		100.0%			
S059C0083A	059C0083A	1.168		100.0%			
S059C0084	059C0084	0.924		99.9%		0.1%	
S059C0085	059C0085	15.804		0.1%		93.0%	6.9%
S059C0088	059C0088	0.757		100.0%			
S059C0089	059C0089	1.025		50.6%	26.8%	22.7%	
S059C0090	059C0090	1.032		87.4%	0.1%	12.5%	
S059C0091	059C0091	1.032		54.6%		45.4%	
S059C0092	059C0092	0.705		100.0%			
S059C0093	059C0093	0.693		100.0%			
S059C0097	059C0097	1.272		53.9%		41.6%	4.5%
S059C010	059C010	11.353	49.9%	15.2%	16.1%	18.7%	
S059C1009	059C1009	3.818		5.3%		94.7%	
S059C1020	059C1020	9.807	0.3%	0.1%	99.7%		
S059C2002	059C2002	2.621		93.4%		6.6%	
S059C2003	059C2003	2.616		100.0%			

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S059C2004	059C2004	2.606	100.0%	
S059C2006	059C2006	1.970	100.0%	
S059C2007	059C2007	2.305	100.0%	
S059C2008	059C2008	2.650	100.0%	
S059C2009	059C2009	2.292	100.0%	
S059C2012	059C2012	2.151	100.0%	
S059C2013	059C2013	2.416	100.0%	
S059C2014	059C2014	2.440	100.0%	
S059C2015	059C2015	2.143	100.0%	
S059C2016	059C2016	2.158	100.0%	
S059C2017	059C2017	2.166	99.8%	0.2%
S059C2020	059C2020	1.297	100.0%	
S059C2021	059C2021	1.730	100.0%	
S059C2022	059C2022	1.952	100.0%	
S059C2023	059C2023	1.483	100.0%	
S059C2024	059C2024	2.003	100.0%	
S059C2025	059C2025	2.048	100.0%	
S059C2026	059C2026	1.701	100.0%	
S059C2032	059C2032	1.855	100.0%	
S059C2033	059C2033	1.722	100.0%	
S059C2034	059C2034	1.970	100.0%	
S059C2035	059C2035	1.448	100.0%	
S059C2036	059C2036	1.608	100.0%	
S059C2037	059C2037	1.950	100.0%	
S059C2038	059C2038	1.746	99.7%	0.3%
S059C2042	059C2042	2.262	99.9%	0.1%
S059C2043	059C2043	2.510	100.0%	
S059C2044	059C2044	2.066	100.0%	
S059C2045	059C2045	2.324	100.0%	
S059C2046	059C2046	1.668	100.0%	
S059C2050	059C2050	1.868	100.0%	
S059C2051	059C2051	2.391	100.0%	
S059C2052	059C2052	2.145	100.0%	
S059C2053	059C2053	1.555	100.0%	
S059C2055	059C2055	2.087	100.0%	
S059C2056	059C2056	1.598	99.9%	0.1%
S059C2060	059C2060	1.743	100.0%	
S059C2061	059C2061	1.649	100.0%	
S059C2062	059C2062	2.492	100.0%	
S059C2063	059C2063	1.869	100.0%	
S059C2064	059C2064	1.849	100.0%	
S059C2065	059C2065	2.212	100.0%	
S059C2066	059C2066	1.739	99.6%	0.4%
S059C2071	059C2071	2.604	99.6%	0.4%
S059C2072	059C2072	2.562	99.7%	0.3%
S059C2073	059C2073	1.726	100.0%	
S059C2074	059C2074	1.997	100.0%	
S059C2075	059C2075	1.977	100.0%	
S059C2076	059C2076	1.389	99.6%	0.4%

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Subcatchment Name	Tributary To Node	Area (acres)	Low Density Residential	Medium Density Residential	High Density Residential	Commercial	Open Space
S059C2082	059C2082	1.879		100.0%			
S059C2083	059C2083	2.067		100.0%			
S059C2090	059C2090	1.165		98.2%	1.8%		
S059C2092	059C2092	1.442		27.3%	49.6%	8.1%	14.9%
S059C2098	059C2098	1.765		88.2%	11.8%		
S059C3003	059C3003	2.644		55.1%		44.9%	
S059C3004	059C3004	2.715		99.7%		0.3%	
S059C3006	059C3006	2.385		99.7%	0.3%		
S059C3007	059C3007	1.320		90.3%		9.7%	
S059C3010	059C3010	3.911		100.0%			
S059C3011	059C3011	5.077		96.6%	3.4%		
S059C3017	059C3017	1.878		100.0%			
S059C3018	059C3018	2.155		100.0%			
S059C3019	059C3019	2.314		100.0%			
S059C3020	059C3020	1.108		100.0%			
S059C3022	059C3022	1.649		100.0%			
S059C3023	059C3023	2.166		100.0%			
S059C3024	059C3024	2.173		100.0%			
S059C3025	059C3025	1.446	0.1%	99.9%			
S059C3026	059C3026	1.453		100.0%			
S059C3029	059C3029	1.691		87.8%	12.0%	0.2%	
S059C3030	059C3030	1.946		99.4%		0.6%	
S059C3031	059C3031	1.981		100.0%			
S059C3035	059C3035	5.917		42.3%	3.4%	46.1%	8.1%
S059C3040	059C3040	2.391		85.0%		15.0%	
S059C3046	059C3046	4.247		34.7%		65.3%	
S059C3050	059C3050	1.494		37.8%	9.0%	53.2%	
S059C3057	059C3057	3.164		87.5%	12.5%		
S059C3058	059C3058	3.575	8.5%	76.0%	11.5%	4.0%	
S059C3059	059C3059	3.915	1.3%	95.9%		2.8%	
S059C3060	059C3060	2.720		85.6%	14.4%		
S059C3061	059C3061	3.443	0.2%	88.3%	11.5%		
S059C3074	059C3074	3.412		99.3%	0.7%		
S059C3077	059C3077	2.372		100.0%			
S059C3081	059C3081	2.303		100.0%			
S059C3083	059C3083	2.564		86.0%	13.8%	0.2%	
S059C3087	059C3087	2.390		57.8%		42.2%	
S059C3089	059C3089	1.882		54.6%		45.4%	
S059C3090	059C3090	1.993		44.4%		51.5%	4.1%
S059C3093	059C3093	4.228		53.1%	7.0%	33.0%	6.9%
S059C3101	059C3101	2.318		100.0%			
S059C3102	059C3102	1.866		100.0%			
S059C3103	059C3103	1.747	0.4%	86.9%	12.7%		
S059C3104	059C3104	2.076		94.5%	5.5%		
S059C3105	059C3105	2.880		99.9%	0.1%		

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Subcatchment Name	Tributary To Node	Area (acres)	Low Density Residential	Medium Density Residential	High Density Residential	Commercial	Open Space
S059C3108	059C3108	2.086		94.3%	5.7%		
S059C3109	059C3109	1.520		100.0%			
S059C3110	059C3110	1.172		99.6%	0.4%		
S059C3111	059C3111	1.392		100.0%			
S059C3112	059C3112	1.631		100.0%			
S059C3113	059C3113	1.872		99.9%	0.1%		
S059C3119	059C3119	2.744	7.2%	82.9%	9.0%	0.9%	
S059C3120	059C3120	3.171		86.1%	13.9%		
S059C3122	059C3122	2.435		99.8%	0.2%		
S059C3123	059C3123	2.596		66.0%	34.0%		
S059C3126	059C3126	1.570		92.4%	6.1%	1.5%	
S059C3126A	059C3126	3.118		69.0%	30.3%	0.7%	
S059C3129	059C3129	3.159		70.7%		29.3%	
S059C3131	059C3131	3.328		85.1%	14.0%	0.9%	
S059C3132	059C3132	2.676		72.4%	27.1%	0.5%	
S059C3135	059C3135	3.385		27.1%	49.7%	23.2%	
S059C3139	059C3139	0.846		64.1%	34.3%	1.6%	
S059C3140	059C3140	2.061		92.3%	6.9%	0.7%	
S059C3141	059C3141	1.407		80.9%		0.2%	18.8%
S059C3142	059C3142	3.492		87.4%	12.5%	0.1%	
S059C3143	059C3143	4.014	7.1%	42.6%	29.9%		20.3%
S059C3144	059C3144	5.784	11.9%	36.4%	47.1%		4.6%
S059C3149	059C3149	2.297	0.1%	99.8%	0.1%		
S059C3171	059C3171	2.260		78.0%	12.6%	9.3%	
S059C3176	059C3176	7.577			52.3%	35.6%	12.1%
S059C4096	059C4096	1.793		80.4%	19.6%		
S059C4100	059C4100	2.567		27.9%	38.4%	33.7%	
S059C4101	059C4101	1.809		30.8%	69.1%	0.1%	
S059C4102	059C4102	3.234		81.2%	10.0%	8.7%	
S059C4127	059C4127	2.056			99.5%	0.4%	
S059C4129	059C4129	2.898	11.6%	28.9%	53.5%	6.0%	
S059C4132	059C4132	4.935	6.2%	1.4%	60.6%	31.7%	
S059C4212	059C4212	5.932		0.1%	0.2%	94.1%	5.6%
S059C4225	059C4225	8.842		2.2%	11.3%	86.5%	
S059C4473	059C4473	0.927		75.2%		24.8%	
S059C4474	059C4474	2.158		89.0%	10.5%	0.5%	
S059C4478	059C4478	3.612		75.8%	24.2%		
S059C4482	059C4482	1.276		100.0%			
S059C4483	059C4483	1.514		82.3%		17.7%	
S059C4489	059C4489	1.625		100.0%			
S059C4490	059C4490	1.663		100.0%			
S059C4494	059C4494	2.428				100.0%	
S059C4499	059C4499	1.917		0.9%		99.1%	
S059C4507	059C4507	1.377		15.0%		85.0%	
S059C4510	059C4510	5.475		20.7%	5.2%	74.1%	

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Subcatchment Name	Tributary To Node	Area (acres)	Low Density Residential	Medium Density Residential	High Density Residential	Commercial	Open Space
S059C4523	059C0081	22.841			0.1%	96.2%	3.7%
S059C4542	059C4542	42.974				85.8%	14.2%
S059C4563	059C4563	4.032		57.1%		42.9%	
S059C842A	059C842A	4.178	8.3%	84.5%		2.4%	4.8%
S059S3013	059S3013	4.372	6.8%	93.2%			
S059S3014	059S3014	4.838	13.8%	81.2%		5.1%	
S059T001	059T001	4.707			100.0%		
S059T017	059T017	3.553	50.2%	2.2%	47.5%		
S059T030	059T030	7.114		0.1%		96.5%	3.4%
S059T038	059T038	2.030		49.1%	21.7%	29.2%	
S059T041	059T041	1.273		98.8%	0.7%		0.5%
S059T042	059T042	1.127		60.7%		39.3%	
S059T071	059T071	2.115		3.7%	48.9%	47.4%	
S059T1006	059T1006	0.728		87.0%	13.0%		
S059T2085	059T2085	1.517		100.0%			
S059T2086	059T2086	1.545		97.2%	2.8%		
S059T2087	059T2087	1.696		66.1%	12.8%		21.1%
S059T2088	059T2088	1.445		100.0%			
S059T2089	059T2089	1.150		88.8%	11.2%		
S059T2096	059T2096	4.442		50.1%	49.9%		
S059T2097	059T2097	1.568		72.8%			27.2%
S059T3065	059T3065	3.627		91.9%	8.1%		
S059T3066	059T3066	2.865		94.4%	5.6%		
S059T3067	059T3067	2.210		100.0%			
S059T3068	059T3068	2.839	11.9%	77.9%	10.3%		
S059T3069	059T3069	2.848		94.4%	5.6%		
S059T3070	059T3070	3.187		99.7%	0.2%	0.1%	
S059T4107	059T4107	6.939			100.0%		
S059T4112	059T4112	11.086			99.8%	0.1%	
S059T4118	059T4118	7.367	7.5%		79.4%	13.0%	
S059T811	059T811	2.029		90.1%	9.9%		
S059T812	059T812	1.236	1.0%	98.8%	0.2%		
S059T813	059T813	1.316		95.3%	4.7%		
S059T815	059T815	2.131		99.7%	0.3%		
S059T816	059T816	1.344	12.5%	57.8%			29.7%
S059T819	059T819	1.518		91.5%			8.5%
S059T823	059T823	11.850		15.8%		79.4%	4.8%
S059T825	059T825	2.108	0.1%	99.9%			
S059T828	059T828	2.121		100.0%			
S059T830	059T830	2.273		91.1%			8.9%
S059T832	059T832	2.411		12.4%	70.1%	17.5%	
S059T849	059T849	3.785	29.0%	54.4%			16.6%
S059T892	059T892	3.810		100.0%			

APPENDIX B

FLOW AND POLLUTANT CONCENTRATIONS
SAMPLERS A-E

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APPENDIX B – FLOW AND POLLUTANT CONCENTRATIONS SAMPLERS A-E

B.1 Introduction

Five flow meters/samplers were installed to collect characterization data for the pollutant model. Four samplers collected runoff from the following types of land use:

- A. Low density residential property (properties greater than 0.25 acre)
- B. Commercial/Industrial properties
- C. High density residential property (apartments and high-rise buildings)
- D. Medium density residential (single family and duplexes on lots less than 0.25 acre)

Samplers A through D were programmed to start when the depth of flow reached one inch and to continue sampling every 15 minutes during the wet weather event until 8 samples were collected. The following pages list the dates that samples were collected and the concentrations of the four pollutants being modeled: Carbonaceous Biochemical Oxygen Demand (CBOD), Total Phosphorous (TP), and Total Suspended Solids (TSS) all as measured in milligrams per liter (mg/l) and *Escherichia coli* (*E. coli*) as measured in colony forming units per deciliter cfu/dl (a deciliter is 1/10 of a liter or 100 milliliters).

The target was to collect eight samples at each site from five rain events. Many runoff events lasted less than the 2 hours of 1-inch flow necessary to collect samples. Batteries died at some sites, so the sampling period was extended to include one additional storm. Site C had an equipment malfunction and only four storms were sampled. Site D had one storm where insufficient liquid was drawn to run all the tests, so only CBOD was analyzed. The dates, sample numbers and pollutant concentrations are listed on the following pages.

The fifth flow meter/sampler was installed for a week in a medium density residential area sewer to measure an hourly flow pattern and pollutant concentrations in sewage on a dry day.

A. Medium density residential sewage

Sampler E was programmed to collect separate samples at discreet times. Samples were taken every hour during the morning and evening peak flow periods. During off-peak periods, the samplers activated every other hour. During the night, an insufficient amount of flow was collected for each of samples 11, 12 and 13. These three samples were combined, analyzed, and reported in the 3:00 am time slot.

B.2 Pollutant Loadings

Pollutant loadings were calculated for each sample. Since the flow meters were programmed to measure the flow rate every five minutes, for samplers A-D, three flow rate readings (before, during and after the sampling) were averaged to calculate the total volume of flow associated with each sample. For sampler E, average hourly flow rates were calculated and used to determine flow volumes. The flow volume times the sample concentration and appropriate unit conversion factors were used to calculate the loadings. The equations are as follows:

$$\text{lbs Pollutant} = \# \text{ Gallons} \times 8.34 \text{ lb/gal} \times \text{Concentration} \times 1 \text{ liter}/1,000,000 \text{ mg}$$

$$\text{Number of CFU} = \# \text{ Gallons} \times 3.7853 \text{ liter/gal} \times \text{Concentration} \times 10 \text{ deciliter/liter}$$

A flow weighted average concentration is shown on the following pages. A flow weighted average is used for the model as being more conservative than geometric means even though geometric means for *E. coli* are used for Lake Erie water quality at beaches.

Sampler A
Lake, west of intersection with Clifton & Forest
Low Density Residential

Flow Volume (Gallons)	Date & Sample #	Sample CBOD (mg/l)	Sample <i>E. coli</i> (cfu/dl)	Sample TP (mg/l)	Sample TSS (mg/l)	Sampler Washoff Loading CBOD (pounds)	Sampler Washoff Loading <i>E. coli</i> (cfu)	Sampler Washoff Loading TP (pounds)	Sampler Washoff Loading TSS (pounds)
3,237	8/03 - #1	20	115,600	2.5	1250	0.540	1.42E+10	0.067	33.744
58,858	8/03 - #2	26	1,004,000	1.11	233	12.763	2.24E+12	0.545	114.374
67,700	8/03 - #3	13	250,000	0.56	68	7.340	6.41E+11	0.316	38.394
43,833	8/03 - #4	14	650,000	0.55	32	5.118	1.08E+12	0.201	11.698
11,339	8/03 - #5	12	570,000	0.44	24	1.135	2.45E+11	0.042	2.270
17,942	8/03 - #6	9	880,000	0.39	18	1.347	5.98E+11	0.058	2.693
11,114	8/03 - #7	9	270,000	0.37	16	0.834	1.14E+11	0.034	1.483
7,918	8/03 - #8	10	240,000	0.36	16	0.660	7.19E+10	0.024	1.057
2,549	8/11 - #1								
228,469	8/11 - #2	29	432,000	0.85	152	55.257	3.74E+12	1.620	289.625
363,477	8/11 - #3	10	112,000	0.38	95	30.314	1.54E+12	1.152	287.983
68,930	8/11 - #4	9	96,000	0.46	43	5.174	2.50E+11	0.264	24.720
8,653	8/11 - #5	20	2,200,000	0.96	63	1.443	7.21E+11	0.069	4.546
257	8/11 - #6								
124	8/11 - #7								
95	8/11 - #8								
432,384	8/18 - #1	20	30,800	1.03	527	72.122	5.04E+11	3.714	1900.404
225,072	8/18 - #2	30	4,800,000	1.20	120	56.313	4.09E+13	2.253	225.252
7,335	8/18 - #3	27	5,000,000	0.76	54	1.652	1.39E+12	0.046	3.304
20,697	8/18 - #4	25	4,200,000	0.63	16	4.315	3.29E+12	0.109	2.762
31,474	8/18 - #5	22	4,200,000	0.64	27	5.775	5.00E+12	0.168	7.087
1,232	8/18 - #6	32	3,160,000	0.56	23	0.329	1.47E+11	0.006	0.236
114	8/18 - #7	47	2,960,000	0.70	31	0.045	1.27E+10	0.001	0.029
23	8/18 - #8	30	4,200,000	0.57	25	0.006	3.67E+09	0.000	0.005
934	9/04 - #1								
2,054	9/04 - #2								
4,886	9/04 - #3	9	90,090	0.41	101	0.367	1.67E+10	0.017	4.115
7,202	9/04 - #4	12	350,000	0.28	39	0.721	9.54E+10	0.017	2.342
6,861	9/04 - #5	67	960,000	1.04	245	3.834	2.49E+11	0.060	14.019
9,464	9/04 - #6	16	545,000	0.40	68	1.263	1.95E+11	0.032	5.367
8,049	9/04 - #7	9	467,000	0.23	23	0.604	1.42E+11	0.015	1.544
5,613	9/04 - #8	9	460,000	0.25	21	0.421	9.77E+10	0.012	0.983
1,113	9/14 - #1								
78,314	9/14 - #2	18	7,840,000	2.27	306	11.757	2.32E+13	1.483	199.861
278,223	9/14 - #3	73	590,000	0.77	123	169.388	6.21E+12	1.787	285.407
134,453	9/14 - #4	33	2,000,000	0.87	109	37.004	1.02E+13	0.976	122.226
41,161	9/14 - #5	35	380,000	0.75	88	12.015	5.92E+11	0.257	30.209
7,358	9/14 - #6	23	142,000	0.60	28	1.411	3.96E+10	0.037	1.718
5,946	9/14 - #7	9	88,900	0.57	23	0.446	2.00E+10	0.028	1.140
5,691	9/14 - #8	9	310,000	0.47	17	0.427	6.68E+10	0.022	0.807
Weighted Average Concentrations						27 mg/l	1.24E+06 cfu/dl	0.84 mg/l	196 mg/l

Sampler B
on Bell just north of Detroit
Mix of Commercial and Medium Density Residential

Flow Volume (Gallons)	Date & Sample #	Sample CBOD (mg/l)	Sample E. coli (cfu/dl)	Sample TP (mg/l)	Sample TSS (mg/l)	Sampler Washoff Loading CBOD (pounds)	Sampler Washoff Loading E. coli (cfu)	Sampler Washoff Loading TP (pounds)	Sampler Washoff Loading TSS (pounds)
250	8/03 - #1	102	177,800	1.51	220	0.213	1.68E+09	0.003	0.459
8,869	8/03 - #2	89	880,000	3.07	432	6.583	2.95E+11	0.227	31.955
10,299	8/03 - #3	31	1,235,600	0.90	102	2.663	4.82E+11	0.077	8.761
16,318	8/03 - #4	50	1,120,000	0.52	60	6.805	6.92E+11	0.071	8.166
14,031	8/03 - #5	58	457,800	0.45	30	6.787	2.43E+11	0.053	3.511
15,899	8/03 - #6	40	488,900	0.31	20	5.304	2.94E+11	0.041	2.652
12,845	8/03 - #7	30	48,890	0.56	18	3.214	2.38E+10	0.060	1.928
15,063	8/03 - #8	27	88,900	0.28	10	3.392	5.07E+10	0.035	1.256
3,623	8/11 - #1	34	144,000	0.87	194	1.027	1.97E+10	0.026	5.862
1,568	8/11 - #2	124	30,400,000	3.10	342	1.622	1.80E+12	0.041	4.473
45,232	8/11 - #3	30	47,200,000	0.78	126	11,317	8.08E+13	0.294	47.532
289,849	8/11 - #4	9	368,000	0.47	114	21,756	4.04E+12	1.136	275.577
48,594	8/11 - #5	11	440,000	0.55	116	4.458	8.09E+11	0.223	47.012
6,022	8/11 - #6	19	4,900,000	0.61	76	0.954	1.12E+12	0.031	3.817
839	8/11 - #7								
209	8/11 - #8								
24,647	8/18 - #1	48	38,500	0.49	134	9.867	3.59E+10	0.101	27.545
127,603	8/18 - #2	26	380,000	0.52	103	27.669	1.84E+12	0.553	109.614
70,296	8/18 - #3	24	370,000	0.59	94	14.070	9.85E+11	0.346	55.109
29,102	8/18 - #4	27	1,000,000	0.53	42	6.553	1.10E+12	0.129	10.194
35,617	8/18 - #5	24	76,900	0.34	55	7.129	1.04E+11	0.101	16.338
23,904	8/18 - #6	11	192,000	0.37	44	2.193	1.74E+11	0.074	8.772
10,032	8/18 - #7	14	92,300	0.45	27	1.171	3.51E+10	0.038	2.259
4,288	8/18 - #8								
2,150	8/25 - #1	19	7,840	0.39	89	0.341	6.38E+08	0.007	1.596
4,324	8/25 - #2	175	148,000	3.78	340	6.311	2.42E+10	0.136	12.262
4,850	8/25 - #3	22	125,000	0.71	48	0.890	2.30E+10	0.029	1.942
510	8/25 - #4								
62	8/25 - #5								
20	8/25 - #6								
7	8/25 - #7								
5	8/25 - #8								
728	9/04 - #1	65	1,280,000	1.31	148	0.395	3.53E+10	0.008	0.899
5,951	9/04 - #2	15	440,000	0.41	45	0.745	9.91E+10	0.020	2.234
14,277	9/04 - #3	9	400,000	0.30	31	1.072	2.16E+11	0.036	3.691
10,677	9/04 - #4	9	128,000	0.23	23	0.801	5.17E+10	0.020	2.048
14,173	9/04 - #5	9	152,000	0.19	24	1.064	8.15E+10	0.022	2.837
11,093	9/04 - #6								
910	9/04 - #7								
188	9/04 - #8								
Weighted Average Concentrations						21 mg/l	2.85E+06 cfu/dl	0.53 mg/l	95 mg/l

Sampler C
Edgewater west of W. 117th St.
High Density Residential

Flow Volume (Gallons)	Date & Sample #	Sample CBOD (mg/l)	Sample <i>E. coli</i> (cfu/dl)	Sample TP (mg/l)	Sample TSS (mg/l)	Sampler Washoff Loading CBOD (pounds)	Sampler Washoff Loading <i>E. coli</i> (cfu)	Sampler Washoff Loading TP (pounds)	Sampler Washoff Loading TSS (pounds)
161	8/03 - #1	58	9,000,000	3.15	189	0.078	5.48E+10	0.004	0.254
2,265	8/03 - #2	44	4,800,000	1.24	90	0.831	4.12E+11	0.023	1.700
5,545	8/03 - #3	15	1,950,000	0.59	15	0.694	4.09E+11	0.027	0.694
7,663	8/03 - #4	10	2,050,000	0.48	15	0.639	5.95E+11	0.031	0.959
5,983	8/03 - #5	11	260,000	0.45	10	0.549	5.89E+10	0.022	0.499
7,502	8/03 - #6	9	431,100	0.36	5	0.563	1.22E+11	0.023	0.313
5,449	8/03 - #7	9	130,000	0.38	10	0.409	2.68E+10	0.017	0.454
6,509	8/03 - #8	9	2,550,000	0.90	5	0.489	6.28E+11	0.049	0.271
13	8/18 - #1								
22,158	8/18 - #2								
83,523	8/18 - #3								
	8/18 - #4								
	8/18 - #5								
	8/18 - #6								
	8/18 - #7								
	8/18 - #8								
1,535	8/25 - #1	12	578	1.14	13	0.154	3.36E+07	0.015	0.166
8,237	8/25 - #2	39	34,000	1.12	107	2.679	1.06E+10	0.077	7.351
4,001	8/25 - #3	9	31,400	0.30	23	0.300	4.76E+09	0.010	0.768
2,331	8/25 - #4	9	15,700	0.23	7	0.175	1.39E+09	0.004	0.136
1,741	8/25 - #5	9	23,500	0.31	4	0.131	1.55E+09	0.005	0.058
1,105	8/25 - #6	9	7,840	0.28	5	0.083	3.28E+08	0.003	0.046
711	8/25 - #7								
648	8/25 - #8								
1,246	9/04 - #1	107	1,440,000	2.49	1450	1.112	6.79E+10	0.026	15.071
8,147	9/04 - #2	12	260,000	2.10	2690	0.815	8.02E+10	0.143	182.782
11,063	9/04 - #3	16	440,000	0.56	508	1.476	1.84E+11	0.052	46.871
8,729	9/04 - #4	9	42,000	0.29	135	0.655	1.39E+10	0.021	9.828
7,506	9/04 - #5	9	23,400	0.23	109	0.563	6.65E+09	0.014	6.823
11,722	9/04 - #6	9	46,000	0.24	165	0.880	2.04E+10	0.023	16.130
5,934	9/04 - #7	9	42,000	0.17	35	0.445	9.43E+09	0.008	1.732
3,007	9/04 - #8	9	46,000	0.18	15	0.226	5.24E+09	0.005	0.376
33,317	9/11 - #1	9	210,000	0.68	93	2.501	2.65E+11	0.189	25.842
59,179	9/11 - #2	9	97,800	0.32	76	4.442	2.19E+11	0.158	37.510
27,114	9/11 - #3	9	133,000	0.35	49	2.035	1.37E+11	0.079	11.080
9,105	9/11 - #4								
4,452	9/11 - #5								
3,533	9/11 - #6								
3,793	9/11 - #7								
3,106	9/11 - #8								
Weighted Average Concentrations						7 mg/l	2.39E+05 cfu/dl	0.33 mg/l	120 mg/l

Sampler D
Hilliard @ Eldred
Medium Density Residential

Flow Volume (Gallons)	Date & Sample #	Sample CBOD (mg/l)	Sample <i>E. coli</i> (cfu/dl)	Sample TP (mg/l)	Sample TSS (mg/l)	Sampler Washoff Loading CBOD (pounds)	Sampler Washoff Loading <i>E. coli</i> (cfu)	Sampler Washoff Loading TP (pounds)	Sampler Washoff Loading TSS (pounds)
711	8/03 - #1	20	380,000	1.73	310	0.119	1.02E+10	0.010	1.838
2,958	8/03 - #2	45	7,100,000	1.90	215	1.110	7.95E+11	0.047	5.303
5,541	8/03 - #3	30	977,800	1.24	205	1.386	2.05E+11	0.057	9.473
7,799	8/03 - #4	12	270,000	0.72	75	0.780	7.97E+10	0.047	4.878
8,253	8/03 - #5	9	200,000	0.53	40	0.619	6.25E+10	0.036	2.753
7,658	8/03 - #6	12	195,000	0.56	20	0.766	5.65E+10	0.036	1.277
7,113	8/03 - #7	9	115,000	0.44	30	0.534	3.10E+10	0.026	1.780
4,486	8/03 - #8	9	105,000	0.55	25	0.337	1.78E+10	0.021	0.935
39,664	8/11 - #1	20	32,000	0.65	335	6.616	4.80E+10	0.215	110.816
49,381	8/11 - #2	12	384,000	0.46	130	4.942	7.18E+11	0.189	53.539
52,399	8/11 - #3	10	352,000	0.47	92	4.370	6.98E+11	0.205	40.205
16,340	8/11 - #4	11	224,000	0.54	78	1.499	1.39E+11	0.074	10.629
4,813	8/11 - #5	32	940,000	0.92	126	1.284	1.71E+11	0.037	5.057
1,742	8/11 - #6	23	640,000	0.82	93	0.334	4.22E+10	0.012	1.351
575	8/11 - #7					0.000	0.00E+00	0.000	0.000
34	8/11 - #8					0.000	0.00E+00	0.000	0.000
1,871	8/25 - #1	75				1.171	0.00E+00	0.000	0.000
1,542	8/25 - #2	46				0.592	0.00E+00	0.000	0.000
1,472	8/25 - #3					0.000	0.00E+00	0.000	0.000
309	8/25 - #4					0.000	0.00E+00	0.000	0.000
16	8/25 - #5					0.000	0.00E+00	0.000	0.000
6	8/25 - #6					0.000	0.00E+00	0.000	0.000
2	8/25 - #7					0.000	0.00E+00	0.000	0.000
132	8/25 - #8					0.000	0.000	0.000	0.000
1,867	9/04 - #1					0.000	0.00E+00	0.000	0.000
4,144	9/04 - #2	59	1,040,000	1.48	200	2.039	1.63E+11	0.051	6.913
5,909	9/04 - #3	27	560,000	0.99	132	1.331	1.25E+11	0.049	6.505
6,726	9/04 - #4	25	254,000	0.55	58	1.402	6.47E+10	0.031	3.253
6,977	9/04 - #5	26	196,000	0.53	76	1.513	5.18E+10	0.031	4.422
6,222	9/04 - #6	22	980,000	0.36	50	1.142	2.31E+11	0.019	2.595
3,799	9/04 - #7	21	400,000	0.42	37	0.665	5.75E+10	0.013	1.172
1,509	9/04 - #8					0.000	0.00E+00	0.000	0.000
12,293	9/11 - #1	33	3,500,000	2.35	148	3.383	1.63E+12	0.241	15.173
31,154	9/11 - #2	23	370,000	0.89	211	5.976	4.36E+11	0.231	54.824
38,195	9/11 - #3	16	210,000	0.41	102	5.097	3.04E+11	0.131	32.492
29,164	9/11 - #4	12	169,000	0.36	58	2.919	1.87E+11	0.088	14.107
11,868	9/11 - #5	11	107,000	0.38	50	1.089	4.81E+10	0.038	4.949
5,800	9/11 - #6	10	310,000	0.41	42	0.484	6.81E+10	0.020	2.032
3,926	9/11 - #7	13	470,000	0.50	41	0.426	6.99E+10	0.016	1.343
3,348	9/11 - #8	13	1,090,000	0.47	38	0.363	1.38E+11	0.013	1.061
Weighted Average Concentrations						17 mg/l	4.53E+05 cfu/dl	0.61 mg/l	124 mg/l

Sampler E Hilliard @ Eldred Medium Density Residential Sewage									
Time	Average Hourly Flow Rate (MGD)	Sample CBOD (mg/l)	Sample <i>E. coli</i> (cfu/dl)	Sample TP (mg/l)	Sample TSS (mg/l)	Pollutant Loading CBOD (pounds)	Pollutant Loading <i>E. coli</i> (cfu)	Pollutant Loading TP (pounds)	Pollutant Loading TSS (pounds)
10:15	0.187								
11:15	0.175	270	1.7E+07	5.39	292	34.0	9.71E+12	0.68	36.7
12:15	0.178								
13:15	0.174	290	3.4E+07	6.58	464	35.4	1.88E+13	0.80	56.6
14:15	0.129								
15:15	0.127	360	3.7E+07	6.26	692	32.0	1.49E+13	0.56	61.4
16:15	0.152								
17:15	0.153	166	8.0E+07	3.69	246	17.6	3.85E+13	0.39	26.1
18:15	0.163	168	3.2E+07	4.49	220	9.5	8.22E+12	0.25	12.5
19:15	0.154	198	3.9E+07	4.68	354	10.6	9.48E+12	0.25	19.0
20:15	0.155	198	3.9E+07	4.68	354	10.7	9.53E+12	0.25	19.0
21:15	0.132	260	7.2E+07	4.32	178	11.9	1.50E+13	0.20	8.2
22:15	0.109	410	5.0E+06	4.68	428	15.6	8.61E+11	0.18	16.2
23:15	0.097	219	4.5E+07	4.77	224	14.6	1.36E+13	0.32	14.9
0:15	0.095								
1:15	0.081								
2:15	0.063								
3:15	0.053	102	2.7E+07	4.26	64	8.9	1.07E+13	0.37	5.6
4:15	0.056								
5:15	0.061								
6:15	0.079	197	5.4E+06	6.82	236	9.6	1.19E+12	0.33	11.5
7:15	0.128	183	7.0E+06	8.31	198	8.1	1.41E+12	0.37	8.8
8:15	0.166	373	1.8E+07	9.47	818	21.5	4.70E+12	0.55	47.1
9:15	0.168	233	6.9E+07	5.93	189	13.6	1.83E+13	0.35	11.0
Average	0.126	241.8	3.51E+07	5.62	330.5				
Weighted Average		240.6	3.66E+07	5.55	336.6				
Geometric Mean			2.60E+07						
Total Load						253.4	1.75E+14	5.84	354.6
SWMM total flow 0.062 MGD SWMM sewage flow 0.051 MGD sewage portion of total flow 82.7 % sewage cfu concentration per 100ml 4.43E+07 cfu/dl									
						2011 sewage flow (MGD) 3.031 Yearly cfu Loading 1.85E+19			

B.3 Sewage Loadings

Sampler E collected 24 hours of sanitary flow. Samples were collected hourly during the morning and evening peak flows, less often throughout the rest of the day. Average and flow weighted averages had similar values. A geometric mean *E. coli* value was also calculated. The more conservative weighted average was used to calculate the sewage concentration ($3.66 \times 10^7 \div 82.7\% = 4.43 \times 10^7$ cfu/dl).

As shown in Section 2.2 the average sewage flow rate reaching the WWTP is 3.031 MGD. This flow rate for 365 days and the sewage concentration were used to calculate the yearly *E. coli* loading using the equation in Section A.2. This value was used in Chapter 6 for comparison to the SWMM output.

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APPENDIX C

GRAPHS OF

SWMM POLLUTANT LOADINGS

VERSUS

METERS A-D MEASURED LOADINGS

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APPENDIX C – SWMM POLLUTANT LOADINGS VERSUS METERS A-D MEASURED LOADINGS

C.1 Introduction

Four flow meters/samplers were installed to collect runoff characterization data for the pollutant model from the following types of land use:

- A. Low density residential property (properties greater than 0.25 acre)
- B. Commercial/Industrial properties
- C. High density residential property (apartments and high-rise buildings)
- D. Medium density residential (single family and duplexes on lots less than 0.25 acre)

The collected runoff samples were analyzed for four pollutants: Carbonaceous Biochemical Oxygen Demand (CBOD), Total Phosphorous (TP), and Total Suspended Solids (TSS) all as measured in milligrams per liter (mg/l) and *Escherichia coli* (*E. coli*) as measured in colony forming units per deciliter cfu/dl (a deciliter is 1/10 of a liter or 100 milliliters). Appendix B shows the pollutant concentrations, flow volumes and calculated 15-minute pollutant loadings for these four parameters.

C.2 SWMM Output versus Sampled Data

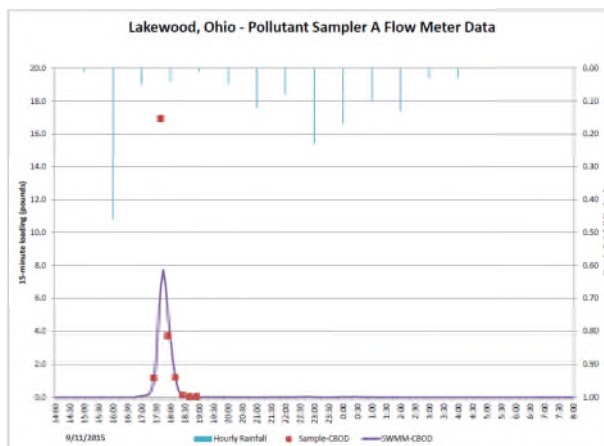
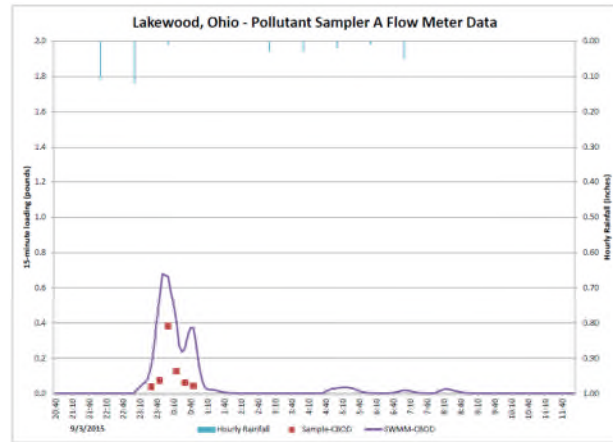
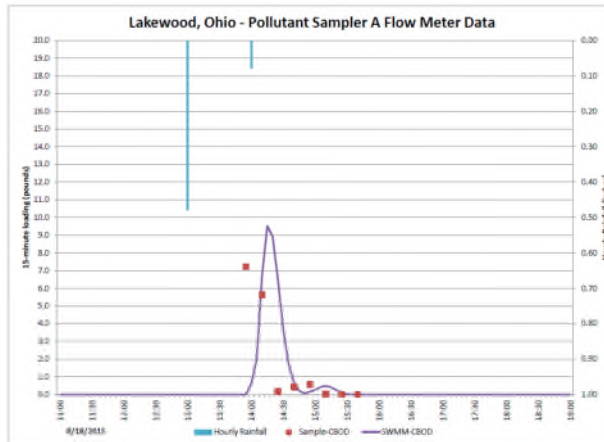
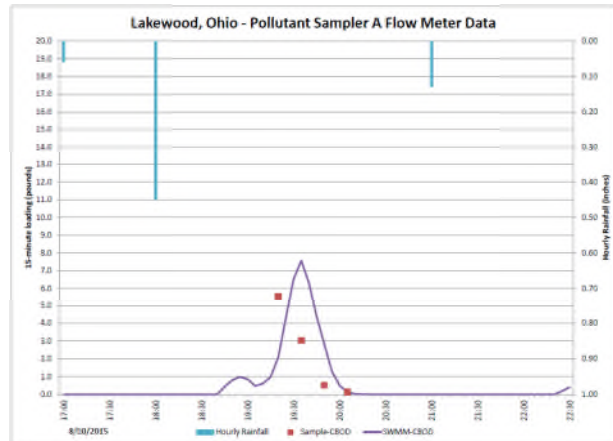
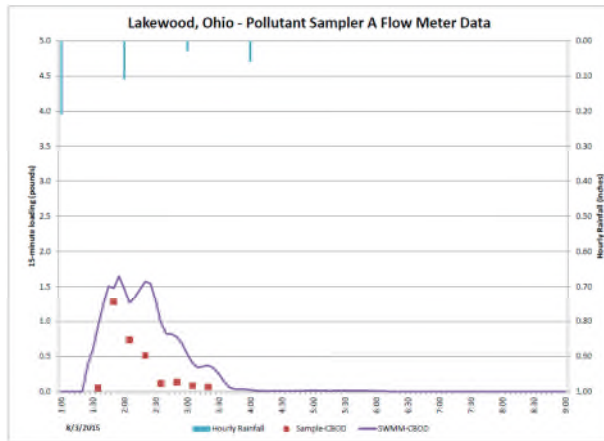
SWMM calculates pollutant concentrations in runoff. These concentrations are based on buildup and washoff equations within the SWMM programming capabilities. For the Lakewood pollutant model the SWMM concentrations were converted to 15-minute loadings, and the loadings were graphed as continuous lines on the following pages. The 15-minute pollutant loadings from the meter/sampler data are shown as discrete points on the same graphs.

The SWMM buildup and wash off parameters were calibrated to have SWMM output model the loadings from the meters/samplers. Buildup parameters were calibrated to have the total SWMM loadings closely match total meter/sampler loadings. The sampled data showed a first flush effect where the majority of the pollutants were washed off within the first hour. The SWMM washoff parameters were calibrated to have the SWMM loadings match this first flush effect.

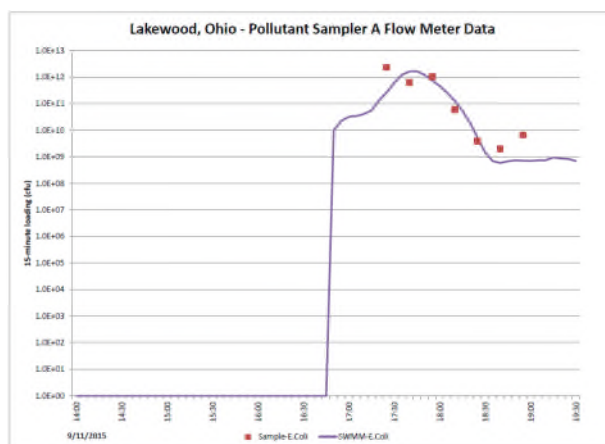
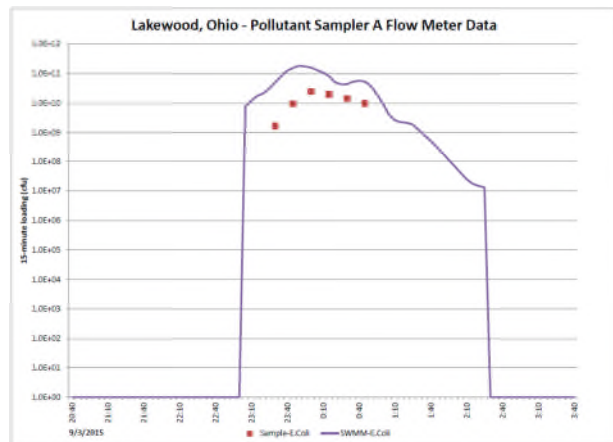
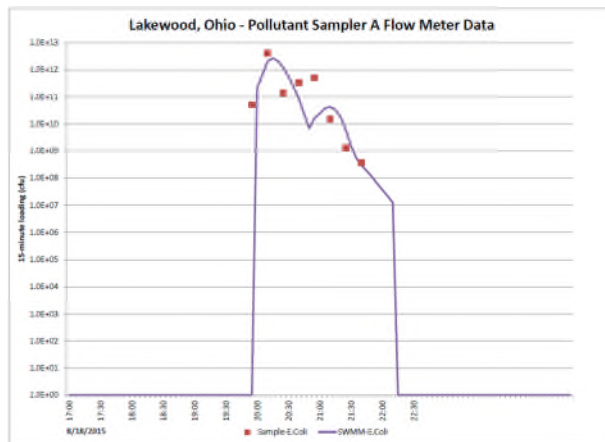
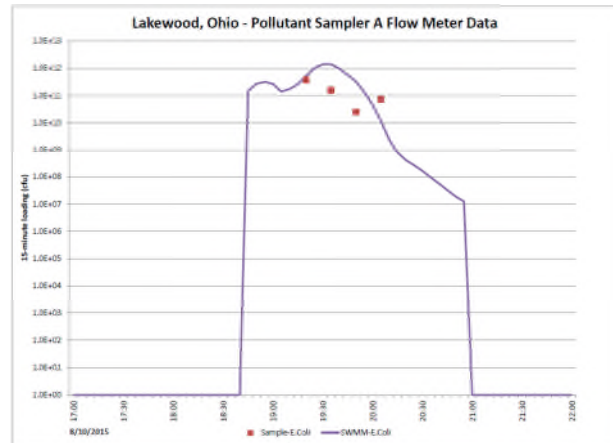
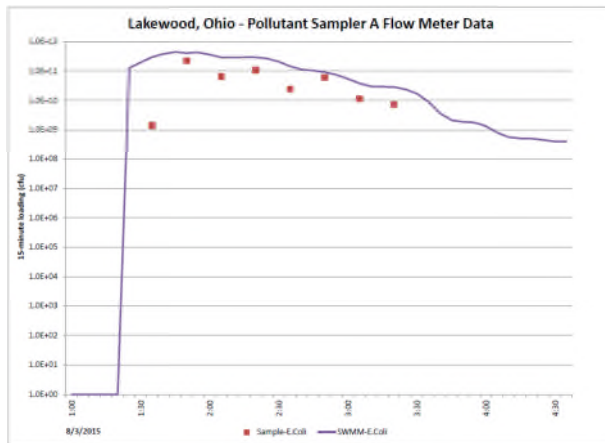
On any given rain event, SWMM output may be more or less than the measured quantities. This is due to the variability of human activity as compared to the structured SWMM buildup equations. CBOD and *E. coli* variations can be influenced inconsistently by pet waste deposition and food litter. TP variations can be influenced when homeowners or lawn care companies apply fertilizer. TSS variations can be influenced by mud tracked onto streets from construction activity. To allow for this variability, greater emphasis was placed on matching the total SWMM pollutant loadings to the metered/sampled loadings as compared to pollutant concentrations.

Notes: 1. Because *E. coli* is plotted on a logarithmic scale, rainfall could not be plotted. Refer to the other pollutant graphs for hourly rainfall data.
2. Hourly rainfall is graphed at the beginning of the hour and may have occurred closer to the pollutant runoff than when it appears on the graph.

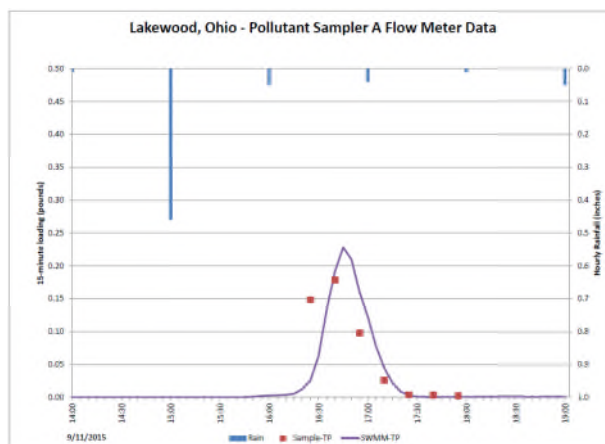
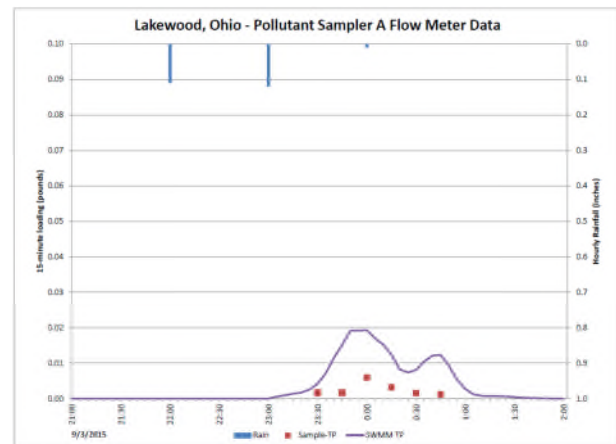
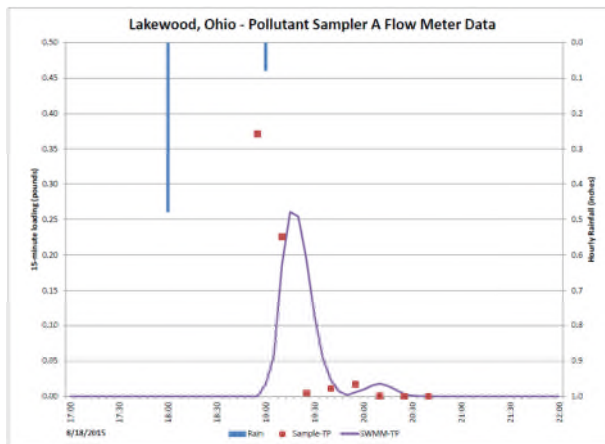
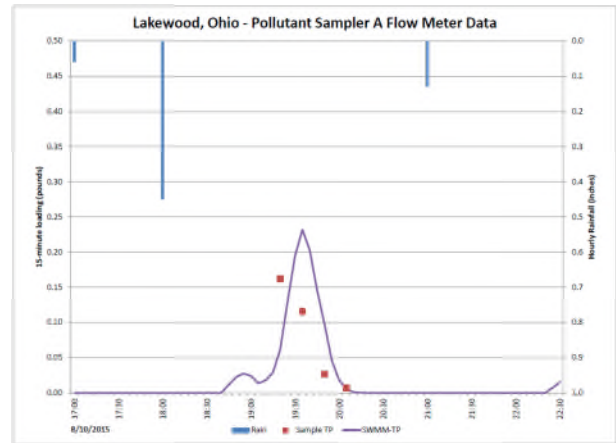
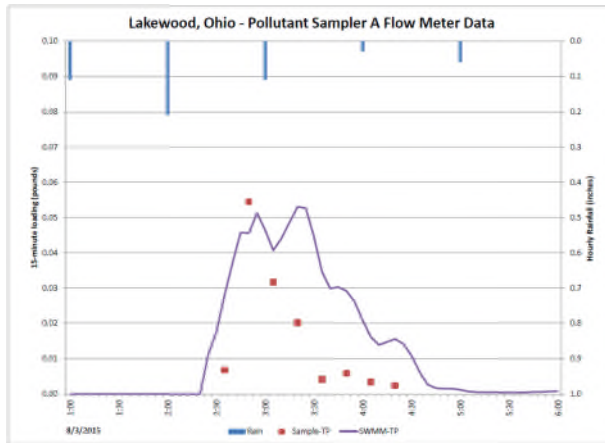
Area A – Low Density Residential - CBOD



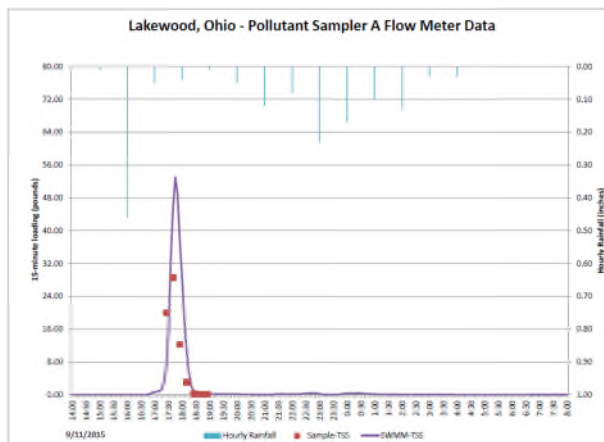
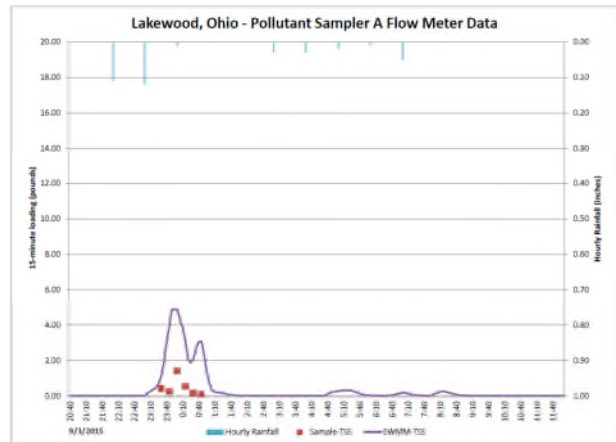
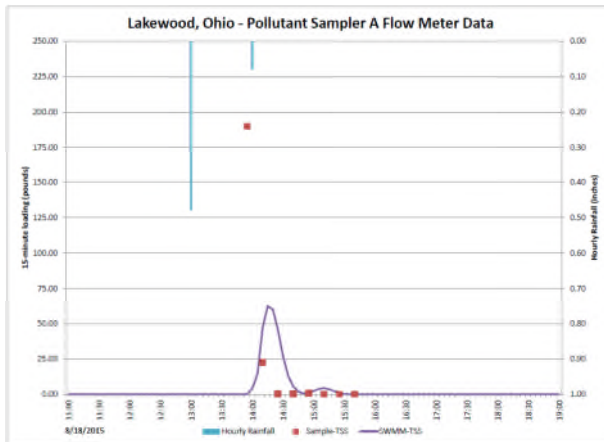
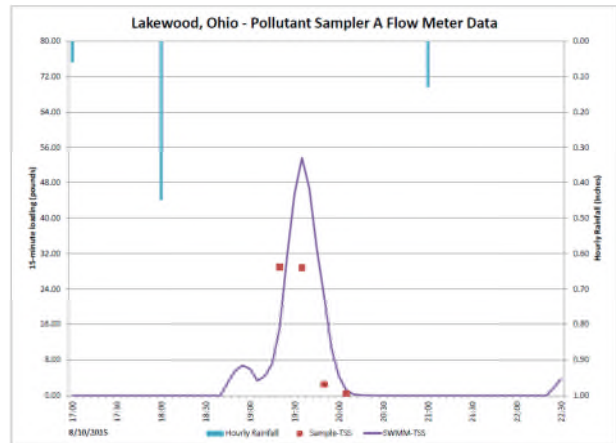
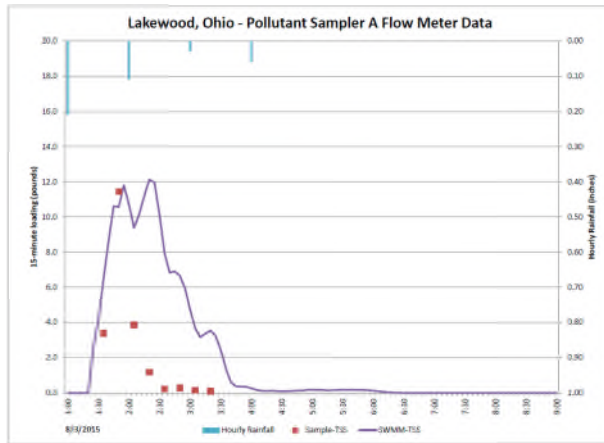
Area A – Low Density Residential – *E. coli*



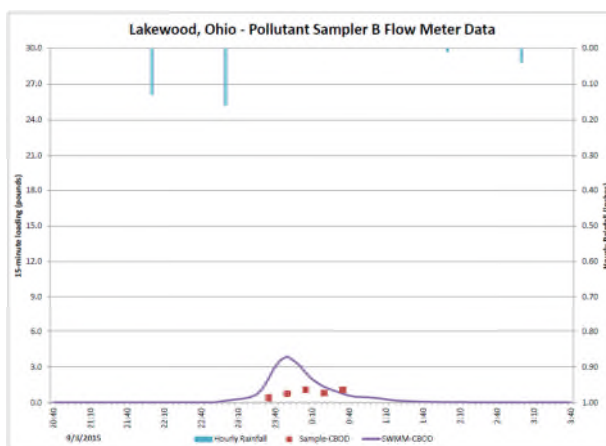
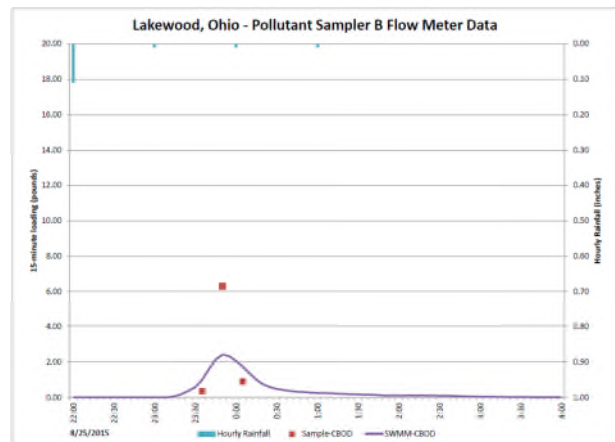
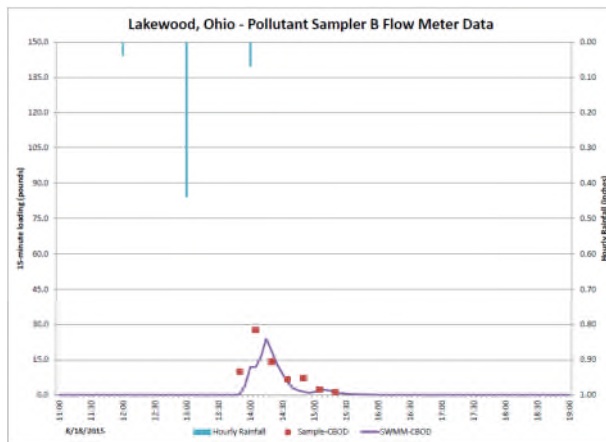
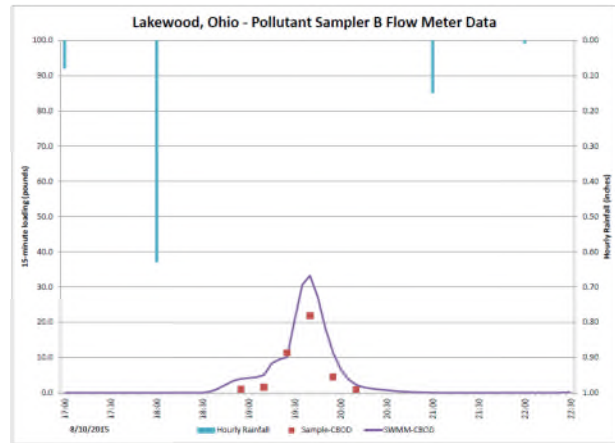
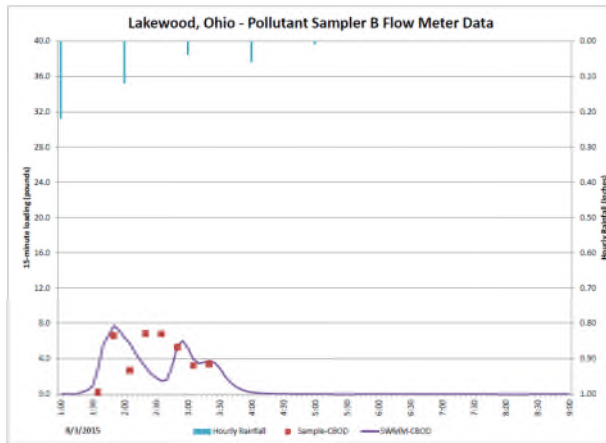
Area A – Low Density Residential - TP



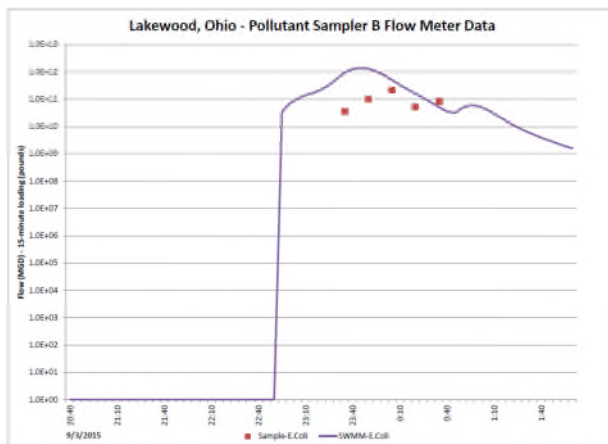
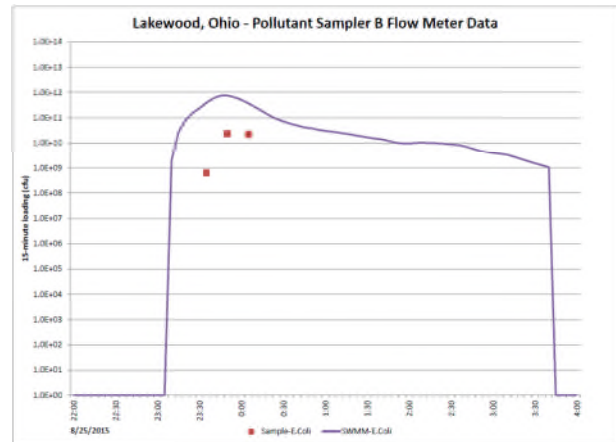
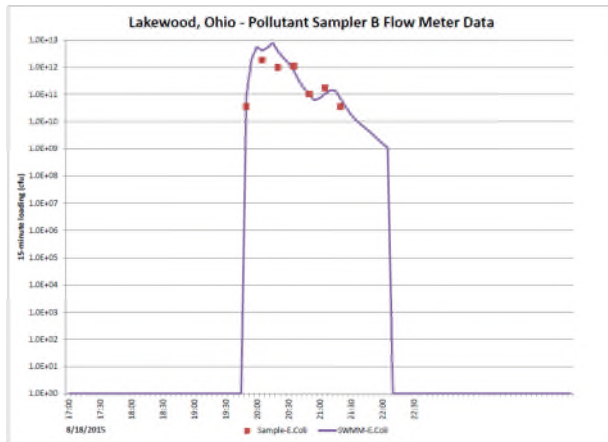
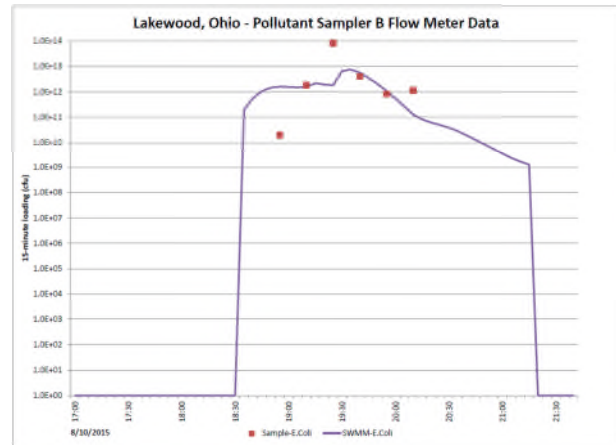
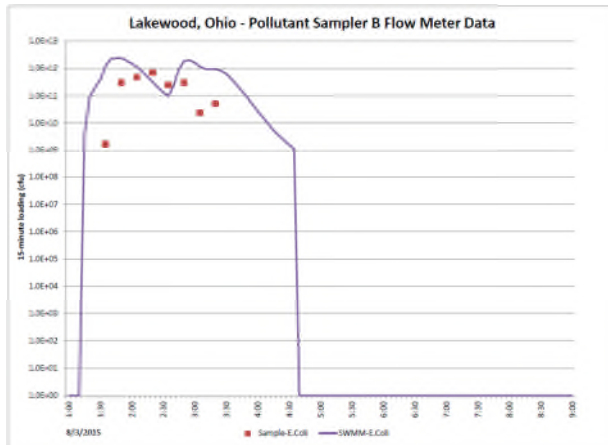
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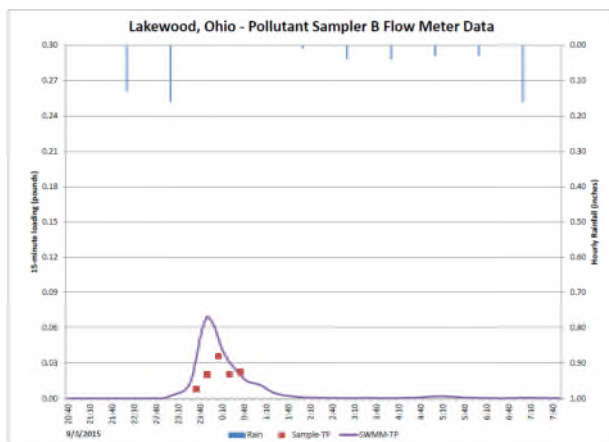
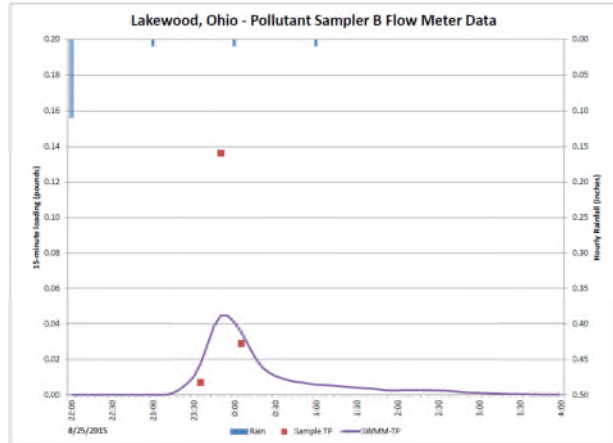
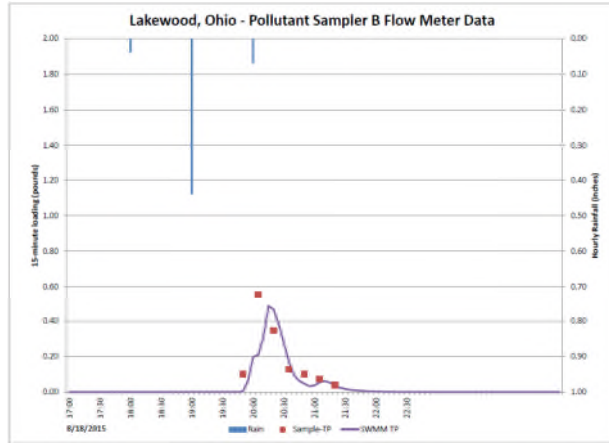
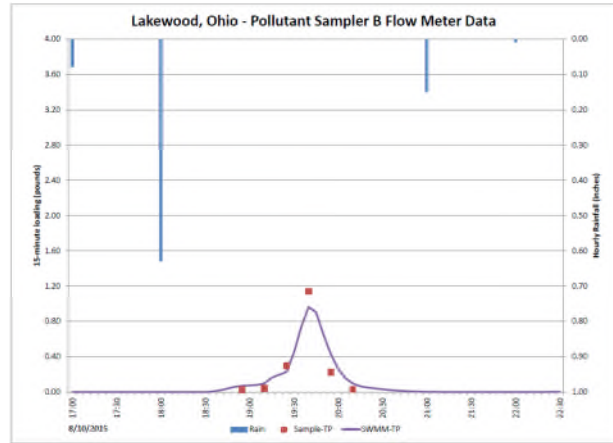
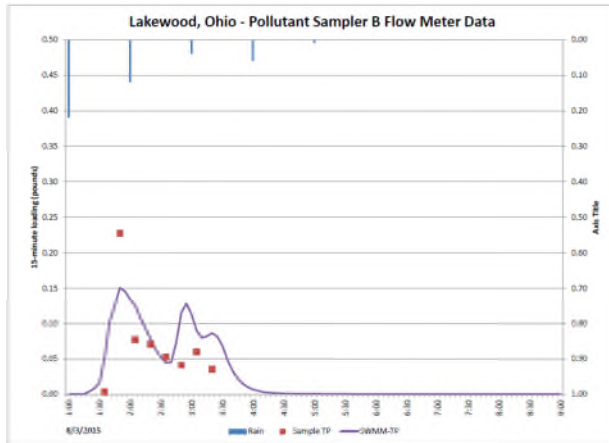
Area B – Commercial - CBOD



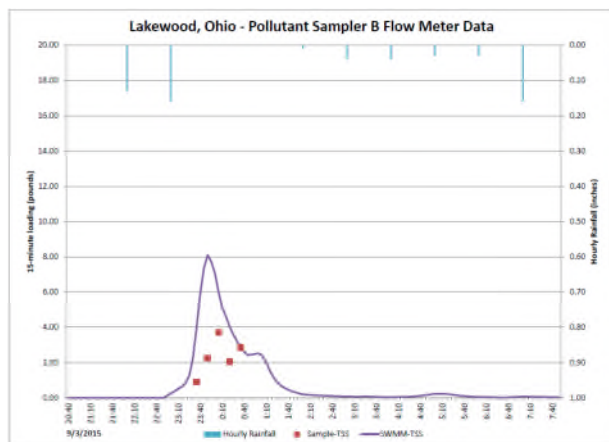
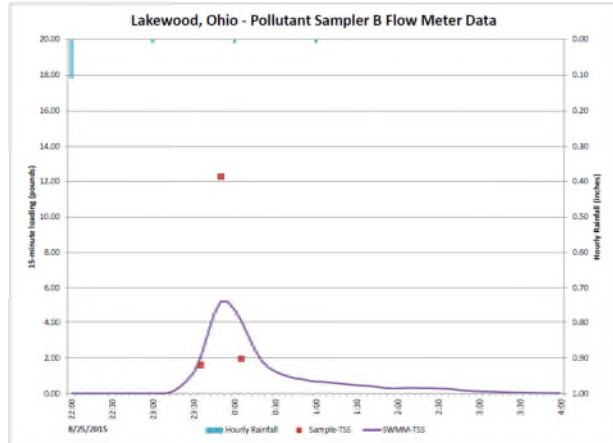
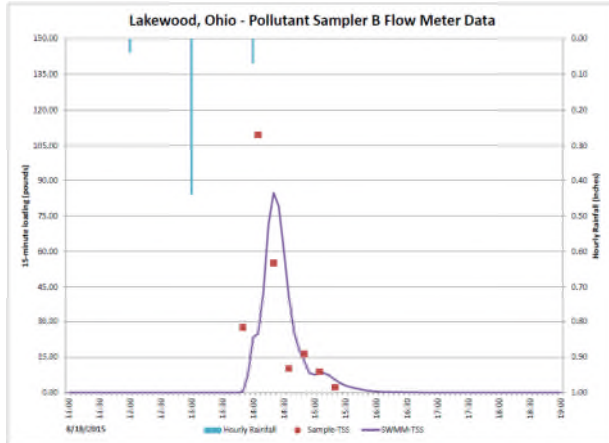
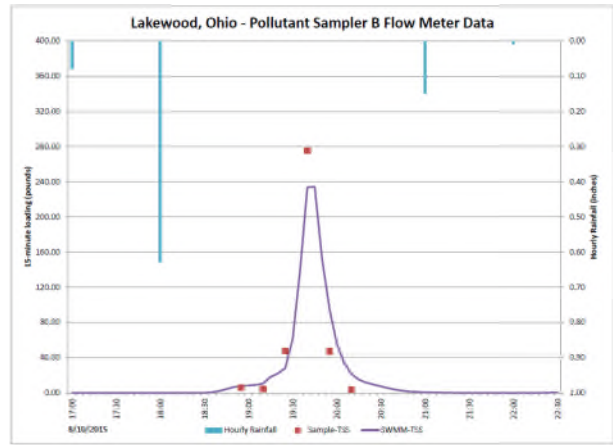
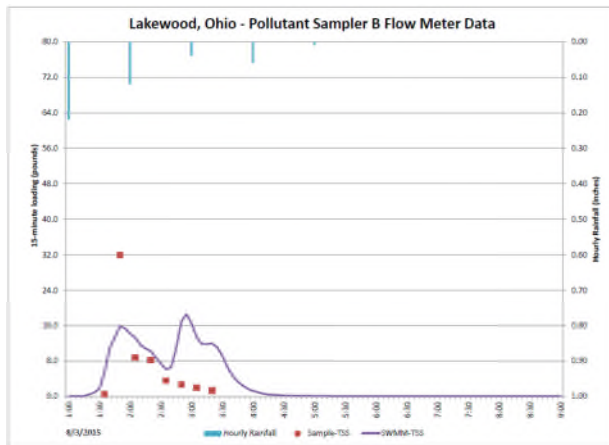
Area B – Commercial – *E. coli*



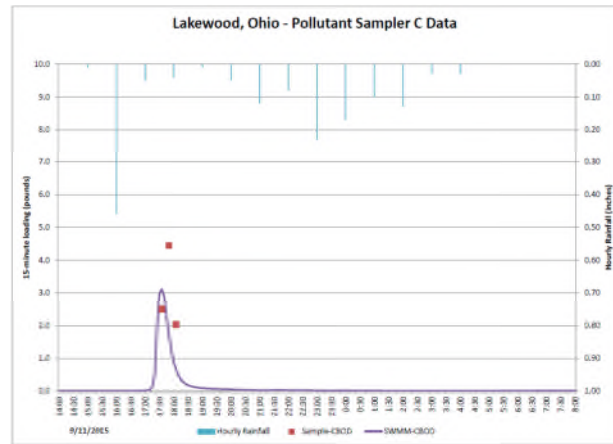
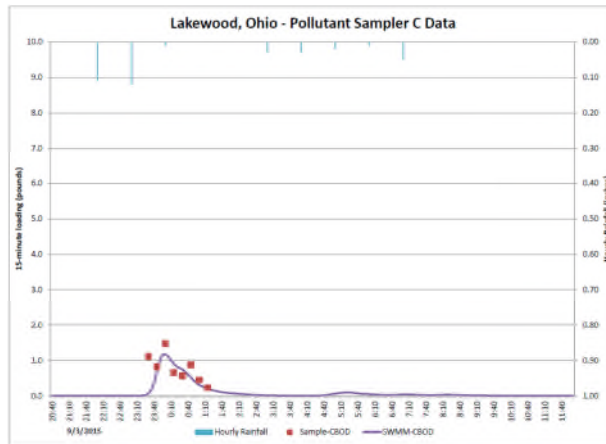
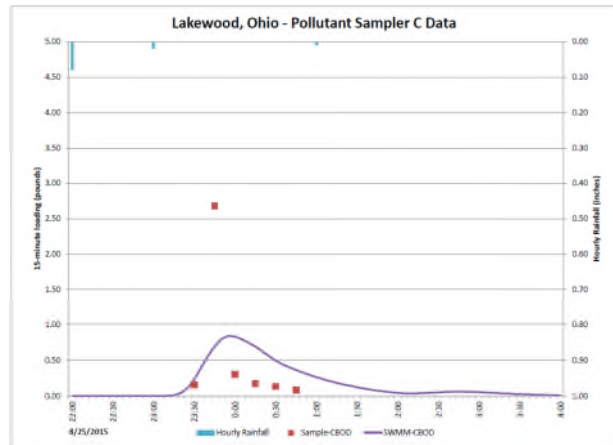
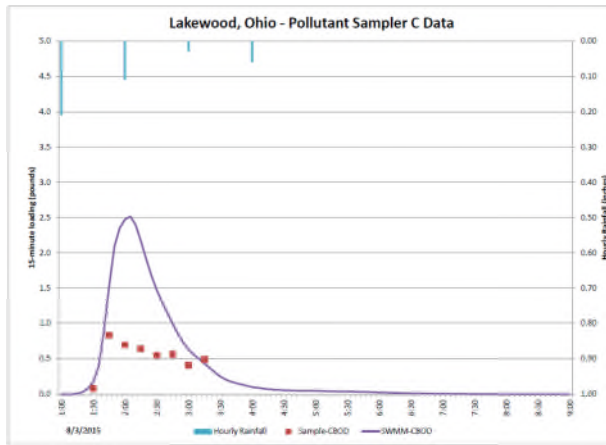
Area B – Commercial - TP



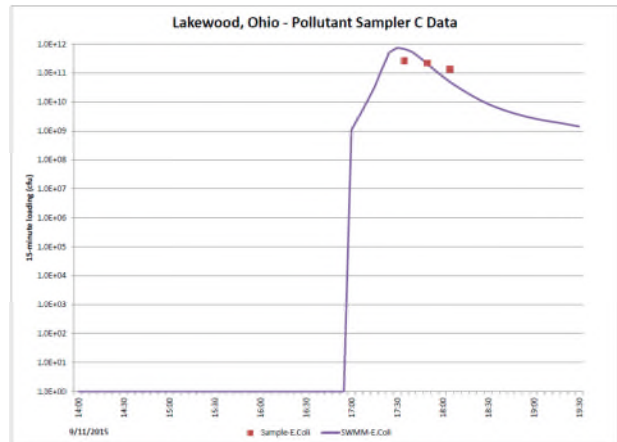
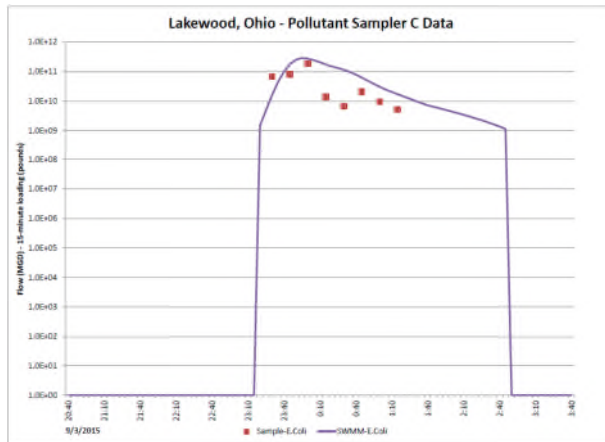
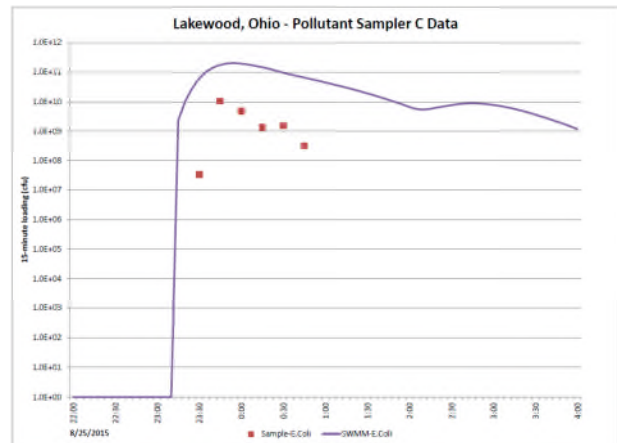
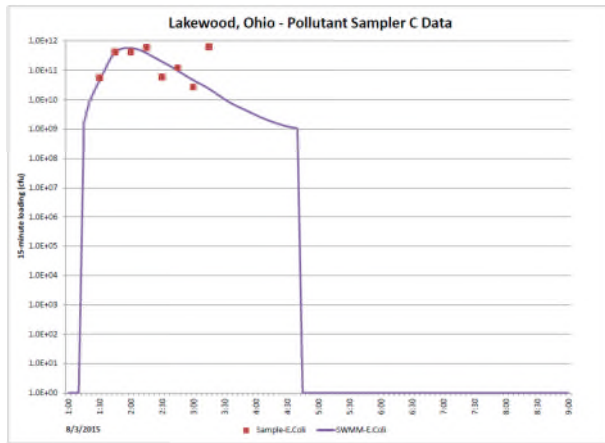
Area B – Commercial - TSS



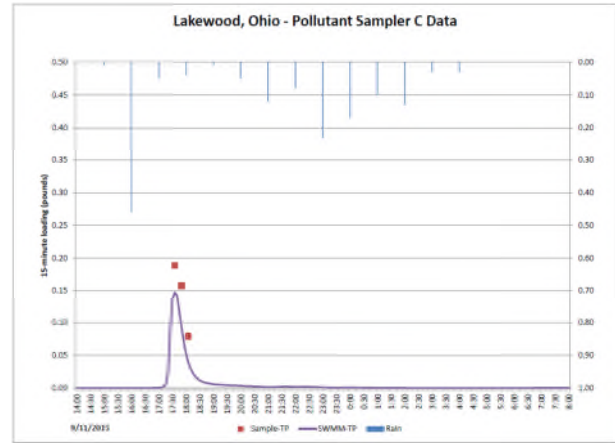
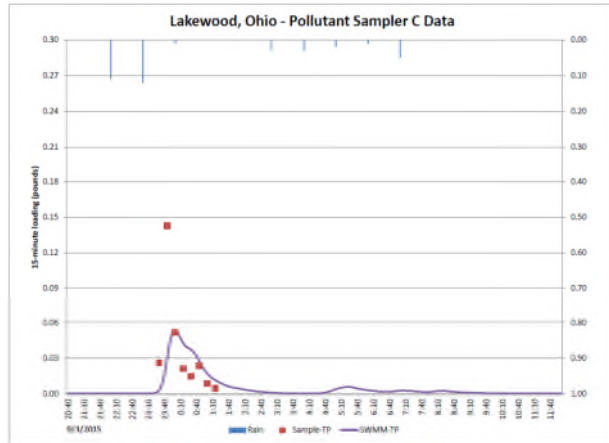
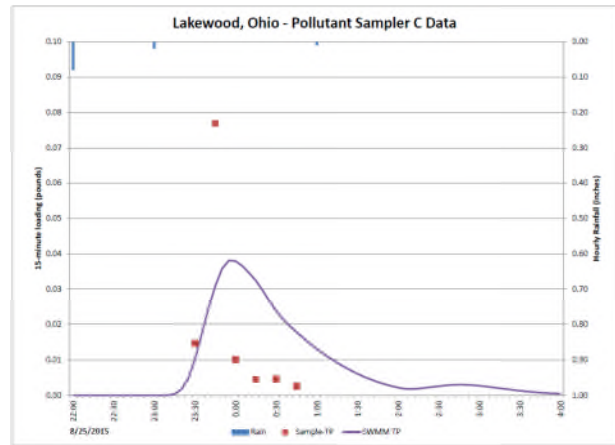
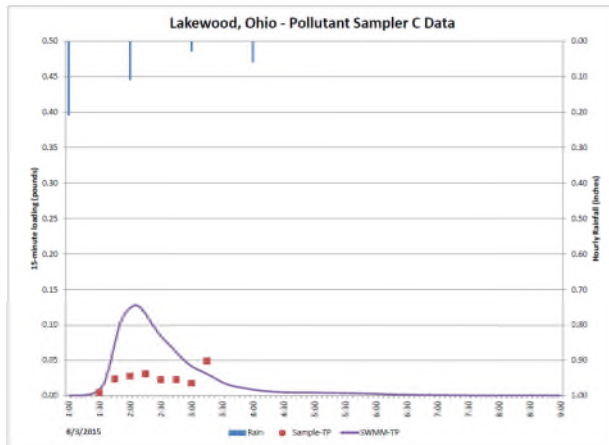
Area C – High Density Residential - CBOD



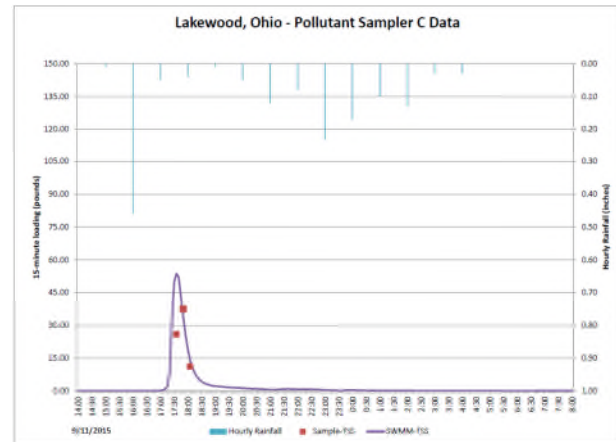
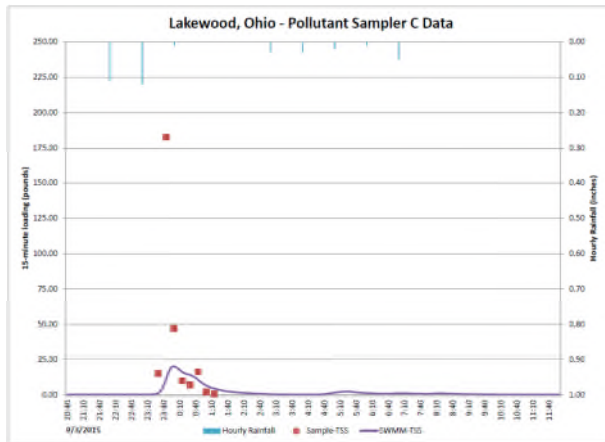
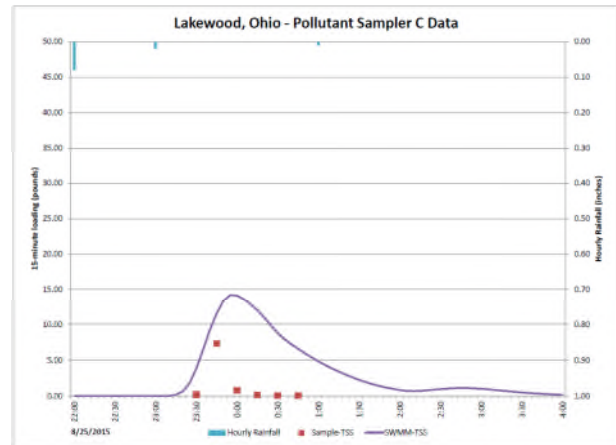
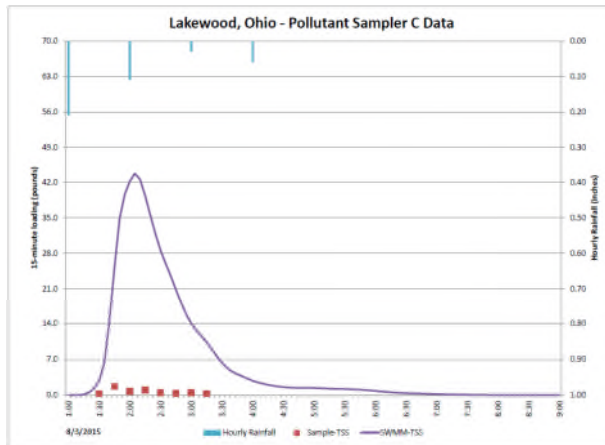
Area C – High Density Residential – *E. coli*



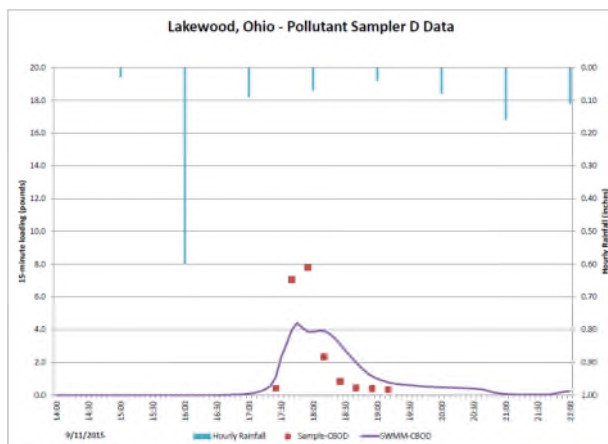
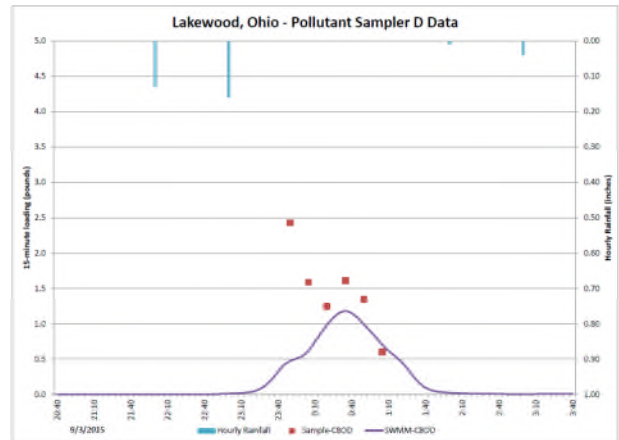
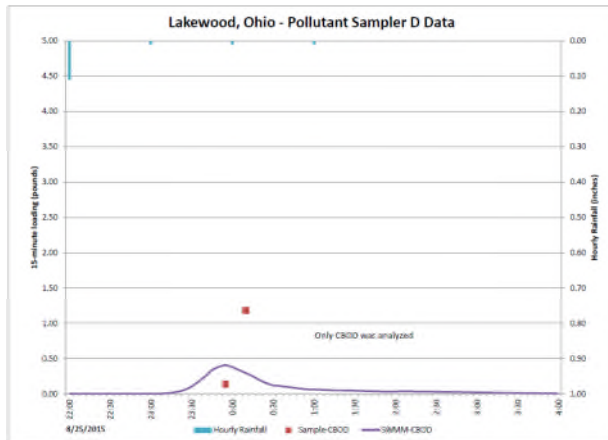
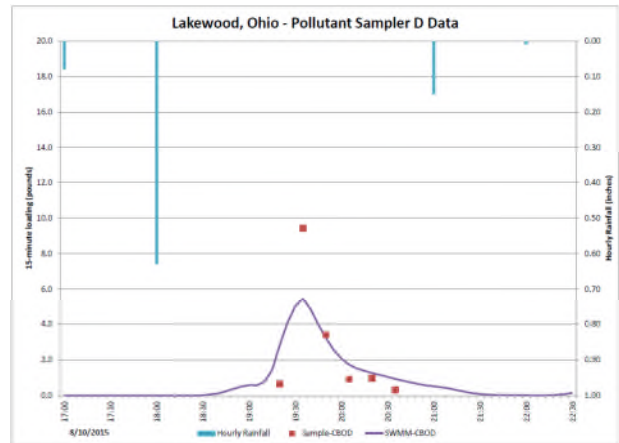
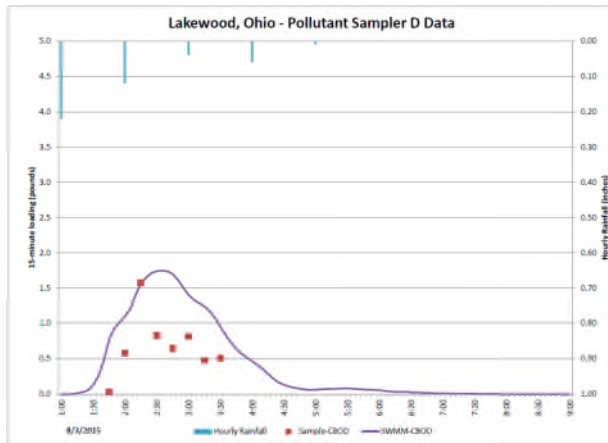
Area C – High Density Residential - TP



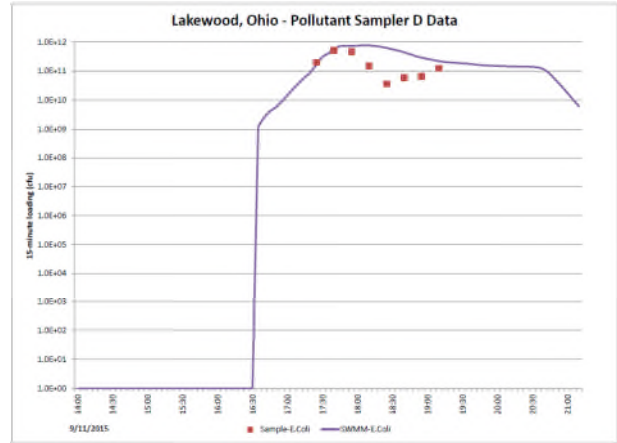
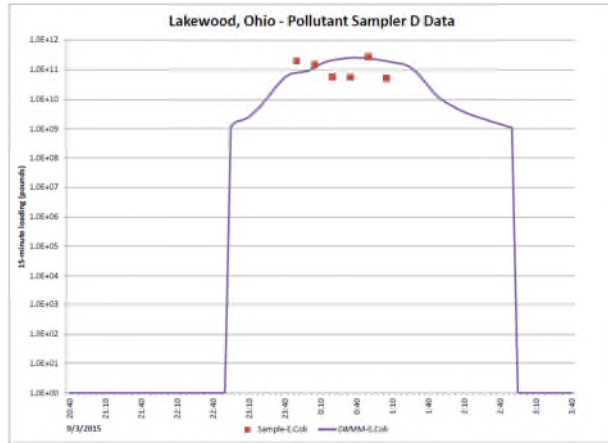
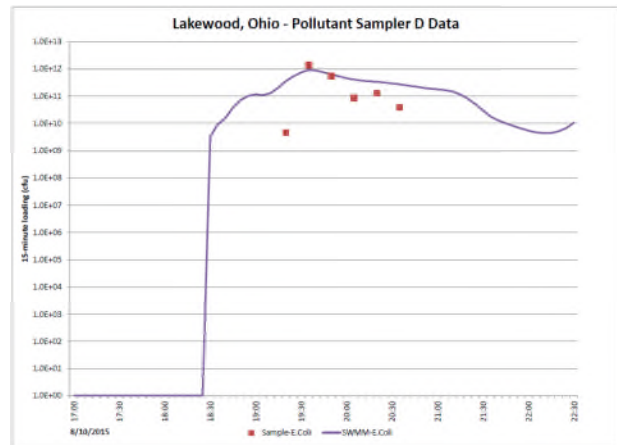
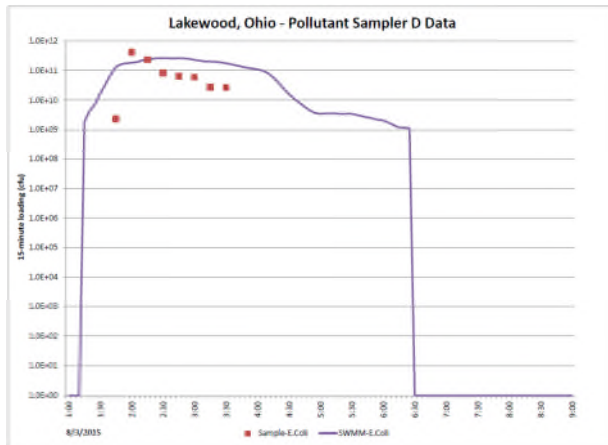
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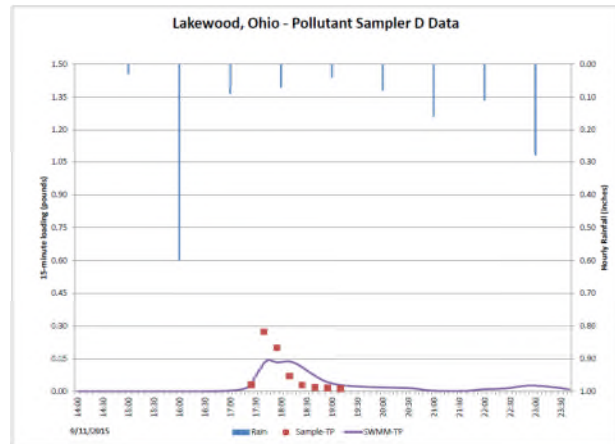
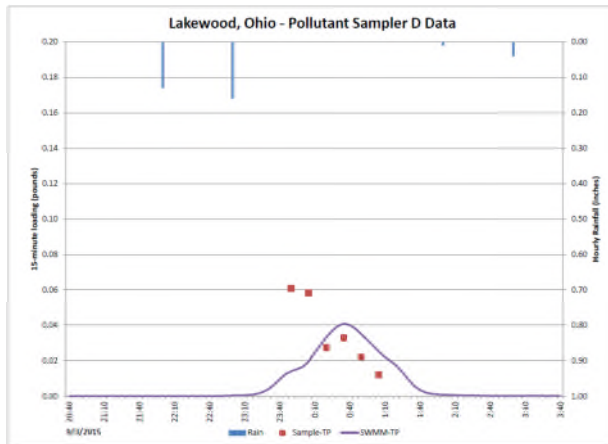
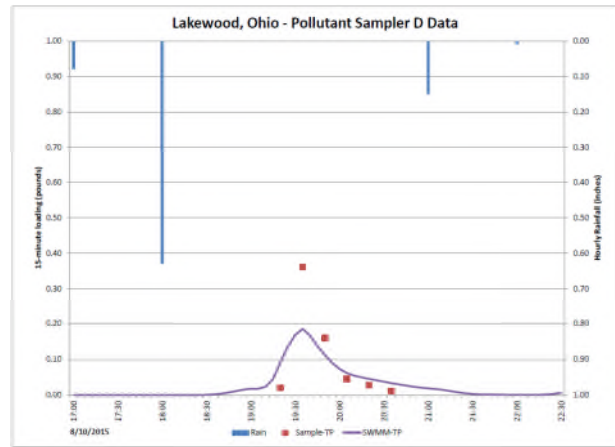
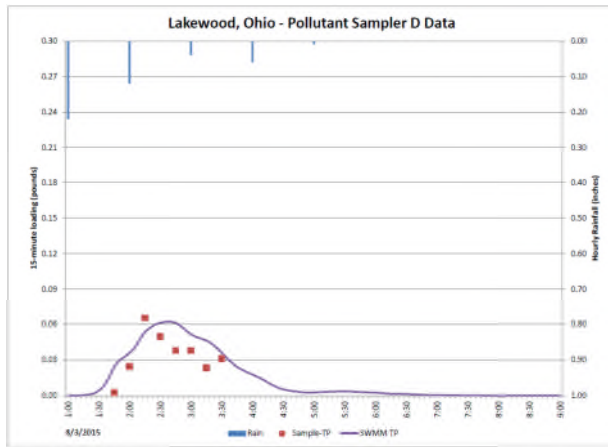
Area D – Medium Density Residential - CBOD



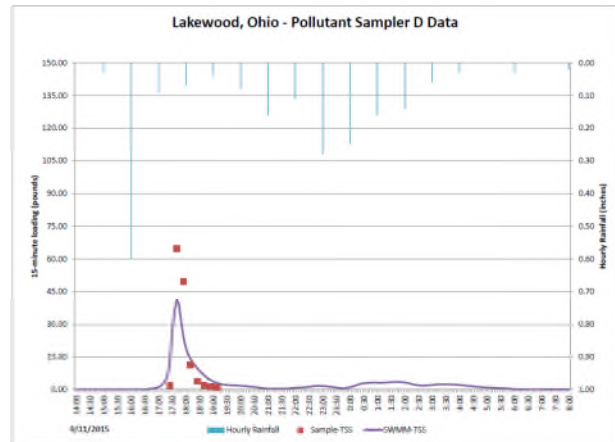
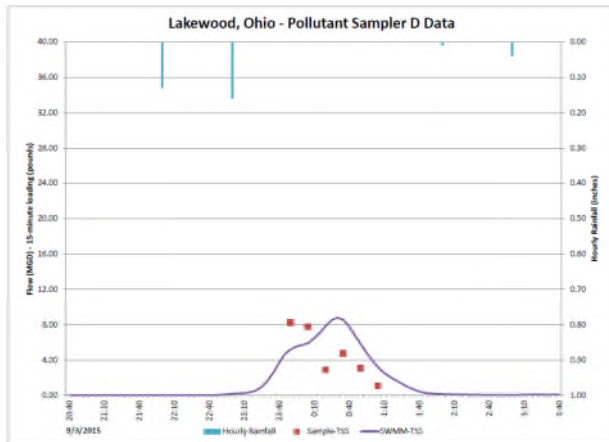
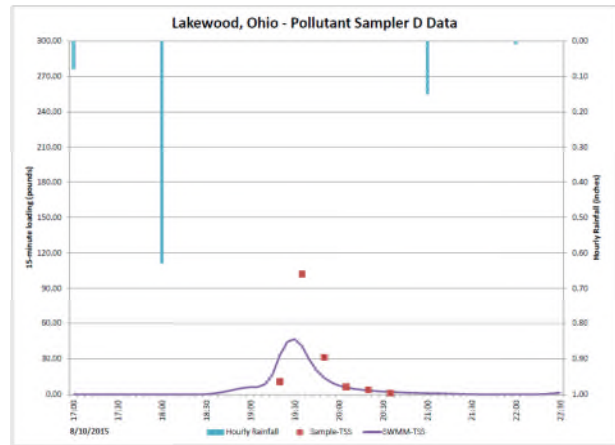
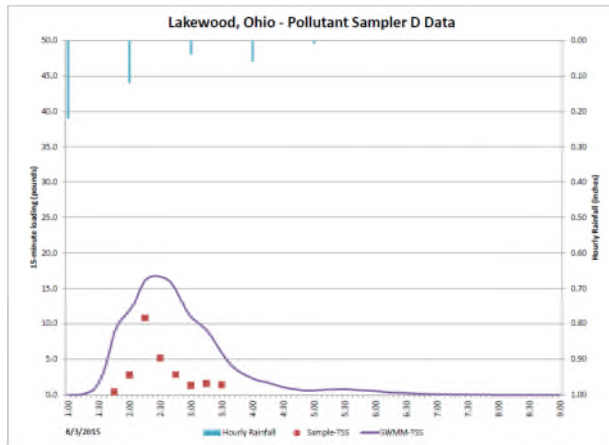
Area D – Medium Density Residential – *E. coli*



Area D – Medium Density Residential - TP



Area D – Medium Density Residential - TSS



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Attachment D
ACTIFO and BIOACTIFLO Pilot Study

LAKESWOOD WASTEWATER TREATMENT PLANT – ACTIFLO AND BIOACTIFLO PILOT STUDY

Prepared for:



Prepared by:



Project No. 14797

November 2015

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1.0 EXECUTIVE SUMMARY

1.1 TECHNOLOGY TESTED

The City of Lakewood conducted a six-week pilot testing program to assess the performance of High Rate Treatment (HRT) technologies. The ACTIFLO® / BIOACTIFLO wet weather High Rate Treatment system, provided by Veolia was piloted during 6 weeks period from June 3 through July 19. The ACTIFLO® process is a high-rate chemical and physical clarification process that involves the formation of suspended solids onto a ballast particle (microsand) followed by lamellar settling. The BIOACTIFLO® is biological configuration by the addition of the contact tank for mixing raw influent with return activated sludge prior to the ACTIFLO unit.

The BIOACTIFLO® biological and/or regular (physical-chemical) ACTIFLO® processes (ballasted flocculation) were tested to determine and demonstrate the viability of for treating high hydraulic and organic loads during wet weather conditions.

An ACTIFLO pilot unit and a biological Contact Tank were brought onsite and setup on temporary asphalt pavement between the Primary Clarifiers and the Aeration Tanks for testing. The Contact Tank included a 3 mm drum screen, coarse bubble diffuser and a blower for aeration. The pilot trailer included:

- Supervisory control and data acquisition (SCADA) system;
- Pumps and injection system for adding process chemicals and recirculation;
- Pumps and valve skid for bringing in wastewater and return activated sludge (RAS) to the Contact Tank at target proportions;
- UV disinfection system (provided by others and located adjacent to the pilot plant trailer).

During normal dry weather conditions, primary effluent was pumped to the pilot system, whereas during wet weather conditions, primary influent was used as feed the pilot system.

1.2 TESTING GOALS AND OBJECTIVES

The goal of this pilot study was to evaluate the ACTIFLO and BIOACTIFLO units and determine efficiencies for primary and primary + secondary treatment, respectively. The pilot study was designed to:

- a. Evaluate system performances by assessing their ability to remove CBOD, TSS, E. coli and total phosphorus.

- b. Determine the optimum combination of coagulant and polymer doses for primary treatment and the ideal MLSS concentration for biological treatment and secondary treatment.
- c. Evaluate the process based on operation and maintenance considerations such as chemical and energy requirements, labor, and ease and duration of startup.
- d. Estimate the sludge production rates and quality of the waste solids production (TSS concentration), and estimate additional disposal costs.
- e. Develop/confirm system design parameters to be used in the preparation of preliminary designs and capital costs estimates;
- f. Develop estimated O&M costs associated with meeting the effluent limit in a full-scale installation.
- g. Confirm CBOD, TSS, and pathogen removal efficiencies under various flow and loading conditions.

The target performance goal for the High Rate Treatment pilot study was to evaluate treated effluent quality to achieve:

- a. effluent requirements specified in the North East Ohio Regional Sewer District (NEORS) consent decree¹:
 - 40 mg/L for total suspended solids (TSS) across seven consecutive activations
 - 40 mg/L for total 5 day carbonaceous biochemical oxygen demand CBOD₅ across seven consecutive activations,
 - 126 colony forming units (CFU)/100 mL (recreational season geometric mean) for E. coli
 - 284 CFU/100 mL (rolling geometric mean for each 7-day period) for E. coli.
- b. NPDES permit requirements for weekly loadings on TSS, CBOD and Phosphorus for blended wastewater treated effluent from HRT system and the secondary effluent from the Lakewood WWTP. The maximum loading rate for TSS, CBOD, and Phosphorus was calculated based on the pilot plant performance data and maximum combined effluent flow rate of 65 MGD. Refer to Section 2 below.

1.3 RESULTS

Following is a summary of the pilot testing results:

¹ Per the Ohio EPA, the target effluent limits for Lakewood should be similar to the Northeast Ohio Regional Sewer District Consent Decree. Ref. telephone conversation with Erm Gomes of the Northeast District Office, February 3, 2015.

- a. Effluent TSS and CBOD levels were consistently within the target limit of 40 mg/L, meeting the NEORS D Consent Decree requirements.
- b. Final effluent E. coli levels after UV disinfection was well within 284 CFU/100 mL expressed as a 7-day rolling geometric mean, meeting the NEORS D and NPDES permit requirements.
- c. All chemicals used in the pilot testing were compatible to the treatment processes in Lakewood WWTP.
- d. During sodium aluminate (NaAlO_2) based BIOACTIFLO testing, the pH value of the effluent (8.6 to 8.8) was higher than that of the influent (7.6 to 7.9) and the sludge structure, and effluent turbidity were not satisfactory.
- e. During the CSO wet weather event and simulated wet weather flow, BIOACTIFLO and ACTIFLO runs were conducted with Alum ($\text{Al}_2(\text{SO}_4)_3$) and Polyaluminum Chloride (PACL) coagulants in conjunction with flocculent to evaluate optimum chemical dosages.
 - 1) For BIOACTIFLO™ mode of operation, optimum dosages for Alum and Polyaluminum Chloride (PACL) are summarized in the table below:

Contact Tank MLSS	Coagulant 1 / Flocculent Concentrations		Coagulant 2/ Flocculent Concentrations	
	Alum, $\text{Al}_2(\text{SO}_4)_3$	Hydrex 3596	PACL	Hydrex 3596
800 mg/L	90 mg/L	3.6 mg/L	60 mg/L	3.2-4.8 mg/L
1200 mg/L	100 - 115 mg/L	5.0 mg/L	80 mg/L	0.3 mg/L

Compared “Coagulant/Flocculent” concentrations at different MLSS concentrations indicate that combination of PACL coagulant with Hydrex 3596 flocculent is the most effective choice of chemical.

- 2) For regular ACTIFLO® mode of operation, optimal dosages of Alum and PACL are summarized in the table below.

	Coagulant 1 / Flocculent		Coagulant 2 / Flocculent	
	Alum, $\text{Al}_2(\text{SO}_4)_3$	Hydrex 3596	PACL	Hydrex 3596
Concentrations	70- 90 mg/L	1.2- 2.0 mg/L	60 mg/L	1.2 mg/L

- i. Compared “Coagulant/Flocculent” combinations during ACTIFLO optimization runs, produced very close effective concentration values.
- ii. During ACTIFLO steady state testing, the effluent TSS, CBOD and phosphorus limits, at provided coagulant and flocculent concentrations,

- consistently met the requirements of the NEORSO Consent Decree and NPDES permit.
- iii. All the coagulants achieved effluent phosphorus concentrations less than 0.5 mg/L.
 - iv. According to the Chemical Usage Present Worth analysis, operational cost of Alum is half of PACL cost. Refer to Appendix 2. Therefore, Alum is recommended choice of chemical for HRT full scale treatment.
- f. Operating cost for running ACTIFLO and BIOACTIFLO is estimated at \$850-1,500 / MG based on the pilot study results at 35 to 45 MGD range.

2.0 INTRODUCTION

The focus of this project was to assess a technology that had the potential to minimize the footprint, environmental impacts, and the cost of treating wet weather flow; and if combined with secondary treated effluent will the technology meet the discharge NPDES permit limits.

The objective of this report is to present a summary of the findings of the ballasted flocculation (ACTIFLO and BIOACTIFLO) pilot tests. The pilot facility was configured to receive raw wastewater: (a) primary influent; (B) primary effluent; and (c) return activated sludge (RAS) stream. Primary effluent was used to simulate wet weather conditions during dry weather and primary influent during the wet weather conditions. RAS was the source of MLSS when the system was run as BIOACTIFLO.

2.1 NPDES PERMIT REQUIREMENTS

The City of Lakewood WWTP is complying with NPDES permit, which in the effect from August 2015 to January 2019. The target effluent quality for the full scale Actiflo HRT system was based on the NPDES permit effluent limits as shown in Table 2.1. The effluent loadings listed in this table are calculated based on average design wastewater flow of 18 MGD.

Table 2.1: Final Effluent Limits, Monitoring and Basis for Lakewood WWTP Outfall NPDES Permit No. 3PE00004001

Parameter	Concentration, mg/L		Loading (lbs/day)	
	Monthly	Weekly	Monthly	Weekly
TSS	20.0	30.0	3002.40	4503.60
CBOD ₅	15.0	23.0	2251.80	3452.76
Phosphorus	1.0	1.5	150.12	225.18
pH	6.5 – 9.0			
E. coli (summer only)	126 #/100 mL	284 #/100 mL	--	--

The HRT pilot study showed that the effluent limits outlined in NPDES permit were achieved consistently during the wet weather testing period. The summary of the data from the actual and simulated wet weather events can be found in Table 2.2. Based on the pilot study results and projections for the full HRT system designed to treat 35 MGD wet weather flow, estimated effluent loading rates are in compliance with the weekly NPDES permit requirements.

Table 2.2: Summary of Pilot Study Average Treated Effluent Parameters

Parameters	ACTIFLO Effluent	Loading, lbs/day
TSS	13.0±1.6 mg/L	3794.5
CBOD ₅	12.0±1.3 mg/L	3502.08
Phosphorus	0.17±0.06 mg/L	49.62
E. Coli	15.0±4.2 CFU/100 mL	-

During wet weather events, flows higher than 30 MGD to the WWTP will be diverted to the ACTIFLO HRT system. The effluent from the HRT will be combined with the secondary effluent from Lakewood WWTP and passed through a common UV disinfection system, which will be upgraded to treat peak hour flow of 65 MGD.

Estimated weighted average solids loadings rate during the wet weather event is shown in Table 2.3 and is based on the following:

- a. The WWTP primary and secondary treatment:
 - 1) Peak Hourly Flow: 30 MGD
 - 2) Treated effluent solids loading rates are based on weekly loads of TSS, CBOD₅ and Phosphorus as shown in Table 2.1.
- b. Actiflo HRT system:
 - 1) Max wet weather flow rate: 35 MGD
 - 2) Treated effluent solids loading rates for TSS, CBOD₅ and Phosphorus are as shown in Table 2.2 above.

Table 2.3: Summary of Estimated WWTP Treated Effluent Solids Loadings for 65 MGD Peak Hourly Wet Weather Flow

WWTP Treatment	Flow Rate, MGD	Weighted Average	7-Day Solids Loadings					
			TSS,		CBOD,		Phosphorus,	
			mg/L	lbs/day	mg/L	lbs/ day	mg/L	lbs/day
Primary+Secondary	30	46%	8.3	2072	6.3	1588	0.1	25
Actiflo	35	54%	7	2049	6.5	1891	0.4	104
Total	65	-	7.6	4121	6.4	3479	0.24	129

The peak hourly wet-weather increase to 65 MGD will not adversely affect receiving waters, since the total suspended and organic loadings are well below the 7-day NPDES permit requirements.

3.0 SCREENING OF TECHNOLOGIES

The City and their Design Professionals have compared four high rate treatment (HRT) technologies offered by the four different manufacturers (Kruger-Veolia, Evoqua, Infilco and WWETCO). The technologies were assessed based on the following information:

- Soliciting pilot plant study proposals;
- Conducting interviews and manufacturer's presentations;
- Site visits.

The information gathered from the candidate HRT processes is summarized in Table 3.1, with brief description of the HRT technologies provided below.

3.1.1 Ballasted Flocculation using Sand Medium (ActiFlo/BioActiFlo)

The ActiFlo® process is a high-rate chemical and physical clarification process that involves the formation of suspended solids onto a ballast particle (microsand) followed by lamellar settling. It allows solids to settle out more quickly, thereby requiring a smaller footprint than conventional clarification. BioActiFlo configuration is obtained by adding a contact tank ahead of the ActiFlo unit.

3.1.2 Ballasted Flocculation using Magnetite Medium (CoMag/BioMag)

The CoMag™ process uses conventional chemical coagulation and flocculation along with the addition of finely ground magnetite as a ballasting agent. The dense magnetite significantly increases the weight and settleability of chemical flocs, resulting in high-rate sedimentation. Approximately 85 percent of the settled sludge is recycled to provide nucleation sites for floc development. Excess sludge is passed through a shear mill followed by a magnetic recovery drum to recover the magnetite before the nearly magnetite-free sludge is further processed. The recovered magnetite is returned to the process. BioMag™ is a similar process using magnetite addition directly to the activated sludge process to improve biological floc settleability.

3.1.3 High Rate Solids Contact Clarification (DensaDeg)

The DensaDeg® process is a high-rate chemical and physical clarification process that combines sludge ballasted clarification and lamella filtration. The DensaDeg® process starts with the addition of a coagulant to destabilize suspended solids. The flow enters the rapid-mix

tank for flash mixing to allow the coagulant to take effect then overflows into the reactor tank where sludge and polymer are added.

3.1.4 High Rate Compressible Media Filter (WWETCO)

The WWETCO FlexFilter™ and Bio-FlexFilter™ use a synthetic fiber media bed that is passively compressed from the sides by the head of the incoming water. The lateral compression forms a cone-shaped porosity gradient that allows the stratification and removal of large and small particles from the top to the bottom of the media bed. The porosity gradient through the media bed, with its ability to handle heavy solids loading, gives the technology a wide range of uses: (a) produce a reuse quality effluent as a tertiary filter; (b) increase the organic removal capacity of the facility, and/or reduce its power consumption; and, (c) treat excess wet-weather flow including biological treatment, as appropriate.

From the information collected, The City and their Design Professional have selected two manufactures, Kruger-Veolia and Infilco Dgrement, to perform a side by side pilot study at the Lakewood WWTP. However, Infilco Degremenot, Inc. has declined participation in the pilot study due to the piloting unit unavailability. Therefore, only ACTIFLO / BIOACTIFLO High Rate Treatment system, presented by Kruger-Veolia manufacturer was piloted at the Lakewood WWTP.

3.2 DESCRIPTION OF THE HIGH RATE TREATMENT TECHNOLOGY

3.2.1 ACTIFLO® Process Description

ACTIFLO® is a high performance and compact clarification system that uses micro-sand ballasted flocculation and settling (Figure 3.1). In this process, a coagulant is added to the influent wastewater before entering the coagulant tank. From the coagulation tank, wastewater overflows into the maturation tank where micro-sand and polymer are added. The micro-sand acts as ballast by providing a large surface area, enhancing the settling of the agglomerated particle. The destabilized suspended solids will bind to the microsand particles via polymer bridging. High mixing energy from the draft tube surrounding the maturation mixer enhances coagulation of the newly formed floc particles. These floc particles agglomerate and grow into high density, microsand ballasted floc. The flocculated particles then flow with the surrounding water under the stilling baffle of the maturation tank into the settling tank.

In the settling tank, the flocculated sludge settles to the individual lamella plates. From there they move down to discharge to the bottom of the clarifier. The capacity of the settling tank is further enhanced by the use of inclined lamella plates. The ballasted sludge collected at the bottom of the settling tank is pumped to hydrocyclones. In the hydrocyclone, the sludge is separated from the microsand by the centrifugal force. From here, the recovered clean microsand is recycled to the maturation tank and the separated sludge is discharge continuously as the final sludge stream.

The following is a summary of benefits of this physical/chemical process as reported by the manufacturer:

- The process offers a high degree of flexibility since it has a short start-up time and reaches steady-state performance quickly.
- The high concentration of micro-sand and injection tank mixing intensity allows the process to handle sudden variations in flow and water quality (such as turbidity or temperature) without compromising effluent quality.
- Chemical (coagulant and polymer) feed can be adjusted to accommodate variations in feed water quality.

Due to the compact nature of this clarification and short hydraulic retention time (less than 10 min), the startup time is short and can accommodate fluctuations in flow rate quickly. Addition of microsand allows the process to handle sudden variations in turbidity, color and temperature.

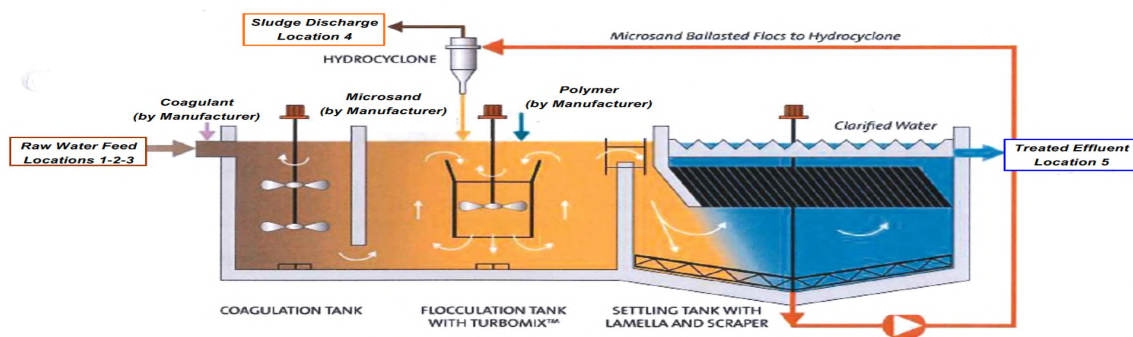


Figure 3.1: ACTIFLO® Process Flow Diagram

Table 3.1: Summary of the presented Chemically Enhanced HRT Technologies

Manufacturer	Foot Print, LxWxH, ft	Pretreatment Requirements	Effluent Quality	Chemicals required	Sludge Production & Concentrations	Pilot Plant Requirements	Seasonal Impact
Kruger/Veolia, ActiFlo BioActiflo	39'x 6.5' x 23' height	- Screen: 5/8"- required; - Grit removal - recommended	- TSS: 50-10 mg/L (85-95% removal); - BOD: 10-40 mg/L (40-60% removal); - UV will work.	- Coagulants: Alum & Ferric based; - HMW anionic polymer; - Sand	- Sludge Production 5% of the influent flow; - Solids Concentration - 0.2-0.6%	- Trailer: 53'x'8'x 13.5' - Contact Tank: 6,000 gal - Actiflo 150 amps + 60 amps for Contact Tank; - Capacity: 202-310 gpm 2-4 gpm potable water	- During dry weather: 20 min. every 2 weeks; - During winter: run some flow through the HRT system or heated mixers to mitigate freezing.
Evoqua, CoMag™ & BioMag™	- Tanks, total of 2, each: 17.5'x 17.5'x 17.5' - Clarifier: ø45-ft or Lamella Clarifier 27'x 27'	- Screen: 1/2"- required; - Grit removal - required	- TSS: ~ 80% removal; - BOD: 56% removal; - UV capable.	- Coagulant: Alum (2 mg/L), FeCl₃; - Dry polymer (1 mg/L)	- TSS 19,000 lb/day - Solids Concentration: 1.5 - 2.0%	- Trailer mounted 10-15% of clarifier underflow is returned to mixing chamber	-
Infilco Degremont, DensaDeg & DensaDeg XRC	Tanks, 2 units, each: 59' x 55' x 6.5'	- Screen: 1/2"- required; - Grit removal - recommended	- TSS: 80-90% removal; - BOD: 10-40 mg/L (40-60% removal); - UV with < 30/30 effluent.	- Alum 30-40 ppm or ferric - Polymer 1-2 ppm	2% sludge for alum; - Produces 6-10 times less sludge than ballasted system.	- Trailer: 54' x 9' x 25' (H) - Capacity:150 -275 gpm, - Power: 90 amps - Lab testing & basic monitoring.	No performance impact - mixer speeds/increase polymer - equipment pumps in controlled environment
WWETCO, FlexFilter™ & Bio-FlexFilter™	5 cells - 3' W x 30' L 108' L x 62'W x 15" H 5 cells with 3 bladders each @ 540 SF each cell	Screen: 1/2"- required;	- TSS: ~ 80% removal; - BOD: 38% removal); - UV capable	Disinfection	4 mgd @ 1,400 mg/l TSS	10 gpm / sf. @ 30 gpm - Power: 120/240/1-ph	None

3.2.2 BIOACTIFLO™ Process Description

The BioActiFlo® process (Figure 3.2) is a high-rate treatment process that combines biological treatment with the ActiFlo® ballasted flocculation high-rate clarification process described in the previous section. Biological treatment is provided by a solids contact basin which is used ahead of the ActiFlo® high rate clarification. This basin has a short hydraulic retention time (20 min) and a lower mixed liquor suspended solids (MLSS) concentration than conventional aeration basins. Biomass in the return activated sludge (RAS) is pumped here so that the microorganisms in the RAS can contact the soluble biochemical oxygen demand (sBOD) in the influent. The target concentration of MLSS in the contact basin is maintained by using a portion of the RAS stream in addition to concentrated sludge from the ActiFlo® high-rate clarification process.

The MLSS is aerated for rapid BOD uptake by the biomass. From the contact tank, wastewater flows to the ActiFlo process. The result is a process that provides high removal efficiency of BOD as well as suspended solids, thereby achieving biological treatment of excess flows while preserving the integrity of plant processes and mitigating washout of biomass.

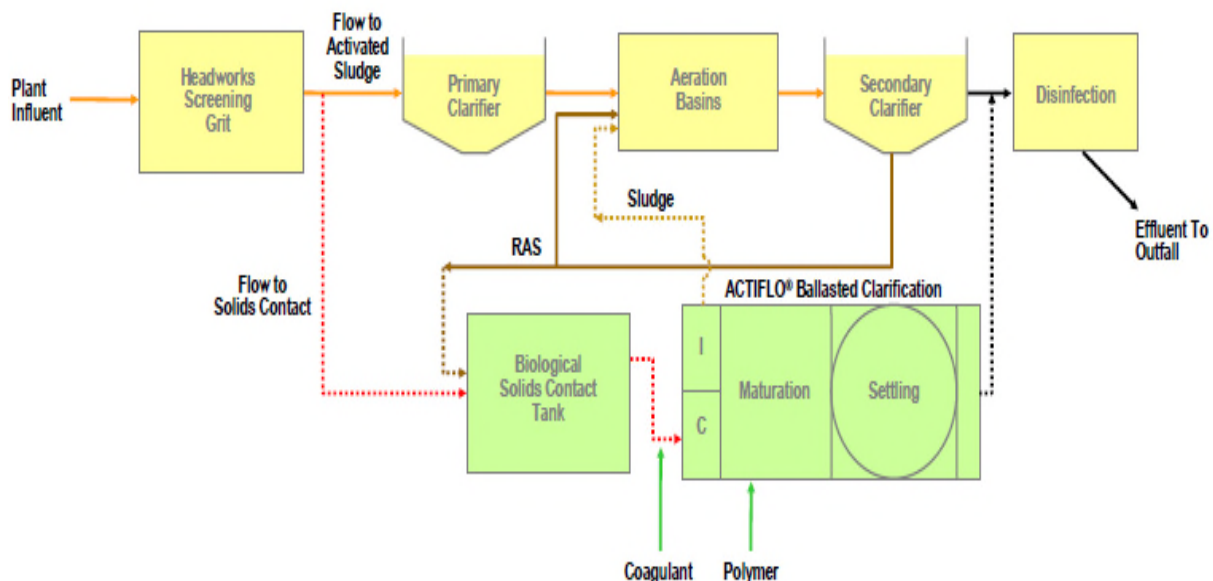


Figure 3.2: BIOACTIFLO™ Process Flow Diagram

3.3 COMPARISON OF ACTIFLO® AND CONVENTIONAL TREATMENT

The primary difference between conventional clarifier and sand-ballasted high rate settling technology of ACTIFLO are as follows:

- a. Smaller footprint and basin requirements: Surface overflow rates of the ACTIFLO process are 25 to 41 times greater than for conventional primary clarification. The higher loading rates significantly decrease basin volume and surface area requirements.
- b. Ability to compensate for influent variability: Due to the high concentration of micro-sand relative to influent particulates, the ACTIFLO process has the ability to accommodate variations in flow and influent quality without compromising effluent quality.
- c. ACTIFLO and BIOACTIFLO process performed better than conventional primary clarification in terms of measured CBOD and TSS removal efficiencies.
- d. Capital cost to treat a unit volume of wastewater with ACTIFLO and BIOACTIFLO is significantly higher than that of the conventional primary clarifier.
- b. The ACTIFLO process requires much less space than primary clarifiers.

4.0 PILOT TESTING

4.1 PILOT PLANT LAYOUT

The container system for an ACTIFLO/BIOACTIFLO pilot unit, supplied by Kruger/Veolia (HRT manufacturer), consisted of a self-contained tractor trailer as shown in Figure 4.1. The pilot unit was located on the asphalt strip between the aeration tank train and the primary clarifiers as shown in Figure 4.2. Submersible pumps were dropped into the channel before and after the primary clarifier as sources to pump influent to the pilot unit.

The ACTIFLO unit, both in regular as well as biological mode of operation was operated from 180 – 210 gpm. These flow rates yielded hydraulic retention times between 0.96 and 1.12 minutes, respectively, in the coagulation tanks 1 and 2. Coagulant was dosed inline into the 4-inch influent pipe inside the trailer followed by a static mixer before entering the first mixing tank (coagulation tank) of the process. Polymer was dosed into the maturation tank. The maturation tank blade used was a 110° pitched hydrofoil blasé to increase mixing energy within the draft tube. The coagulation and injection mixers as well as the maturation mixer were run at 100%.



Figure 4.1: ACTIFLO®/BIOACTIFLO® Process Setup

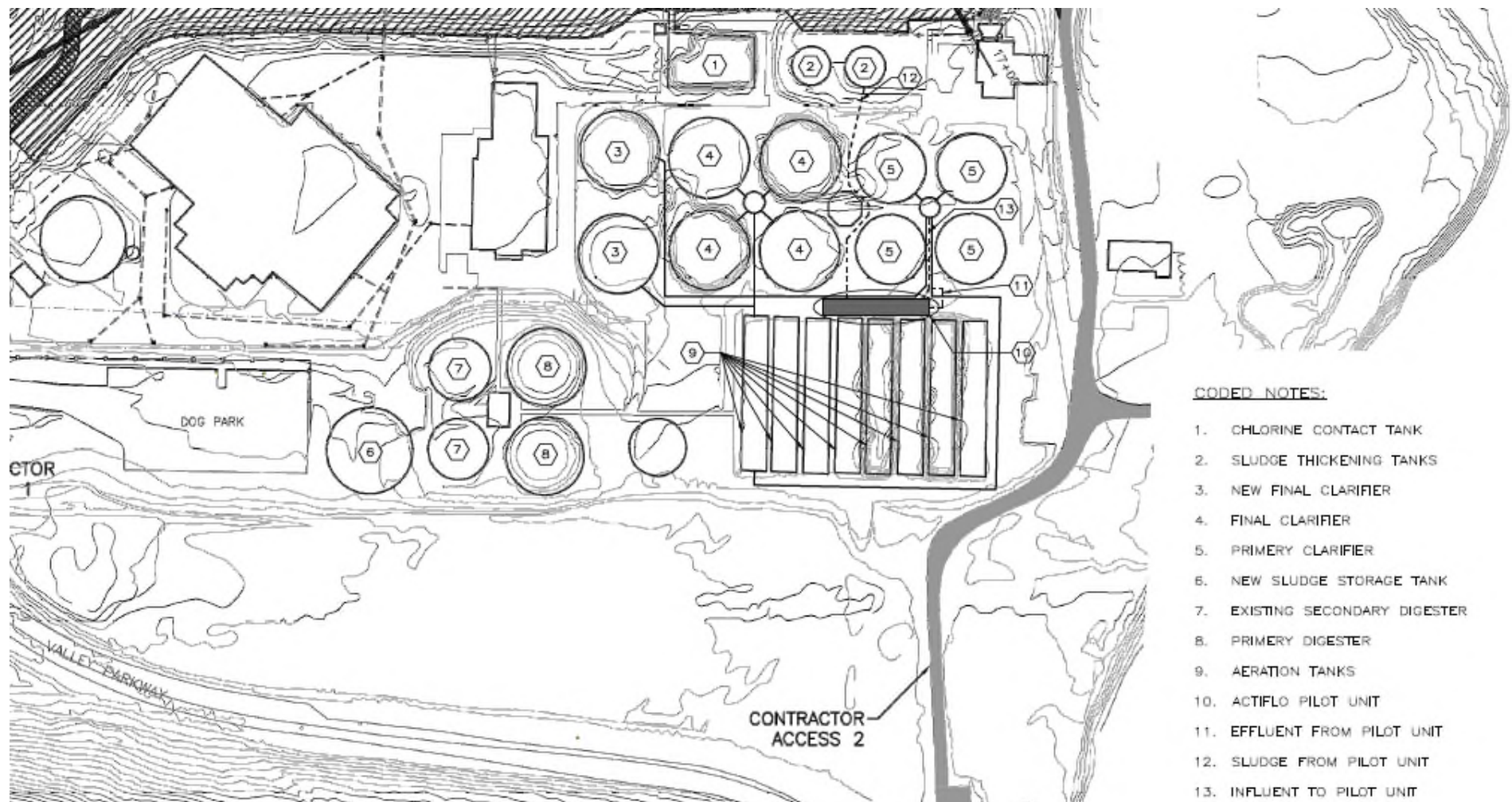


Figure 4.2: Pilot Plant Location

4.2 ACTIFLO® PILOT UNIT DESCRIPTION

ACTIFLO® pilot unit can be used for simulating regular ACTIFLO® process or BIOACTIFLO® by adding a contact tank before the pilot unit. Details on the pilot unit are provided in Table 4.1.

Table 4.1: ACTIFLO® and BIOACTIFLO™ Pilot Unit Specification

Parameter	Unit	Value
<u>Coagulation Tank – 1</u>		
Volume	Gal	200
Length	In.	30
Height	In.	53
Width	In.	29
<u>Coagulation Tank – 2</u>		
Volume	Gal	207
Length	In.	30
Height	In.	53
Width	In.	30
<u>Maturation Tank</u>		
Volume	Gal	596
Length	In.	46
Height	In.	53
Width	In.	56
<u>Settling Tank</u>		
Volume	Gal	473
Surface Area	Ft ²	5.8
<u>Krebs Hydrocyclone</u>		
Recirculation Rate	GPM	21
Overflow/Sludge	GPM	16.8
Underflow/Sand Slurry	GPM	4.2
<u>Contact Tank</u>		
Volume	Gal	5,485
Length	In.	75.8
Height	In.	55
Width	In.	60

Hydraulic detention times available in each section of the pilot unit at various influent flow rates are summarized in Table 4.2.

Table 4.2: ACTIFLO® Pilot Unit Hydraulic Retention Times

Flow Rate (gpm)	Recirculation Rate (gpm)	Rise Rate (gpm/ft ²)	Coagulation Zone 1 (min)	Coagulation 2 (min)	Maturation (min)	Settling (min)	Total HRT (min)
202	21	32	0.99	1.02	3.03	2.43	7.48
190	21	60	1.05	1.09	3.23	2.58	7.95

4.3 COAGULANT CHEMICAL DATA

Coagulants evaluated during the pilot study were as follows:

- Sodium Aluminate, NaAlO_2 : 32% w/w, active S. G. = 1.33
- Aluminum Sulfate, $\text{Al}_2(\text{SO}_4)_3 \cdot 14\text{H}_2\text{O}$: 48% w/w, S. G. = 1.33
- Polyaluminum Chloride, $\text{Al}_2(\text{OH})_x\text{Cl}_{6-x}$: 30% w/w, S. G. = 1.37

4.3.1 Coagulant Limitation – Non Ferric

ACTIFLO/BIOACTIFLO units have been reported to perform very well when aluminum and iron based coagulants were used at optimum concentrations. However, ferric or ferrous ions are not to be used in the pilots because of their incompatibility with the type of diffusers installed at LWWTP.

The coagulants selected for testing in the pilot study were aluminum based. Among them, sodium aluminate has been currently used by the LWWTP as coagulant in the primary clarifier.

4.4 POLYMER TYPE INFORMATION USED FOR PILOT STUDY AND ITS COMPATIBILITY

Three types of dry, anionic polymers, manufactured by Crown Solution were evaluated during the pilot study. The dry polymer was made up as 0.3% w/w solution (3 g/L). These polymers are:

- Hydrex 3502
- Hydrex 3596
- Hydrex 3572

The polymer current used at the LWWTP for dewatering sludge on belt filter presses is dry cationic type, CLARIFLOC CE-1040, by Polydyne, Inc. If ACTIFLO sludge is co-settled in the primary clarifiers, no significant interaction between the current polymer and those to be tested during pilot study is noticed.

4.5 MICROSAND DATA

The microsand utilized during the pilot study was #65 (effective size 134 μm , uniformity coefficient of 1.69) manufactured by Manlet Brothers of Indiana, Inc.

The microsand concentration was measured every day to ensure the designed microsand concentration was retained in the system. The recycle rate is typically designed for a flow rate

of 10 – 17% of the ACTIFLO® process influent, depending on the application. The hydrocyclone splits the influent slurry with approximately 20% returning to the system (underflow) and 80% exiting as sludge (overflow). Ideally, the 20% is limited to sand recycle.

Sampling is performed using a graduated cylinder to capture one liter of underflow from the hydrocyclone apex (Figure 4.3). The micro-sand should be allowed to settle out in the cylinder for 60 seconds. Once settled, the volume of sand (settled) is measured. The concentration of microsand is calculated using the bulk density of microsand (1.77 g/mL), the volume of microsand that settled out in the cylinder, and the total sample volume. The ACTIFLO® process influent and hydrocyclone influent flow rates are also needed for calculating the microsand concentration as shown in Equation 4.1:

$$C = \frac{V_S}{V_T} * \frac{Q_R}{Q_I} * \frac{X}{100} * 1.77$$

Eq. 4.1

where,

C – Microsand concentration, g/mL
 V_S – Volume of settled microsand after 60 seconds, mL
 V_T – Tank sample volume, L
 Q_R – Hydrocyclone flow rate, gpm
 Q_I – Influent flow rate, gpm
 X – Recycle percentage, % (if 20%, then X= 20)
 1.77 – Bulk density of microsand, g/mL

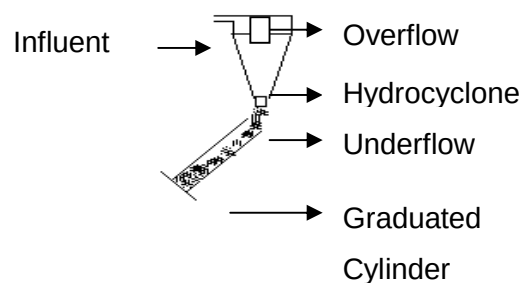


Figure 4.3: Schematic of Hydrocyclone and Sampling Location

4.6 CHEMICAL DOSE CALCULATIONS

All chemical dosages are determined by performing the drawdowns on calibration columns attached to feed tubing. A drawdown is the measured volumetric flow rate of the chemical being

dosed into the system. Drawdowns (mL/sec) require an accurate measuring column and a stopwatch. With the chemical in the column, the chemical is drawn out at the desired pump speed for at least 1 minute (the longer the drawdown, the more accurate the calibration).

4.6.1 Coagulant Dose

The coagulant dose takes into account the percent activity and the density of the compound. The ACTIFLO® process influent flow rate (gal/hr) and the measured drawdown (mL/sec) are also needed in the calculation. The coagulant dose rate is calculated using Equation 4.2:

$$X_c = \frac{C}{100} * \rho * \frac{1000mg}{g} * \frac{Q_c}{Q_i} * \frac{3600 sec}{hour} * \frac{1 gal}{3.785 L}$$

Eq. 4.2

Where:

X_c – Coagulant dose, mg/L

C – Activity of coagulant, % (if 30%, then $C = 30$)

ρ - Density of coagulant, g/mL

Q_c – Coagulant feed rate, mL/sec

Q_i – Influent flow rate, gal/hr

4.6.2 Polymer Dose

First, the concentration of the batched polymer has to be calculated. This is done on either a mass or volume basis. For example, if the polymer is prepared by mixing 3 grams of dry polymer or 3 mL of emulsion per one liter of water, then the resulting polymer concentration is 0.3%. In order to calculate the polymer dose the drawdown (mL/min) and the influent flow rate (gal/hr) are needed. The polymer dose rate is calculated using Equation 4.3 below:

$$X_p = C * \frac{1000mg}{g} * \frac{Q_p}{Q_i} * \frac{3600 sec}{hour} * \frac{1 gal}{3.785 L}$$

Eq. 4.3

Where:

X_p – Polymer dose, mg/L

C – Concentration of polymer solution, g/L

Q_p – Polymer feed rate, mL/sec

Q_i – Influent flow rate, gal/hr

4.6.3 Mols of Metal Dosed per Mol of Phosphorus Removed

The mols of metal dosed per mol of phosphorus removed is a function of sludge recycle and non-sludge recycle samples. The ratio is calculated using Equation 4.4:

$$\frac{\frac{C_I * X}{MW_M}}{\frac{C_{Pinf} - C_{Peff}}{MW_P}} = \frac{\text{mol metal dosed}}{\text{mol P removed}}$$

Eq. 4.4

Where:

C_I – Coagulant dose, mg/L

MW_M – Molecular weight of metal ion, g/mol

C_{Pinf} C_{Peff} – Amount of P removed, mg/L

MW_P – Molecular weight of P, g/mol

X – Conversion factor for metal ion weight Vs. coagulant weight:

$$X \text{ for aluminum sulfate: } 0.0908 = \frac{\text{molecular weight of } Al_2}{\text{molecular weight of } Al_2(SO_4)_3 \cdot 14H_2O}$$

$$X \text{ for sodium aluminate: } 0.6576 = \frac{\text{molecular weight of } Al_2}{\text{molecular weight of } NaAlO_2}$$

$$X \text{ for polyaluminum chloride: } 0.309 = \frac{\text{molecular weight of } Al_2}{\text{molecular weight of } Al(OH)_n Cl_{6-n} \cdot n \cdot XH_2O}$$

4.7 FIELD INSTRUMENT CALIBRATIONS

Calibrations of the field instruments were conducted accordingly to the following procedure (Table 4.3):

- The bench top turbidity meter (Hach model 2100N) was calibrated using the Stabcal method found on pages 20 – 23 of the Hach manual for 2100N
- Bench top pH meter (Orion 3-Star) was calibrated using the recommended method on page 19 of the Manual for Bench top pH/ISE meters; this is a three point manual calibration buffer method.
- The online pH meters (GLI International, model 53P) were calibrated using the recommended method in Sections 5.2 on pages 58-67 of the instruction manual.

- d. The online influent/effluent turbidity meters, TSS meter and DO probes (SOLITAX) were calibrated using the recommended calibration method, which can be found on pages 37-39 of the Hach Company Manual for SOLITAX sc turbidimeters.

Table 4.3: Pilot Unit Field Testing Instruments and Methods

Parameter	pH	Alkalinity (mg/L as CaCO ₃)	Turbidity (NTU)	UV ₂₅₄
Instrument	Orion 3-Star	Test kit, model AL-AP	Hach 2100N	RealTech P200 TOC analyzer
Method	Epoxy body refillable pH/ATC triode	Drop count titration with sulfuric acid	US EPA method 180.1	Hach method 10054

- e. The portable UV₂₅₄ meter was calibrated using the recommended Hach method 10054. UV₂₅₄ is a measure of ultraviolet absorption at a wavelength of 254 nm. This parameter is a surrogate measure for natural organic matter present in water. One of the benefits of monitoring UV₂₅₄ is that it is an important factor in identifying the “optimal” coagulant dose.

4.8 DAILY STARTUP AND SHUTDOWN PROCEDURE

During the pilot testing period, the pilot unit was operated on a continuous mode for 8 – 9 hours a day. In general, daily startups consisted of manually starting process equipment and instruments and verifying the metering accuracy of the chemical feed pumps.

Shutdown consisted of reversing the startup procedure and allowing the sand pump to run for a period of ten minutes after all the equipment had been shutdown to remove sand from the settling tank hopper.

4.9 SAMPLING SCHEME

Samples were split and sent for analyses in two different external labs except for E. coli analyses. Samples collected were divided into two containers and sent one each to CWM laboratory and WLI laboratory for analyses. E. coli analyses were performed by WLI Laboratories only.

Testing parameters analyzed as part of the pilot testing, and the corresponding reference methodologies are summarized in Table 4.4. The following overall sampling approaches were implemented during the pilot testing:

1. During storm events or simulated storm related flow conditions, grab samples were taken from the influent and effluent streams, once every 30 to 60 minutes;
2. During dry weather flow conditions, grab samples were taken as described for the storm conditions. However, the samples were composited. The decision on whether or not to composite the samples were made by the pilot unit operator based on the influent flow to LWWTP and the influent turbidity values recorded at the time of sampling.

Table 4.4: Testing Methodology and Sample Type for Core and Supplemental Parameters

Parameter	Reference or Methodology	Influent	Effluent	Dry Weather	Storm Weather
TSS	EPA 160.2 / SM 2540 D	X	X	C	G
VSS	EPA 160.4		X	C	G
CBOD ₅	EPA 405.1 / SM 5210 B	X	X	C	G
E. coli	EPA 1603	X	X	C	G
pH ^(a)	EPA 150.1	X	X	C	G
Temperature ^(a)	EPA 170.1	X		C	G
Turbidity ^(a)	EPA 180.1 / SM 2130 B	X		C	G
Alkalinity	EPA 310.2	X		C	G
UV Transmittance			X	C	G
Phosphorus	EPA 365.1	X	X	C	G

Notes:

(a) In-line analysis with instruments.

C – Composite sample

G – Grab sample

In-line monitoring (for pH, temperature and turbidity) and sampling was provided. The pilot plant operator took readings from the in-line monitoring.

Flow monitoring of influent and final effluent was carried out continuously. The flow totalizers were provided for influent flow and RAS flow. Details of the flow monitoring methods, calibration procedures, and the data analysis, evaluation and QA/QC procedures were documented by the pilot operator.

5.0 PILOT TESTING – CHEMICAL DOSAGE OPTIMIZATION

Chemical optimization tests were performed on the influent with various coagulant and flocculent chemicals in order to understand their ability to remove suspended solids. Suspended solids concentrations in the raw and treated samples were analyzed by measuring their turbidity because it is instantaneous. In order to understand how well the turbidity values can be related to their TSS, TSS analytical results from the two external laboratories were compared with the corresponding turbidity values for various samples (Figure 5.1).

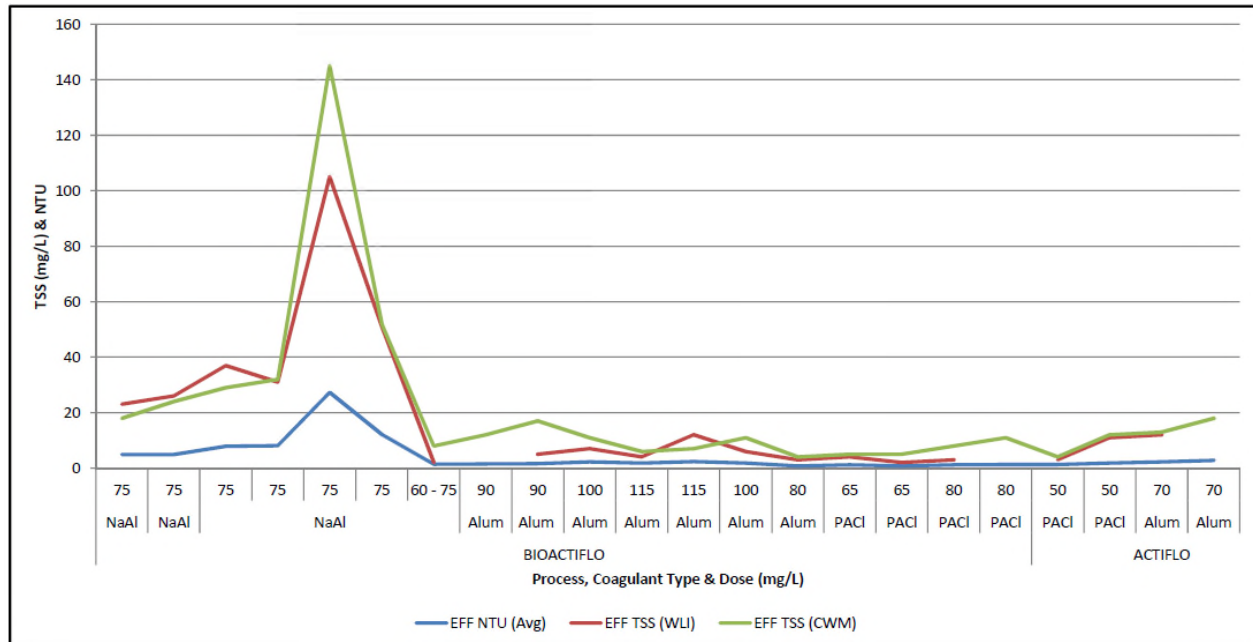


Figure 5.1: Turbidity and suspended solids values from Pilot Effluent Samples

It must be noted that TSS analysis was completed only on composite samples. Since composite NTU data were not collected, grab sample NTU values were averaged and compared with TSS. The data from the pilot shows a ratio of 4.4-5.0 mg/L TSS to 1 NTU comparing both outside lab data.

5.1 BIOACTIFLO®

After the initial setup, the pilot unit was operated in BioACTIFLO mode during the first phase of testing. For the first two days, testing was performed to optimize coagulant dose and polymer dose before testing rise rate. Optimal condition for mixed liquor suspended solids (MLSS) concentrations, contact tank retention times, and ACTIFLO® hydraulic loading rates were set

based on the pilot plant operator experience. Continuous runs were performed using sodium aluminate, alum, and polyaluminum chloride at varying polymer and MLSS concentrations.

Sodium aluminate (NaAlO_2) was selected as a candidate coagulant because (a) it is being used by the WWTP, and (b) ferric or ferrous based coagulants are not compatible with the type of diffusers at the WWTP. Aluminum sulfate ($\text{Al}_2(\text{SO}_4)_3$) and Polyaluminum chloride (PACL) were selected as the other non-ferrous coagulants. The BIOACTIFLO™ was operated while the plant was experiencing CSO wet weather events. Operating conditions and the results of samples collected during BIOACTIFLO™ testing are provided in the following sub-sections.

5.1.1 Sodium Aluminate

Initial testing of the BIOACTIFLO mode of pilot testing began on June 3, 2015 in order to develop optimization curves for the process chemicals and parameters. For this purpose, samples collected were analyzed by bench-top analytical instruments and in-line analyzers only. TSS is correlated to readings from in-line turbidity analyzers for the influent and effluent streams. CBOD removal is proportional to the amount of biomass it comes in contact with in the contact tank.

Varying doses of coagulants and polymer were tested to determine the minimum chemical doses required in order to achieve the effluent TSS and CBOD limits. This optimization step was repeated each time the MLSS concentration in the Contact Tank was changed (800 and 1,200 mg/L target concentrations were tested). As a coagulant, sodium aluminate was tested at dosages in the range of 55 to 90 mg/L. At the same time, dry anionic polymer Hydrex 3596 was used at doses ranging from 2.8 to 3.66 mg/L. Effluent samples were collected at the various conditions. The ACTIFLO® portion of the train was operated with a hydraulic loading rate of 32 gpm/ft². After each parameter change, NTU, UV_{254} , and visual observations were used as an onsite means of judging effluent quality. This field data provided fairly instant feedback and aided in parameter change decisions. Data from the optimization is outlined in Table 5.1.

For a contact tank MLSS concentration of 1200 mg/L, a dose of 75 mg/L sodium aluminate and 3.6 mg/L Hydrex 3596 polymer are most effective at reducing effluent turbidity to an optimal level. At a contact tank MLSS concentration of 800 mg/L, a slightly lower dose of both sodium aluminate and Hydrex 3596, 60 mg/L and 3.3mg/L respectively, give the optimal effluent turbidity level. The sodium aluminate reduced turbidity to an adequate level, but at the expense

of pH increasing to above 8.5 in the effluent. After two days of optimization testing, the pilot unit was shifted to steady state run.

Table 5.1: BIOACTIFLO Sodium Aluminate Optimization Data (Kruger Lab Analysis)

Date	Time	Contact Tank		Coagulant	Polymer	pH		Turbidity		
		HRT (min)	MLSS (mg/L)	NaAlO ₂ (mg/L)	3596 (mg/L)	Inf	Eff	Inf (NTU)	Eff (NTU)	Removal (%)
6/3/2015	13:45	21.6	1,200	60	2.8	7.76	8.50	36.7	12.7	65.4
	14:15	21.4		70		7.76	8.57	39.50	10.30	73.9
	14:45	22.1		80		7.81	8.64	41.70	9.09	78.2
	15:15	21.2		90		7.80	8.68	42.90	31.10	27.5
	15:45	21.2		75		7.79	8.56	43.10	39.20	9.0
	16:25	21.9			3	7.78	8.56	44.70	11.50	74.3
	16:45	21.6			3.2	7.77	8.58	45.50	9.86	78.3
	17:05	21.7			3.4	7.74	8.57	45.60	5.95	87.0
	17:25	21.3			3.6	7.74	8.56	45.40	5.53	87.8
6/11/2015	9:00	23.3	800	60	3.7	7.67	8.84	48.90	5.57	88.6
	9:30	23.2			3.5	7.70	8.84	35.60	5.16	85.5
	10:00	23.6			3.3	7.60	8.82	259.00	5.34	97.9
	11:00	22.4		55	3.5	7.79	8.78	91.40	6.69	92.7
	12:00	22.5		65		7.86	8.79	57.80	6.05	89.5
	12:30	23.0		70		7.82	8.84	39.20	5.82	85.2

5.1.2 Aluminum Sulfate

BIOACTIFLO™ pilot testing with aluminum sulfate began on Monday June 15th, 2015. During the optimization testing with aluminum sulfate, MLSS concentrations of 400, 800 and 1200 mg/L were maintained in the contact tank. Aluminum sulfate was used as coagulant and tested at doses ranging from 70 - 110 mg/L. After testing various doses of alum, anionic polymer Hydrex 3596 was tested with doses ranging from 3.0 – 5.0 mg/L. After testing each combination of alum and polymer doses, samples were collected and tested in Veolia's lab. The ACTIFLO® portion of the train was operated with a hydraulic loading rate of 32 gpm/ft². After each parameter change, NTU, UV₂₅₄, and visual observations were used as an onsite means of judging effluent quality. This field data provided fairly instant feedback and aided in parameter change decisions. Data from the optimization is outlined in Table 5.2. The results of this testing presented below:

- At a contact tank concentration of 800 mg/L: A dose of 90 mg/L of aluminum sulfate and 3.7 mg/L of Hydrex 3596 polymer was most effective at reducing effluent turbidity to an optimal level.

- b. At a contact tank concentration of 1200 mg/L: A slightly higher dose of both aluminum sulfate and Hydrex 3596, 100 mg/L and 5.0 mg/L respectively, gave the optimal effluent turbidity level. Hydrex 3596 polymer was most effective at reducing effluent turbidity to an optimal level.
- c. At a 400 mg/L contact tank concentration: An aluminum sulfate dose of 90 mg/L and a Hydrex 3596 polymer dose of 3.0 mg/L gave an optimal effluent turbidity.

Table 5.2 BIOACTIFLO™ Aluminum Sulfate Optimization Data

Date	Time	Contact Tank		Coagulant Alum (mg/L)	Polymer 3596 (mg/L)	pH		Turbidity		
		HRT (min)	MLSS (mg/L)			Inf	Eff	Inf (NTU)	Eff (NTU)	Removal (%)
6/15/2015	14:15	22.9	800	70	3.7	7.65	6.72	103.00	1.78	98.3
	14:55	24.4		80		7.43	6.74	96.90	1.53	98.4
	15:25	30.3		90		7.63	6.61	94.70	1.07	98.9
	15:55	31.2		100		7.23	6.50	86.60	1.03	98.8
	16:25	21.2		110		7.43	6.57	87.70	1.53	98.3
6/18/2015	8:45	20.4	1,200	90	3.6	7.72	6.81	27.90	1.53	94.5
	9:15	20.4		100		7.74	6.88	29.40	4.53	84.6
	9:45	20.1		90	3.8	7.63	6.93	36.30	21.10	41.9
	11:00	20.9		100	5	7.64	6.89	36.90	1.62	95.6
6/24/2015	9:20	23.1	400	90	3.2	7.58	6.85	26.50	1.77	93.3
	9:40	22.4			3.3	7.57	7.00	36.20	2.54	93.0
	10:00	22.7			3	7.61	6.97	41.20	2.05	95.0
	11:30	22.5		100	3.4	7.60	6.85	33.10	2.27	93.1
	11:50	22.4			3.6	7.60	7.08	31.70	2.58	91.9
	12:10	22.6			3.2	7.63	6.99	32.20	1.99	93.8
	12:30	22.6			3	7.59	6.92	31.30	1.74	94.4

During optimization testing, the effluent turbidity averaged 3.2 mg/L with a standard deviation of 4.9 mg/L. This high standard deviation was caused by the turbidity value of 21 mg/L measured in the sample collected on June 18th, from testing with 1,200 mg/L MLSS, 90 mg/L alum and 3.8 mg/L polymer. This data point is considered an outlier because it is more than three standard deviations farther from the mean effluent turbidity value. This high value can be due to an error in reporting of the results or due to sample contamination.

After the completion of the optimization tests, dose-performance curves developed from the optimization test results were used to perform steady state operation at the desired contact tank concentration.

5.1.3 Polyaluminum Chloride (PACL)

BIOACTIFLO™ pilot testing with PACL began on Friday June 26th, 2015 with the generation of coagulant and flocculent dose based optimization plots. During optimization testing with PACL, a MLSS concentration of 800 mg/L was targeted in the contact tank. PACL was used as coagulant and tested at doses ranging from 50 - 80 mg/L. Dry anionic polymer Hydrex 3596 was used at a dose of 3.6 mg/L, and samples were collected. The ACTIFLO® portion of the train was operated with a hydraulic loading rate (HLR) of 32 gpm/ft². After each parameter change, NTU, UV₂₅₄, and visual observations were used as an onsite means of judging effluent quality. This field data provided fairly instant feedback and aided in parameter change decisions. Data from the optimization is outlined in Table 5.3.

Table 5.3: BIOACTIFLO™ Polyaluminum Chloride Optimization Data

Date	Time	Contact Tank		Coagulant	Polymer	pH		Turbidity		
		HRT (min)	MLSS (mg/L)	PACL (mg/L)	3596 (mg/L)	Inf	Eff	Inf (NTU)	Eff (NTU)	Removal (%)
6/26/2015	9:00	22.0	800	50	3.6	7.57	6.62	16.40	1.48	91.0
	9:30	22.0		60		7.65	6.84	16.30	1.20	92.6
	10:00	22.0		70		7.67	6.71	19.50	1.20	93.8
	11:00	21.3		80		7.65	6.74	21.60	2.81	87.0

A contact tank concentration of 800 mg/L, a dose of 70 mg/L PACL, and 3.6 mg/L Hydrex 3596 polymer were found to be the most effective at reducing effluent turbidity to the optimal level. The days following creation of the optimization curves were used to perform steady state operation at the desired contact tank concentration.

5.2 ACTIFLO®

During the second portion of the pilot study (July 7th – 14th) the RAS flow was cut off and the system was operated as an ACTIFLO® process. Coagulant and polymer doses were varied throughout the week to provide a wide range of data. Hydrex 3596 polymer was compared to Hydrex 3502 and aluminum sulfate and PACL were tested as coagulants. A summary of operating conditions and the results of samples collected during ACTIFLO™ pilot testing can be found in the subsections below.

5.2.1 Aluminum Sulfate (Al₂(SO₄)₃) and Polyaluminum Chloride Optimization (PACL)

After initial operation of the pilot unit as BIOACTIFLO®, the ACTIFLO® pilot testing began on Tuesday July 7, 2015. A few days of testing was dedicated to varying chemical doses to

determine the best operating parameters for meeting the TSS and CBOD effluent goals. During this period of testing the following ACTIFLO® parameters were used:

- Hydraulic loading rate was 60 gpm/ft²
- PACL was dosed from 40 – 60 mg/L
- Aluminum sulfate was tested at 60 – 70 mg/L
- Hydrex 3596 and Hydrex 3502 polymers were tested at doses from 1.0 – 2.0 mg/L.

A summary of results from samples collected during the optimization of ACTIFLO® testing is presented in Table 5.4.

Table 5.4: ACTIFLO™ Aluminum Sulfate and Polyaluminum Chloride Optimization Data

Date	Time	Coagulant	Polymer	pH		Turbidity		
		(mg/L)	(mg/L)	Inf (s.u.)	Eff (s.u.)	Inf (NTU)	Eff (NTU)	Removal (%)
1. PACL			3596					
7/7/2015	9:45	50	1.2	7.67	6.88	30.60	1.37	95.5
	10:15	45		7.65	7.10	27.50	1.59	94.2
	10:45	40		7.60	7.08	29.30	1.88	93.6
	11:15	55		7.62	6.80	31.10	1.42	95.4
	11:45	60		7.63	6.84	33.00	1.36	95.9
	13:15	50	1.1	7.58	7.00	35.30	1.59	95.5
	13:45		1.0	7.58	6.94	40.40	2.10	94.8
	14:15		1.3	7.50	7.02	41.60	2.25	94.6
2. PACL			3502					
7/9/2015	9:00	50	1.2	7.29	6.62	53.00	1.12	97.9
	9:30		1.3	7.40	6.87	49.60	1.27	97.4
	10:00		1.4	7.21	6.79	54.30	1.24	97.7
	10:30		1.1	7.42	7.17	43.50	2.01	95.4
	11:15		1.2	7.27	7.13	41.60	1.80	95.7
3. Alum			3596					
7/13/2015	12:00	60	1.2	7.46	6.82	51.70	2.21	95.7
	12:30	70		7.43	6.87	44.10	1.30	97.1

During the optimization of ACTIFLO® testing the turbidity was used as a process control by the ACTIFLO operator. The conclusions based on the results presented in the table above are as follows:

- The ACTIFLO system performance is not greatly affected by the type of the coagulant. Both coagulants, the PACL and aluminum sulfate, were found to reduce turbidity to an optimal level.
- Hydrex 3596 and Hydrex 3502 were both extremely effective at reducing the turbidity. Hydrex 3502 allowed more carry over compared to Hydrex 3596. The Hydrex 3502 is a

lower molecular weight polymer than Hydrex 3596. When there is a sudden fluctuation in solids through the ACTIFLO® process, the Hydrex 3596 performs more effectively.

- c. Dosages of 50 mg/L PACL, 60 mg/L aluminum sulfate, and 1.2 mg/L Hydrex 3596 and Hydrex 3502 were found to be the effective at reducing turbidity to an optimal level.

6.0 PILOT TESTING - PERFORMANCE

6.1 BIOACTIFLO®

After completing the optimization testing with each of the three coagulants selected, steady-state tests were run with the corresponding coagulant. In the Contact Tank, MLSS concentration was targeted to be at 400, 800 and 1,200 mg/L for a certain number of days for each coagulant. During this steady-state run, samples were composited during dry weather events, and kept as grab samples during wet weather events. Samples were split and sent to two different laboratories for analysis, except for E. coli. For those parameters that were analyzed in two different laboratories, the result was expressed as the average.

The testing results for TSS, CBOD and phosphorus, when operated BIOACTIFLO in steady state mode with various coagulants are shown in Appendix A, Figures 1-6, also summarized in Table 6.1 below.

Table 6.1: BIOACTIFLO Steady State Operation Results

Type of Coagulant	BIOACTIFLO Effluent Concentrations				
	TSS, mg/L	CBOD ₅ , mg/L	sCBOD ₅ , mg/L	Phosphorus, mg/L	E. Coli
Sodium Aluminate, NaAlO ₂	21-52	9-13	4-9	0.37 -0.42	65 CFU/100 mL
Alum, Al ₂ (SO ₄) ₃	5-9	4-15	3-11	0.07-0.2	
PACL	2-4	5-11	4-9	0.07-0.09	

Following, is a summary of BIOACTIFLO steady state pilot testing results:

- The NEORSO Consent Decree and NPDES permit requirements for TSS, CBOD and phosphorus effluent concentrations were met consistently with Alum and PACL coagulants.
- The Alum and PACL coagulants resulted in very similar effluent concentrations.
- All three coagulants were able to achieve effluent phosphorus below 0.5 mg/L under steady state continuous operation.
- Sodium aluminate is the least effective coagulant.
- The TSS removal rate was observed in the range of 50 to 95%. Refer to Appendix A, Figure 3.
- The average amount of CBOD load removed by the BIOACTIFLO per unit mass of MLSS maintained in the Contact Tank is 0.20 ± 0.11 lb of CBOD per lb of MLSS. The relationship between the amount of influent CBOD removed and the amount of MLSS maintained in the Contact Tank is shown in Appendix A, Figure 8.

- g. Effluent E. coli concentration in the effluent reached 312 CFU/100 mL on one occasion when sodium aluminate was used. Refer to Appendix A, Figure 17.

6.2 ACTIFLO

ACTIFLO® steady state testing, dosing PACL as coagulant, began on Wednesday July 8, 2015. The feed source was Primary Effluent, and PACL coagulant dosed at 50 mg/L and Hydrex 3596 polymer dosed at 1.2 mg/L. The hydraulic loading rate (HLR) was maintained at 60 gpm/ft². The second composite sample with PACL began on July 9, 2015, the PACL coagulant was dosed at 50 mg/L and Hydrex 3502 polymer was dosed at 1.2 mg/L.

The first effluent composite sample, with aluminum sulfate as the coagulant, began on Monday July 13th, 2015. The feed source was Primary Effluent, and aluminum sulfate coagulant and Hydrex 3596 polymer were dosed at 70 mg/L and 1.2 mg/L, respectively. The aluminum sulfate coagulant was dosed at 70 mg/L for the second day of continuous testing and 90 mg/L for the third day. The aluminum sulfate dose was varied due to changing influent conditions. Hydrex 3596 polymer was dosed at 1.2 mg/L on the second day and 1.5 mg/L on the third day. A full range of lab samples were taken, split and sent to the two third-party labs. The data from the five test runs (composite samples) can be found in Table 6.2 and also viewed on Appendix A, Figures 13-16.

Table 6.2: ACTIFLO™ Aluminum Sulfate and Polyaluminum Chloride Steady State Data

Date	Time	Coag't	TSS			CBOD ₅			sCBOD ₅			Phosphorus		
			Inf	Eff	RE	Inf	Eff	RE	Inf	Eff	RE	Inf	Eff	RE
7/8/15	11:45	PACL	298	11	96%	62.4	6.9	89%	11.3	6.8	40%	4.1	0.10	97%
7/9/15	15:30	PACL	37	4	89%	14.4	3.7	74%	5.7	4.1	28%	0.7	0.06	91%
7/13/15	15:30	Alum	16	12	25%	54.1	9.8	82%	15.9	7.6	52%	2.0	0.13	93%
7/14/15	11:00	Alum	83	13	84%	43.6	9.6	78%	12.1	6.2	49%	2.9	0.22	92%
	14:45	Alum	81	18	78%	20.5	13.5	34%	14.8	8.4	43%	2.6	0.19	93%

Note: RE –removal efficiency.

The testing results for TSS, CBOD, phosphorus, when operating ACTIFLO in steady state mode with various coagulants are shown in Appendix A, Figures 13-15 and summarized in Table 6.3 below.

Table 6.3: ACTIFLO Steady State Operation Results

Type of Coagulant	ACTIFLO Effluent Concentrations				
	TSS, mg/L	CBOD ₅ , mg/L	sCBOD ₅ , mg/L	Phosphorus, mg/L	E. Coli
Alum, Al ₂ (SO ₄) ₃	12-14	11-13	8-9	0.13-0.21	X CFU/100 mL
PACL	4-10	8-11	6-11	0.13-0.62	

Based on the overall summary of effluent data presented in Tables 6.2 and 6.3, obtained from ACTIFLO steady state pilot testing, the conclusions are drawn as follows:

- The NEORSO Consent Decree and NPDES permit requirements for TSS, CBOD₅ and phosphorus effluent concentrations were met consistently with Alum and PACL coagulants.
- The PACL and aluminum sulfate coagulants were effective and resulted in similar effluent concentrations for TSS, CBOD, and phosphorus.
- Both aluminum sulfate and polyaluminum chloride were able to achieve effluent phosphorus below 0.7 mg/L under steady state continuous operation.
- Observed TSS removal rate was ranging between 74 to 97%. Refer to Appendix A, Figure 14.

6.3 DISINFECTION

During operation of the BIOACTIFLO[®] and ACTIFLO[™] at the Lakewood WWTP, the effluent from the ACTIFLO[®] was passed through a portable UV system. Samples were taken before and after the UV unit for E. Coli analyses. The goal for removal is to achieve 126/100 mL E. coli (recreational season geometric mean) and 284/100 mL E. coli (rolling seven days of activation geometric mean).

E. Coli samples were sent to WLI laboratory for analysis. The results of the composite samples taken are shown in in Table 6.4.

Table 6.4: E. Coli Sample Analysis Results

Date	E. coli (CFU/100 mL)		
	Raw	Inf. to UV	Eff. from UV
6/8/2015		770,000	23
6/9/2015		1,500,000	65
6/10/2015		2,500,000	310
6/16/2015	590,000	116,000	2
6/17/2015		170,000	12
6/22/2015		134,000	5
6/23/2015		17,740	4
6/24/2015		250,000	32
6/25/2015		260,000	20
6/29/2015		91,000	<1
6/30/2015		78,000	4
7/1/2015		35,000	16
7/6/2015		68,000	2
7/9/2015		11,610	8
7/13/2015		270,000	10
7/14/2015		1,070,000	20

The E. Coli reduction through the UV system, after being treated by both the ACTIFLO® and BIOACTIFLO™ processes, met the removal goal of 126/100 mL recreational season geometric mean for all but one of the samples taken (Appendix A, Figure 17). The 284/100 rolling seven day geometric mean was met over the entire duration of the study (Appendix A, Figure 18).

7.0 EVALUATION OF BIOACTIFLO AND ACTIFLO

7.1 DISCHARGE PERFORMANCE

Target performance goals and continuous run trial results at optimum chemical doses are summarized in Table 7.1. Values shown in Table 7.1 are based on an average of all continuous trials performed at optimum chemical doses. Total and soluble CBOD and TSS are included in the table for comparison purposes.

Table 7.1: Effectiveness of Process to Achieve Performance Goals

Parameter	Unit	Target		Measured Performance		
		NEORS D	NPDES 7-day	Sodium Aluminate	Alum	PACL
BIOACTIFLO™						
Effluent CBOD ₅	mg/L	<40	23	11.3±1.9	8.3±4.0	9.5±3.0
Effluent sCBOD ₅	mg/L	N.E.	NA	6.7±2.0	6.0±3.3	7.3±2.9
Total sCBOD ₅ removal	%	N.E.	NA	59.3	72.2	76.8
Effluent TSS	mg/L	<40	30	30±15	7.4±2.2	3.0±0.8
Effluent Total P	mg/L	N.E.	0.7	0.39±0.02	0.12±0.04	0.12±0.10
Effluent E. coli	CFU/100mL	<126 ^a	<126	133±155	12.5±11.6	6.2±6.1
		<284 ^b	<284	--	10.9±4.8	6.5±6.1
ACTIFLO®						
Effluent CBOD ₅	mg/L	<40	23	--	12.0±1.3	9.3±1.7
Effluent sol. CBOD ₅	mg/L	NE	NA	--	8.5±0.2	8.3±2.8
Total sCBOD ₅ removal	%	NE	NA	--	70.8	89.2
Effluent TSS	mg/L	<40	30	--	13.0±1.6	6.7±3.1
Effluent Total P	mg/L	NE	0.7	--	0.17±0.06	0.32±0.27
Effluent E. coli	CFU/100mL	<126 ^a	<126	--	15.0±4.2	5.0±4.2
		<284 ^b	<284	--	--	--

Notes:

NE.: Performance goal was not established in the NEORSD consent decree for HRT pilot.

a - Geometric mean for each day in which a discharge occurs.

b - Rolling geometric mean for each seven-day period.

Based on the overall summary of effluent data presented in Table 7.1 above, it can be inferred that BIOACTIFLO and ACTIFLO can achieve effluent that meets the discharge standards consistent with both NEORSD consent decree for pilot testing as well as the secondary standards for CBOD₅, TSS, and phosphorus based the current NPDES permit for Lakewood WWTP.

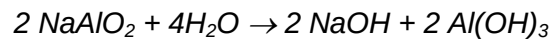
The BIOACTIFLO mode of operation was able to achieve better effluent quality than ACTIFLO. However, the overall effluent quality achieved with ACTIFLO only is sufficient to meet target effluent quality. Therefore, the investment for contact tank required in order to operate as

BIOACTIFLO does not appear to be justified unless blending of the HRT effluent with plant effluent prior to disinfection requires HRT biological treatment by the Ohio EPA.

7.2 COAGULANT AND POLYMER PERFORMANCES

During BIOACTIFLO™ testing, pilot unit was operated at a hydraulic loading rate (HLR) of 32 gpm/ft² and MLSS concentration in the contact tank above 800 mg/L, the effluent goals were met by using following chemicals (refer to Figure 5.1):

- a. Sodium aluminate (NaAlO₂) was found not very effective and with a drastic effect on pH. Sodium aluminate raises the effluent pH to about 8.9 when it is dosed as a coagulant. Each mole of sodium aluminate produces one mole of sodium hydroxide as shown in the equation below:



In order to neutralize pH, acid such as sulfuric acid must be added. For the optimum sodium aluminate dose of 75 mg/L, volume of concentrated sulfuric acid needed to neutralize is calculated to be 0.35 mL per 1 gallon of effluent.

The use of sodium aluminate (NaAlO₂) as a coagulant did not achieve consistent TSS removal sufficient to meet NPDES limit. Based unsatisfactory quality of sludge flocculation and requirement for acid to neutralize final effluent, the sodium aluminate is not recommended for use as coagulant.

- b. PACL and aluminum sulfate coagulants with Hydrex 3596 as polymer was found to be effective in BOD removal even at high influent concentrations associated with the first flush wet weather flow.

As shown in Table 7.2, the cost per unit volume treated (per 1 MGD) associated with PACL is significantly higher than those associated with aluminum sulfate. Due to inadequate level of performance, sodium aluminate is not considered during regular ACTIFLO run.

Table 7.2: Comparison of Process Chemical Costs

Chemical	Optimum Dose (mg/L)	Unit Cost (\$/lb)	Daily Chemical Cost (\$/day/MGD)
BIOACTIFLO™			
Sodium Aluminate- NaAlO_2	60	0.23	115
Aluminum Sulfate - $\text{Al}_2(\text{SO}_4)_3$	100	0.50	417
PACL	65	1.80	976
Hydrex 3592	3	2.25	56
Sulfuric Acid (H_2SO_4)	175	0.14	204
Ballast Sand	3	0.10	2.50
ACTIFLO®			
Aluminum Sulfate	100	0.50	417
PACL	65	1.80	976
Hydrex 3592	1.0	2.25	19
Ballast Sand	2.5	0.10	2.10

Overall, the performance level of Alum and PACL are comparable and both these coagulants were able to achieve the target effluent quality:

- Effluent CBOD in the BIOACTIFLO was well within the target of 40 mg/L, ranging from 8.3 to 11.3 mg/L for the three coagulants tested. With alum and PACL, the soluble fraction of the BOD (72% and 77%, respectively) is much higher than that with sodium aluminate (59%).
- Analysis of the amount of biomass added to the Contact Tank and the amount of CBOD removed showed a relatively consistent 0.2 lb CBOD removal per lb of MLSS present in the system. This indicates that some biological removal of CBOD is possible even though the contact time is only about 27 minutes.
- Phosphorus removal is more effective with alum and polyaluminum chloride (90 – 95%) compared to times when sodium aluminate (80 – 85%) was added as a coagulant. For the entire BIOACTIFLO run, the effluent phosphorus remained less than 0.5 mg/L regardless of the metal salt used for coagulation.
- During ACTIFLO® testing the goals were met using either PACL or aluminum sulfate as coagulant, Hydrex 3596 and Hydrex 3502 as polymers, and operating at a hydraulic loading rate of 60 gpm/ft². This higher overflow rate was achieved by inserting inclined plates in the clarifier tank. Testing during wet weather flow was more representative because of the influent wastewater characteristics that would be realized during the full scale application of each process.
- The maximum influent total CBOD observed was 73 mg/L. Total CBOD removal efficiency was observed in the range of 50 to 85%. CBOD₅ reduction is totally related to

solids removal accomplished and thereby any oxygen demand exerted by the organic portion of those solids. As shown in Appendix A, Figure 13, the CBOD₅ removal efficiency is proportional to its influent concentration. Overall, the effluent total and soluble CBOD were similar and remained in the range of 8 to 12 mg/L, indicating that the final effluent is mostly soluble CBOD.

- f. Phosphorus removal also appears to be dependent on the particulate fraction in the influent. The influent phosphorus during the ACTIFLO run ranged from 1.1 to 6.3 mg/L. The effluent phosphorus concentrations ranged from 0.2 to 0.6 mg/L (Appendix A, Figure 15). This result indicates that almost all phosphorus removal occurs because of chemical precipitation, with no significant biological uptake.

Based on these findings and the unit cost, the most favorable coagulant for this application appears to be Alum.

7.3 SLUDGE GENERATION AND HANDLING

Due to the higher TSS removal efficiency, the ACTIFLO process will generate more sludge than the conventional primary treatment process. At the same time, the ACTIFLO sludge stream has a significantly lower solids concentration. Based on the observations during the pilot study, ACTIFLO sludge stream concentrations ranged between 1,000 and 21,000 mg/L during the pilot study. Based on the average sludge concentration of 8,000 mg/L, ACTIFLO sludge flow rates are estimated to be up to 30 gDS/gal of wastewater treated.

7.4 COST ANALYSIS

Present worth analysis of chemical usage for ACTIFLO and BIOACTIFLO options to treat 35 MGD and 45 MGD of wet weather flow are presented in Appendix B. The annual operating costs for the alternatives were based on the assumption that the full scale HRT unit will be operated for 23 days each year. This is based on the number of days overflow was observed during the summer of 2015. During each day of operation, the system is assumed to operate at full capacity the entire day. In reality, the chemical dosing system is capable of changing the dosage according to the actual pollutant load entering the HRT unit.

8.0 CONCLUSIONS AND RECOMMENDATIONS

Lakewood WWTP pilot testing results indicate that both ACTIFLO® and BIOACTIFLO™ modes of operation are viable options for treating wet weather flows. Other relevant comments are as follows:

- a. ACTIFLO system is recommended over BIOACTIFLO as the preferred HRT because it can achieve the desired effluent quality at lower cost.
- b. Sodium aluminate is not a preferred coagulant because of its poor floc structure, high effluent pH (very close to the upper end of the discharge limit), and its inability to consistently maintain effluent TSS below 40 mg/L during wet weather conditions. Feeding acid can achieve neutral pH. However, this means adding a hazardous chemical inventory to the HRT building which is not desirable.
- c. During CSO weather and simulated CSO weather BIOACTIFLO™ operation, the TSS and CBOD limits of < 40 mg/L were met during every run using PACL and aluminum sulfate. Optimal dosages for PACL, aluminum sulfate, and Hydrex 3596 polymer at the two optimal tank concentrations of 800 and 1200 mg/L are as follows:
 - Best performance occurred at 800 mg/L MLSS, 3.7 mg/L of Hydrex 3596 polymer, and 70 – 110 mg/L of alum. The above mentioned parameters consistently achieved 78.3% – 98.9% of TSS removal.

Contact Tank	Coagulant 1/ Flocculent Concentrations		Coagulant 2 / Flocculent Concentrations	
	PACL	Hydrex 3596	Al ₂ (SO ₄) ₃	Hydrex 3596
MLSS 800 mg/L	60 mg/L	3.2 – 4.8 mg/L	90 mg/L	3.6 mg/L
MLSS 1200 mg/L	80 mg/L	3 mg/L	100 - 115 mg/L	5.0 mg/L

- d. During CSO weather and simulated CSO weather ACTIFLO® operation the TSS and CBOD limits of < 40 mg/L were met during every run using PACL and aluminum sulfate. Optimal dosages form PACL, and aluminum sulfate during ACTIFLO® operation are as follows:
 - PACL dosed at 50 mg/L and Hydrex 3596 polymer dosed at 1.2 mg/L.
 - Aluminum Sulfate dosed at 70 - 90 mg/L and Hydrex 3596 polymer dosed at 1.2 - 2.0 mg/L. It must be noted that the TSS removal efficiency with aluminum sulfate did not change significantly with higher doses.
- e. PACL in combination with polymer 3502 provided the highest and most consistent turbidity removal efficiencies, although all coagulants tested were able to achieve effluent compliance.

- f. Aluminum sulfate is the optimum choice of coagulant based on its lower unit cost than PACL and its ability to achieve the target effluent parameters.
- g. During both ACTIFLO[®] and BIOACTIFLO[™] modes of operation, effluent E. Coli concentration remained well below the rolling 7-day geometric mean limit of 284 CFU/100 mL. On June 10, 2015 (first wet weather flow during the pilot study), the effluent E. Coli exceeded the maximum daily mean value of 126 CFU/100 mL.
- h. During BIOACTIFLO[™] and ACTIFLO[®] operation, the effluent phosphorus was consistently below 0.2 mg/L when alum and PACL were used as coagulant. On one occasion, during the wet weather flow on June 10, 2015, the effluent phosphorus exceeded 2 mg/L after 1.5 hours of operation with sodium aluminate as coagulant.
- i. ACTIFLO[®] HRT system proved to be sufficient to consistently achieve the NEORSR Consent Decree and NPDES effluent limits for TSS, CBOD₅, Phosphorus and E.coli as show in the table below.

Parameter	Units	NEORSR Limit	NPDES Limit		ACTIFLO Effluent ^a
			Monthly Avg	Weekly Maximum	
TSS	mg/L	40	20	30	13.0±1.6
CBOD ₅	mg/L	40	15	23	12.0±1.3
Phosphorus	mg/L		1.0	1.5	0.17±0.06
E. COLI ^b	CFU/100 mL	126	126	-	15.0±4.2
E. COLI ^c	CFU/100 mL	284	284	-	-

a- Alum as coagulant and Hydrex 3596

b- Recreational seasonal geometric mean

c- E.coli below 284 CFU/100 mL as a 7-day rolling geometric mean

APPENDIX A
BIOACTIFLO & ACTIFLO STEADY STATE PILOT RUNS
FIGURES 1-18

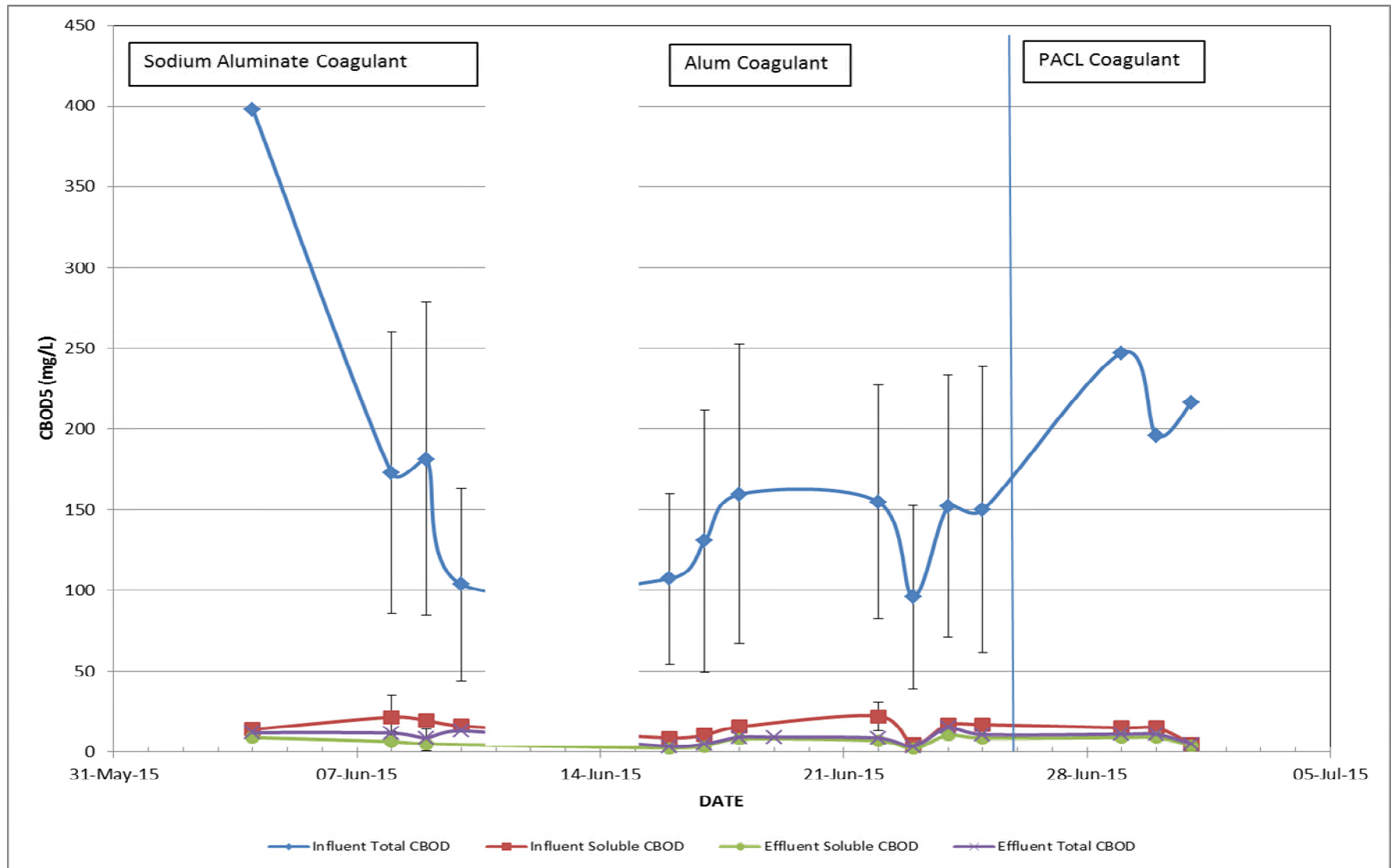


FIGURE 1: BIOACTIFLO® PILOT RUN – TOTAL AND SOLUBLE CBOD

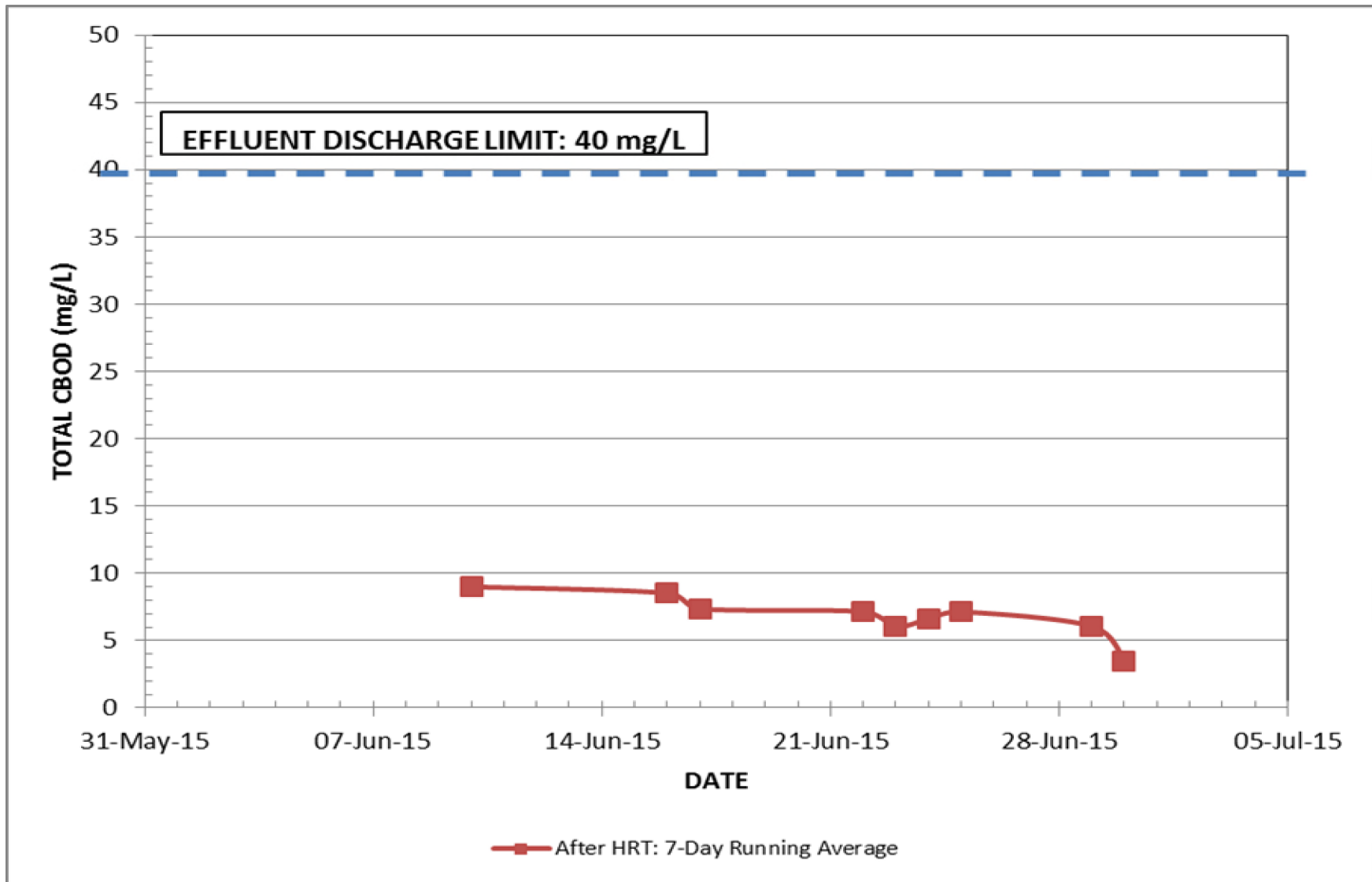


FIGURE 2: BIOACTIFLO® PILOT RUN – EFFLUENT TOTAL CBOD 7-DAY RUN AVERAGE OF FLOW WEIGHTED ARITHMETIC MEAN

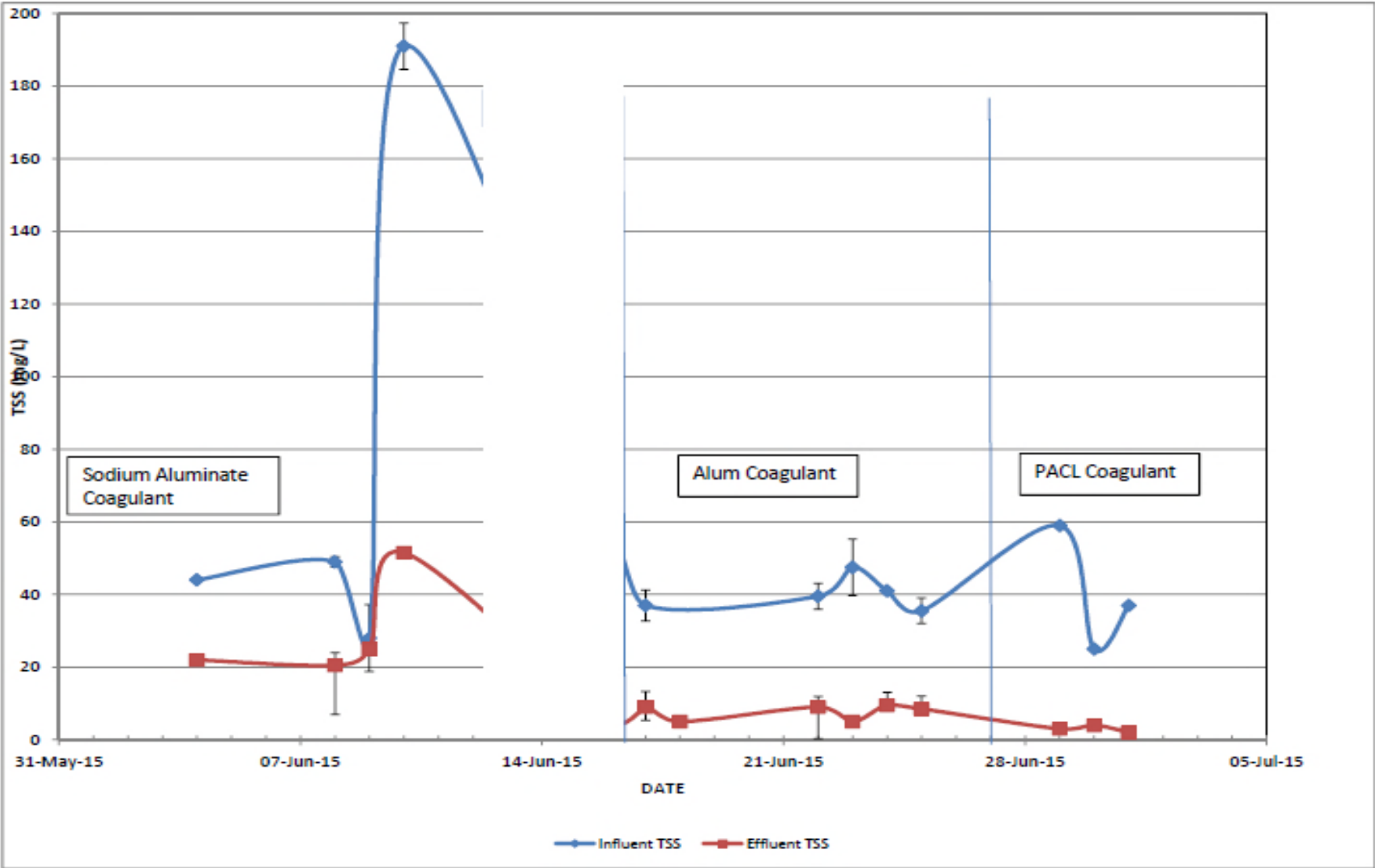


FIGURE 3: BIOACTIFLO® PILOT RUN – INFLUENT AND EFFLUENT TSS

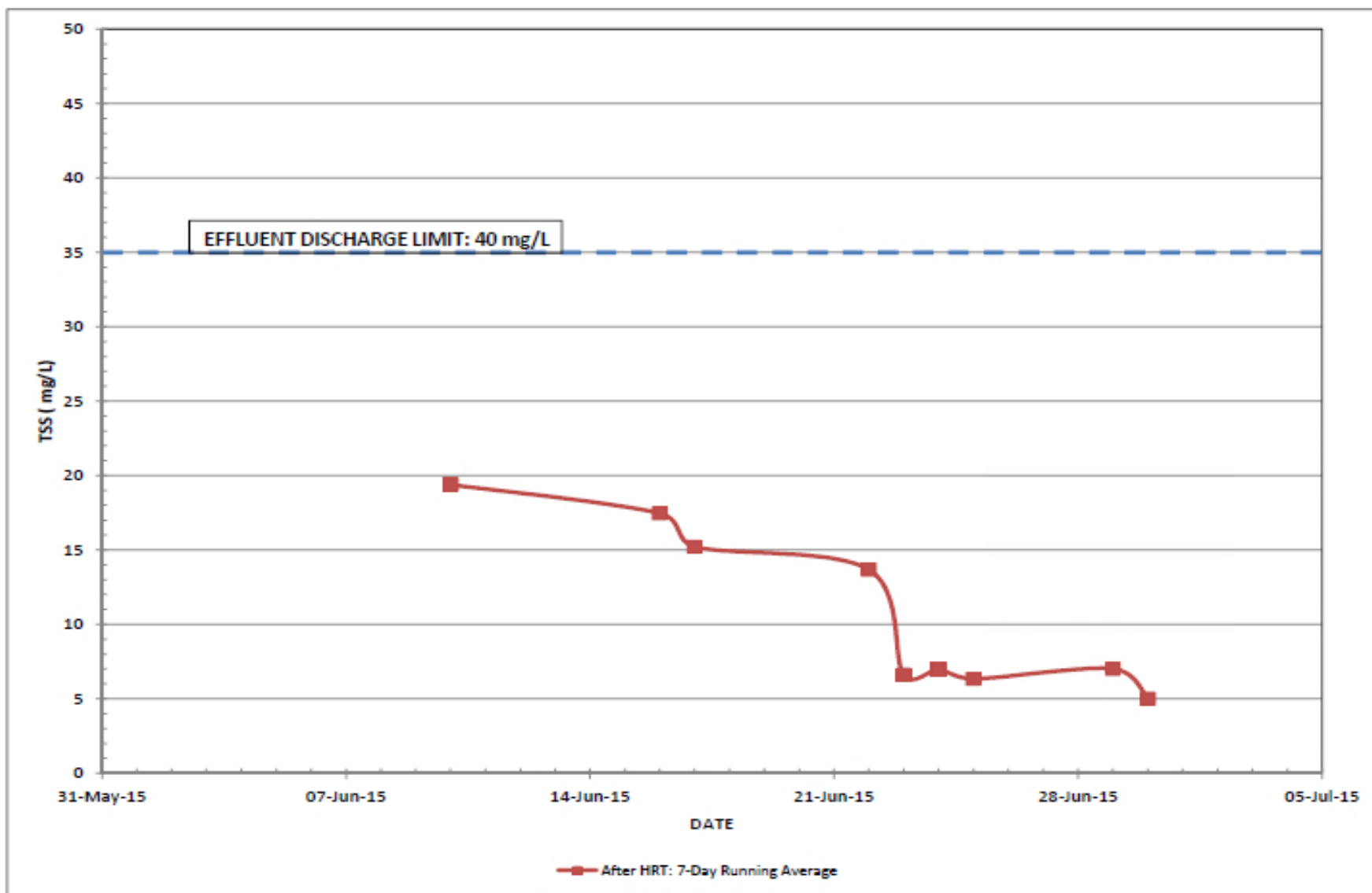


FIGURE 4: BIOACTIFLO® PILOT RUN - EFFLUENT TSS 7-DAY RUN AVERAGE OF FLOW WEIGHTED ARITHMETIC MEAN

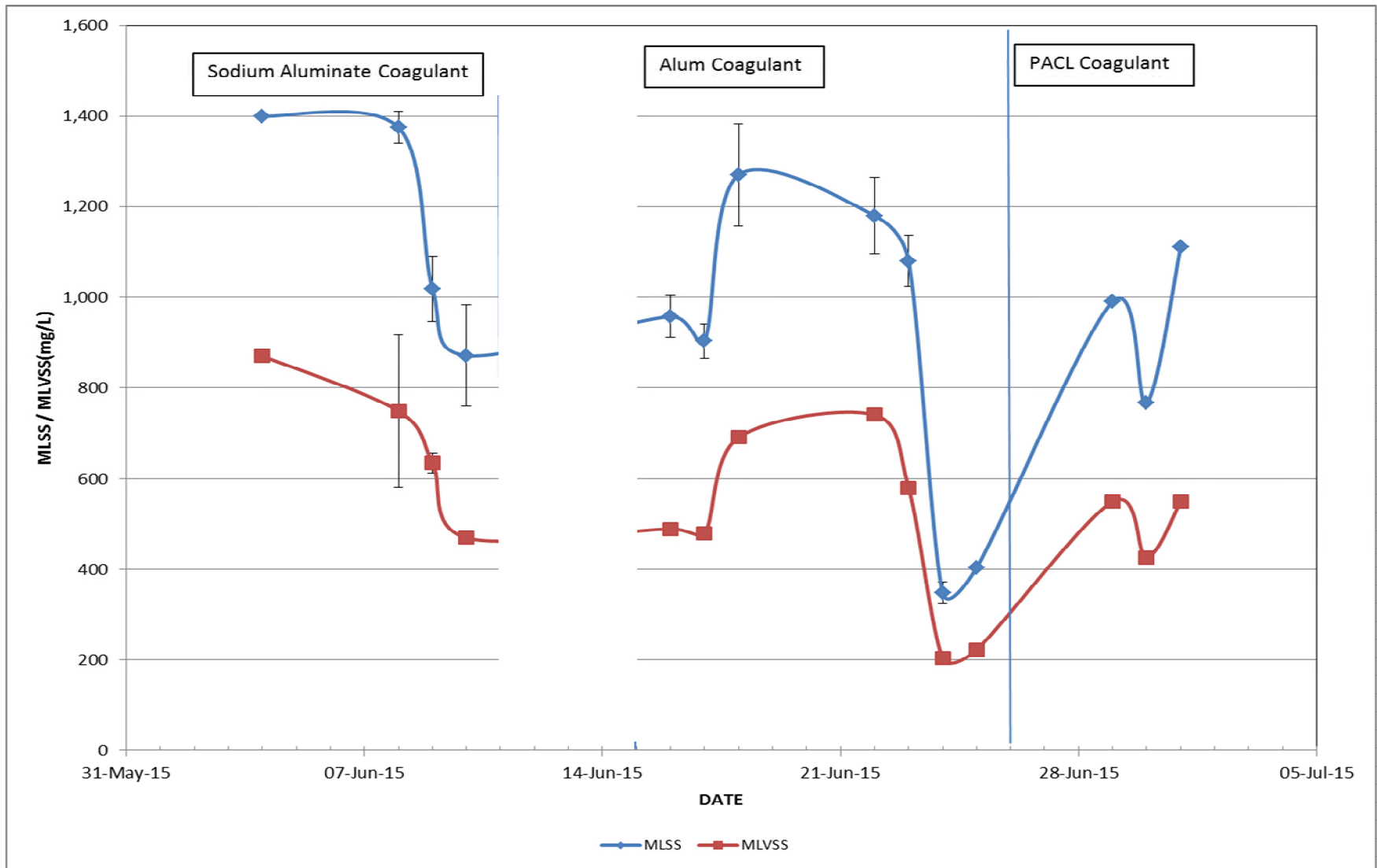


FIGURE 5: BIOACTIFLO® PILOT RUN – CONTACT TANK MLSS AND MLVSS

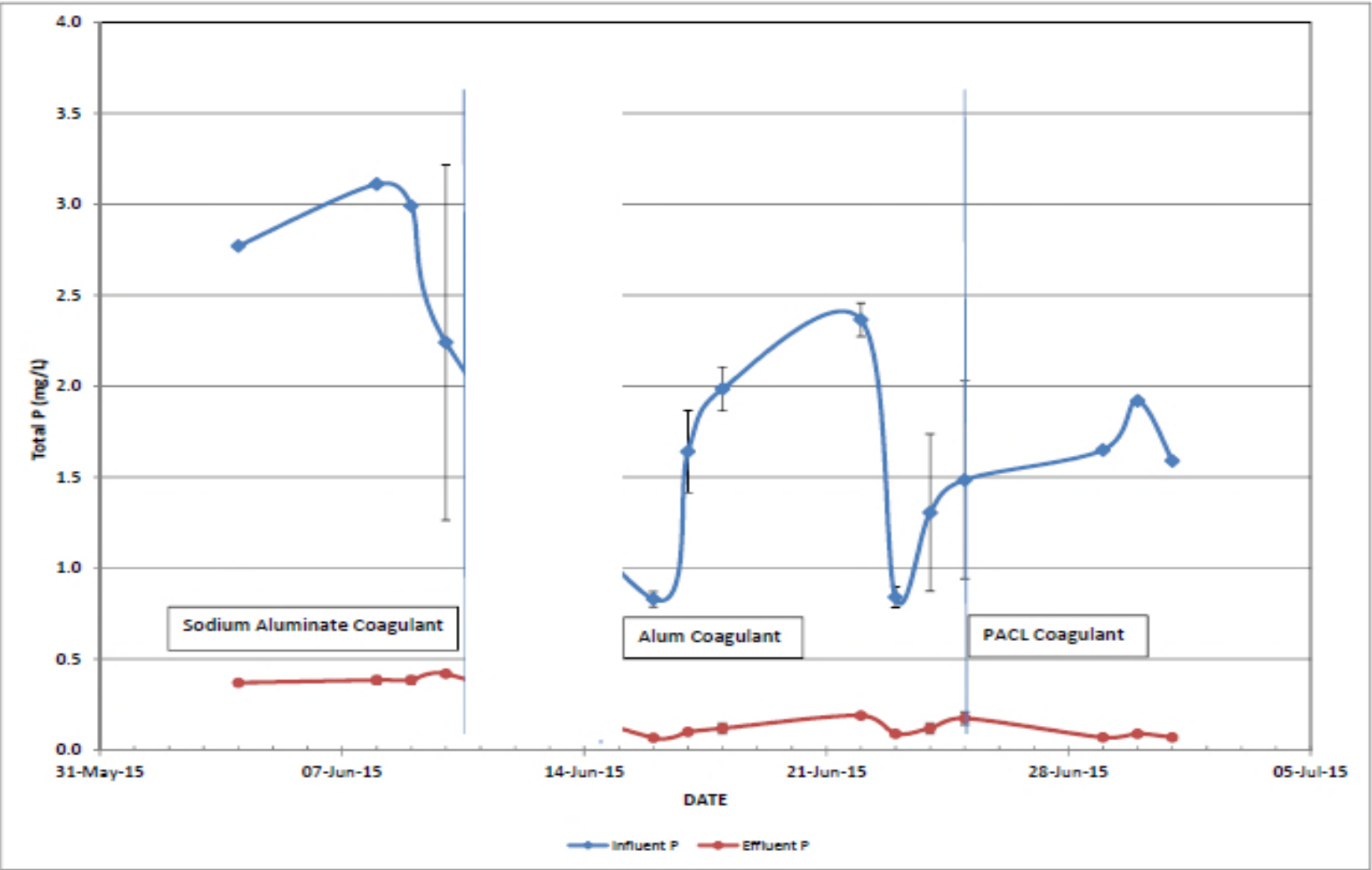


FIGURE 6: BIOACTIFLO® PILOT RUN – INFLUENT AND EFFLUENT TOTAL PHOSPHORUS

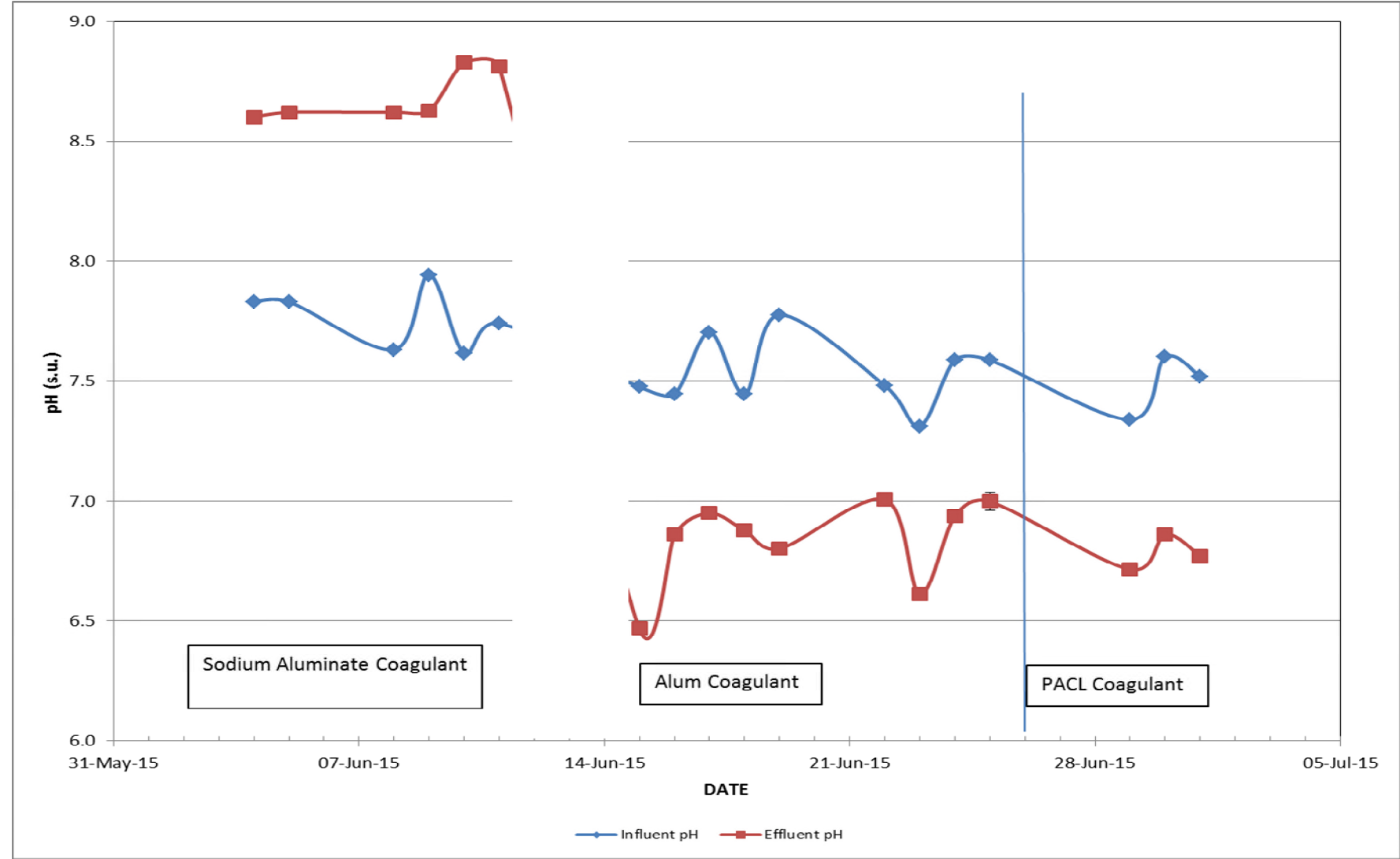


FIGURE 7: BIACTIFLO® PILOT RUN – INFLUENT AND EFFLUENT pH

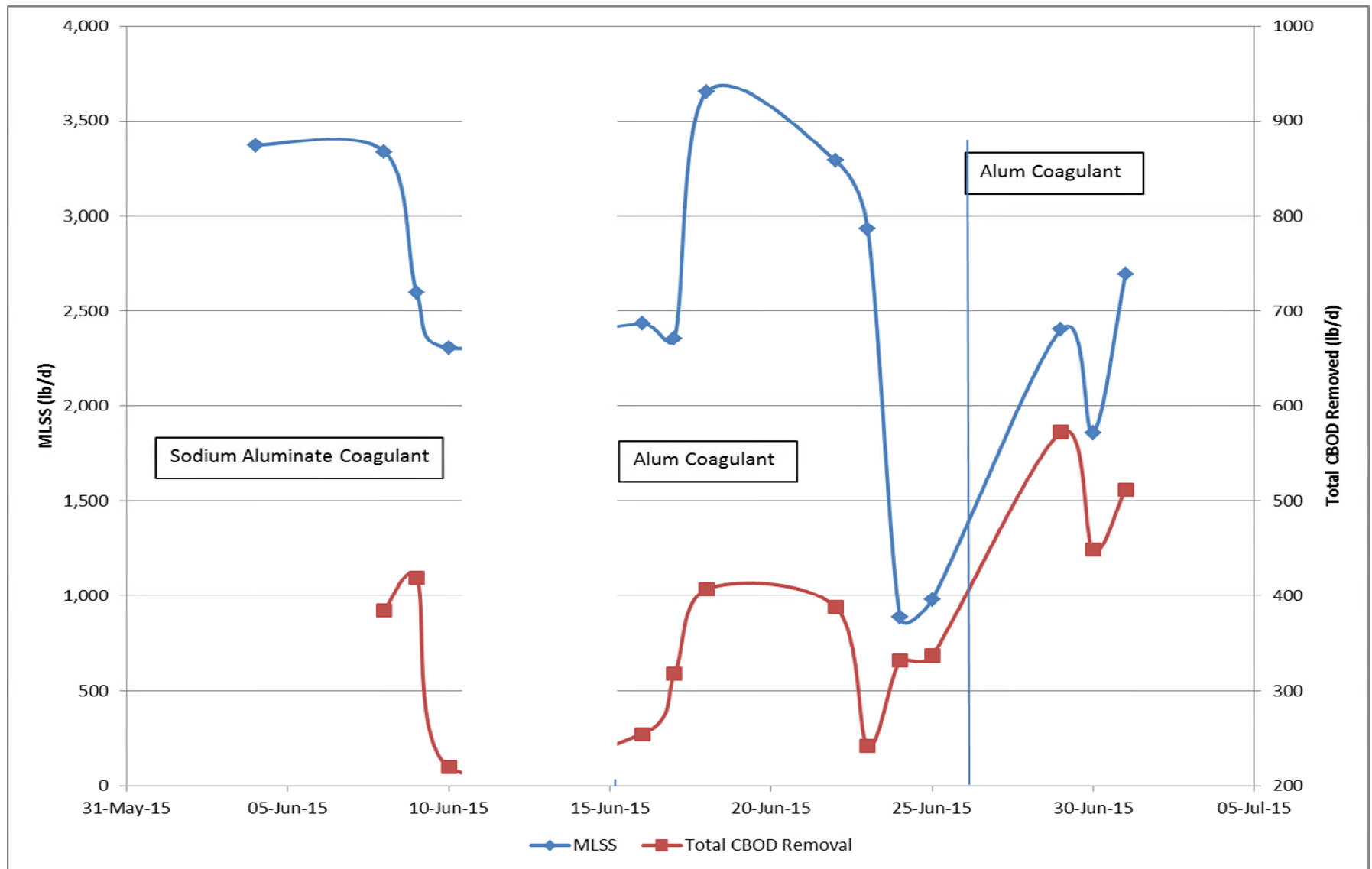


FIGURE 8: BIOACTIFLO® PILOT RUN – CBOD REMOVAL AND MLSS

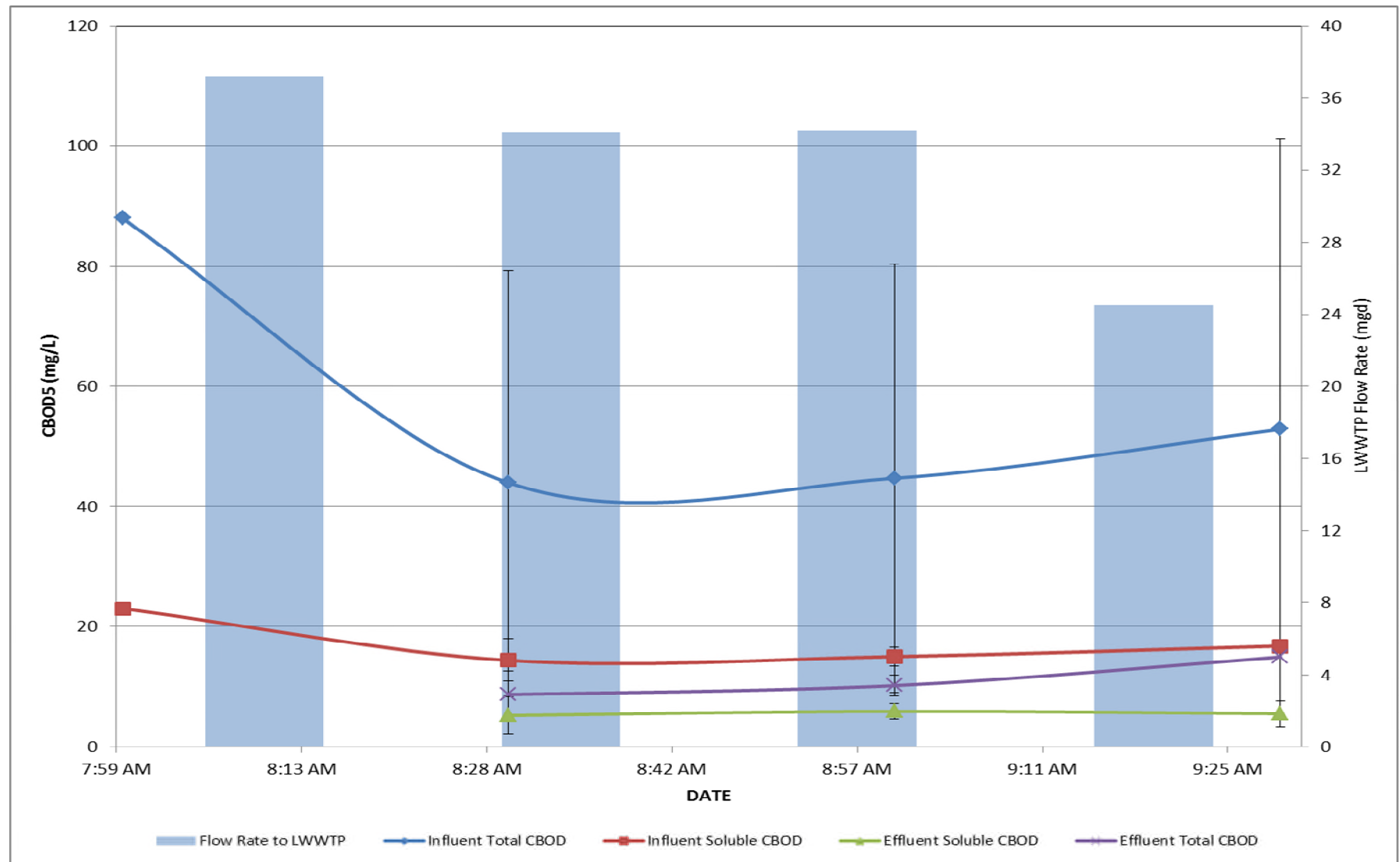


FIGURE 9: WET WEATHER BIOACTIFLO PILOT RUN ON JUNE 10 2015 – TOTAL AND SOLUBLE CBOD

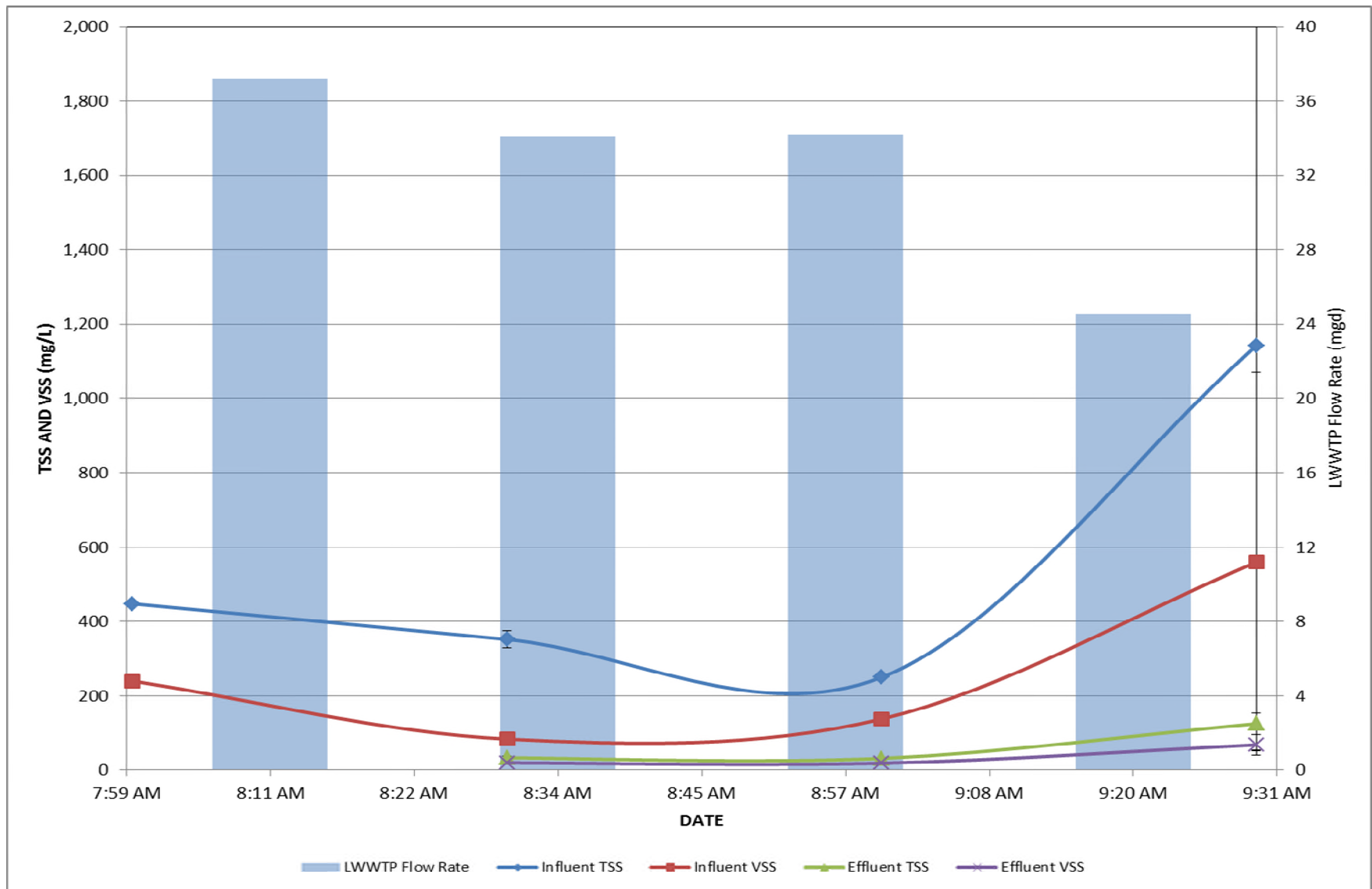


FIGURE 10: WET WEATHER BIOACTIFLO PILOT RUN ON JUNE 10 2015 – TSS AND VSS

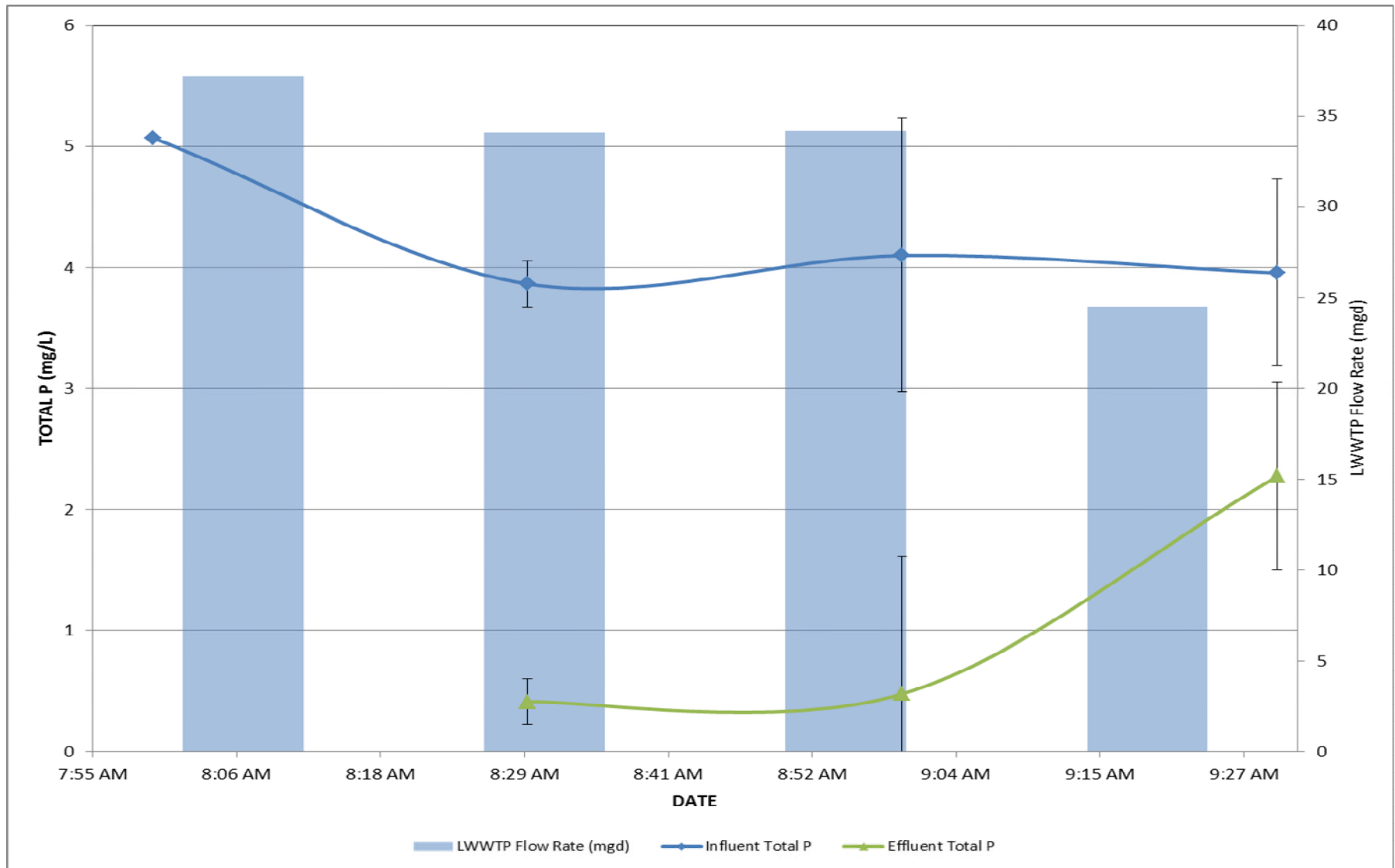


FIGURE 11: WET WEATHER BIOACTIFLO PILOT RUN ON JUNE 10 2015 – TOTAL PHOSPHORUS

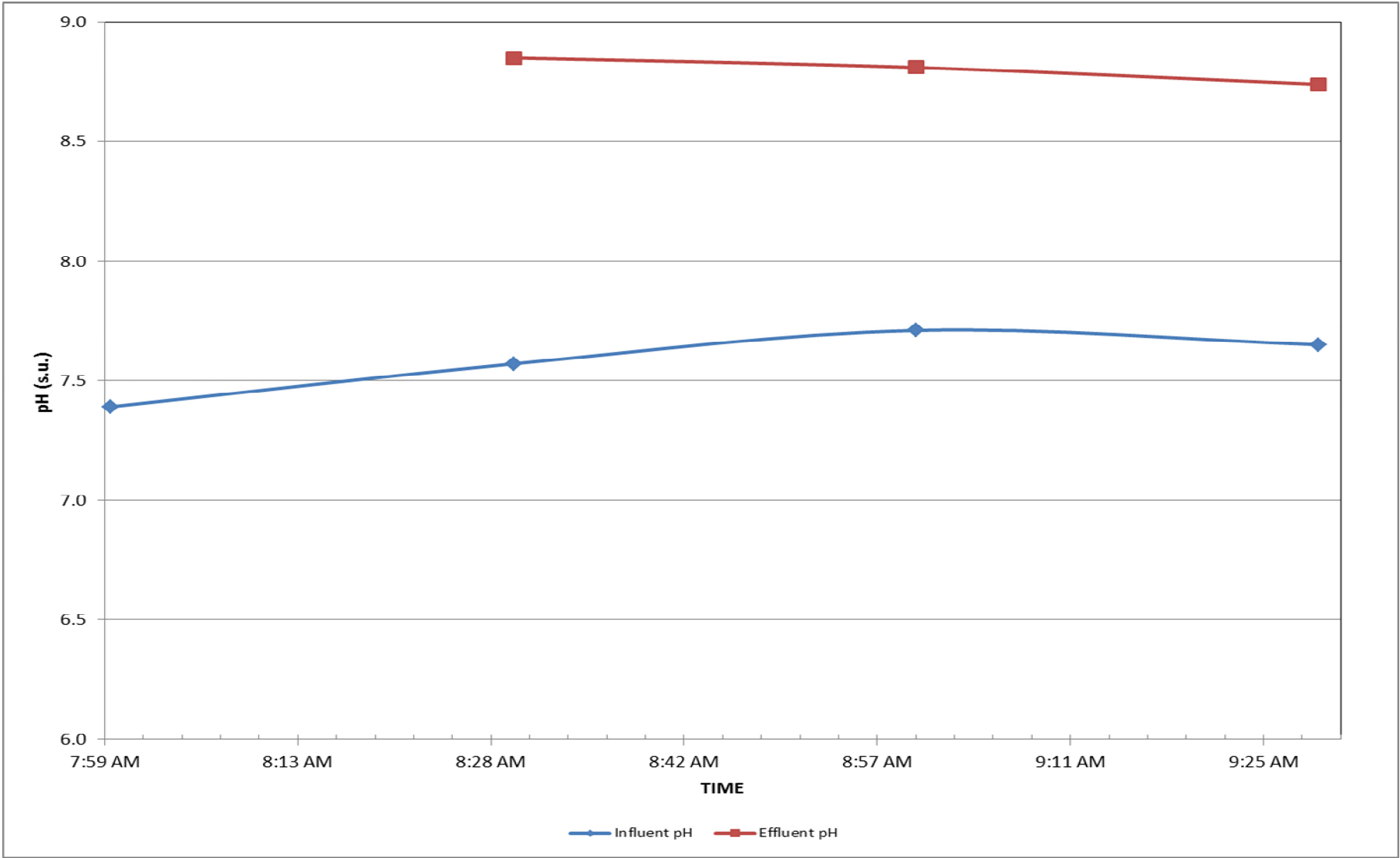


FIGURE 12: WET WEATHER BIOACTIFLO PILOT RUN ON JUNE 10 2015 – INFLUENT AND EFFLUENT pH

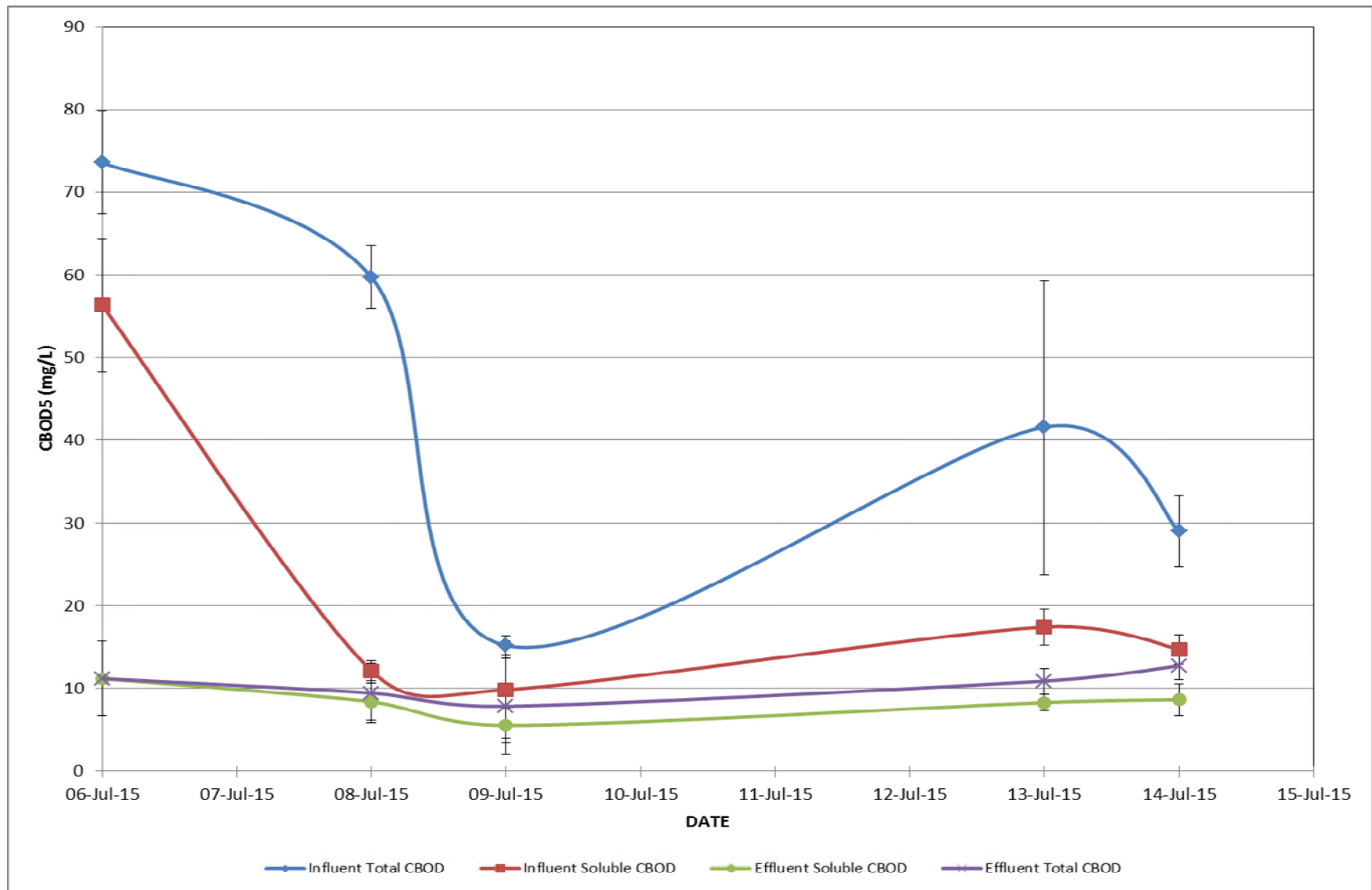


FIGURE 13: ACTIFLO PILOT RUN – TOTAL AND SOLUBLE CBOD

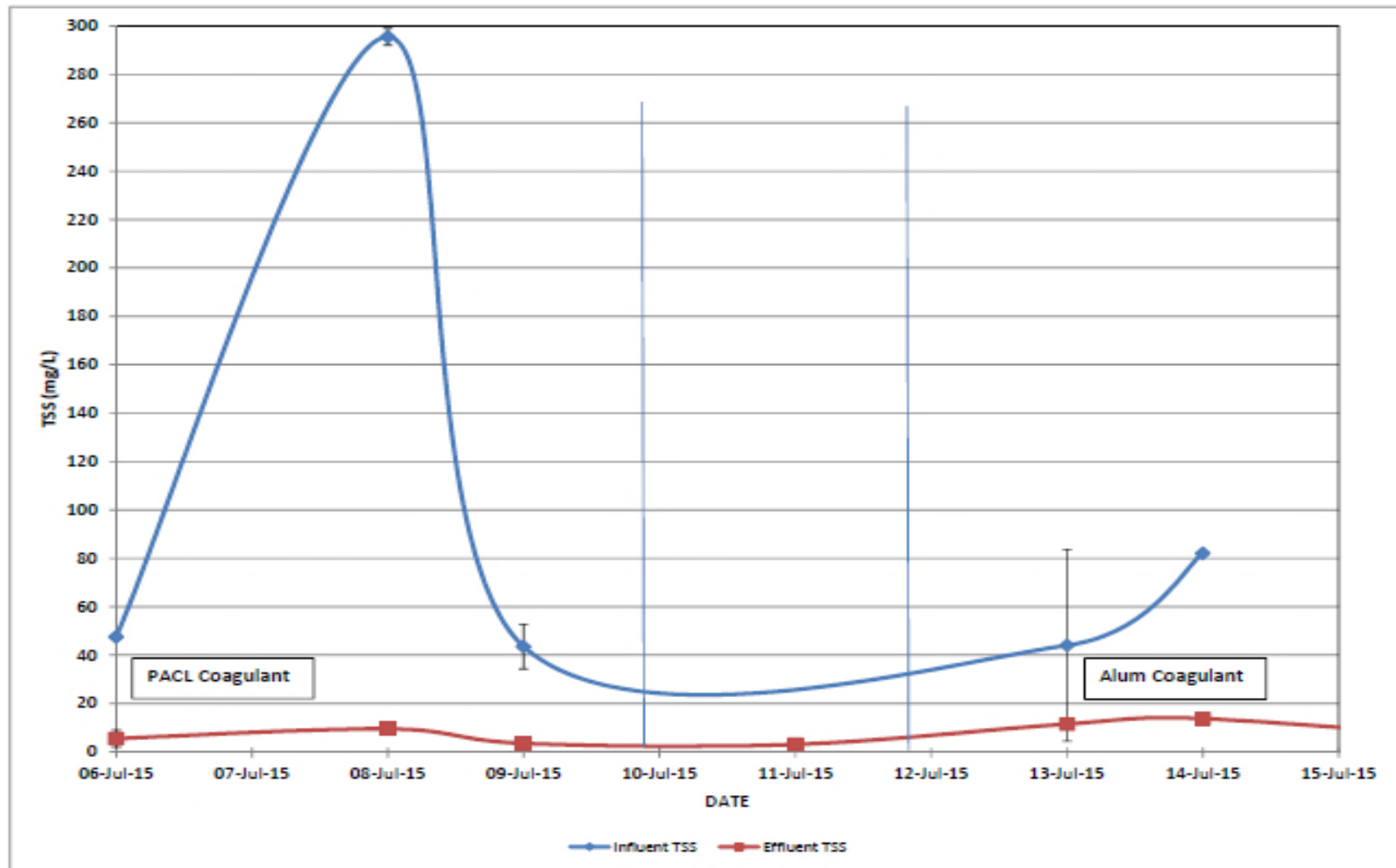


FIGURE 14: ACTIFLO PILOT RUN – INFLUENT AND EFFLUENT TSS

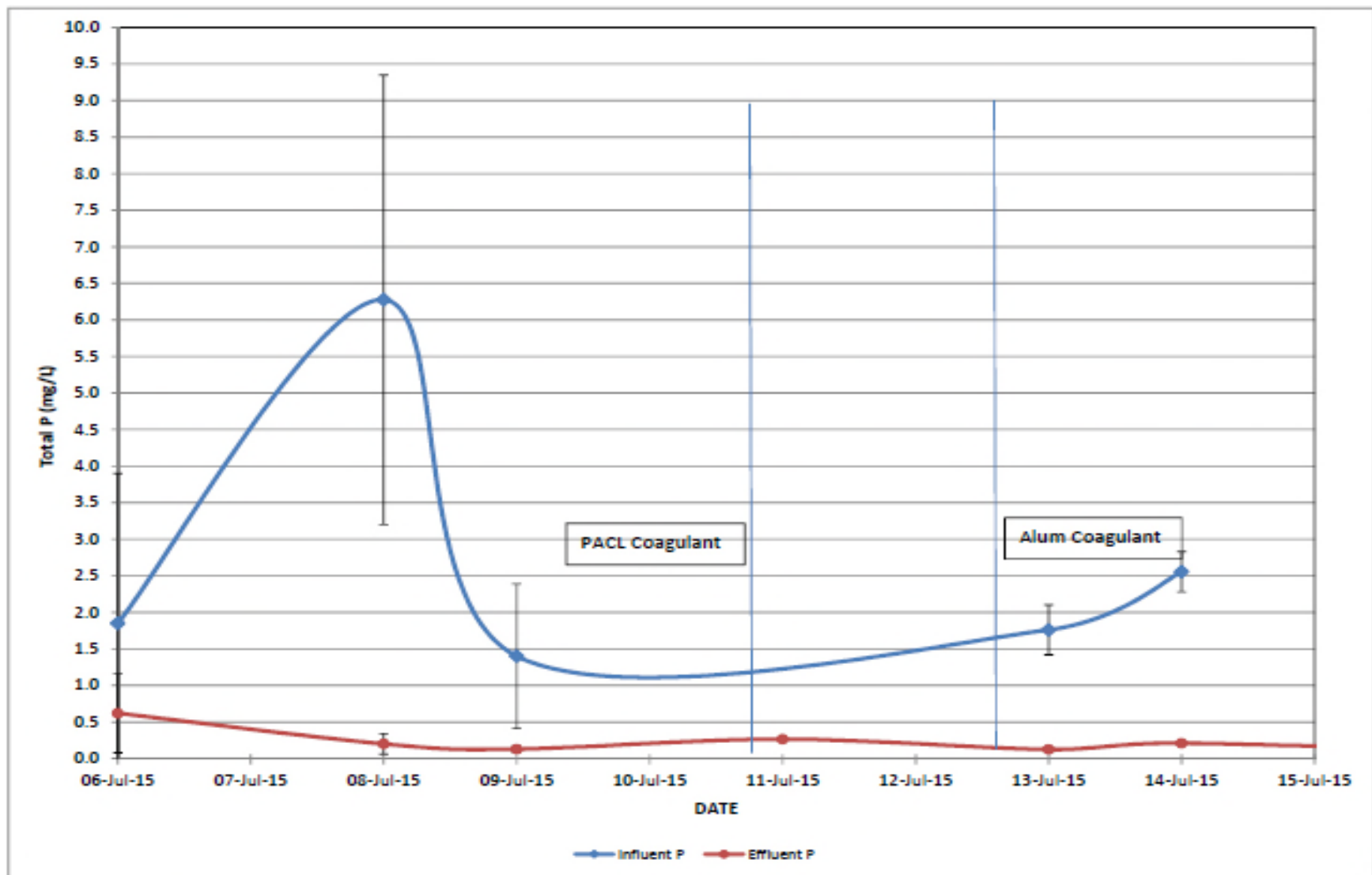


FIGURE 15: ACTIFLO PILOT RUN – INFLUENT AND EFFLUENT TOTAL PHOSPHORUS

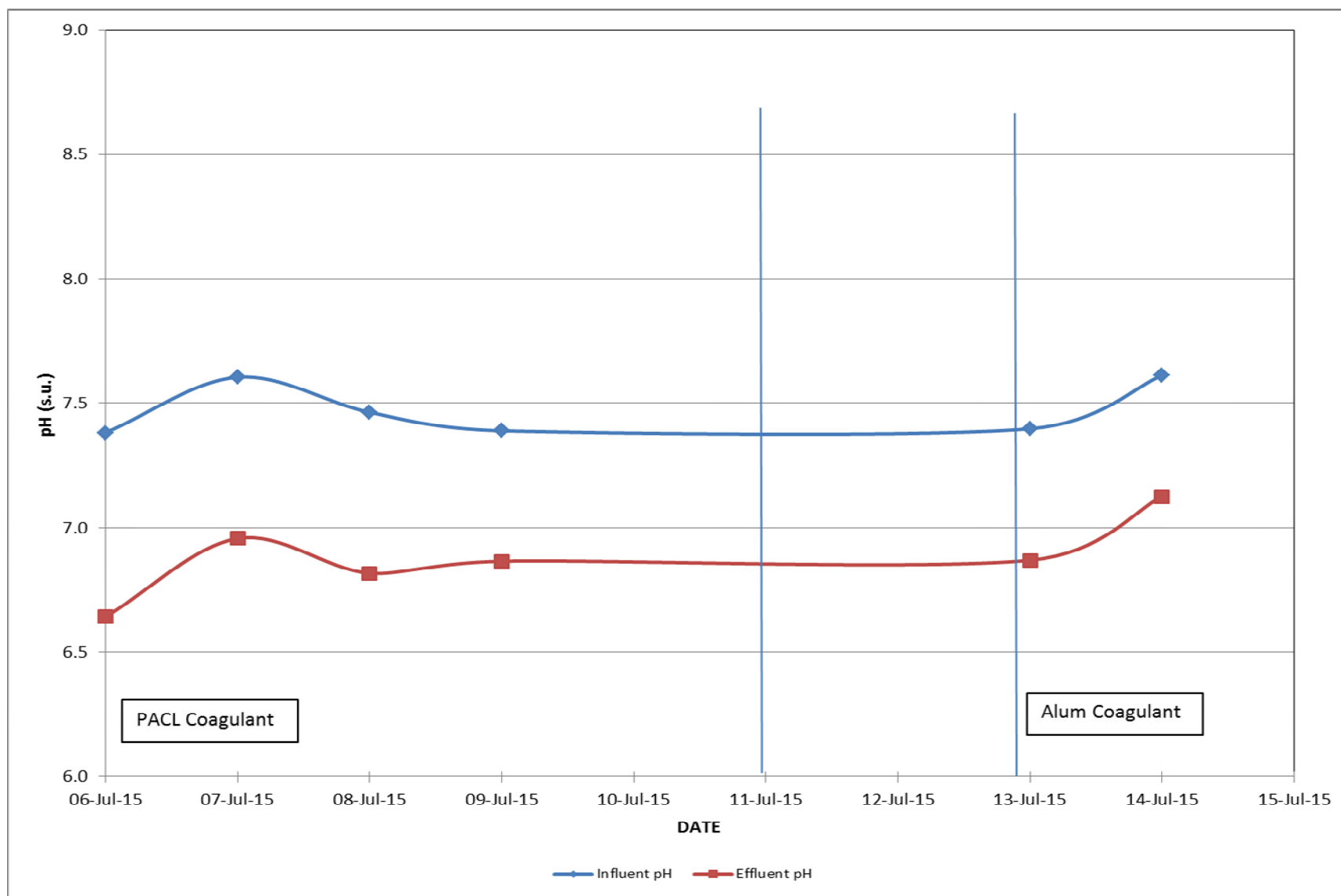


FIGURE 16: ACTIVFLO PILOT RUN – INFLUENT AND EFFLUENT pH

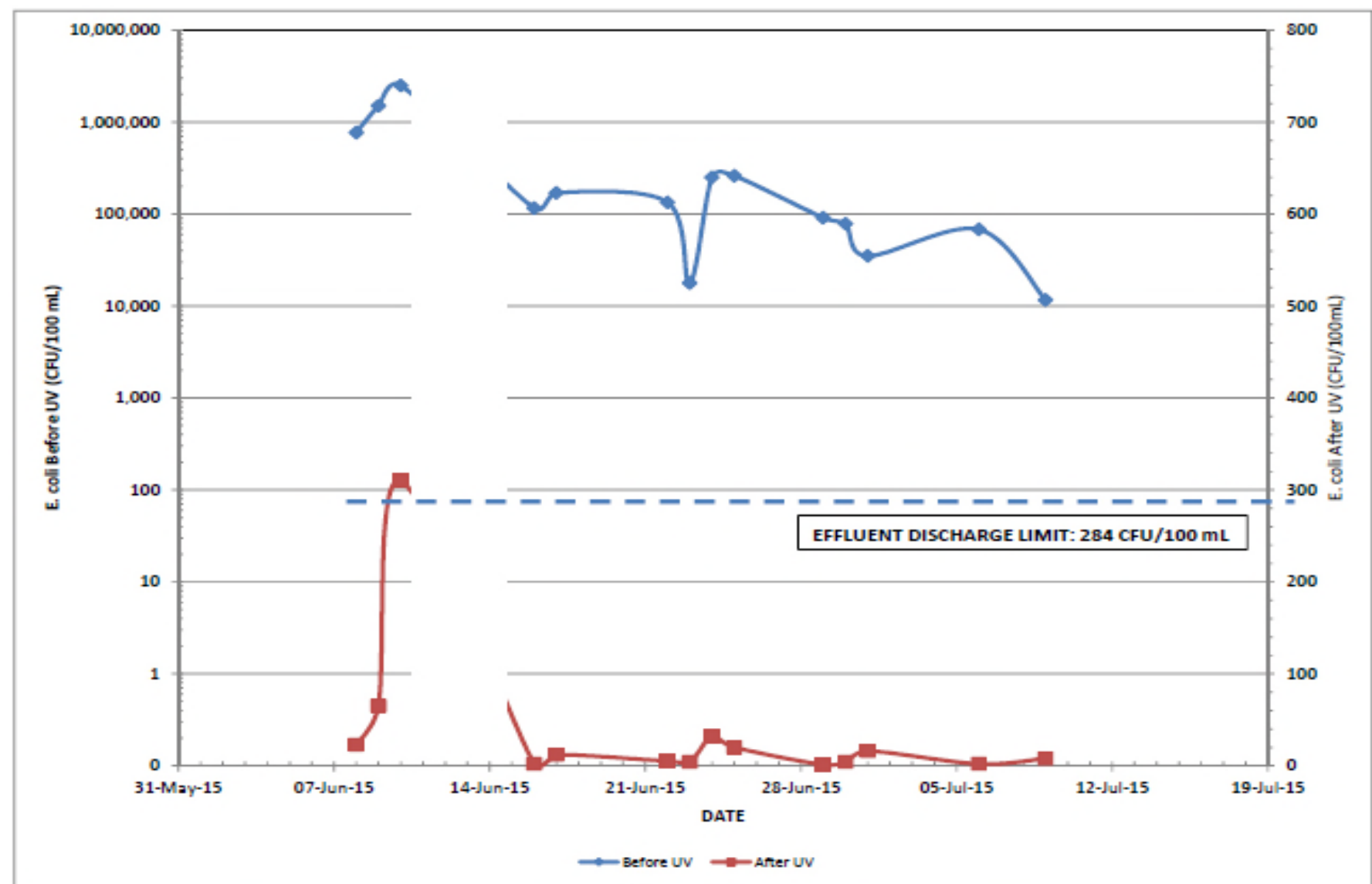


FIGURE 17: BIOACTIFLO/ACTIFLO PILOT RUN – E.COLI DAILY VALUE

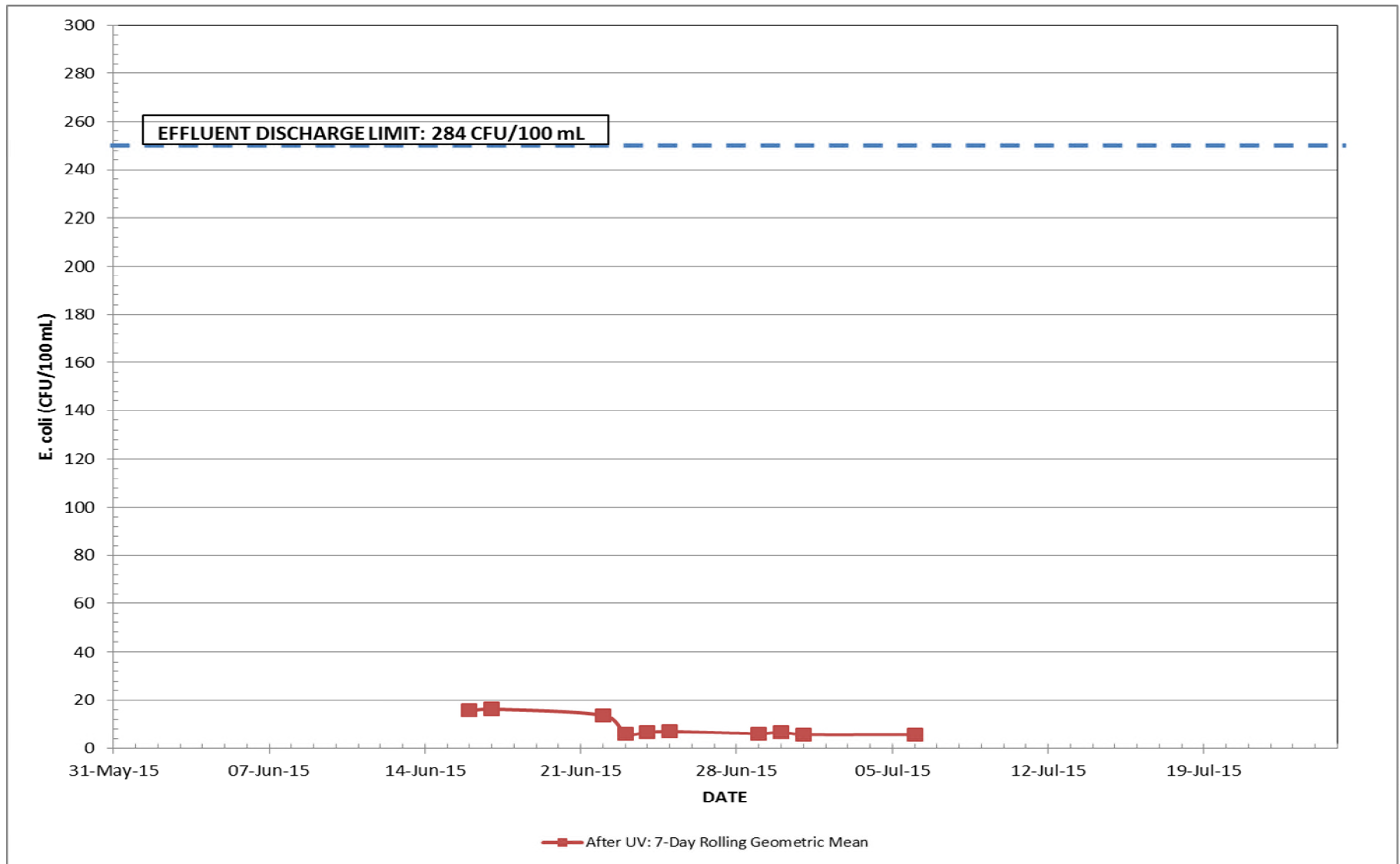


FIGURE 18: BIOACTIFLO/ACTIFLO PILOT RUN – E. COLI 7-DAY ROLLING GEOMETRIC MEAN

APPENDIX B

PRESENT WORTH ANALYSIS OF BIOACTIFLO & ACTIFLO HIGH RATE TREATMENT SYSTEMS

PRESENT WORTH (PW) ANALYSIS OF CHEMICAL USAGE FOR BIOACTIFLO AND ACTIFLO ALTERNATIVES

Present worth analysis is based on 20 years of equipment service life and 3% interest rate /year .

Alternative	Description	Chemical Dosage						Unit Chemical Cost						Daily Chem Cost	PW of Annual Chemicals ^b	
		NaAlO ₂ (lb/d)	Alum (lb/d)	PACL (lb/d)	Polymer (lb/d)	H ₂ SO ₄ (gal/d)	Sand (lb/d)	NaAlO ₂ (\$/lb)	Alum (\$/lb)	PACL (\$/lb)	Polymer (\$/lb)	H ₂ SO ₄ (\$/gal)	Sand (\$/lb)			
1. BIOACTIFLO																
35 MGD	-NaAlO2 ^a	17,514	26,271	17,514		3,308	876	0.23	0.50	1.80	2.25	2.15	0.10	13,375	3,937,000	
	- ALUM				1,168						2.25		0.10	15,850	4,543,200	
	- PACL				1,051						2.25		0.10	33,977	9,739,000	
45 MGD	-NaAlO2	22,518	33,777	22,518		22,518	1126	0.23	0.50	1.80	2.25	2.15	0.10	17,660	5,061,900	
	- ALUM				1,501						2.25		0.10	20,379	5,841,200	
	- PACL				1,351						2.25		0.10	43,685	12,521,500	
2. ACTIFLO																
35 MGD	- ALUM		29,190	18,974	467		876	--	0.50	1.80	2.25		0.10	15,733	4,509,700	
	- PACL				350						2.25		0.10	35,028	10,040,100	
45 MGD	- ALUM	-	37,530	24,395	600	-	1,126	--	0.50	1.80	2.25		0.10	20,229	5,798,200	
	- PACL				450					2.25		0.0	45,036	12,908,700		

Notes:

- (a) Sodium aluminate.
- (b) Overflow events assumed to occur 23 days in a year.
- (c) ACTIFLO Overflow sludge from the full scale unit is assumed to be brought back to LWWTP and removed along with its primary sludge.

APPENDIX C

VEOLIA PROPOSAL FOR PILOT STUDY – MAY 20, 2015

Purchase Order No. 3441-15

Kruger, Inc.

Attn: Drew Bostian

4001 Weston Pkwy

Cary, NC 27513

Date: 5/26/2015

CT Job No.: 14797

PLEASE ENTER OUR ORDER FOR THE FOLLOWING:

QUANTITY	DESCRIPTION	UNIT PRICE	AMOUNT
1	Pilot testing of ACTIFLO/BIOACTIFLO process at the Lakewood, Ohio Wastewater Treatment Plant	\$ 69,000.00	\$ 69,000.00
	Kruger Pilot Agreement Terms and Conditions in Attachment B Will Apply.		
			Total \$ 69,000.00

CONDITIONS

Render all invoices promptly with above Purchase Order Number and Job Number. This order is to be accepted only at prices and terms specified hereon unless we are advised otherwise. There is no verbal understanding other than conditions stated in this order. Materials purchased on the order are subject to our inspection and approval. Rejected material will be held at Seller's risk or returned at his/her expense. Our count will be accepted as final and conclusive on all shipments not accompanied by packing tickets.

BY 

SUBCONSULTANT STANDARD CONDITIONS

ARTICLE 1 — PAYMENTS TO SUBCONSULTANT

1.01 General

A. SUBCONSULTANT's services and compensation under this Agreement have been agreed to assuming the orderly and continuous progress of the Project through completion consistent with CT CONSULTANT'S scheduling of the overall design.

1.02 Other Provisions Concerning Payments

Preparation of Invoices. Invoices will be prepared in accordance with SUBCONSULTANTS' standard invoicing practices and will be submitted to CT CONSULTANTS by SUBCONSULTANT monthly, unless agreed otherwise.

Approval of Invoices. CT CONSULTANTS shall review invoices submitted by SUBCONSULTANT within 5 days of receipt and shall promptly either approve said invoices or notify SUBCONSULTANT of any disputed items.

Time of Payment: CT CONSULTANTS shall bill OWNER monthly on account of SUBCONSULTANT's services and shall pay SUBCONSULTANT within 14 days of the time CT CONSULTANTS receives payment from Owner on account thereof.

ARTICLE 2 GENERAL CONSIDERATIONS

2.01 Standards of Performance

The standard of care for all professional and related services performed or furnished by SUBCONSULTANT under this Agreement will be the care and skill ordinarily used by members of SUBCONSULTANT's profession practicing under similar circumstances at the same time and in the same locality. SUBCONSULTANT makes no warranties, express or implied, under this Agreement or otherwise, in connection with these services.

SUBCONSULTANT shall be responsible for the technical accuracy of its services, data and Documents resulting therefrom, and CT CONSULTANTS shall not be responsible for discovering deficiencies therein. SUBCONSULTANT shall correct such deficiencies without additional compensation, except to the extent that such action is directly attributable to deficiencies in CT CONSULTANTS' furnished information.

2.02 Use of Documents

A. All Documents prepared or furnished by SUBCONSULTANT pursuant to this Agreement are instruments of service in respect to This Part of the Project and SUBCONSULTANT may retain an ownership and property interest therein (including the right of re-use at the discretion of SUBCONSULTANT) whether or not This Part of the Project is completed.

2.03 Insurance

A. SUBCONSULTANT shall procure and maintain insurance as follows identifying CT CONSULTANTS as an additional insured:

Workmen's Compensation	Statutory
Employer's Liability Insurance	\$1,000,000 ea. Accident
General Liability Insurance	\$1,000,000 ea. Occurrence
\$1,000,000 General Aggregate	
Automobile Insurance	\$1,000,000 Bodily Injury
\$1,000,000 Property Damage	
Errors/Omission	\$1,000,000 ea. Occurrence

2.04 Allocation of Risks

A. *Indemnification.* 1. To the fullest extent permitted by law, CT CONSULTANTS and SUBCONSULTANT shall indemnify and hold harmless each other's officers, directors, partners and employees from and against any and all costs, losses and damages (including, but not limited to, all fees and charges of attorneys, and other professionals and all court or arbitration or other dispute resolution costs) caused solely by the negligent acts or omissions of CT CONSULTANTS' or SUBCONSULTANT's officers, directors, partners, employees, in the performance and furnishing of SUBCONSULTANT's services under this Agreement.

2. To the fullest extent permitted by law, SUBCONSULTANT's total liability to CT CONSULTANTS and anyone claiming by, through, or under CT CONSULTANTS for any cost, loss or damages caused in part by the negligence of SUBCONSULTANT, including those for whom SUBCONSULTANT is responsible, and in part by the negligence of CT CONSULTANTS or any other negligent entity or individual, shall not exceed the percentage share that SUBCONSULTANT's negligence bears to the total negligence of CT CONSULTANTS, and all other negligent entities and individuals.

2.05 Successors, Assigns, and Beneficiaries

CT CONSULTANTS and SUBCONSULTANT each is hereby bound and the partners, successors, executors, administrators and legal representatives of CT CONSULTANTS and SUBCONSULTANT are hereby bound to the other party to this Agreement and to the partners, successors, executors, administrators and legal representatives (and said assigns) of such other party, in respect of all covenants, agreements and obligations of this Agreement.

Neither CT CONSULTANTS nor SUBCONSULTANT may assign, sublet or transfer any rights under or interest (including, but without limitation, monies that may become due or monies that are due) in this Agreement without the written consent of the other, except to the extent that any assignment, subletting or transfer is mandated or restricted by law.

2.06 Equal Employment Opportunity

CT CONSULTANTS, INC. is an EEO/AAP Employer and has adopted a policy on nondiscrimination on the basis of race, religion, color, sex or national origin with regard to recruitment, hiring, training, upgrading, promotion and discipline of employees or applicants for employment. During the performance of this Agreement, the SUBCONSULTANT agrees to fulfill the following requirements and further agrees:

That in the hiring of employees for the performance of work under this Agreement or for any subcontract related thereto, the SUBCONSULTANT shall not, by reason of race, color, religion, sex, age, disability, national origin or ancestry, discriminate against any citizen in the employment of a person qualified and available to perform work to which this Agreement relates; and,

That the SUBCONSULTANT, or any person acting on behalf of the Subconsultant shall not, in any manner, discriminate against, intimidate or retaliate against any employee hired for the performance of work under this Agreement on account of race, color, religion, sex, age, disability, national original or ancestry; and,

That the SUBCONSULTANT shall maintain an approved written Affirmative Action Program for the employment and effective utilization of persons from the economically disadvantaged groups identified by Section 122.71(E)(I) of the Ohio Revised Code, and shall annually file an updated Affirmative Action Program and a progress report on its implementation with the State.



May 19, 2015

Robert Greytak
CT Consultants Inc.
8150 Sterling Court
Mentor, OH 44060
Columbus, OH
Phone: (440) 951-9000

Re: ACTIFLO® & BIOACTIFLO™ Pilot Study Proposal

Dear Mr. Greytak,

Please find the following pilot proposal and data package for ACTIFLO & BIOACTIFLO™ testing at the Lakewood Wastewater Treatment Plant. This proposal summarizes set-up requirements for our pilot unit and includes an agreement for the cost of pilot testing.

As per the attached documents, the rental cost for an ACTIFLO®/BIOACTIFLO™ pilot unit is \$10,000 per week. This cost includes pilot engineers to operate the pilot unit and rental cost of the equipment. The cost of round trip freight will be an additional \$9,000. The total cost for a six (6) week ACTIFLO®/BIOACTIFLO™ pilot will be \$69,000. The quote/contract excludes third party analytical lab fees and additional equipment needed for operations not listed in Attachment A. If additional weeks are anticipated or needed, please add \$10,000 for each additional week. The cost of the pilot study will be reimbursed by deducting \$69,000 from the price of the full scale equipment if the Customer purchases a full scale system within ²⁴₄₂ months of the pilot invoice.

The price excludes sales and/or use taxes. The Customer agrees to provide the necessary tax exemption certificate for sales tax exemption prior of a pilot agreement executed by all parties. Furthermore, the Customer accepts responsibility for all applicable state and local sales taxes as Kruger is not registered to collect or remit state sales and/or use taxes.

The proposed testing period for the pilot study is June 1st – June 30th, 2015. Pilot setup would begin on May 26th, 2015 and pilot decommissioning would take place after June 30th, 2015. Please sign page 2 and 12 of the proposal and return the attached agreement along with the Customer's Sales Tax Exemption Certificate to confirm the pilot unit for this testing period. If you have any questions on this proposal or data package, or other requirements for preparation, please do not hesitate to contact me at (919) 653-4572.

Sincerely,

Drew Bostian
Pilot Group Manager, US Municipal Solutions
WATER TECHNOLOGIES

office : +1 919 653-4572 / cell : +1 336 671-0921 / fax : +1 919 677-0082
Kruger Inc. / 4001 Weston Pkwy / Cary, NC 27513 / USA
drew.bostian@veolia.com



DEMONSTRATION TEST AGREEMENT

THIS DEMONSTRATION TEST AGREEMENT (this "Agreement") is made as of the 19th day of May 2015, by and between I. Kruger Inc., ("KRUGER") and ~~the City of Lakewood, OH~~ ("Customer"). **CT CONSULTANTS, INC.**

1. KRUGER has submitted to the Customer, dated May 19, 2015 (the "Proposal", a copy of which is appended hereto as Attachment A) concerning the use of a mobile ACTIFLO/BIOACTIFLO™ Pilot Unit (the "Unit") at Lakewood Wastewater Treatment Plant located in Lakewood, OH (the "Facility"), and Customer desires to accept the Proposal on the terms and conditions herein set forth.
2. KRUGER shall at all times maintain ownership of the Unit, but shall make the Unit available at the Facility for a six (6) week period, mutually acceptable to KRUGER and the Customer, for the completion of a demonstration test (the "Demonstration") as described in the Proposal. The Customer shall provide, at its sole cost and expense, the personnel, services and other support items necessary to completion of the Demonstration, as described in the Proposal. In consideration for making the Unit available for the Demonstration, the Customer shall pay to KRUGER the sums set forth in the Proposal.
3. KRUGER'S provision of the Unit for completion of the Demonstration shall be subject to all of the terms and conditions set forth in Attachment B hereto, each of which are incorporated by reference as if fully set forth herein. The provisions of Attachment B shall survive the expiration or earlier termination of this Agreement. Initially capitalized words and phrases used in Attachment B without definition shall have the meanings ascribed to such words and phrases in this Agreement.
4. This Agreement may be executed in two or more counterparts, each of which shall be deemed to be an original, but all of which together shall be deemed to be one and the same instrument. Any written notice or other written information to be communicated pursuant to or in connection with this Agreement shall be delivered by reputable overnight courier or certified mail, return receipt requested, to the addresses appearing on the signature page of this Agreement.

IN WITNESS WHEREOF, the parties hereto have caused their duly authorized representatives to execute and deliver this Agreement as of the day and year first above written.

_____ Facility Legal Name	I. Kruger Inc. d/b/a KRUGER
By: <u>Richard J. Tafelice, V.P.</u> Print Name: <u>Richard J. Tafelice</u>	By: _____ Print Name: _____
Title: <u>Vice President</u>	Title: _____
Address: <u>8150 Sterling Ct.</u> <u>Mentor, OH 44060</u>	Address: <u>4001 Weston Parkway</u> <u>Cary, NC 27513</u>



Agreement for ACTIFLO[®] and BIOACTIFLO[™] Pilot Testing

Client: ~~City of Lakewood~~ *CT CONSULTANTS, INC.*

Location: Lakewood Wastewater Treatment Plant

Dates of Testing: June 1st – 30th, 2015. Pilot setup will be completed during the prior week starting on May 26th and pilot decommissioning will take place after June 30th.

Cost of Testing: \$10,000 per week (A week being defined as forty hours per week, typical first shift hours, and excluding weekends and holidays).

Freight Cost: \$9,000 roundtrip

Total Cost: The total cost of a six (6) week ACTIFLO[®] and BIOACTIFLO[™] pilot test will be \$69,000. This includes pilot setup and pilot decommissioning. If additional weeks of testing are needed, \$10,000/week will be added to the total cost. The cost of the pilot study will be reimbursed by deducting \$69,000 from the price of the full scale equipment if the Customer purchases a full scale system within ~~24~~ *42* months of the pilot invoice.

Payment Terms: Billing to be at the completion of pilot testing with payment due net thirty (30) days.

Tax Exemption: The Customer agrees to provide the necessary tax exemption certificate for sales tax prior of a pilot agreement executed by all parties.

Conditions: All of the conditions as stated in the Demo Test Agreement, Pilot Study Specifications and Proposal Package (Attachment A, specifically Section III c-e) and the attached Standard Terms and Conditions (Attachment B) are acceptable to both parties.

Agreed Upon and Accepted By:

I. Kruger Inc.
4001 Weston Parkway
Cary, NC 27513

By: _____

Date: _____

CT Consultants, Inc.
2150 Starling Ct.
Mentor, OH 44060

By: _____

Richard J. [Signature]
Vice President

Date: *5/22/2015*

P.O. # _____



Pre-Arrival Checklist for the ACTIFLO®/BIOACTIFLO™ Pilot Plant

- ☐ Tax Exemption Certificate forwarded to Kruger (if applicable).
- ☐ The 480V electric supplies* are hooked up and an electrician is scheduled to be on site the morning of the trailer's scheduled arrival.
- ☐ A suitable site* is available and prepared for arrival. Trailer jack supports (pieces of 2" x 10" or 2" x 12") are on site and available for use.
- ☐ Equipment is on site to move and lower the submersible pumps*. Personnel to operate the equipment are available.
- ☐ Crane is scheduled to be onsite to unload the solids contact tank*.
- ☐ Enough 4" PVC pipe or 4" rigid hose is available to run the waste sludge* to the selected disposal location.
- ☐ 4" influent piping or hose* is on site and prepared to hook up.
- ☐ 6" Effluent piping* is on site and ready to hook up. A suitable effluent disposal location is chosen.
- ☐ A large container is available for catching the screened solids.
- ☐ Potable service water (garden hose connections) is available.*
- ☐ All chemicals* (except flocculant aid polymer) which will be used should be readily available and delivered to the pilot day tanks.
- ☐ Personnel* are scheduled to be on site to assist with hook up of the pilot plant.

* These items are fully detailed in the technical specification section.

Please sign and return this list to Kruger. The ACTIFLO®/BIOACTIFLO™ pilot plant will be delivered after the receipt of this document.

Engineer	<u>CT CONSULTANTS</u>	<u><i>Richard J. [Signature]</i></u>	<u>5/22/2015</u>
	print here	sign here	date
Client	<u>CT CONSULTANTS</u>	<u><i>Richard J. [Signature]</i></u>	<u>5/22/2015</u>
	print here	sign here	date



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2. KRUGER shall at all times maintain ownership of the Unit, but shall make the Unit available at the Facility for a six (6) week period, mutually acceptable to KRUGER and the Customer, for the completion of a demonstration test (the "Demonstration") as described in the Proposal. The Customer shall provide, at its sole cost and expense, the personnel, services and other support items necessary to completion of the Demonstration, as described in the Proposal. In consideration for making the Unit available for the Demonstration, the Customer shall pay to KRUGER the sums set forth in the Proposal.

3. KRUGER'S provision of the Unit for completion of the Demonstration shall be subject to all of the terms and conditions set forth in Attachment B hereto, each of which are incorporated by reference as if fully set forth herein. The provisions of Attachment B shall survive the expiration or earlier termination of this Agreement. Initially capitalized words and phrases used in Attachment B without definition shall have the meanings ascribed to such words and phrases in this Agreement.

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_____ Facility Legal Name	I. Kruger Inc. d/b/a KRUGER
By: <u><i>Richard J. Tafelice</i></u> Print Name: <u><i>Richard J. Tafelice</i></u>	By: _____ Print Name: _____
Title: <u><i>Vice President</i></u>	Title: _____
Address: <u><i>8150 Sterling Ct.</i></u> <u><i>Mentor, OH 44060</i></u>	Address: <u><i>4001 Weston Parkway</i></u> <u><i>Cary, NC 27513</i></u>



ATTACHMENT B TERMS AND CONDITIONS

1. **General.** (a) At all times during the term of this Agreement the Unit shall remain the personal property of KRUGER and shall not, by accession or otherwise, become a fixture or part of the real property at the Facility. At the conclusion of the Demonstration, the CUSTOMER shall permit KRUGER access to the Facility for the time period necessary for KRUGER to remove the Unit. (b) The CUSTOMER shall procure all licenses, permits and approvals necessary to the performance of any Demonstration and shall be responsible for complying with all laws and regulations of governmental authorities and agencies affecting any such Demonstration, including without limitation, rules and regulations concerning safety and environmental matters. Notwithstanding the provisions of paragraph 1 (b) herein, KRUGER shall be responsible for any violation of law, rule or regulation caused by the Unit or KRUGER employees.

2. **Confidentiality; Ownership of Results.** All results, information, data, procedures, formulas, compilations, methods, techniques and processes, whether in writing or otherwise, relating to the Unit or any Demonstration ("Information") shall be received and maintained in confidence by the CUSTOMER, and/or any of its consultants or engineers, and shall not (with the exception of a lawful order of a court of competent jurisdiction or as required to be disclosed by CUSTOMER to any governmental agency in connection with its efforts to obtain any permits, licenses or approvals) be disclosed, directly or indirectly, by any such recipient, except to those of their employees who need to receive such information to enable the CUSTOMER to evaluate the results of any Demonstration. The CUSTOMER shall not, nor shall it permit its consultants or engineers to use or permit the use of any of such Information for any purpose other than to evaluate the results of and Demonstration. All Information, including results, data, discoveries, inventions, and improvements, whether or not patentable or copyrightable, any and all expressions of computer programs, manuals, data bases and all forms of computer hardware, firmware and software, conceived, made, first reduced to practice, or developed by either party arising out of the conduct of any Demonstration shall be the sole and exclusive intellectual property of KRUGER with respect to any and all countries, their territories and possessions.

3. **Warranty.** NO WARRANTIES, INCLUDING BUT NOT LIMITED TO, WARRANTIES REGARDING PERFORMANCE OR WARRANTIES OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE, HAVE BEEN GIVEN OR SHALL BE IMPLIED HEREIN REGARDING THE UNIT, THE INFORMATION, ANY DEMONSTRATION OR THE RESULTS OF ANY DEMONSTRATION.

4. **Indemnification.** KRUGER shall indemnify, defend and hold harmless CUSTOMER from and against any and all claims, demands, actions and causes of action, including without limitation, claims on account of personal injury, including death, or damage to or loss of tangible property of third parties to the extent caused by the negligent or other wrongful acts or omissions of KRUGER. CUSTOMER shall indemnify, defend and hold harmless KRUGER from and against any and all claims, demands, actions and causes of action, including without limitation, claims on account of personal injury, including death, or damage to or loss of tangible property of third parties to the extent caused by the negligent or other wrongful acts or omissions of CUSTOMER.

5. **Limitation of Liability.**

(a) Except for the obligation of Kruger and CUSTOMER to indemnify each other for any personal injury or third party property damage claims pursuant to paragraph 4, the aggregate liability of either party, including without limitation for or with respect to their affiliates and employees, arising out of or in connection with the Agreement, any Demonstration or the Unit, including without limitation liability based upon or arising from indemnification or contribution, breach of contract or warranty, strict liability, negligence or other tort, or any other legal or equitable theory, shall not exceed the greater of (i) the amount paid by the CUSTOMER to KRUGER for the Demonstration; or (ii) \$50,000.

(b) Notwithstanding anything to the contrary herein, in no event shall either party be liable to the other for consequential, incidental, indirect, special, exemplary or punitive damages of any kind, or for loss of profits, revenues or product, or loss of use of any property (whether by shutdown, operation at less than capacity or otherwise), regardless of whether any of the foregoing damages are based directly or indirectly upon indemnification or contribution, breach of contract, strict liability, negligence or other tort, or any other legal theory or equitable claim.

6. **General Provisions.** The Agreement, together with the Attachments thereto, represents the entire agreement between the parties with respect to the subject matter thereof, and supersedes all prior negotiations, purchase orders, representations or agreements, whether written or oral. The Agreement and these terms and conditions may not be amended except by mutual written agreement of KRUGER and the Customer. No course of performance or failure to strictly enforce any term shall be construed as a waiver thereof. Waiver of any term shall not constitute a waiver of any other term or a continuing waiver. The Agreement, including its Attachments, shall be binding on the parties' respective successors and assigns; provided that the CUSTOMER may not assign, delegate or permit any other transfer thereof without KRUGER'S prior written consent. The Agreement and its Attachments shall be governed by and construed in accordance with the laws of the State of North Carolina, without regard to its conflict of laws provisions.



APPENDIX D

PILOT PLANT PROTOCOL – JUNE 2, 2015

WET WEATHER IMPROVEMENT FOR LAKEWOOD WASTEWATER TREATMENT PLANT – PILOT TESTING PROTOCOL

Prepared for:



Prepared by:



June 2, 2015

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LIST OF ABBREVIATIONS

ADDF –	Average Design Daily Flow
ADF –	Average Daily Flow
BOD –	Biochemical Oxygen Demand
CBOD –	Carbonaceous BOD
sBOD –	Soluble BOD
CSO –	Combined Sewer Overflow
HRT –	High Rate Treatment
IWWIP –	Integrated Wet Weather Improvements Plan
LTCP –	Long Term Control Plan
LWWTP –	Lakewood Wastewater Treatment Plant
MDF –	Maximum Daily Flow
MLSS –	Mixed Liquor Suspended Solids
NEORSD –	Northeast Ohio Regional Sewer District
RAS –	Return Activated Sludge
TSS –	Total Suspended Solids
WAS –	Waste Activated Sludge

1.0 INTRODUCTION

The City of Lakewood Wastewater Treatment Plant (LWWTP) discharges to Lake Erie on the northern edge of Cuyahoga County. The LWWTP sewage collection system is a combined sewerage system that serves the municipalities of Lakewood and Rocky River. The sewer collection system is comprised of approximately 75% separate sanitary and 25% combined storm and sanitary sewers. The combined portion of the system contains nine combined sewer overflows (CSOs) which discharge to Lake Erie and the Rocky River when the system is hydraulically overloaded; six discharges to Lake Erie and three discharges to the Rocky River.

The City of Lakewood is required by the local NPDES permit to develop an Integrated Wet Weather Improvement Plan (IWWIP) to address the CSOs. Among the nine CSO outfalls present, outfall 3PE00004002 is located nearest to the plant (just before the aerial sewer) and is known to discharge the largest volume most frequently. The measured average annual overflow volume at this CSO outfall for the data period July 2007 through June 2012 was 47 million gallons (NPDES Fact Sheet for the City of Lakewood WWTP, 2014). The average volume discharged per occurrence was 0.97 million gallons.

As part of the effort to control overflows, the City intends to develop a basis of design for a high rate treatment (HRT) system to provide treatment for the excess flows above the WWTP hydraulic capacity, which occur during wet-weather conditions.

The City of Lakewood has conducted the unified selection process based on five (5) leading Wet Weather High Rate Treatment systems manufacturers:

- Evoqua, the Comag™ Ballasted Coagulation-Flocculation Treatment
- Infilco Degremont, Inc – DensaDeg / DensaDeg XRC Chemically Enhanced HRT
- Kruger-Veolia, ActiFlo / BioActiflo Chemically Enhanced HRT
- Evoqua, CoMag™ /BioMag System
- WesTech, WWETCO FlexFilter™ and Bio-FlexFilter™

In order to compare the HRT technologies offered by the different manufacturers and to obtain better knowledge of the proposed process, the City and their Design Professionals solicited pilot plant study proposals; conducted interviews and manufacturer's presentations; users' contacts; and planned site visits. The following evaluation criteria were implemented for the assessment of each HRT technology presented by each Manufacturer:

- a. Foot Print
- b. Preliminary Treatment Requirements
- c. Flow Stream
- d. Effluent capabilities
- e. Operation and maintenance
- f. Seasonal impacts
- g. Sludge density, quantity, composition
- h. Chemicals required
- i. Ramp up sequence and time frame
- j. Scope of Supply, warranties, process guarantees and cost
- k. Installation requirements

From these presentations and information collected, the City and their Design Professionals have sent out notification letters to two selected vendors inviting them to perform a side by side pilot study at the Lakewood WWTP:

- Kruger-Veolia - ActiFlo / BioActiflo
- Infilco Degremont, Inc - DensaDeg / DensaDeg XRC

However, Infilco Degremont, Inc. has declined participation in the pilot study, stating that piloting unit Densadeg, model XRC, will not be available during the scheduled (June-July) timeframe. Therefore, only ActiFlo/BioActiflo wet weather HRT system, presented by Kruger-Veolia manufacturer, is planned to be piloted at the Lakewood WWTP.

The flow rate to be handled by the wet weather HRT system has been estimated using Storm Water Management Model (SWMM) with the goal to reduce the number of overflow events in CSO 002 to four (4) per typical year or less. As such, the full-scale HRT system is expected to have a capacity to handle 30 MGD flow, and located adjacent to or within LWWTP. The exact capacity requirement for the HRT system will be determined based on the results from further SWMM modeling and IWWIP Implementation.

The primary purpose of the pilot plant study is to determine effectiveness of treating wet-weather flows using the ActiFlo or BioActiflo process. Secondary objectives are to develop design and operating parameters for the HRT technology; provide scale up criteria required for the design of a full-scale treatment plant under various flow and load conditions, and confirm selected technology can achieve performance objectives. This WWTP HRT Pilot Study Plan describes the proposed work plan to be implemented during June 1 through July 15, 2015.

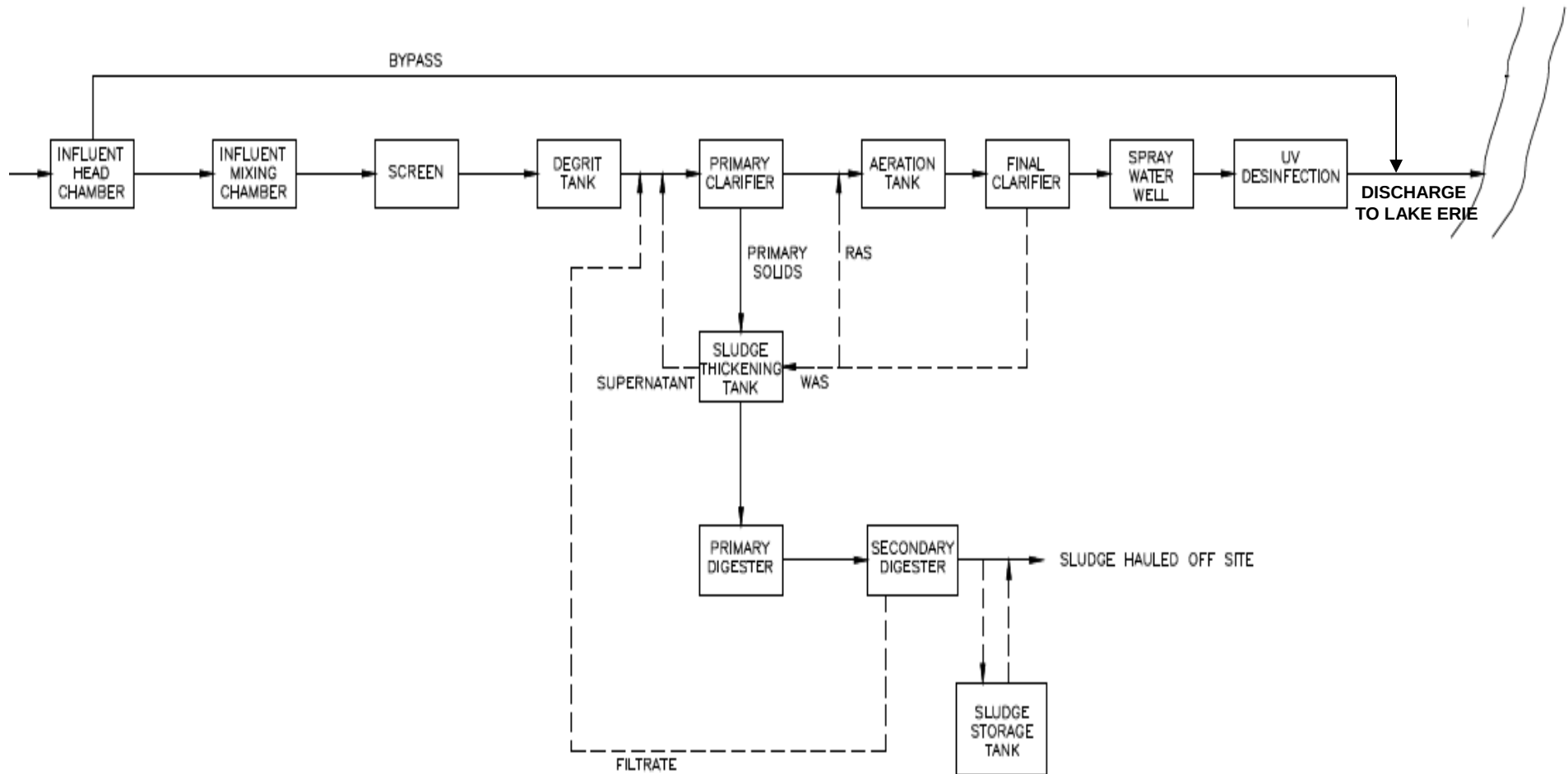
2.0 EXISTING TREATMENT SYSTEM

The LWWTP is an activated sludge based wastewater treatment plant. It is designed to treat an average design flow of 18 MGD. The LWWTP influent parameters are provided in Table 1.

TABLE 1
LAKEWOOD WWTP INFLUENT PARAMETERS

Parameter	Units	Annual	Wet Weather
ADDF	MGD	18	-
ADF	MGD	7.33	16
MDF	MGD	38.25	38.25
TSS	mg/L	140	67
CBOD	mg/L	110	48.2

Wet stream processes consist of coarse screening, grit removal, primary clarification, aeration and coagulation, conventional activated sludge, secondary clarification, and UV disinfection. Solids streams process for the primary solids and secondary waste activated sludge consist of solids thickening tank, primary and secondary anaerobic digesters. The LWWTP flow diagram is shown on Figure 1. The NPDES discharge permit for this treatment facility is included in Attachment-A.

**FIGURE 1: EXISTING LWWTP FLOW BLOCK DIAGRAM**

3.0 PILOT TEST APPROACH

3.1 PILOT PLANT OBJECTIVE

The treatment objective of the pilot program is to demonstrate the effectiveness of the Chemically Enhanced High Rate Treatment Technology ActiFlo / BioActiflo to consistently and reliably achieve NPDES permit levels of TSS and BOD. The CE-HRT Pilot Plant program approach was developed based on requirements specified in the NEORSD Consent Decree. The Pilot Plant study has the following objectives:

- a. Confirm BOD and TSS, pathogens removal efficiencies under various flow and loading conditions:
 - Achieve 40 mg/L Total Suspended Solids (TSS) and total BOD across seven consecutive activations;
 - Achieve 126/100 ml E. coli (recreational season geometric mean), 284/100 ml E. coli (rolling seven days of activation geometric mean), if samples can be collected after going through disinfection.
- b. Identify optimum chemical doses;
- c. Estimate the chemical requirements necessary to meet the effluent limits in a full-scale installation and provide opinion of probable O&M costs;
- d. Estimate the sludge production rates and quality of the waste solids production (TSS concentration), estimate additional disposal costs;
- e. Develop / confirm system design parameters to be used in the preparation of preliminary designs and capital costs estimates;
- f. Develop estimated O&M costs associated with meeting the effluent limit in a full-scale installation.

3.2 INFLUENT PRETREATMENT REQUIREMENTS

Influent to the pilot unit should be screened, and possibly degritted. Final assessment of the pretreatment should be made based on the recommendations from the technology manufacturers according to their jar testing results.

3.3 PRE-PILOT SITE INSPECTION AND JAR TESTING

Manufacturer shall schedule a site visit 7-days prior to pilot unit on-site delivery to conduct site inspection, view operations, discuss plant issues with knowledgeable personnel and review the pilot work plan. During this site visit the Pilot Unit Vendor shall address any practical considerations associated with the physical set up of the pilot plant such as:

- a. Pilot unit location
- b. Utilities requirements for power and water
- c. Wastewater feed alternative locations
- d. Scope of work and responsibilities

The City of Lakewood shall arrange for 10 gallons of primary effluent and 5 gallons of secondary effluent samples for primary effluent sample dilution during BOD analysis, preferably during a bypass event. Samples to be collected in the beginning of May and shipped to the following address:

Kruger Inc.

Attn: Jeff Privott/ Wastewater Samples

1500 Garner Rd, Suite C

Raleigh, NC 27610

Phone: (888-578-4378)

The sampling procedure for Jar Testing and Water Sample Form are included in Appendix – B. Lakewood WWTP requires the use of an aluminum based coagulant; ferrous or ferric based coagulants shall not be used. The jar testing and bench scale studies shall be conducted prior to pilot trials by the Manufacturer to determine following:

- a. Selection of aluminum based coagulant type and dosage requirements.
- b. Selection of polymer type and dosage requirements.

3.4 PILOT PLANT SETUP

The container system for an Actiflo / Bio Actiflo pilot unit, supplied by Kruger/Veolia (HRT vendor), consists of a self-contained tractor trailer as shown in Figure 2. The planned location of the pilot unit during field demonstration is shown in Figure 3. The pilot unit will be stationed in the 30,000 square feet of staging area on the east side of the treatment plant, with an unfinished ground surface elevation of 18.7 feet above the 100 year floodplain elevation (about 576 feet above mean sea level). The staging area will be prepared by the City of Lakewood WWTP, Ohio to provide leveled surface (asphalt, concrete or well packed gravel) to support 60,000 lbs.



FIGURE 2: PILOT UNIT TRAILER

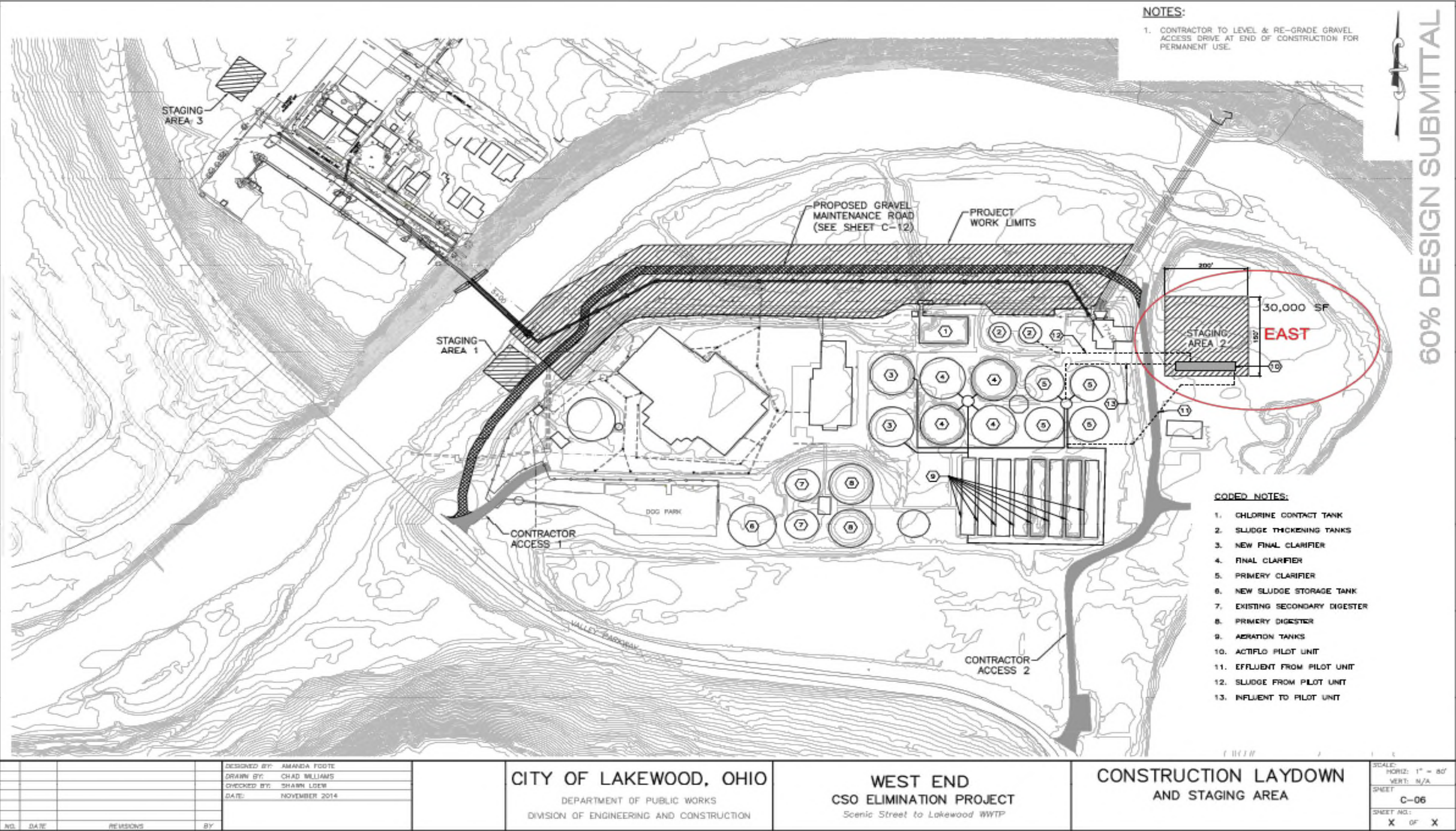


FIGURE 3: PILOT TESTING STAGING AREA

3.5 PILOT PLANT PROCESS DESCRIPTION

3.5.1 Actiflo Unit

This section focuses on the use of ActiFlo Unit for the Pilot Study. A Process Flow Diagram for Actiflo system is shown in Figure 4. LWWTP primary influent or primary effluent will be utilized for the pilot plant testing. The points of raw water intake, sludge discharge, and effluent discharge for the Actiflo Pilot Unit are shown in Figure 5.

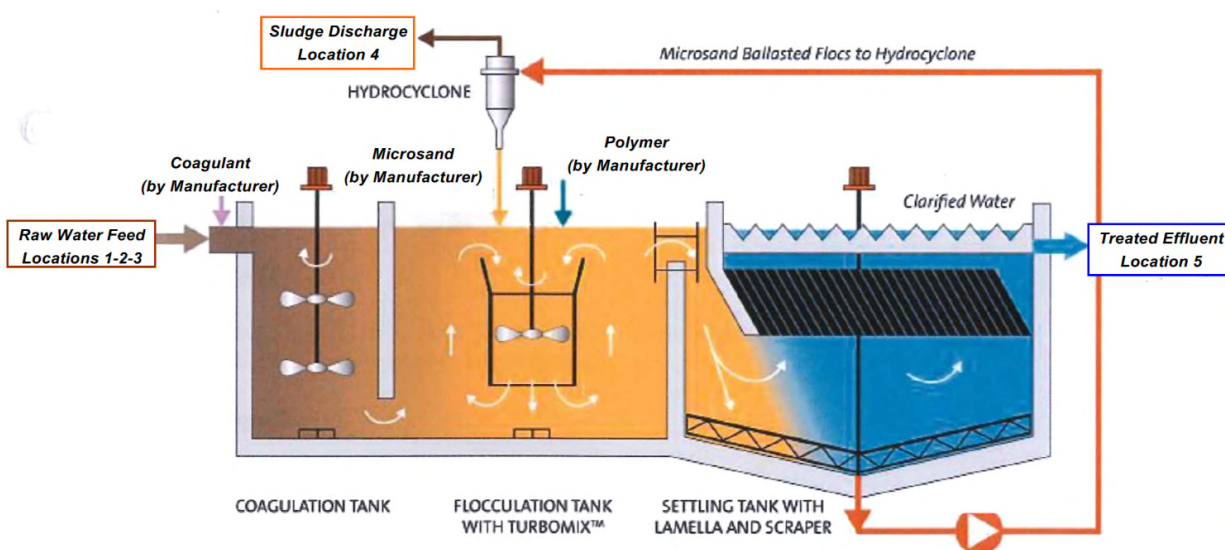


FIGURE 4: ACTIFLO PROCESS FLOW DIAGRAM

Three alternate locations from which wastewater stream can be pumped to the pilot units are shown in Figure 5:

- Location № 1 is immediately downstream of Screen #2 – can be used if grit removal is not necessary for the influent to the pilot;
- Location № 2 is in the channel downstream of the degrit tanks – can be used to supply wastewater after screening and grit removal;
- Location № 3 is the effluent channel from primary clarifier - can be used to represent dilute flow which is typical during storm events.

Floor elevation and water surface elevation for the above mentioned locations are given in Table 2.



TABLE 2

WATER AND FLOOR ELEVATION AT POTENTIAL LOCATIONS TO PUMP WASTEWATER TO PILOT UNITS

Year	Flow Rate (Mgd)	Influent Head Chamber	Influent Mixing Chamber	After Screen	Degrit Chamber	Bypass After Degrit	Prim. Clar. Eff. Channel	Aeration Tank Influent	Final Sludge Well	Primary Sludge Well	Sludge Thickener
Water Surface Elevation (Feet)											
2001	35	27.82	27.71	26.25	25.90	25.23	23	21.97	20.5	22.3	28.91
	20	26.75	26.71	25.48	25.05	24.58	-	-	-	-	-
Floor Elevation (Feet)											
2001/1980		23.99	23.28	23.28	23.17	23.06	20.35	17.47	10.67	11.6	17.75
Water Depth (Feet)											
2001/1980		3.83	4.43	2.97	2.73	2.17	2.65	4.5	9.5	10.7	11.16
Influent: Approx. Distance To Pilot Units (feet)											
-	-	750	225	200	210	220	155				
Biosolids to Contact Tank: Approx. Distance To Pilot Units (feet)											
-	-	-	-	-	-	-	-	-	202	-	-
Effluent: Approx. Distance from Pilot Units (feet)											
-	-	-	-	-	-	-	-	186	-	-	-
Waste Sludge: Approx. Distance from Pilot Units (Feet)											
-	-	-	-	-	-	-	-	-	-	194	213

The ActiFlo process combines two water treatment technologies: ballasted flocculation and plate settling. Raw water is pumped into the coagulation tank of the sand-ballasted system, where a coagulant (alum based or poly-poly-aluminum chloride) is added to destabilize the surface charge of suspended solids and colloidal matter in the influent stream. Typically, hydraulic retention time in this tank is approximately 2 minutes. The water then flows into the injection tank where polymeric flocculent and microsand are added to initiate floc formation. Microsand in conjunction with the polymer dosed in the system promotes flocculation and acts as a weighted structure to produce a very dense floc with a high settling velocity. These serve as a “seed” for floc formation and development in the next process step. A hydraulic retention time of about 2 minutes is also maintained in this tank. Treatment continues as the water passes through the underflow passage from the injection tank to the maturation or flocculation tank. In this tank, gentle mixing provides ideal conditions for bridging between the microsand and the destabilized suspended solids. Typical hydraulic retention time in the maturation tank is between 6-8 minutes. From this tank, the fully formed ballasted floc enters a settling tank equipped with inclined lamella plates or tube settlers depending on the application, which allow the rapid and effective removal of the “microsand/sludge” floc. Clarified water is collected in troughs located above the settling plates, while the settled microsand/sludge slurry is continuously pumped to hydrocyclones. Sludge and microsand particles are separated by the centrifugal force in the hydrocyclones. The lighter sludge is discharged while the heavier sand is re-injected by gravity into the system. Typical Actiflo process performance in achieving removal efficiencies for Total BOD and TSS removal:

- Total BOD removal: 40 - 65%
- TSS removal: 90 - 95%
- E. coli removal: Not available

3.5.2 BioActiflo

This section focuses on the use of BioActiflo Unit for the Pilot Study. Alternatives for the influent uptake locations as described for the Actiflo mode of operation will be made available for the BioActiflo pilot plant testing. The alternative points of raw water intake, sludge discharge, and effluent discharge for the BioActiflo Pilot Unit are shown in Figure 6, and BioActiflo process schematic in Figure 7.

The BioActiflo process is a high-rate treatment process that combines biological treatment with the Actiflo ballasted flocculation high-rate clarification process. Biological treatment is provided

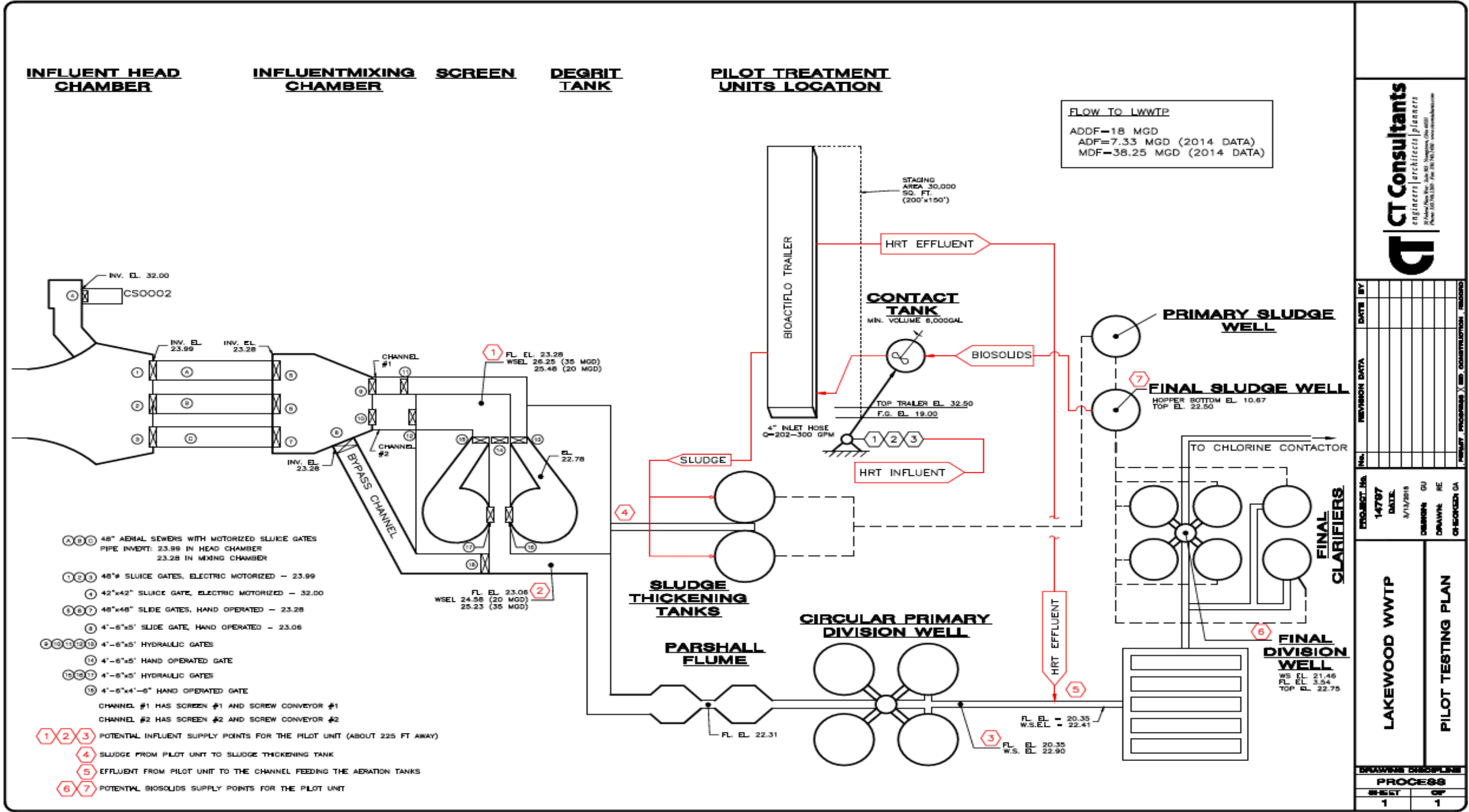


FIGURE 6: PILOT TESTING FLOW DIAGRAM FOR BIOACTIFLO

by a solids contact basin which is used ahead of the Actiflo high rate clarification. This basin has a shorter hydraulic retention time and a lower mixed liquor suspended solids (MLSS) concentration than conventional aeration basins. Contact Tank will be provided by the manufacturer (steel tank of 26' x 7.3' x 7' and 12,000 lb), with drum screen and blower. City should arrange for the following:

- A front-end loader to off-load from a flat-bed truck to a level surface near the pilot trailer as directed by the pilot unit operator;
- Power supply as shown in Tables 3 and 4; and,
- A roll-off bin to collect screenings from the drum screen and to remove screenings daily.

Biomass in the return activated sludge (RAS) is used to utilize soluble biochemical oxygen demand (sBOD) as a substrate. A 2 HP, variable speed submersible pump with 60 feet of hose will be provided by the pilot unit provider to transfer RAS to the contact tank. *The soluble BOD uptake rate is a function of the RAS/wastewater contact time and the amount of the biological solids in contact with the primary wastewater.* The target concentration of MLSS in the contact basin is maintained by using a portion of the RAS stream in addition to concentrated sludge from the Actiflo high-rate clarification process. One of the pilot test (Fort Smith, AR, 2006) results suggest an optimum contact time of 15 – 20 minutes and up to 1,200 mg/L MLSS concentration.

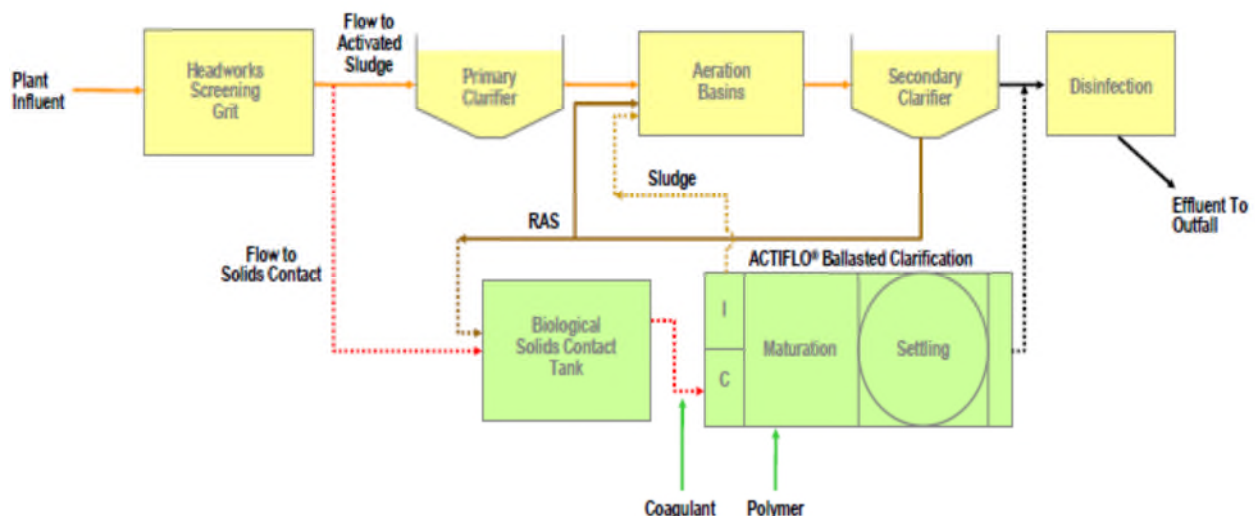


FIGURE 7: BIOACTIFLO PROCESS SCHEMATIC

The MLSS is aerated for rapid BOD uptake by the biomass and then flows from the solids contact tank. From contact tank, it flows to the Actiflo high-rate clarification process which uses coagulation, injection of microsand and polymer, settling and sand recirculation as described in the Actiflo technology summary in the previous subsection. The result is a process that provides high removal efficiency of BOD as well as suspended solids, thereby achieving biological treatment of excess flows while preserving the integrity of plant processes and mitigating washout of biomass. This pilot testing focuses on BioActiflo performance for BOD and TSS, as well as pathogen removal. Typical BioActiflo process reliability in achieving removal efficiencies for Total BOD and TSS removal:

- Total BOD removal > 85%
- TSS removal > 90 %
- Pathogens, E. coli: Not available

For BioActiflo pilot testing, at the maximum of 300 gpm flow rate, the contact tank volume is 6,000 gallons. Alternate sources of mixed liquor to the contact tank are shown in Figure 6.

- (a) Location №1 for biosolids to BioActiflo Contact Tank is the Final Division Well – can be used if fresh mixed liquor is required; and,
- (b) Location № 2 is the Final Sludge Well – can be used if concentrated waste activated sludge (WAS) is required.

Based on the historic operating data, aeration tank MLSS concentration is in the range of 2,000 – 4,000 mg/L. WAS stream is expected to have about 10,000 mg/L TSS. At 200 gpm of influent flow, about 20 gpm of WAS or 50 to 100 gpm of mixed liquor should be added to result in 1,000 mg/L TSS.

3.5.3 Underflow (Sludge) Discharge Location

Sludge from the pilot units can be discharged into one of the following locations:

- (a) Common wet well collecting sludge from the primary clarifiers;
- (b) Sludge thickening tanks; or,
- (c) Primary digester.

3.5.4 Effluent Discharge Location

Effluent from the pilot units can be discharged to effluent collection channel of primary clarifiers before discharging into the aeration tanks.

For the full-scale HRT, the existing 66" effluent pipe can be potentially used to discharge effluent.

3.5.5 Utilities

City of Lakewood is responsible for providing power and water supply to the pilot unit, as specified in Table 4.

Power: 480 V, 3-phase, 210 Amp (150 Amp to Actiflo trailer and 60 Amp to Contact Tank related equipment); 1/0 AWG mining grade electrical cable; three (3) 3f wires and a ground for connection to the customer's end.

Water: One (1) garden hose connection located on driver's side of trailer towards the front and 100 ft of garden hose. The service water will supply water to the office sink and polymer batch system in the pilot unit trailer.

Screenings Removal: screenings generated by rotary drum screen shall collected and removed daily by plant personal.

4.0 PILOT PLANT TECHNOLOGY AND EQUIPMENT DESCRIPTION

4.1 PILOT UNIT SPECIFICATION

The Actiflo High Rate Treatment (HRT) technology, presented by Kruger/Veolia, has been selected for on-site demonstration. The pilot unit is containerized, with hookups for influent, effluent, and sludge streams.

The ActiFlo/ BioActiflo pilot unit equipment described in this section includes furnishing all labor, equipment materials, tools and incidentals required for a complete and operable HRT pilot unit installation, including, but not limited to, the equipment summarized in Table 3.

TABLE 3
ACTIFLO / BIOACTIFLO PILOT UNIT TECHNICAL SPECIFICATION

PARAMETERS	ACTIFLO
Model, Type	PP# 2, Pilot Trailer, with BioActiflo option
Vendor	Kruger/Veolia
Trailer Dimensions	53' x 8' x 13.5'
Flow Rates	202 – 310 gpm Nominal capacity: 50 gpm Operating Range: 25-125 gpm
Empty Weight	39,000 lbs
Operating weight	60,000 lbs
Process Capacity	Nominal: 202 gpm @ 32 gpm/ft ² ; Maximum Flow: 310 gpm @ 50 gpm/ft ² .
Volumetric Capacity	2,521 gal
Power Requirements	480V, 3-phase, 150 amps (Actiflo trailer) + 60 amps (Contact Tank)
Pretreatment Requirement	Screening (5/8") - required Grit removal is recommended
Water Requirements	2-4 gpm
Coagulant ⁽²⁾ Supply	Aluminum based, supplied by Manufacturer
Polymer	Yes, supplied by Manufacturer
Ballast Sand	Yes, supplied by Manufacturer
Solids Contact Tank (for BioActiflo)	6,000 gal capacity, with a drum screen

Table 3 cont'd:

Pilot Plant includes following equipment:	Two (2) submersible raw water feed pump, 300 gpm, equipped with VFD; One (1) submersible RAS feed pump, 20 gpm, equipped with VFD. Two (2) coagulant tanks equipped with two (2) coagulant tank mixers; One (1) maturation tank equipped with one (1) maturation tank mixer and one (1) draft tube. One (1) manual set of basket strainers One (1) tube/plate settling module One(1) rubber-lined sand recirculation pump; One (1) hydrocyclone (U-3); Contact Tank for BioActiflo, Volume ~ 4,000 gal One (1) magnetic flowmeter for continuous monitoring of raw water flow for ActiFlo; One (1) magnetic flowmeter for continuous monitoring of sand recirculation rate; Two (2) additional magnetic flowmeter for BioActiflo system provided: - one (1) for continuous monitoring of influent to Contact Tank; - one (1) for RAS to Contact Tank; Two (2) pH meters for raw water pH and coagulated water pH; Two (2) in-line turbidity meters for raw water and settled water turbidities (Make: HACH Optiquant); Two (2) dry/emulsion polymer makeup tanks, with mixers; Two (2) variable speed polymer feed pumps; One (1) coagulant chemical storage tank; One (1) pH adjustment chemical storage tank, with mixer One (1) variable speed pH adjustment feed pump One (1) MCC One (1) PLC based control panel
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In order to continuously operate the pilot unit, connections must be established between designated zones of the treatment plant to supply influent to and to receive effluent, and waste sludge from the pilot system. Scope of supply for the vendor and the City are summarized in the following Table 4.

TABLE 4

ACTIFLO / BIOACTIFLO HYDRAULIC AND POWER CONNECTION

Hydraulic Connections supplied by Kruger	Scope of Supply by the City of Lakewood WWTP
1. Influent:	
a. One (1) raw water submersible pump, VFD controlled. The pump is 3'-dia x 3'(H) and weighs ~ 300 lbs; comes with 70 foot power cord that is plugged into the pilot unit. b. 100 ft of 4" hose with male and female camlock connections; c. The pilot unit has one 4" female camlock raw water inlet connection located on driver's side of trailer towards the front; d. The submersible pump has a 4" male camlock discharge.	a. Equipment (backhoe, bobcat, forklift, etc.) to remove the raw water pump from the back of the pilot unit and place it in the raw water source. b. Additional cable and junction box to extend the power cable of the pump ~ 150 ft would be required. Refer to Table 2.5-1. c. 4" flexible hose with male camlock and female camlock fittings: ~150 ft from would be required. Refer to Table 2.5-1.
2. Process Sludge:	
a. 50 ft of 4" hose with male and female camlock connections; b. One (1) 4" female camlock discharge connections located on driver's side of trailer towards the rear; c. The pilot unit process sludge is approximately 12 gpm at 0.1-0.5% solids. The process sludge is gravity discharged with approximately 5 feet of head.	a. Additional 4" rigid hose to run the sludge from the pilot unit to the discharge site, L = 150 - 175 ft. b. Since the process sludge is gravity discharged it may need to be pumped to the sludge discharge site. If this is the case the client will need to supply a catch container and trash/sludge pump with float system.
3. Effluent:	
a. 50 ft of 6" hose with male and female camlock connections b. One (1) 6" female camlock connection located on driver's side of trailer over the rear axle. c. The pilot unit process settled water discharge is approximately 200 gpm with approximately 10 ft of head.	a. Additional 6" rigid hose L = 150 ft. b. The process settled water is gravity discharged and may need to be pumped to the discharge site. If this is the case the client will need to supply a catch container and discharge pump with a float system capable of handling the peak flow needed for the test.

Table 4 cont'd

4. Biosolids to Contact Tank (BioActiflo)	
a. Contact Tank provided by Vendor: 26'(L) x 7.3'(W) x 7'(H). b. 50 ft of 3" hose with camlock for RAS influent. c. Drum screen and blower.	a. Contact Tank needs to off loaded from flat bed and set on the leveled ground. The dead load of the Contact Tank is 12,000 lbs. Front end loader shall be provided for this work. b. Additional 3" hose L = 175 ft. c. 480V, 3 phase and 60 Amp power supply d. Roll-off bin to collect screenings and haul off daily.
5. Service Water	
a. One (1) garden hose connection located on driver's side of trailer towards the front and 100 ft of garden hose. b. The service water will supply water to the office sink and polymer batch system.	a. Pressurized potable water and a connection.
6. Laboratory Sink and Chemical Tank Drain	
a. 50 ft of 2" hose with male and female camlock connections b. One (1) 2" male camlock connection located on the driver's side of the trailer towards the front. c. The pilot unit laboratory sink and chemical drain water discharge is intermittent flow with approximately 4 ft of head.	a. Additional 2" rigid hose (if needed). b. The laboratory sink and chemical drain is gravity discharged and may need to be pumped to the discharge site. If this is the case the City of Lakewood supply a catch container and discharge pump with a float system capable of handling the peak flow needed for the test. It could also be easily combined with effluent or sludge if these items are also being pumped.
7. Electrical	
a. 70 ft, 480 Volt, 150 Amp electrical supply cable b. The electrical cable is 1/0 AWG mining grade cable. c. The electrical cable connection to the pilot trailer is a quick connection Hubbell plug located on the passenger side of the trailer towards the middle d. The electrical cable connection for the customer's end is consists of three (3) 3f wires and a ground. The diameter of the cable is 1.72 inches.	a. A 480 Volt, 150 Amp service and an electrician who will hard wire the cable to the supply. b. The client will need to supply any additional cable that is needed to reach the power supply.

5.0 FLOW MONITORING AND SAMPLE COLLECTION LOCATIONS

This section specifies the nature of samples to be taken as part of this testing protocol, as defined in the Standard Methods for the Examination of Water and Wastewater (1992).

Grab sampling refers to a sample collected at a particular time and place. This can represent only the composition of the source at that time and sampling point. Grab samples are relevant for semi-continuous systems or transient events such as the change in influent characteristics resulting from a storm event for a limited period of time. Grab samples of influent and effluent to be collected every 30 minutes to 1 hour frequency and for 4 hours a day by the pilot unit operator. Samples shall be sent by the City to a designated certified lab to analyze for the following parameters:

- Core parameters: TSS, BOD₅ (total and soluble), and E. coli.
- Treatability parameters: pH, alkalinity, temperature, TDS, soluble BOD and COD, total and soluble P, o-P, UV transmittance, VSS and particle size distribution. For soluble fraction of the parameters, samples must be filtered with 0.45 um filter.

Composite sampling refers to a mixture of several grab samples of equal volume collected at the same sampling point at different times. Composite sampling is relevant for establishing the average concentration that will be used in calculating loading rate, removal efficiency, etc. Composite sampling can be done for a continuous treatment system such as municipal WWTP. Flow weighted compositing of samples shall be performed or directions to perform shall be provided by the pilot operators based on the influent flow rate measured at various hours of that day.

Split Sampling: A sample that has been divided into two containers for analysis by separate laboratories. In the case of pilot testing, one sample should be given to LWWTP for in house analysis, and the other to an external certified analytical laboratory. Analysis of these samples provides an excellent means of identifying any discrepancies in the WWTP's analytical techniques and procedures when compared to results from the certified third party laboratory.

Chain of custody for the samples collected each day shall be performed by the pilot unit operators. Procurement of sample containers, sample storage, and shipment to the third party analytical laboratory shall be the responsibility of the City.

Testing parameters to be analyzed as part of the pilot testing, and the corresponding reference methodologies are summarized in Table 5. The following overall sampling approach will be applicable for the pilot testing:

1. During storm events or simulated storm related flow conditions, grab samples will be taken from the influent and effluent streams, once every 30 to 60 minutes;
2. During dry weather flow conditions, grab samples will be taken as described for the storm conditions. However, the samples can be composited if the flow conditions during the time of sampling are not significantly different from each other. The decision on whether or not to composite the samples can be made by the pilot unit operator based on the influent turbidity values recorded at the time of sampling.

TABLE 5
TESTING METHODOLOGY AND SAMPLE TYPE FOR CORE & SUPPLEMENTAL
PARAMETERS

Parameter	Reference or Methodology	Influent	Effluent	Dry Weather	Storm Weather
TSS	EPA 160.2 / SM 2540 D	X	X	C	G
VSS	EPA 160.4		X	C	G
CBOD5	EPA 405.1 / SM 5210 B	X	X	C	G
E. coli	EPA 1603	X	X	C	G
pH ^(a)	EPA 150.1	X	X	C	G
Temperature ^(a)	EPA 170.1	X		C	G
Turbidity ^(a)	EPA 180.1 / SM 2130 B	X		C	G
Alkalinity	EPA 310.2	X		C	G
UV Transmittance			X	C	G
Settleable Solids	EPA 160.5		X	C	G
Phosphorus	EPA 365.1	X	X	C	G

Notes:

(a) In-line analysis with instruments.

C – Composite sample

G – Grab sample

In-line monitoring (for pH, temperature and turbidity) and sampling is preferred instead of taking a sample from the selected source location. A sample port must be provided in the influent and effluent line for this purpose. Pilot operator is responsible for periodically noting down the in-line monitoring data.

Flow monitoring of influent and final effluent must be carried out continuously. Flow totalizer should also be utilized to collect aggregate flow data. The flow monitoring equipment shall be part of the vendor pilot units. Details of their flow monitoring methods, calibration procedures, and the data analysis, evaluation and QA/QC procedures should be documented by the pilot operator.

The City shall collect the rainfall data from a rain gage station located at the LWWTP in order to obtain rainfall intensity and duration. This data will give a perspective on the magnitude of rain event and how it affected the quality of influent to LWWTP.

Based on the flow rate data available for LWWTP, influent can be considered representative of a rain event when the flow rate reaches 16 MGD (11,111 gpm) or higher for a minimum duration of 40 minutes.

An assessment of the variation of actual storm-related influent quality (core and supplemental) throughout the storm event is necessary and shall be carried out by the City during the pilot testing period. It is particularly important to examine the incidence of peak concentration periods that may challenge the test equipment, except for the “first flush” or highly polluted segment of storm induced influent which should be sent to the main plant secondary treatment system. Ensure a means of communication between the City and the pilot operators regarding rain event/storm flow.

The nature of storm and the number of storm events to be used for testing must be defined by the Pilot Plant Operator in the experimental design. A correlation between the influent flow data and the rainfall measurements must be made to define the duration of a storm event.

Testing must try to capture the entire storm event induced influent quantity and quality conditions that the HRT is expected to treat. The following conditions must be included in the treatment protocol by the pilot system operator during storm event testing:

- a. Pilot equipment must be tested for one or more storm events;
- b. During each storm event, flow rate must be $\geq 60\%$ of the equipment capacity (Q_d) for any continuous period of a storm event, with a minimum of three times the hydraulic retention time. This hydraulic retention time is calculated using Q_d and the total volume of the test equipment as supplied by the manufacturer. Results from storm events should be reported discretely.

- c. Testing using storms producing influent flow rates < 60% of Q_d and for durations 3 x hydraulic retention time using Q_d (36 minutes as shown in Table 6) is acceptable. Results must be reported separately.

TABLE 6
FLOW RATE AND DURATION OF STORM EVENT FLOW TO PILOT UNIT

Parameter	Units	Value
Empty Weight	lb	39,000
Operating Weight	lb	60,000
Volumetric Capacity Estimate	gal	2,516
Maximum Flow Capacity, Q_d	gpm	310
60% of Q_d	gpm	190
HRT at 60% Q_d	min	13.2
3 x HRT at Q_d	min	39.73

For Actiflo pilot unit, storm related influent (actual or synthetic) must be delivered at a flow rate of 190 gpm or more for a period of at least 36 minutes. Table 6 summarizes the volumetric capacities of the pilot units and the duration and flow conditions to be maintained to represent storm events.

Flow meters are provided with the pilot system. Locations of flow meters provided are summarized below:

1. Influent line to the pilot unit;
2. Sludge recirculation line in the pilot unit;
3. Biosolids feed line to the Contact Tank when the pilot is run in BioActiflo mode; and,
4. Feed line from the Contact Tank to the pilot unit when it is run in BioActiflo mode.

The following generalizations are applicable regarding the pilot unit waste sludge flow rates:

1. Waste sludge generation rate will be 80% of the recirculation flow rate;
2. During Actiflo mode, recirculation flow rate will be 4 – 6% of influent flow rate; and,
3. During Bio Actiflo mode, recirculation flow rate will be 10 – 12% of influent flow rate.

Besides that of the regular influent (dry weather flow), the characterization of storm influent must be carried out by the City designated operator. A representative location to obtain storm influent must be determined and samples collected. Based on the storm influent characteristics, a suitable location shall be determined by the pilot unit operator (in consultation with CT) to draw influent to

simulate storm event. For LWWTP, water from the Primary effluent channel could be a representative stream of dilute influent for storm events. A part of the effluent sample from various operating conditions should be sent to an ultraviolet disinfection (UV) manufacturer for evaluation. The extent of light transmission through the sample at 254nm wavelength (%T, UV_{254}) is an indicator for the ability to provide disinfection.

If it is decided by the pilot plant operator and CT to employ simulated flows instead of natural storm flows for the purpose of verification testing, then its water quality must be characterized at a representative location. If the simulated flow were to be a blend of water from two different locations, then a sample mixture must be made up (by the pilot operator with assistance from the City) at the right proportion. This sample must be evaluated by comparing its characteristics with that of the storm flow. The right mixture will be developed by trial and error. Hydraulic load of the simulated influent can be constant or time varied to match storm flow characteristics. The simulated flow pattern must be documented and presented in the verification report and verification statement.

6.0 SCOPE OF WORK

6.1 SCOPE OF WORK BY KRUGER/VEOLIA

- A. Mobilize, deliver, set-up, demobilize and remove pilot plant
- B. Provide a trained Kruger/Veolia operator for 40 hours per week, during normal plant operations of 7 am to 4 pm, Monday through Friday, for duration of the pilot program.
- C. Arrange all transportation of pilot equipment and Kruger/Veolia operators.
- D. Develop work plan for pilot test with City and their consulting engineer.
- E. Meet with the City and consulting engineer to discuss site prep requirements for trailer.
- F. Provide coagulant, ballast and polymer for entire test period.
 - 1. If the pilot unit trailer does not include space for storing process chemicals, a separate container shall be brought in to the staging area. Size of this chemical trailer shall be determined based on the expected chemical consumption during the pilot run. Pilot vendor must provide an estimate of the chemical supplies containers to be stored in the staging area for the duration of the pilot run.
- G. Perform all sample collection as presented in Table 5.
- H. Provide split samples to the City to analyze for TSS, BOD, E. coli, and other identified parameters by their designated laboratory. Analysis of split samples will be at the City's expense.
- I. Provide technical support at site during the test period to ensure completion of a successful test program.
- J. Provide any necessary replacement parts that may be required to complete the pilot plant test program without delay in schedule.
- K. Daily summary logs at the end of each day of pilot operation shall be issued to the City and their engineer.
- L. Develop a comprehensive Pilot Report which details the results and conclusion of the trials and full-scale HRT system proposal shall be developed and issued in draft form within three weeks of completion of the trials.

6.2 SCOPE OF SUPPLY BY THE CITY OF LAKEWOOD WWTP

- A. One or two Lakewood WWTP personnel should be available on the first two days and the last day to assist Kruger/Veolia with connections and disconnecting hose and respond to logistical needs.

- B. Lakewood staff will not operate the pilot unit, but will regularly observe the pilot unit operation.
- C. Provide a secure and level area to accommodate the pilot plant trailer. The pilot plant will be located at 1699 Cleveland Metro Park Dr., Lakewood, OH 44107.
- D. Provide source of influent to be treated, caustic, and utilities for the entire pilot test program.
- E. Provide indoor location for storage of all chemicals.
- F. Provide containers for all split, grab and composite samples with appropriate preservation chemicals.
- G. Provide refrigerator space for storing samples.
- H. Supply 1-2 gpm of service water (garden hose) suitable for wash down / cleaning and polymer make-down purposes.
- I. Provide for laboratory analysis of all split samples desired for by either the City or their Consulting Engineer.
- J. With the exception of microsand, if the client wishes Kruger/Veolia to evaluate other coagulants, caustic (or other source of alkalinity) and polymers other than those provided by Kruger/Veolia, the source of those will be by other during the test period.
- K. The following accommodations in the Plant may be utilized by the Kruger/Veolia pilot operators, as needed:
 - Computer workstation and printer
 - Fax machine
 - Work room with tools and work benches
 - Small refrigerator and microwave
 - Bathroom facilities, including a shower
 - Lab scale/balance

7.0 IMPLEMENTATIONS SCHEDULE

Pilot Unit Delivery:	May 25 th , 2015
Duration of the pilot testing phase:	45 days* including the installation, startup, test run and decommissioning.
Pilot Study Trial Start Date:	May 28, 2015
* Days are defined as Monday through Friday unless stated otherwise.	

Pilot Trial End Date:	July 9, 2015 (30 days)
Pilot Plant Studies Report from Vendor:	August 10, 2015
Submit Basis of Design to EPA:	October 5, 2015

8.0 PILOT TEST PROTOCOL WORK PLAN

Experimental design must define the test conditions, performance measures, measurement requirements and data quality indicators for verification testing. Inputs to the experimental design must include the knowledge of equipment operation, site characteristics, influent characteristics, jar test results, and the verification testing objectives. The planned pilot program protocol is as follows:

1. Evaluate up to two coagulants, provide time permits: including: poly-aluminum chloride (PAC1-EPIC 58) or alum. The selection of the target coagulant will be based on the pilot unit operator's jar testing results.

***Note:** Vendor to be informed that ferric or ferrous ions are not to be used in the pilots because of issues with the type of diffusers at LWWTP. City currently uses Sodium Aluminate and has no issues. (City of Lakewood, Meeting Notes from 01/14/2015)*

2. Conduct jar tests to determine chemicals selection and their dosages, ballast dosages required for ensuring treatment efficacy. Jar testing must be carried out on at least one or two actual storm influent flow samples averaged for the storm event. If simulated flow is being used for the verification jar testing, jar testing shall be completed on both a simulated flow sample and an actual storm influent sample.
3. The first three days will be devoted to setting up the trailer and performing some minor modification and tunings to the process prior to system startup.

4. Develop dose response curves for each selected coagulant: One dosage for each selected coagulant shall be determined to produce best effluent quality, so that the low end capabilities of the process can be determined. Influent and effluent grab samples shall be taken for each dosage and analyzed for:
 - Alkalinity
 - Total Phosphorus
 - TSS
 - TBOD₅
 - pH and Temperature
 - Turbidity
5. Develop dose response curves for polymer: One dosage for polymer shall be determined to produce best effluent quality so that the low end capability of the process can be determined. Influent and effluent grab samples shall be taken for each dosage and analyzed for:
 - Alkalinity (typical total alkalinity 100-150 mgCaCO₃/L)
 - Total Phosphorus
 - TSS
 - TBOD₅
 - pH and Temperature
 - Turbidity (after Actiflo, typically 5 to 25 NTU)
6. Develop dose response curves for pH: The optimum pH for the selected coagulant shall be determined that achieves the best effluent quality so that the low end capabilities of the process can be determined. Influent and effluent grab samples shall be taken for each dosage and analyzed for:
 - Alkalinity (on a daily basis, measure once a day; if <100 mg/L, perform a pH curve)
 - pH and Temperature
 - Turbidity
7. For each selected coagulant, the pilot shall be run at a steady state for two (2) days. Sludge production rates will be measured during this operational scenario. Influent and effluent composite samples will be taken and analyzed as provided for in Table 7. Samples

will be composited manually during the course of each steady state day. At least 6 grab samples will constitute a composite sample.

8. For each selected coagulant, the flow will be increased for two – 4-hour periods (1/2 day) to determine the impact of changing flows. Coagulant and polymer dosing will be flow paced; all other variables will be kept constant. Influent and effluent composite samples will be taken and analyzed as provided for in Table 7. Samples will be composited manually during the 4-hour period. At least 4 grab samples will constitute the composite sample.
9. For each selected coagulant, the influent TSS concentration will be increased for two – 4-hour periods (1/2 day) to determine the impact of changing concentrations and ability for the HRT process to handle secondary clarifier upsets. Coagulant and polymer dosing will be flow paced; all other variables will be kept constant. Influent and effluent composite samples will be taken and analyzed as provided for in Table 7. Samples will be composited manually during the 4-hour period. At least 4 grab samples will constitute the composite sample.

Vendor shall collect and record operational information on a daily basis consisting of (but not limited to) the following items:

1. Flow (gpm)
2. Coagulant type and dose
3. Polymer type and dose
4. Caustic or Acid type and dose
5. Micro sand (ballast) concentration
6. RAS and WAS rates and underflow concentrations
7. pH
8. Influent and Effluent Turbidity

TABLE 7
PILOT PROGRAM PROTOCOL

Week	Day	Protocol	Analytical Lab Sampling	# Analytical Lab Samples	Bench Top Samples	Comments
A	B	C	D	E	F	G
1	1	Actiflo/BioActiflo Delivery & Setup	-	-	-	Unload and place contact tank with a crane, level the pilot trailer, make electrical connection, place valve and flow meter skids.
1	2	Actiflo/BioActiflo Setup	-	-	-	Unload and place Raw/Contact tank/RAS pumps with forklift, provide a hose connections, setup pilot lab, test raw/RAS pumps, calibrate contact tank TSS probe.
1	3	Actiflo/BioActiflo Setup				
1	4	Actiflo/BioActiflo Setup				
BIOACTIFLO (PRIMARY + RAS), CSO MODE						
2	1	<u>Coagulant Optimization:</u> - Influent after screen & contact tank; - Operate at a loading rate of 40 gpm/sft; - Flow Rate ~ 250 gpm with 12% of recirculation flow ~ 30 gpm; - Aluminum sulfate dose response curve with 6 points; - Hold polymer constant.	Grab Sampling: Influent (2) & Effluent (5 for each coagulant dose and 5 for each polymer dose) for – BOD, P, E. coli and TSS, and from Contact Tank (2) for for TSS / VSS.	From the pilot: 2+5+5+2=14 samples, Plus grab samples	Grab samples for UVT.	Collect 2 liters of each influent and effluent samples, and 1 liter of contact tank samples.
2	1	<u>Polymer Optimization:</u> - Influent after screen & contact tank; - Operate at a loading rate of 40 gpm/sft; - Flow Rate ~ 250 gpm with 12% of recirculation flow ~ 30 gpm. - Dose aluminum from coagulant curve. - Perform polymer curve over 5 point.				

Table 7 cont'd

A	B	C	D	E	F	G
2	2	<u>Steady State Run:</u> ▪ Influent after screen & contact tank; ▪ Operate at a loading rate of 40 gpm/sft; ▪ Flow Rate ~ 250 gpm with 12% of recirculation flow ~ 30 gpm; ▪ MLSS 1200 mg/L ▪ Contact Tank HRT = 20 min.	Composite Sampling: Influent & Effluent for - BOD, sBOD, P, TSS; eff E. coli (after UV); Sludge - TSS; Biosolids – TSS & VSS.	From the pilot: $2 \times 4 + 1 + 1 + 1 = 11$ Plus grab samples	Grab samples for UVT.	Collect 6 L of each sample; split each sample between the City lab (in-house analysis) and the certified analytical lab
2	3	<u>Steady State Run:</u> ▪ Influent after screen & contact tank; ▪ Operate at a loading rate of 40 gpm/sft; ▪ Flow Rate ~ 250 gpm with 12% of recirculation flow ~ 30 gpm; ▪ MLSS 1200 mg/L; ▪ Contact Tank HRT = 20 min.	Composite Sampling: Influent & Effluent for - BOD, sBOD, P, and TSS; eff. E. coli - (before and after UV); Sludge - TSS; Biosolids – TSS & VSS.	From the pilot: $2 \times 4 + 2 + 1 + 1 = 12$ Plus grab samples	Grab samples for UVT.	Collect 6 L of each sample; split each sample between the City lab (in-house analysis) and the certified analytical lab
2	4	<u>Steady State Run:</u> ▪ Influent after screen & contact tank; ▪ Operate at a loading rate of 40 gpm/sft; ▪ Flow Rate ~ 250 gpm with 12% of recirculation flow ~ 30 gpm; ▪ MLSS 1200 mg/L; ▪ Contact Tank HRT = 20 min.	Composite Sampling: Influent & Effluent for - BOD, sBOD, P, TSS; eff E. coli (after UV); Sludge - TSS; Biosolids – TSS & VSS.	From the pilot: $2 \times 4 + 1 + 1 + 1 = 11$ Plus grab samples	Grab samples for UVT.	Collect 6 L of each sample; split each sample between the City lab (in-house analysis) and the certified analytical lab
2	5	<u>Steady State Run:</u> ▪ Influent after screen & contact tank; ▪ Operate at a loading rate of 40 gpm/sft; ▪ Flow Rate ~ 250 gpm with 12% of recirculation flow ~ 30 gpm; ▪ MLSS 800 mg/L; ▪ Contact Tank HRT = 20 min.	Composite Sampling: Influent & Effluent for - BOD, sBOD, P, TSS; eff E. coli (after UV); Sludge - TSS; Biosolids – TSS & VSS.	From the pilot: $2 \times 4 + 1 + 1 + 1 = 11$ Plus grab samples	Grab samples for UVT.	Allow 3 hrs to switch MLSS from 1200 to 800 mg/L and for Coagulant & Polymer Optimization

Table 7 cont'd

A	B	C	D	E	F	G
3	1	<u>Steady State Run:</u> ▪ Influent after screen & contact tank; ▪ Operate at a loading rate of 60 gpm/sft; ▪ Flow Rate ~ 250 gpm with 12% of recirculation flow ~ 30 gpm; ▪ MLSS 800 mg/L; ▪ Contact Tank HRT = 20 min.	Composite Sampling: Influent & Effluent for - BOD, sBOD, P, and TSS; eff. E. coli - (before and after UV); Sludge - TSS; Biosolids – TSS & VSS.	From the pilot: $2 \times 4 + 2 + 1 + 1 = 12$ Plus grab samples	Grab samples for UVT	Collect 6 L of each sample; split each sample between the City lab (in-house analysis) and the certified analytical lab
3	2	<u>Steady State Run:</u> ▪ Influent after screen & contact tank; ▪ Operate at a loading rate of 40 gpm/sft; ▪ Flow Rate ~ 250 gpm with 12% of recirculation flow ~ 21 gpm; ▪ MLSS 800 mg/L; ▪ Contact Tank HRT = 20 min.	Composite Sampling: Influent & Effluent for - BOD, sBOD, P and TSS; eff E. coli (after UV); Sludge - TSS; Biosolids – TSS & VSS.	From the pilot: $2 \times 4 + 1 + 1 + 1 = 11$ Plus grab samples	Grab samples for UVT.	Collect 6 L of each sample; split each sample between the City lab (in-house analysis) and the certified analytical lab
3	3	<u>Steady State Run:</u> ▪ Influent after screen & contact tank; ▪ Operate at a loading rate of 40 gpm/sft; ▪ Flow Rate ~ 250 gpm with 12% of recirculation flow ~ 21 gpm; ▪ MLSS 400 mg/L; ▪ Contact Tank HRT = 20 min.	Composite Sampling: Influent & Effluent for - BOD, sBOD, P, and TSS; eff E. coli (after UV); Sludge - TSS; Biosolids – TSS & VSS.	From the pilot: $2 \times 4 + 1 + 1 + 1 = 11$ Plus grab samples	Grab samples for UVT.	Allow 3 hrs to switch MLSS from 1200 to 800 mg/L and for Coagulant & Polymer Optimization
3	4	<u>Steady State Run:</u> ▪ Influent after screen & contact tank; ▪ Operate at a loading rate of 40 gpm/sft; ▪ Flow Rate ~ 250 gpm with 12% of recirculation flow ~ 21 gpm; ▪ MLSS 400 mg/L; ▪ Contact Tank HRT = 20 min.	Composite Sampling: Influent & Effluent for - BOD, sBOD, P, and TSS; eff. E. coli - (before and after UV); Sludge - TSS; Biosolids – TSS & VSS.	From the pilot: $2 \times 5 + 1 + 1 = 12$ Plus grab samples	Grab samples for UVT.	Collect 6 L of each sample; split each sample between the City lab (in-house analysis) and the certified analytical lab
3	5	<u>Steady State Run:</u> ▪ Influent after screen & contact tank; ▪ Operate at a loading rate of 40 gpm/sft; ▪ Flow Rate ~ 250 gpm with 12% of recirculation flow ~ 21 gpm; ▪ MLSS 400 mg/L; ▪ Contact Tank HRT = 20 min.	Composite Sampling: Influent & Effluent for - BOD, sBOD, P, and TSS; eff E. coli (after UV); Sludge - TSS; Biosolids – TSS & VSS.	From the pilot: $2 \times 4 + 1 + 1 + 1 = 11$ Plus grab samples	Grab samples for UVT	Collect 6 L of each sample; split each sample between the City lab (in-house analysis) and the certified analytical lab

Table 7 cont'd

A	B	C	D	E	F	G
ACTIFLO (PRIMARY ONLY), CSO MODE						
4	1	<u>Coagulant Optimization:</u> ▪ Influent after screen; ▪ Operate at a loading rate of 60 gpm/sft; ▪ Flow Rate ~ 190 gpm with 6% recirculation flow; ▪ Aluminum sulfate dose response curve with 6 points; ▪ Hold polymer constant.	Grab Sampling: Influent (2) & Effluent (6 for each coagulant dose and 5 for each polymer dose, respectively) for - BOD, P & TSS.	2+6 = 8 samples	Grab Samples at each coagulant dose for: UVT.	▪ Coagulant dose point should be outside of trailer in order to achieve close to 2 minutes of coagulation time. Do not use static mixer just dosing spool. pH adjust as necessary. ▪ Collect 3 L of each sample. ▪ .
4	1	<u>Polymer Optimization:</u> ▪ Influent after screen; ▪ Operate at a loading rate of 60 gpm/sft; ▪ Flow Rate ~ 190 gpm with 6% of recirculation flow; ▪ Dose aluminum from coagulant curve; ▪ Perform polymer curve over 5 point.		2+5 = 7 samples		
4	2	<u>Steady State Run:</u> ▪ Influent after screen; ▪ Operate at a loading rate of 60 gpm/sft; ▪ Flow Rate ~ 190 gpm with 6% of recirculation flow; ▪ Dose aluminum & polymer at optimal dose.	Composite Sampling: Influent & Effluent for - BOD, sBOD, P, and TSS; eff. E. coli (after UV); Sludge - TSS.	From the pilot: 2x4+1+1 = 10 Plus grab samples	Grab samples for UVT.	▪ Coagulant dose point should be outside of trailer in order to achieve close to 2 minutes of coagulation time. Do not use static mixer just dosing spool. pH adjust as necessary. ▪ Effluent NTU goal of 3-5 NTU ▪ pH adjust as necessary
4	3	<u>Steady State Run:</u> ▪ Influent after screen; ▪ Operate at a loading rate of 60 gpm/sft; ▪ Flow Rate ~ 190 gpm with 6% of recirculation flow; ▪ Dose aluminum & polymer at optimal dose.	Composite Sampling: Influent & Effluent for - BOD, sBOD, P and TSS; eff. E. coli (before and after UV); Sludge - TSS.	From the pilot: 2x4+2+1 = 11 Plus grab samples	Grab samples for UVT.	Collect 6 L of each sample; split each sample between the City lab (in-house analysis) and the certified analytical lab

Table 7 cont'd

A	B	C	D	E	F	G
4	4	<u>Steady State Run:</u> - Influent after screen; - Operate at a loading rate of 60 gpm/sft; - Flow Rate ~ 190 gpm with 6% of recirculation flow; - Dose aluminum & polymer at optimal dose.	Composite Sampling: Influent & Effluent for - BOD, sBOD, P, and TSS; eff. E. coli (after UV); Sludge - TSS.	From the pilot: $2 \times 4 + 1 + 1 = 10$ Plus grab samples	Grab samples for UVT.	Collect 6 L of each sample; split each sample between the City lab (in-house analysis) and the certified analytical lab
4	5	<u>Steady State Run:</u> - Influent after screen; - Operate at a loading rate of 60 gpm/sft; - Flow Rate ~ 190 gpm with 6% of recirculation flow; - Dose aluminum & polymer at optimal dose.	Composite Sampling: Influent & Effluent for - BOD, sBOD, P and TSS; eff. E. coli (before and after UV); Sludge - TSS.	From the pilot: $2 \times 4 + 2 + 1 = 11$ Plus grab samples	Grab samples for UVT.	Collect 6 L of each sample; split each sample between the City lab (in-house analysis) and the certified analytical lab
5	1	<u>Steady State Run:</u> - Influent after screen; - Operate at a loading rate of 60 gpm/sft; - Flow Rate ~ 190 gpm with 6% of recirculation flow; - Dose aluminum & polymer at optimal dose.	Composite Sampling: Influent & Effluent for - BOD, sBOD, P, E. coli and TSS; Sludge - TSS.	From the pilot: $2 \times 5 + 1 = 11$ Plus grab samples	Grab samples for UVT.	Collect 6 L of each sample; split each sample between the City lab (in-house analysis) and the certified analytical lab
5	2	TBD	-	-	-	-
5	3	TBD	-	-	-	-
5	4	Pilot Breakdown	-	-	-	-

Notes:

1. CSO estimated coagulant: 50-150 mg/L
2. CSO estimated polymer: 0.6 – 1.5 mg/L
3. Sludge: Waste sludge from Actiflo/BioActiflo Pilot Unit
4. Biosolids: Solids in Contact Tank after combining RAS with influent stream

9.0 REPORTING AND FOLLOWUP

The pilot testing is expected to be completed during the first week of July 2015. Analytical results for all the samples taken during the pilot run should be made available to CT by the third week of July. CT will analyze the results and ascertain if the pilot system was able to consistently meet the treatment objectives (as explained under section 3.1 of this report) both under dry weather and wet weather flow conditions.

With the results from both the Actiflo and BioActiflo mode of operation, the following questions shall be addressed:

1. Will it be necessary to have Bio Actiflo configuration or is Actiflo sufficient in order to achieve the required effluent quality?
2. If Bio Actiflo is needed, what is the optimum TSS/VSS needed in the contact tank in order to achieve effluent soluble BOD concentration of 40 mg/L?
3. How much lead time and effort is involved to tune up the pilot unit to handle wet weather flow and to reach steady-state effluent?
4. What is the operating cost (utilities, chemicals and labor) per unit volume of wastewater handled by the pilot unit?
5. Has there been any limitation in LWWTP with respect to influent supply to or effluent/sludge receipt from the pilot unit during the study period?

After sufficiently evaluating the suitability of an HRT system to LWWTP, the data from the pilot run will be used towards scale-up from pilot system to full scale system to handle overflow stream. Further, SWMM simulations shall be repeated with the pilot data to check if it will be possible to limit the number of overflow events to less than four per year.

APPENDIX A

Final Effluent Limits And Monitoring Requirements for Lakewood WWTP Outfall NPDES 3PE00004001

Final effluent limits and monitoring requirements for Lakewood WWTP outfall 3PE00004001 and the basis for their recommendation

the basis for their recommendation.						
Effluent Limits						
		Concentration		Loading (kg/day)		
Parameter	Units	Monthly Average	Daily Maximum	Monthly Average	Daily Maximum	Basis ^b
Flow Rate	MGD	-----	Monitor-----	-----	-----	M ^c
Water Temperature	°C	-----	Monitor-----	-----	-----	M ^c
Dissolved Oxygen	mg/L	-----	Monitor-----	-----	-----	PD
Total Suspended Solids	mg/L	20.0	30.0 ^d	1363	2044 ^d	PD
CBOD ₅ ^e	mg/L	15.0	23.0 ^d	1022	1567 ^d	PD
Phosphorus	mg/L	1.0	1.5 ^d	68.0	102 ^d	PT
Phosphorus ^f	mg/L	----- Seasonal Calculated Loading of 0.7 -----				BEJ
Chemical Oxygen Demand	mg/L	-----	Monitor-----	-----	-----	PD
Total Filterable Residue	mg/L	-----	Monitor-----	-----	-----	BEJ
pH	S.U.	-----	6.5 to 9.0	-----	-----	WQS
Oil and Grease	mg/L	----- Not to exceed 10 at any time -----				WQS, BEJ
<i>E. coli</i> (Summer Only)	#/100 mL	126	284 ^d	--	--	WQS
Mercury	ng/L	23.0	1700	0.00157	0.12	VAR
Silver	µg/L	-----	Monitor-----	-----	-----	RP, BEJ
Copper	µg/L	-----	Monitor-----	-----	-----	M ^c , RP
Total Kjeldahl Nitrogen	mg/L	-----	Monitor-----	-----	-----	BEJ
Ammonia	mg/L	-----	Monitor-----	-----	-----	BEJ
Nitrite + Nitrate	mg/L	-----	Monitor-----	-----	-----	M ^c
Free Cyanide	mg/L	-----	Monitor-----	-----	-----	M ^c
Nickel	µg/L	-----	Monitor-----	-----	-----	M ^c
Zinc	µg/L	-----	Monitor-----	-----	-----	M ^c
Cadmium	µg/L	-----	Monitor-----	-----	-----	M ^c
Lead	µg/L	-----	Monitor-----	-----	-----	M ^c
Chromium	µg/L	-----	Monitor-----	-----	-----	M ^c
Dissolved Hexavalent Chromium	µg/L	-----	Monitor-----	-----	-----	M ^c
Whole Effluent Toxicity						
Acute Toxicity	TU _a	-----	Monitor-----	-----	-----	WET
Chronic Toxicity	TU _c	-----	Monitor-----	-----	-----	WET

^a Effluent loadings based on average design discharge flow of 18 MGD.

^b Basis Definitions

BEJ	Best Engineering Judgment
M	BEJ of Permit Guidance 1: Monitoring Frequency Requirements for Sanitary discharges
PD	Plant Design Criteria
PT	Phosphorus treatment required under OAC 3745-33-06(C)
RP	Reasonable Potential for requiring water quality-based effluent limits and monitoring

- requirements in NPDES permits [OAC 3745-33-07(A)]
- VAR Mercury variance-based limits [OAC 3745-33-07(D)(10)]
- WLA Wasteload Allocation procedures (OAC 3745-2)
- WQS Ohio Water Quality Standards (OAC 3745-1-07)
- WET Minimum testing requirements for whole effluent toxicity [OAC 3745-33-07(B)(11)]
- ^c Monitoring of flow and other indicator parameters is specified to assist in the evaluation of effluent quality and treatment plant performance
- ^d Weekly average limit
- ^e Five-day carbonaceous biochemical oxygen demand
- ^f Loading calculations are described in Part II, Item AF of the permit.

APPENDIX B

Kruger Jar Testing Water Sample and Raw Water Sampling Procedure



Jar Testing Water Sample Form

Project Name: _____
 Project Number: _____
 Date Shipped: _____

Water Sample Matrix: _____
 Volume of Sample: _____
 Packaging: _____

INITIALS	DATE	
		Client/Customer a. Name : _____ b. Address : _____ c. City : _____ d. State : _____ e. Zip Code : _____ f. Phone : _____
		Kruger Personnel Contact a. Name : _____ b. Phone : _____

REQUIRED NAME FOR VERIFICATION OF SAMPLE COLLECTED AND RECEIVED

COLLECTED BY: _____

RECEIVED BY: _____



I. Kruger Inc.
4001 Weston Parkway
Cary, NC 27513

TELEPHONE 919-677-8310
FACSIMILE 919-677-0082

Sampling Procedure for Jar Testing:

Materials and Methods How To Collect :

NOTE: To minimize contamination, rinse out the container with the sample prior to making the final collection.

- **Drinking Water Source:** Sample should be representative of the raw water source and should be obtained prior to chemical treatment
- **Wastewater Source:** Sample should be representative of the raw water source and should be obtained after screening and prior to chemical treatment.
- **Typical Collection Procedure**
 1. Use 5 gallon collapsible plastic "camping containers" (found at Wal-Mart)
 2. Funnel to fill containers neatly
 3. Rectangular coolers with wheels if possible which can hold two 5 gallon containers, coolers with wheels will be easier to handle
 4. Blue Ice or leak safe bagging filled with ice, Frozen Blue Ice preferred

Required Sample Size:

- Collect minimum of 10 gallons for standard testing
 1. Minimal screening of chemicals (Coag, polys, PAC, oxidizers, etc.)
 2. Minimal screening of dosages
 3. Minimal analysis for lab (NTU, pH, TOC, TP, etc.)
- Collect minimum 20 gallons for extensive testing
 1. Significant testing chemistries (Chemical types, chemical dosages, pH levels, oxidation, filtration, water types/blends, full-scale plant simulation, etc.)
 2. Significant analysis for lab (TSS, TP, OP, TOC, DOC, BOD, Metals, etc.) requiring large treated water volumes

Maximum Hold Times Prior to Testing From Collection (On Ice or Refrigerated and Air Tight Seal:

- Surface/Ground Water: 8 Days
- WW: 3 Days
- Sludge: 1 Day or Onsite
- IW: Can be kept up to a couple of weeks depending on characteristics, this is case by case

Labeling:

Samples must be properly labeled with a waterproof marker that will not wash off during transport or handling. Sample location must be legible and should be recorded with the date sampled and the name of the collector.

Kruger Jar Testing Water Sample Form must be affixed to the outside of the shipping container in order to be received in the Kruger lab in North Carolina.



I. Kruger Inc.
4001 Weston Parkway
Cary, NC 27513

TELEPHONE	919-677-8310
FACSIMILE	919-677-0082

Chemical Preference:

1. Polymer: If the plant has a polymer currently being used on site and would like to have it tested, please ship 100 mL sample with the water sample(s).
2. Coagulant: If the plant has a coagulant currently being used on site and would like to have it tested, please ship 100 mL sample with the water sample(s).
3. Chemical X: If the plant uses a preferred chemical and would like to have it tested, please ship appropriate amount to do testing.

Shipping:

Ensure that the sample is properly sealed and does not leak. Transit time is an important factor that can influence the water quality. All sample(s) should be delivered overnight to Kruger.

Sample shipments must be coordinated with Kruger (Jeff Privott) prior to shipment and are accepted Monday – Thursday between 8:00 AM and 4:00 PM.

NOTE: Shipments received on Friday will not be tested until the following Monday and may not be representative of the true application due to the weekend time lapse.

Ship to Address:

I. Kruger Inc.
Attn: Jeff Privott/Water Samples
1500 Garner Rd. Suite C
Raleigh, NC 27610
T: 888-KrugerUSA (888-578-4378)

Attachment E
High Rate Treatment Basis of Design

Basis of Design Memorandum High Rate Treatment Facility

September, 2016

CLEAN WATER LAKEWOOD



Rebuilding the Pipeline for Our Future

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CHAPTER 1 - INTRODUCTION

1.1 PURPOSE

The purpose of this Basis of Design Memorandum is to provide initial design parameters for a High Rate Treatment Facility (HRT system) for treatment of the wet-weather flow at the City of Lakewood WWTP, Ohio. The City of Lakewood (City) was issued a National Pollutant Discharge Elimination System (NPDES) Permit by the Ohio Environmental Protection Agency (OEPA) regarding discharges to the waters of the State of Ohio from the City's Wastewater Treatment Plant (WWTP). The City of Lakewood is required by the Ohio NPDES permit to address the CSO overflows, particularly CSO 002, outfall 3PE00004002 located nearest to the plant.

The City of Lakewood is committed to provide the HRT system for treatment of flows in excess of the WWTP hydraulic capacity, which occur during wet-weather conditions. As a part of the effort to develop of basis of design for a HRT system to control overflows, the City has initiated and completed the following steps:

- A. Conducted unified selection process based on five (5) leading Wet Weather High Rate Treatment systems manufactures presentations. From these presentations, the City and their Design Professionals have selected two (2) manufacturers each with two (2) treatment processes: Veolia-Kruger with ACTIFLO[®] and BIOACTIFLO[®] and Infilco Degremont, Inc. with DensaDeg[®] and DensaDeg XRCTM, and invited them to perform side-by-side pilot studies at the LWWT. The manufacturer Infilco Degremont, Inc. declined participation in the pilot study so the City of Lakewood has chosen the ACTIFLO[®] and BIOACTIFLO[®] processes for further study.
- B. Developed a Pilot Plant Protocol for piloting ACTIFLO[®] and BIOACTIFLO[®] systems, presented by the manufacturer Veolia-Kruger.
- C. Conducted a pilot testing program during a six (6) week period from June 3 through July 19, 2015 to assess the performance of ACTIFLO[®] and BIOACTIFLO[®] wet weather HRT systems.
- D. Reviewed collected data during the Pilot Plant testing and provided a Pilot Plant Report assessing the performance of the ACTIFLO[®] and BIOACTIFLO[®] HRT processes.
- E. Developed and evaluated six (6) HRT system layout alternatives.

1.2 HIGH RATE TREATMENT FACILITY BASIS OF DESIGN

The LWWT is an activated sludge based wastewater treatment plant. It is designed to treat an average day designed flow of 18 MGD (dry-weather flow), and the sustained peak primary and secondary treatment capacity for wet-weather flows of 30 MGD. The LWWT influent parameters are provided in Table 1-1.

Table 1-1: Lakewood WWTP Influent Parameters

Parameter	Units	Annual	Wet Weather
ADDF	MGD	18	-
ADF	MGD	7.33	16
MDF	MGD	38.25	38.25
TSS	mg/L	140	67
CBOD	mg/L	110	48.2

The flow rate to be handled by the wet weather HRT system has been estimated using the Storm Water Management Model (SWMM). The full-scale HRT system design capacity is sized to handle 35 MGD and located within adjacent to the LWWTP. During wet-weather events, flows in excess of 30 MGD will be diverted to the ACTIFLO® HRT facility. Therefore, combined wet-weather treatment capacity at City of Lakewood WWTP and proposed HRT facility will be rated 65 MGD.

The LWWTP wet stream processes consist of fine screening, grit removal, primary clarification, aeration and coagulation, conventional activated sludge, secondary clarification, and UV disinfection. Solids streams process for the primary solids and secondary waste activated sludge consist of solids thickening tank, primary and secondary anaerobic digesters. The LWWTP flow diagram is shown on Figure 1.1.

The HRT pilot study effluent quality indicated that the HRT may be able to meet the NPDES permit effluent limits as shown in Table 1-2 but under full scale operation would be expected to meet the probable limits proposed by the Ohio EPA as shown in Table 1-3. The effluent loadings listed in this table are calculated based on average design wastewater flow of 18 MGD.

Table 1-2: Lakewood WWTP Final Effluent Limits, Outfall NPDES Permit No. 3PE00004001

Parameter	Concentration, mg/L		Loading (lbs/day)	
	Monthly	Weekly	Monthly	Weekly
TSS	20.0	30.0	3002.40	4503.60
CBOD5	15.0	23.0	2251.80	3452.76
Phosphorus	1.0	1.5	150.12	225.18
pH	6.5 – 9.0			
E. coli (summer only)	126 #/100 mL	284 #/100 mL	--	--

Table 1-3: Summary of Pilot Study Average Treated Effluent Parameters

Parameters	Effluent Quality	
	ACTIFLO®	Ohio EPA Probable Limits
TSS, mg/L	13.0±1.6	30
CBOD ₅ , mg/L	12.0±1.3	-
Phosphorus, mg/L	0.17±0.06	-
<i>E. coli</i> , CFU/100 mL	15.0±4.2	126 / 284 ⁽¹⁾

Notes:

- 1) *E.coli*: 126 colony forming units (CFU)/100 mL during recreational season geometric mean and 284 CFU/100 mL of rolling geometric mean for each 7-day period.

The estimated weighted average loading rate, obtained during the wet weather events for the combined total flow of 65 MGD, WWTP and HRT facilities, is shown in Table 1-4 and is based on the following:

1. The WWTP primary and secondary treatment:
 - a. Peak Hourly Flow: 30 MGD
 - b. Treated effluent solids loading rates are based on weekly loads of TSS, CBOD₅ and phosphorus as shown in Table 1-2 above.
2. ACTIFLO® HRT system:
 - a. Max wet weather flow rate: 35 MGD
 - b. Treated effluent solids loading rates for TSS, CBOD₅ and phosphorus are as shown in Table 1-3 above.

Table 1-4: Summary of Estimated WWTP Treated Effluent Solids Loadings for 65 MGD Peak Hourly Wet Weather Flow

WWTP Treatment	Flow Rate, MGD	Weighted Average	7-Day Loadings					
			TSS,		CBOD,		Phosphorus,	
			mg/L	lbs/day	mg/L	lbs/ day	mg/L	lbs/day
Primary+Secondary	30	46%	8.3	2,072	6.3	1,588	0.1	25
ACTIFLO®	35	54%	7	2,049	6.5	1,891	0.4	104
Total	65	-	7.6	4,121	6.4	3,479	0.24	129

Based on the pilot study results and projections for the full HRT system designed to treat 35 MGD wet weather flow, estimated effluent loading rates are in compliance with the probable HRT effluent limits. The summary of the HRT influent and effluent parameters are provided below:

Table 1-5: Lakewood Wet Weather HRT Influent / Effluent Design Parameters

Parameter	Units	Influent	HRT Effluent, Limits
Max Wet Weather Flow	MGD	35	-
Average TSS, mg/L	mg/L	100	40
Average CBOD ₅ , mg/L	mg/L	37	-
Phosphorus, mg/L	mg/L	4	-
<i>E. coli</i> , CFU/100 mL	-	-	126 / 284

1.3 HRT SYSTEM IMPLEMENTATION

The HRT system is designed as a high-rate physical/chemical ACTIFLO[®] process, capable of treating wastewater during dry-weather flows, operating as nutrient removal facility, and also treating peak wet-weather flows during wet weather periods. The ACTIFLO[®] process is capable of intermittent operation with short start up and shut down times, and designed with two parallel trains which will provide maximum operational flexibility of running one or both trains depending on the wastewater flow.

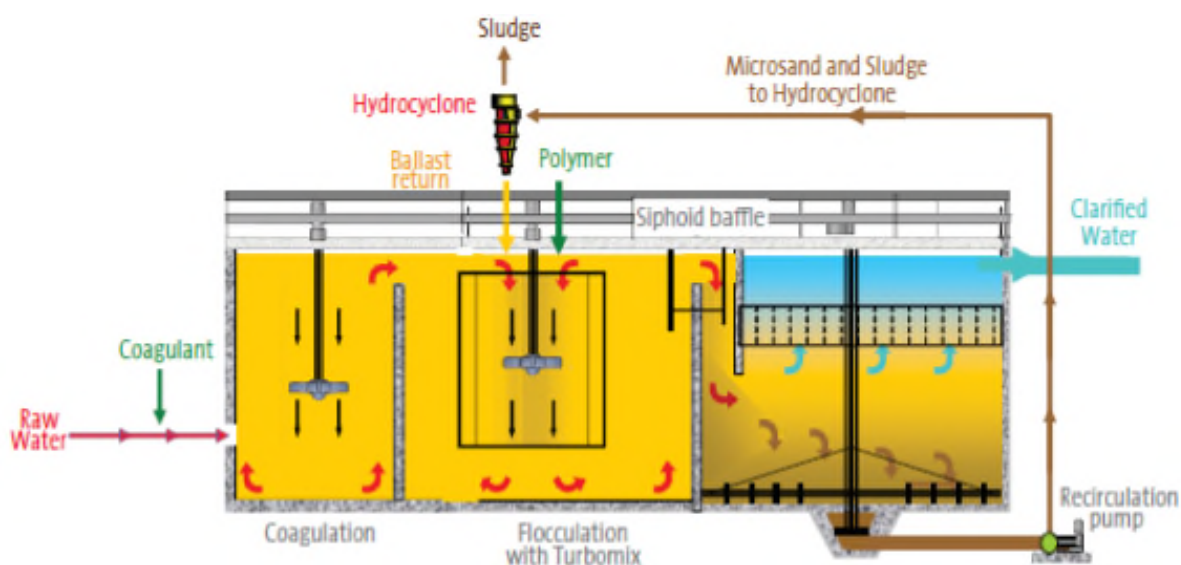


Figure 1-1: Veolia's ACTIFLO[®] High Rate Treatment Process

The ACTIFLO[®] process combines two water treatment technologies: ballasted flocculation and plate settling. The six (6) HRT system alternatives were reviewed and evaluated based on the location and number of ACTIFLO[®] trains. The HRT system in Alternatives No 1-5 was located on the northwest side of the existing Headworks Building, and in Alternative No 6 on the east side.

First, the ACTIFLO® and BIOACTIFLO® HRT treatment options were evaluated based on treatment efficiency, capital and Operation & Maintenance costs, and constructability economic analysis and with biological treatment, the BIOACTIFLO® process which combines biological treatment with the ACTIFLO® ballasted flocculation high-rate clarification. Biological treatment is provided by a solids contact basin which is used ahead of the ACTIFLO® high-rate clarification.

The variations for each developed HRT system alternative were as follows:

1. BIOACTIFLO® and single train of ACTIFLO®, located on northwest side.
2. BIOACTIFLO® with two (2) trains of ACTIFLO® system, located on northwest side.
3. BIOACTIFLO® with three (3) train ACTIFLO® system, located on northwest side.
4. ACTIFLO® with a single train, located on northwest side.
5. ACTIFLO® with two (2) parallel trains, located on northwest side.
6. ACTIFLO® with two (2) parallel trains, located on east side

Each of these alternatives included a new headworks building with the screen and grit removal processes prior to BIOACTIFLO®/ACTIFLO® treatment and new UV disinfection. The limitations of these alternatives were:

- Space constraints, preventing from future expansion
- Potential problem for influent flow splitting between the WWTP and new HRT system
- Hydraulics
- HRT system constructability near existing processes equipment.
- Accessibility

Alternative No. 6 is the preferred, with the HRT system located directly east of the existing Headworks Building, with the new Headworks Building mirroring the existing Headworks Facility. Refer to Figures 1.1 through 1.3. This option includes:

- New influent mixing chamber
- New Headworks Facility with the screen and grit removal
- ACTIFLO®, 2 parallel trains
- UV Disinfection
- Effluent Diversion Chamber
- New siphon piping

Based on HRT Pilot Study Report stating that ACTIFLO® achieves the desired effluent quality at lower operational cost than BIOACTIFLO®, has smaller footprint and smaller maintenance cost. The ACTIFLO® system is recommended over BIOACTIFLO® as preferred HRT system (Alternative 6A).

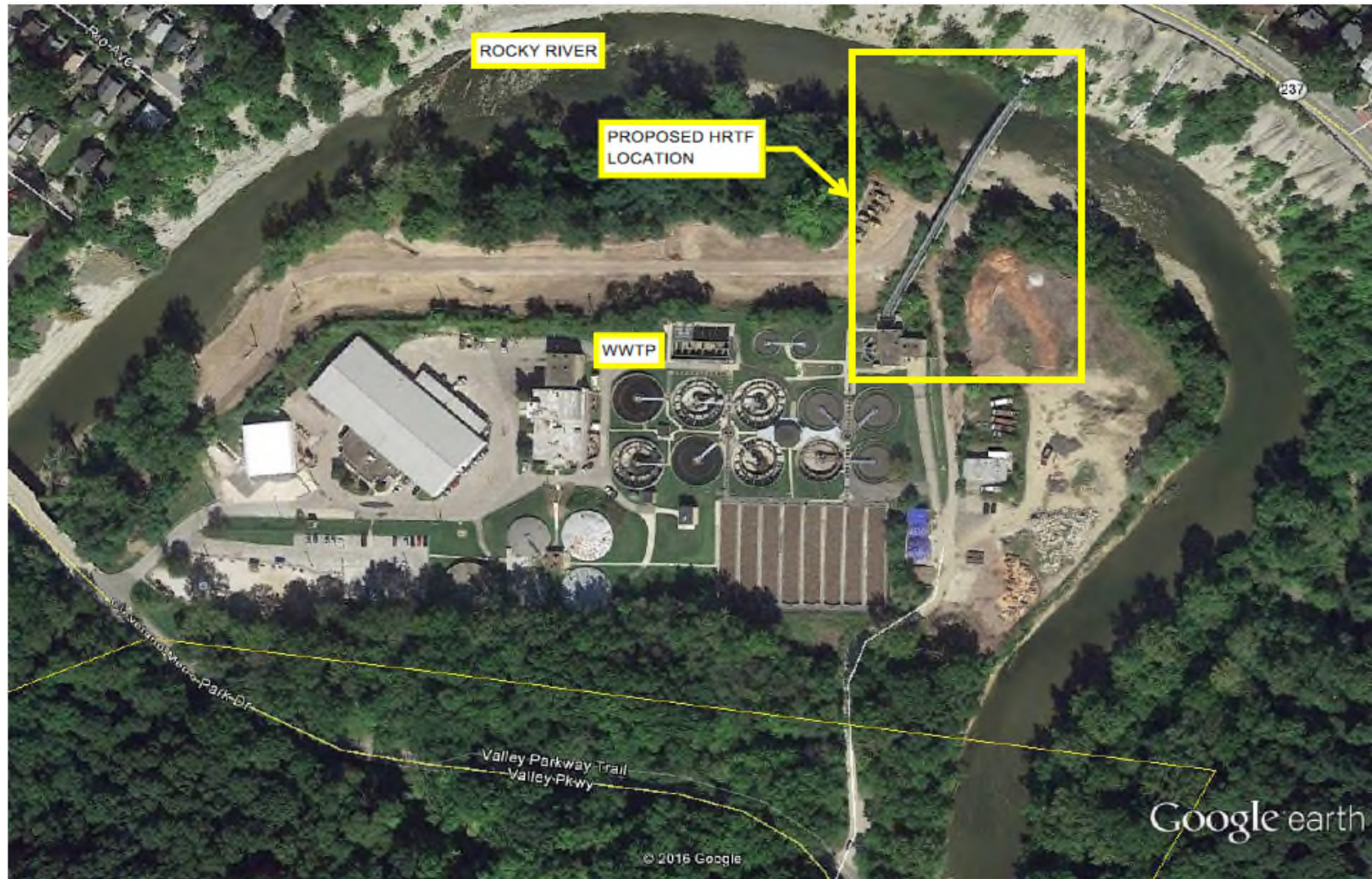


Figure 1-2: Aerial View of Lakewood WWTP with Proposed HRT System Location

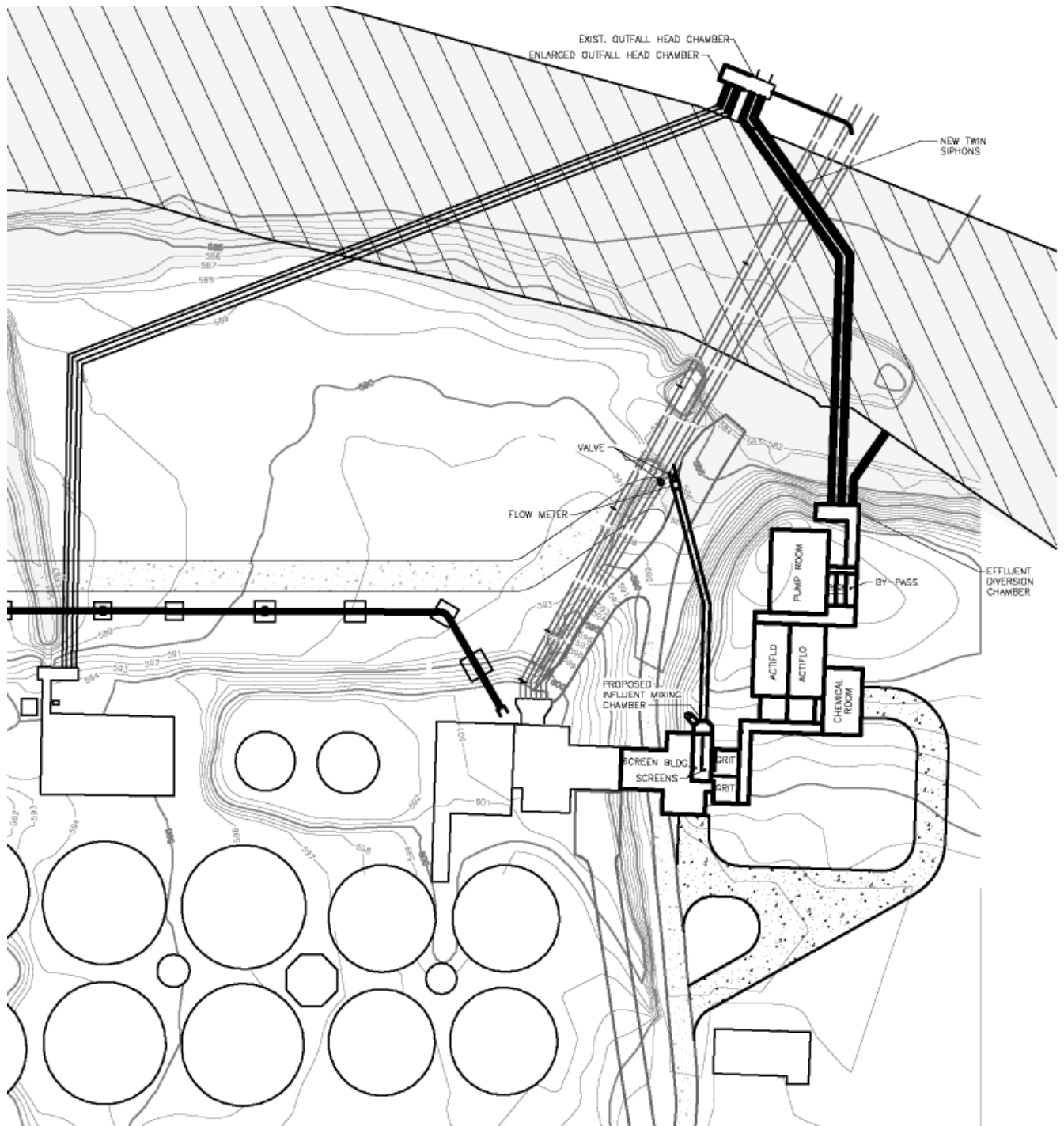


Figure 1-3: Alternative No. 6 HRT System Layout

The Alternative No. 6A offers the most operational flexibility by providing two (2) parallel treatment trains and convenience of construction. Three options are being considered to divert the high rate storm flows to the HRT system. Two options involve an installation of a new 48" diameter aerial sewer from the existing aerial sewer and the other would be a channel or pipe from the Influent Mixing Chamber. Refer to Chapter 3 for detailed discussion.

The new Headworks Facility includes dual screen influent channels with self-cleaning mechanical screens (Aqua Guard® UltraClean™ by Parkson Corporation) installed in each channel with a dedicated washer compactor unit (Aqua WashPress® by Parkson Corporation) under each screen. This arrangement is similar to the existing headworks facility and also provides redundancy for operation. The choice of equipment will also match existing plant equipment for operation and maintenance ease. Each screen capacity is sized to handle a peak flow of 35 MGD. Slide gates will be installed upstream and downstream of each screen to provide flow control and isolation of each screen during its maintenance. Ultrasonic level transducers will be provided to control screen and washer compactor operation (cleaning/washing cycle).

The screened wastewater flow after the screens is directed to the Grit Facility. The Grit Facility will consist of two hydraulically driven grit removal systems (Eutek HeadCell® by Hydro International). The separation of grit from the influent is accomplished using a series of polyethylene conical plates that are stacked to allow for a large amount of surface area in a small footprint. The polyethylene settling trays are submerged in a concrete chamber. Wastewater is introduced to each settling tray tangentially by a distribution header that provides equal distribution of flow. The induced vortex flow pattern causes solids to settle on the trays which then direct the solids to a collection sump for removal. Degritted wastewater flows out of the trays and into the grit chamber where it then flows over an effluent weir. Volatile solids are typically too large to settle on the trays and pass through the system. The settling trays have a hydrophobic surface that minimizes grease buildup and keeps them clean. Figure 1.4 below shows an illustration of the HeadCell® equipment.

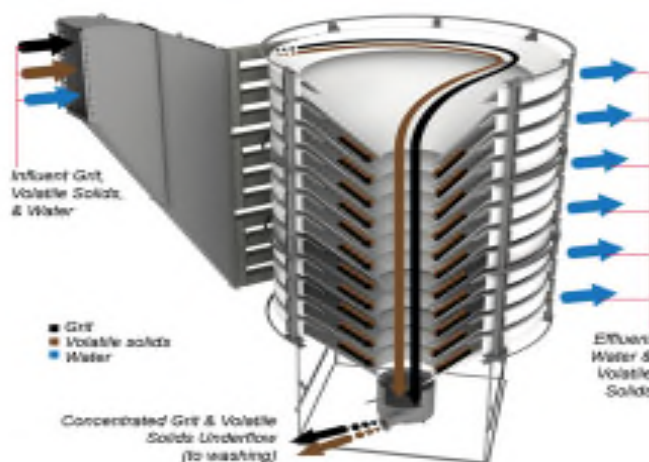


Figure 1-4: Headcell® Grit Removal System

The Eutek HeadCell® provides high removal efficiency, removing:

- 99.5% of 150 mesh size grit particles,
- 60% and more of total solids removal and
- 15% or less of volatile solids removal.

The HeadCell® has low energy consumption, accommodates high turndown ratios, has no internal particles, and with small process footprint provides large surface area.

The HRT system general equipment list, process equipment capacities and estimated power requirements is provide in Table 1-8 below.

1.4 HRT SYSTEM SOLIDS HANDLING

The HRT system is expected to generate a solids flow rate of 0.515 MGD (360 GPM) at the 35 MGD treatment rate with a 1% peak solids content. The peak solids content is based on the maximum generated from the pilot testing conducted by Viola-Kruger during June of 2015. The average solids content was estimated to be 0.8% during the pilot study.

Since the sludge flow generated by the HRT system has already been screened and de-gritted it could be sent directly to the Primary Setting Tanks. The LWWTTP sustained peak primary and secondary treatment capacity for wet-weather flows will be 30.0 MGD. If the HRT system solids are transferred directly to the Primary Settling Tanks the flow rate through the primaries will only increase 1.7%.

Table 1-6: HRT Sludge Flow to Primary Tanks

Maximum Flow	MGD	GPM	Percent
Existing WWTP Influent	30.0	20,833	98.3
HRT System Sludge	0.515	360	1.7
Total	30.515	21,193	100.0

Table 1-7: HRT Effect on Primary Clarifiers Surface Overflow Rate (SOR)

Flow Source	SOR (GPD/SF)	SOR 10-States Standards at PHF Rate (GPD/SF)
Existing WWTP Influent	2,260	-
HRT System Sludge	39	-
Total	2,299	2,000

The Primary Setting Tanks have a calculated peak Surface Overflow Rate (SOR) of 2,260 gallons per day per square foot (GPD/SF) based on 30 MGD. The HRT system sludge flow will contribute an additional 39 GPD/SF yielding a total of 2,299 GPD/SF. The calculated SOR exceeds the 10-States Standards recommended design standard of 2,000 GPD/SF. However, a stress test conducted in 2007 concluded that the clarifiers could handle a sustained flow rate of 3,014 GPD/SF with no notable increase in solids carry-over.

The 0.8% average dry weight solids estimated to be generated by the HRT system is equivalent to 30 grams dry solids per gallon or 0.0661 pounds dry solids per gallon. At the 35 MGD (360 GPM) flow rate the additional solids will be 24 pounds dry solids per minute or 17.3 tons dry solids per day. This will be the estimated average additional load sent to the Anaerobic Digesters when the HRT system is in operation.

Table 1-8: HRT System General Equipment List

№	Equipment	No. of Trains	No. of units per Train	Size	Capacity, per unit	Drive, Hp		Manufacturer
						per unit	Total	
1.	Screening							
	Screen	2	1	5.5' x 13'x 75deg Openings spacing: 6 mm	35 MGD	2	4	Parkson, Aquaguard: AGUC-MN-A
	Screen Press	2	1			2	4	Parkson, Aqua Press: AWP8-4
2.	Grit Removal							
	Grit Tanks	2	1	12'-dia x 19' H	27 MGD	-		HydroGrit
	Grit Pump	2	1	-	250 gpm	15	30	--
	Grit Classifier	1	-	-		1	1	--
	Solids Conveyor	1	-	-		1	1	--
3.	ACTIFLO System							
	ACTIFLO	2	1		17.5 MGD	-	-	Kruger
	Coagulation Tank Mixer	2	1	20' x 20' x 28'	-	12.5	25	--
	Maturation Tank Mixer	2	1	11.4' x 20' x 28'	-	1-5	30	--
	Settling Tank Scraper	2	1	29.5' x 20' x 28'	-	5	10	--
	Sand Recirculation/Sludge Flow Pump	2	3	-	550 gpm	50	300	--
4.	Disinfection System							
	UV Disinfection	2	1	13.5'(L)x4.3'(W) x 7.5'(D) 2 banks per channel, 72 lamps total	17.5 MGD	13.4	26.8	Trojan

CHAPTER 2 - IDENTIFICATION OF AFFECTED UTILITIES

2.1 UTILITY INTERFERENCES

A thorough review was conducted of existing WWTP drawings from past and current projects. The site plans in the following drawing sets were reviewed:

- Improvements to Sewage Treatment Plant, August 1938 (MacDowell)
- Sewage Treatment Plant Improvements, 1961 (Woodruff)
- Treatment Plant and Outfall EPA Project No. C391184-03, 1980 (Watermation, Inc.)
- Disinfection Improvements, June 1993 (Benza)
- Aerial Sewer and Headworks Improvements, December 2001 (URS)
- Secondary Digester Improvements, 2009 (CT Consultants)
- West End CSO Elimination Project, 2015 (CT and AECOM)

The review indicates that there will be no interferences presented by existing WWTP piping or other public utilities. However, the Ohio Utilities Protection Service (OUPS) should be contacted prior to any excavation in the proposed HRT system area.

2.2 EXISTING PLANT UTILITIES

Existing plant utilities that will be needed for all of the HRT system process systems are Spray Water, Plant Water, Tank Drain (WWTP sewerage), and electrical power. The Spray Water is final clarifier effluent that is collected and pumped back through the WWTP to uses in various processes.

2.3 WATER REQUIREMENTS

The mechanical screens have spray cleaning systems and will need 35 GPM at 40 PSI each when they are in operation.

The washer compactor has a wash zone to remove organics and will need 10 GPM at 60 PSI each when in operation.

The grit removal systems will need fluidizing water injected into the bottom of the grit collection tanks. The amount required is 20 GPM at 50 PSI each.

The ACTIFLO® process will require up to 35 GPM for diluting and about 45 GPM for delivering coagulating, flocculating, and de-foaming chemicals to the process. A maximum of 80 GPM of good, clean water will be required.

Table 2-1: Estimated Water Requirements

Description	Quantity	Spray Water (gallons)	Plant Water (gallons)
Screens ¹	2	72	-0-
Washer/Compactors ¹	2	20	-0-
Grit Removal Tanks ²	2	40	-0-
ACTIFLO process ²	2	-0-	75
Total ³		132 (0.2 mgd)	75 (0.1 mgd)
Notes: ¹ – Peak but intermittent water requirement. ² – Continuous water maximum requirement. ³ – Maximum water flow added to the process is 207 GPM (0.3 MGD)			

The WWTP Spray Water will require filtering before use. A common filtering system can be installed on the main supply pipe entering the HRT system. It is recommended the filter has an automatic backwashing feature.

It is not known at this writing if there will be environmental facilities (such as restrooms) within the HRT system requiring a potable water supply.

2.4 TANK DRAINING

Floor drains and provisions for draining all channels and tanks will be provided. The existing tank draining system will be investigated in detail to see if it can accommodate the HRT system. If the existing tank draining system cannot then a new wet well with a pumping system may be needed. It may be possible to utilize the grit removal pumps if this becomes a necessity. Floor drains can drain back into the wastewater channels.

2.5 ELECTRICAL POWER

Electrical power requirements are discussed in more detail in another section below.

CHAPTER 3 - SITE AND CIVIL DESIGN ISSUES

3.1 HRT SYSTEM INFLUENT SEWER

Three options are being considered to divert the high rate storm flows to the HRT system. Two options involve a new aerial sewer from the existing aerial sewer and the other would be a channel or pipe from the Influent Mixing Chamber. See Appendix E for plan details of the influent sewer options.

3.2 AERIAL INFLUENT SEWER WITH SPLITTER BOX

The aerial sewer will span from the existing east side 48" aerial influent sewer over to the RTF's Influent Chamber.

The pipe will be approximately 155' long, 48" in diameter, and will require at least two piers for support. It would be advisable to construct as few piers as possible in the floodway. The existing aerial influent sewer piers, specifically Piers 2 and 3 will be analyzed to see if they will be able to support the new pipe junction.

Pipe material selection for the aerial sewer will be determined once a final supporting method is selected. Ultraviolet (UV) protection and watertight joints will be necessary since the pipe will be exposed to the elements and will be adjacent to a natural waterway. A maintenance walkway and access port will be built into the structure for long-term inspections and maintenance. Pipe materials to be considered include reinforced concrete pipe (RCP), centrifugally cast fiberglass reinforced polymer mortar pipe (CCFRPMP), ductile iron pipe (DIP), and lined steel pipe. The 10 State Standards recommends DIP with mechanical joints for aerial crossings.

In order to maintain the option of bringing flow into either the AATP or the HRT system a means of flow diversion is required. Valves or a diversion structure (splitter box) would be needed. Valves will not be considered here as they are cost prohibitive. They would cost around \$150,000 each and weigh 10 tons apiece requiring a rather large and robust supporting structure. An elevated structural concrete splitter box with two motor operated slide gates will be considered for flow control.

Similar to the other river crossings, flow in the aerial sewer will need to be protected from freezing temperatures. The sewer will be designed with insulation to reduce the potential for freezing, specifically for dry weather flows. The aerial sewer pipe will be designed with at least one maintenance access port.

3.3 DEDICATED INFLUENT SEWER

This option would use the same aerial sewer pipe as described above but it would be without the diversion structure. The HRT system influent would come directly from the Influent Head Chamber without the option of directing flow to the WWTP. The

remaining aerial sewer into the WWTP would be abandoned. Flow to the HRT system would be controlled at the Influent Head Chamber with the existing slide gates and/or a new flow control weir.

3.4 SEWER FROM WWTP INFLUENT MIXING CHAMBER

An open channel flume or a pipe may direct flow from the WWTP's Influent Mixing Chamber to the HRT system influent point. A flume could also serve as a location to measure the flow rate into the HRT system. The means to divert flows beyond 30 MGD to the HRT system will need to be incorporated in the Influent Mixing Chamber.

3.5 HIGH RATE TREATMENT FACILITY

The HRT system will consist of eight main structures that will be mostly constructed out of reinforced structural concrete and concrete masonry units. The structures are an influent chamber, two screening channels in a building, two grit removal tanks, a chemical building, the ACTIFLO[®] process tanks in two multi-chambered trains, two ultraviolet disinfection channels with a by-pass channel, two effluent channels, and an effluent diversion chamber.

The site's underlying soils will need to be investigated for their ability to support these structures. Approximately five soil borings are recommended to be performed under the HRT system footprint. The borings should penetrate to at least 15' below the deepest structure. This will require several of the borings to be approximately 25' to 30' deep. A geotechnical firm will be consulted to investigate the subsurface soils and provide structural foundation recommendations.

In addition to the structures identified above additional site features such as access drive(s), side walk(s), signage, landscaping, and yard fencing and lighting will need to be considered.

3.6 RIVER CROSSING EFFLUENT SIPHONS

The HRT system's effluent will be discharged from the Effluent Diversion Chamber to the WWTP's existing Tunnel Head Chamber on the other (north) side of the river. The river crossing will consist of two pipes placed under the river in a depressed sewer, more commonly referred to as a siphon sewer. There will be two pipes utilized depending on the discharge flow rate. The pipes are estimated to be 30 inch and 36 inch in diameter and each are expected to be approximately 400 ft long.

Pipe material selection for the siphon sewers will be determined once a subsurface soils investigation has been completed. Pipe materials to be considered include pre-stressed reinforced concrete pipe (PRCP), centrifugally cast fiberglass reinforced polymer mortar pipe (CCFRPMP), and ductile iron pipe (DIP).

Approximately the first 100 ft and last 50 ft of these pipes can be installed by traditional open cut methods. The middle 250 ft of river crossing pipe will require jack-and-bore installation requiring jacking and receiving pits with a driven steel casing.

3.7 OVERFLOW PIPE

The overflow pipe will discharge from the Effluent Diversion Chamber to the Rocky River. The pipe is 54 inch in diameter and will be approximately 125 ft long. Pipe materials to be considered include reinforced concrete pipe (RCP) and centrifugally cast fiberglass reinforced polymer mortar pipe (CCFRPMP). This pipe can be installed by traditional open cut method.

The pipe outlet will require a reinforced concrete headwall and some form of stream bed protection such as a concrete pad or large diameter rock channel protection. The outfall point will also need to be identified with a sign printed with the required National Pollutant Discharge Elimination System (NPDES) permit information.

CHAPTER 4 - ELECTRICAL DISTRIBUTION

4.1 EXISTING CONDITIONS

The LWWTP electric service is provided by the Cleveland Electric Illuminating Company (C.E.I.). Existing plant drawings show a 750 KVA pad-mounted transformer with 480V, 3Phase, 3 Wire secondary. The transformer feeds the Main Switch Gear with a bus rating of 3000A, protected by a set of 2000A fuses.

Power is distributed to motor control centers around the plant from the Main Switch Gear via underground electric feeders in conduit. Some of the conduits pass through the existing tunnels. The existing motor control center closest to the proposed HRT facility is MCC-SG, located in the existing Headworks Building. This motor control center is fed via 600A feeder from the main switch gear. Per the 2001 Headworks Upgrade drawings, the connected load at MCC-SG is 333A.

4.2 ANALYSIS

The Electrical Demand data for the last five years shows that the peak power demand for the plant is 778 kVA, at 94% PF, which equates to 936A at 480V, 3phase, and approximately 47% plant wide load diversity. This data shows that the main plant switch gear has adequate capacity to handle a substantial increase in electrical load that may be expected with a plant upgrade. The 750 kVA transformer, however, may be undersized already and consideration should be given to replacement. As part of the future construction project coordination with the power utility will be necessary. The design engineer will communicate the projected load increase to C.E.I. and the utility will perform the transformer upgrade, if necessary. Applying the plant wide diversity figure of 47% to the MCC-SG gives 157A of expected electrical demand at that motor control center. This shows that MCC-SG will be able to support the connection of the new loads associated with the HRT upgrade.

4.3 PROPOSED APPROACH

As part of the HRT system a new electric/control room will be constructed where the electrical distribution equipment and control panels for the new equipment will be housed. It is expected that a multi-section motor control center will be used for power distribution and control for the majority of the new equipment. The projected connected load for the HRT system is 300 kVA. This includes all of the process equipment, lighting, HVAC and other miscellaneous loads.

A new fused disconnect switch will be installed inside the MCC-SG and a new three phase feeder will be routed to the new HRT system electric room.

CHAPTER 5 - INSTRUMENTATION AND CONTROL PHILOSOPHY

HRT will be utilized to treat wet weather flow during storm events and maintenance of HRT will require weekly operation of the system. The system is designed such that it is to be operated in two parallel trains. Each train consists of a screen, a headcell, an ACTIFLO train and a UV channel. The operation of the two trains will be based on the level of flow into the system. Each train will treat up to 17.5 MGD, giving the system a total flow capacity of 35 MGD.

Automatic electrical gates will be used to control the path of the flow therefore gates will control which train the flow enters. From start-up to 17.5 MGD, flow will proceed through 1 train. When the flow exceeds 17.5 MGD, both trains will be used.

5.1 HRT START-UP PROCEDURE (AUTO-MODE)

- A. Prior (8-12 hours) the wet weather event:
 - 1. Open the Influent line to HRT
 - 2. Select the Train 1/2
 - 3. Establish the flow path
 - a. Train 1:
 - Open gates: SG-#1, SG-#3, SG-#5, SG-#7, SG-#9, SG-#11
 - Close gates: SG-#2, SG-#4, SG-#6, SG-#8, SG-#10, SG-#12, SG-#13
 - b. Train 2:
 - Open gates: SG-#2, SG-#4, SG-#6, SG-#8, SG-#10, SG-#12
 - Close gates: SG-#1, SG-#3, SG-#5, SG-#7, SG-#9, SG-#11, SG-#13
 - c. Check gate positions
- B. HRT Start-Up of selected train occurs when flow level in the Influent Mixing chamber reaches a pre-set water level, then selected train starts operation:
 - 1. Screen No. 1/2 – Auto Start
 - 2. Grit system No. 1/2 – Auto Start
 - 3. ACTIFLO system No. 1/2 - Auto Start
 - a. Coagulation and polymer injection, recirculation pump
 - 4. UV Disinfection No.1/2 – Auto Start
 - 5. If water level in the Influent Mixing Chamber continues to rise, reaching Water Level elevation equivalent to 17.5 MGD influent flow, the second train shall be activated in Auto Start mode.

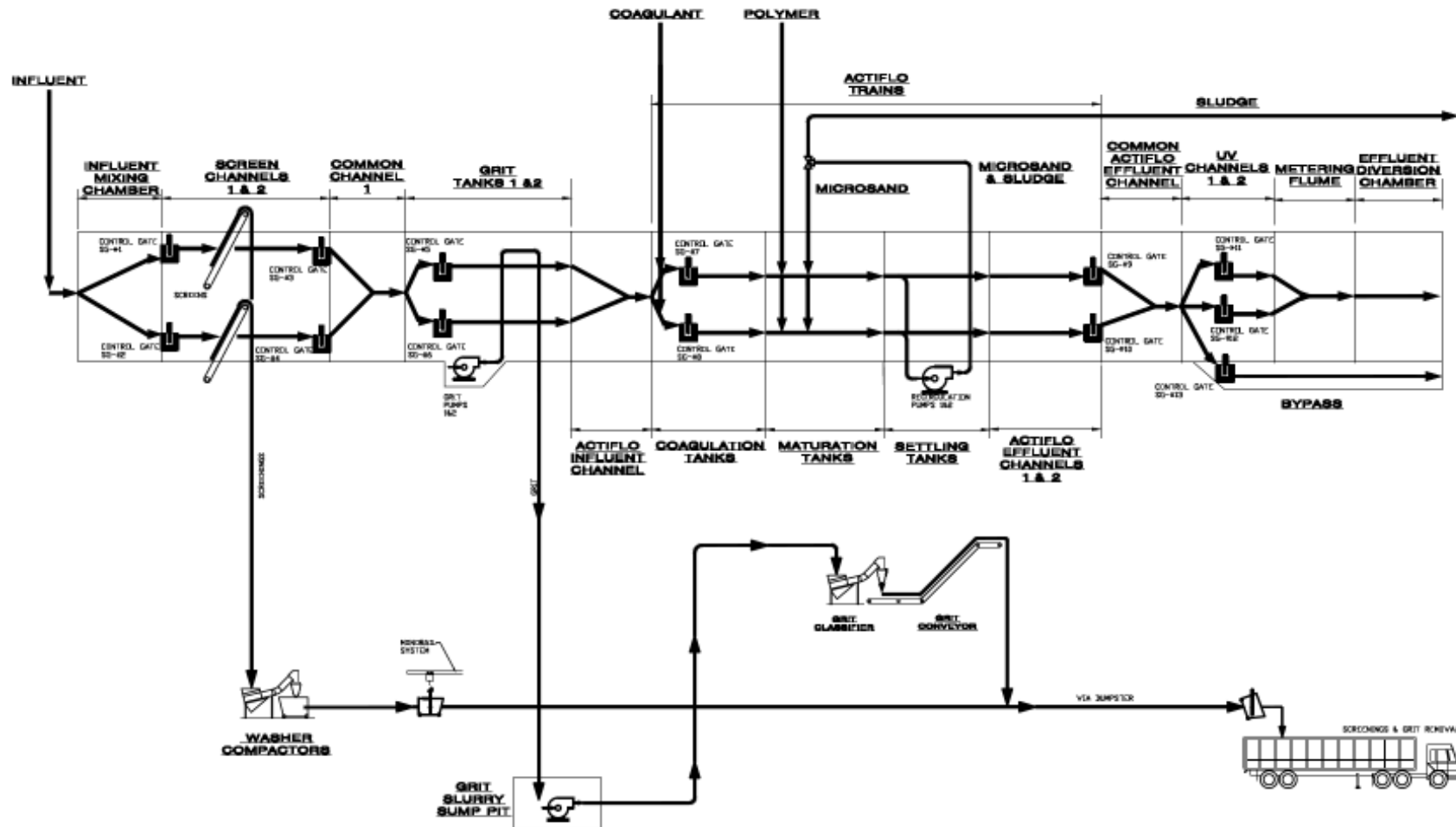


Figure 5-1: Instrumentation and Control Diagram

Table 5-1: Slide Gates List

Gate Number	Control
SG # 1	flow from the influent mixing chamber to Screen Channel 1
SG # 2	flow from the influent mixing chamber to Screen Channel 2
SG # 3	flow from Screen Channel 1 to common channel 1
SG # 4	flow from Screen Channel 2 to common channel 1
SG # 5	flow from common channel 1 to grit tank 1
SG # 6	flow from common channel 1 to grit tank 2
SG # 7	flow from common ACTIFLO influent channel to ACTIFLO Train No. 1
SG # 8	flow from common ACTIFLO influent channel to ACTIFLO Train No. 2
SG # 9	flow from ACTIFLO train 1 to common ACTIFLO effluent channel
SG # 10	flow from ACTIFLO train 2 to common ACTIFLO effluent channel
SG # 11	flow from common ACTIFLO effluent channel to UV channel 1
SG # 12	flow from common ACTIFLO effluent channel to UV channel 2
SG # 13	flow from common ACTIFLO effluent channel to bypass channel

CHAPTER 6 - COST BENEFIT ANALYSIS

A Cost-Benefit Analysis comparing operational and maintenance cost with pollutant reduction rate was performed using information provided by the Viola- Kruger pilot testing, the various equipment manufacturers, and professional experience with the various processes involved.

6.1 OPERATING COST

Operating costs are based on the 35 MGD maximum daily flow rate and the pollutant load encountered during the pilot testing conducted by Veolia-Kruger during June of 2015.

The major portion of the operating costs comes from just the operation of the ACTIFLO[®] process. Table 6-1 presents a breakdown of the operating costs at 35 MGD.

Table 6-1: Estimated ACTIFLO[®] System Operating Cost at 35 MGD

Item	Estimated Average Dose ¹	Estimated Unit Cost ²	Estimated Daily Operating Cost ⁴
Polymer	1.00 mg/L (dry)	\$ 4500 / ton	\$656.78
Sand Loss	2.0 mg/L	\$ 200 / ton	\$58.38
Coagulant (Aluminum Sulfate)	75 mg/L (dry)	\$ 450 / ton	\$4,925.81
Power Consumption	123 Hp	\$ 0.08 / kW-hr	\$158.49
Total Estimated Daily Operating Cost ⁴			\$5,799.46
Operating Cost per 1,000 Gallons			\$0.166
<u>Notes:</u> 1) Total operating HP used to calculate kW-hr assumes power draw of 90% of total nameplate HP and does not include standby equipment. 2) Dosages based on Kruger pilot testing during CSO wet weather events (6/16, 6/29) to achieve NPDES limits for CBOD, TSS, and phosphorus. 3) Estimated chemical and power costs may vary based on regional contract pricing. 4) For nominal capacity operating 24 hours per day.			

The ancillary operating costs during HRT system operation consists of both of the screens and washer compactors in operation as well as the solids transfer conveyor, both grit pumps, the grit classifier, and the UV disinfection system. Table 6-2 presents a breakdown of the ancillary equipment operating costs at 35 MGD.

Table 6-2: Estimated Ancillary System Operating Cost at 35 MGD

Equipment	No of Units	Total, Hp	Cost
Screens	2	2	\$2.58
Washer Compactor	2	2	\$2.58
Solids Conveyor	1	1	\$1.29
Grit Classifier	1	1	\$1.29
Grit Pumps	2	15	\$19.33
UV Disinfection (as HP)	2	26.8	\$34.53
Total Requirements ¹ per Day:		47.8	\$62
Total per 1,000 Gallons:		\$0.00144	\$0.0018
Power Cost: \$ 0.08 / kW-hr			
1) Total operating HP assumes power draw of 90% of total nameplate HP and does not include standby equipment.			

The estimated cost to operate the HRT system during the peak flow event of 35 MGD is \$6,448 per day or \$0.13 per 1,000 gallons of inflow treated. Table 6-3 presents the total operating cost summary for the HRT system operating at 35 MGD.

Table 6-3: Estimated Total Operating Cost at 35 MGD

Description	Daily Cost	Cost per 1,000 gallons
Screening, Grit Removal, UV ¹	\$62	\$0.002
ACTIFLO [®] 1,2	\$5,800	\$0.166
Total Operating Cost	\$5,862	\$0.168
with Contingency at 10%	\$6,448	\$0.18
Notes: 1) Power costs at 0.08 per kilowatt-hour 2) ACTIFLO [®] chemical dosages based on Kruger pilot testing during CSO wet weather events (6/16, 6/29) to achieve NPDES limits for CBOD, TSS, and phosphorus.		

6.2 MAINTENANCE COST

An attempt has been made to try and quantify annual maintenance costs even though they are rather minor when compared to the overall operating costs of the HRT system. Maintenance items taken into consideration include regular inspections, tank cleaning after events, equipment lubrication, screen chain replacement, and UV disinfection bulb replacement.

Weekly inspections will take approximately an hour or two. At an employee hourly rate of \$50/hour the annual cost will be \$5,200.

The HRT system will need to be operated for a short period of time on an approximately weekly basis to ensure timely operation at the beginning of storm events. The weekly operation will ensure that the system is in a “stand-by” position. Taking the daily operating cost as mentioned in the previous section above and operating the system for 8 hours (1/3 of a day) once a week yields a weekly cost of \$1,954 or an annual cost of \$101,608.

Tank cleaning and general clean-up after HRT system operational events would occur approximately ten times per year. With two employees taking eight hours to conduct cleaning activities that yields 160 hours/year. At an employee hourly rate of \$50/hour the annual cost will be \$8,000.

Equipment requiring lubrication includes the screens, the washer-compactor, the grit classifier, and the solids transfer conveyor. Since this equipment will never be in continuous operation it may only need serviced once or twice per year. A conservative estimate would be no more than 16 hours/year. At an employee hourly rate of \$50/hour the annual cost will be \$800.

The UV bulbs should last a long time because they will only be operated periodically. A worst case scenario would be five bulbs failing per year. At an approximate cost of \$300 each that yields a total annual cost of \$1,500.

Miscellaneous items such as general building maintenance (HVAC, plumbing, etc.), housekeeping, chemical inventory accounting, etc. will need to be performed. Estimating approximately two hours per week for such tasks and at an employee hourly rate of \$50/hour the annual cost will be \$5,200.

Table 6-4: Estimated Maintenance Costs

ITEM	ANNUAL COST	DAILY COST	COST PER 1,000 GALLONS
Inspections	\$5,200	\$14.25	\$0.0004
Weekly Operation	\$101,608	\$278.38	\$0.0080
Cleaning	\$8,000	\$21.92	\$0.0006
Lubrication	\$800	\$2.19	\$0.0001
UV Bulb Replacement	\$1,500	\$4.11	\$0.0001
Miscellaneous	\$5,200	\$14.25	\$0.0004
TOTAL	\$122,308	\$335	\$0.0096

In summary the annual maintenance cost for the HRT system will be approximately \$122,308 and the cost for 1,000 gallons of treatment is approximately \$0.01.

6.3 COST PER POLLUTANT LOAD REMOVED

The total of the Daily Operating and Maintenance costs, \$6,448.00 and \$355.00 respectively, estimated in the previous sections is \$6,803.00.

Table 6-5: Estimated Total O&M Cost at 35 MGD

Description	Daily Cost	Cost per 1,000 gallons
Operations	\$6,448	\$0.18
Maintenance	\$335	\$0.01
Total Operating Cost	\$6,803	\$0.19

The primary pollutants to be removed by the HRT system are total suspended solids (TSS), biochemical oxygen demand (CBOD), and phosphorus (P). The projected amounts of those pollutants to be removed on a daily basis at the 35 MGD flow rate and the estimated costs to remove them are presented in the following table.

Table 6-6: Estimated Total Daily Operating Cost at 35 MGD

Parameters	Influent		Effluent		Solids Removed	Total Daily Operating Cost, \$/day
	mg/L	lbs/day	mg/L	lbs/day	lbs/day	
TSS	100	29,190	30	8,757	20,433	0.18
CBOD	37	10,800	15	4,378	6,422	0.06
Phosphorus	4	1,168	1	292	876	0.008
Totals		41,158		13,427	27,731	0.25

The estimated total cost to remove a pound of the pollutants is \$0.25. Estimated daily operating cost of TSS, CBOD and phosphorus removal individually was calculated based as a fraction of total solids removed (27,731 pounds per day (ppd)) and estimated total daily operating cost (\$0.25 /day).

CHAPTER 7 - PUBLIC ENGAGEMENT

Maintaining meaningful communication with stakeholders and the public was of utmost importance in the development of Lakewood's Integrated Wet Weather Improvement Plan (IWWIP). Lakewood established a stakeholder involvement process which involved publicizing the group, asking for volunteers, having monthly public meetings, and using the public's preferences to shape the plan.

7.1 Goals

This section presents Lakewood's approach to municipal and public participation in the development of its IWWIP.

Successful implementation of any integrated plan depends on having the support of the community. If the public and elected officials have a shared vision for integrating wastewater and stormwater management with land use planning, then funding and implementation are more likely to follow.

Public Input Goals:

- 1) Help educate and engage the public on Lakewood's storm and sanitary sewer infrastructure
- 2) Help educate and engage the public on overflows
- 3) Help educate and engage the public on green and grey infrastructure options
- 4) Obtain suggestions from public for how Lakewood might reduce its overflows

Lakewood's IWWIP goals include the following:

- 1) Meet or exceed NPDES permit requirements
- 2) Comply with CSO policy
- 3) Foster public understanding of the need for this IWWIP; solicit public preferences; maintain positive working relationship with public; gather support for its implementation

7.2 BALANCING PUBLIC OUTREACH AND TECHNICAL ANALYSIS

While the plan must be based on science (such as: hydrology, water quality, and hydraulics) if technical analysis is completed in isolation of stakeholder understanding the plan is less likely to be brought to fruition. Accommodating smart growth and development in a very developed landscape like Lakewood (~70% impervious) is a balancing act involving planning, engineering, and public input in decision making.

Achieving integration of the engineering, planning, and ecological perspectives was initiated via strong communication alongside data collection, modeling, and analysis. The results of the models were used in working sessions with the stakeholders so the public can use it to aid in decision making. Coordination and effective communication between the various public and municipal participants will directly impact long-term planning and success of wet weather controls.

7.3 LAUNCHING “CLEAN WATER LAKEWOOD”

The public participation discussion began in March 2015. In order to gain valuable input Lakewood needed a public that understands the intricacies of the problem. It was decided to start a program, branded “Clean Water Lakewood: Rebuilding the Pipeline for Our Future” and ask for citizen volunteers to join. A logo was developed and articles were placed on the city’s website, newspaper, Facebook page, and on Twitter asking for volunteers who would dedicate themselves to monthly meetings and discussion on how Lakewood can improve their water infrastructure and reduce pollution going into Lake Erie and Rocky River.

Approximately 18 people ended up committing themselves to monthly meetings. CWL meetings were scheduled from 7-9PM on the 3rd Tuesday of every month starting in July of 2015.

In addition to the Lakewood citizen volunteers, a number of city of Lakewood employees were also attending the meetings, including representatives from the following departments: Mayor’s Office, Department of Public Works, the Building and Planning Department, and City Council.

One goal the city had for the CWL taskforce was to start public participation early in Phase 1 of the NPDES permit, and continue it indefinitely. In Phase 1 the city started educating the public on CSOs and the possible solutions, and in Phase 2, the city needs to create a firmer plan of action to reduce these overflows to be in compliance with the CSO policy.

After the initial introductory meeting, two fieldtrips were scheduled. The first included a complete tour of the LWWTP and the nearby CSOs. The second field trip was an interactive tour of the Cleveland Metroparks’ Watershed Stewardship Center in Parma, OH, a part of West Creek Reservation. Each meeting had a separate topic, as noted in Table 7-1. The first six monthly meetings were targeted as education meetings, and then starting in December, participants broke into four smaller groups, each focusing on a different street or neighborhood in Lakewood, including: Larchmont Ave., Lake Ave., Birdtown, and Parkwood Ave.

The groups brainstormed and came up with very thoughtful and creative solutions. Summaries of the modeling suggestions were emailed to the group members to ensure what they asked for were captured. After determining how much volume was captured

using their suggestions in the model, the results were shared both in person and via email. With these results the participants were able to see what was successful at reducing overflows, and what likely isn't.

Table 7-1. Topics covered in monthly meetings and their purpose.

Session Theme	Session Purpose
Introductory meeting: CSO challenge	Set the tone for the meetings, introduce everyone, explain overflows
Tour of WWTP	To learn how the treatment plant works, show them where some overflows occur when it rains, discuss high rate treatment
Tour of Watershed Stewardship Center	To learn about effectiveness, maintenance, and challenges of various types of green infrastructure installed
Clean Water Act	To learn about NPDES permits and why Lakewood has one; Erm Gomes, and Brianne Ciccone, of OEPA's Northeast District Office gave overview of NPDES program
Source control on private property: infiltration and inflow	To learn how homeowners play a role in reducing volume of water going into sanitary sewer
Green infrastructure	To understand the advantages and disadvantages of various green infrastructure options for addressing CSOs
Lakewood's vision	To understand how this IWWIP might fit into their community vision
Modeling suggestions for section of Lake Ave.	To discuss preferences for reducing CSOs in example study areas. These were 4-person breakout groups focusing on a specific neighborhood; suggestions to be modeled were based on knowledge of system
Modeling suggestions for Larchmont Ave.	
Modeling suggestions for Birdtown neighborhood	
Modeling suggestions for Parkwood Ave.	
Modeling results for Lake Ave.	Reviewing modeling results with each group, what was successful, what was not
Modeling results for Larchmont Ave.	
Modeling results Birdtown neighborhood	
Modeling results for Parkwood Ave.	
Discussing results and take-aways	Entire large group meeting to share their understanding of the results and what it means for future planning

CHAPTER 8 - HYDRAULIC MODELING

A HRT Model was created in SWMM to assist in sizing the HRT and verifying that the HRT design was effective in controlling CSO-002. The HRT Model was based on the IWWIP Existing Conditions Model, but rather than containing a flow rate-limited pipe and simple outfall to represent the LWWTP, the HRT Model provided a more detailed representation of the LWWTP and included the LWWTP effluent pipes to the lake. Additionally, the HRT model included the HRT in various representations as the basis of design was developed.

8.1 HRT CAPACITY DETERMINATION

A first set of scenarios using the HRT Model were designed to determine how much capacity would be needed at the HRT. Using a flow rate-limited pipe in the model to represent the HRT's treatment capacity, several scenarios were run to examine the effects on the system from the HRT at various treatment capacity levels. Results were analyzed for the Typical Year to determine the effectiveness at reducing overflows at CSO-002.

In the Typical Year, 61.6 MGD was the peak flow rate reaching the influent chamber where CSO-002 is located. Subtracting out 30 MGD for the LWWTP, a remainder of just over 30 MGD would be handled by the HRT. The model confirmed that this eliminates any overflows at CSO-002 in a Typical Year.

The upstream effects were also considered. Since the LWWTP and HRT can together treat 65 MGD, which is slightly more than the maximum flow that will reach the influent chamber in a Typical Year, the influent chamber at CSO-002 does not build up head and lowers the water elevation upstream. Although this slightly reduces some upstream overflows along the interceptor, it does not eliminate upstream overflows due to capacity limitations in the interceptor.

8.2 EVALUATION OF OUTFALL

The outfall from the WWTP to the lake was evaluated to ensure it has capacity for the additional flow from the HRT. It was determined that the outfall pipe could carry around 75 MGD, which surpasses the 65 MGD required from the LWWTP and HRT. The model also was used to get the water surface elevation in the effluent tunnel head chamber (after the siphons) under 65 MGD. This elevation is used in the HRT hydraulic calculations.

In addition, the City performed an inspection of the outfall pipe, including sonar of the submerged portion. The pipe was determined to be structurally sound and in good shape. Some of the armor stone needed to be replaced near the diffuser, but the diffuser is in good shape.

8.3 HRT HYDRAULIC CHECK

The model was also used as a check for the HRT hydraulics. Once the calculations in Appendix D were completed, key hydraulic points were added to the model and the model was run to ensure that the HRT had the desired effect on the system. This was also used to ensure that there would be enough capacity to use one of the aerial sewer influent lines for the HRT influent.

The resulting model had eliminated any overflows at CSO-002 in the typical year. The detailed modeling done at the HRT was then integrated into the IWWIP model.

CHAPTER 9 - PERMITTING ISSUES

Various environmental and construction permits are going to be required to complete the proposed effluent siphon sewer under the Rocky River. At least five (5) government agencies have been identified that may have some jurisdiction over the project. The individual agency involvement is explained in more detail below.

9.1 UNITED STATES DEPARTMENT OF DEFENSE, ARMY CORP OF ENGINEERS (USACE)

The USACE has legislative jurisdiction over all activities conducted in navigable waters and wetlands in the United States. A construction permit will be required by Section 10 of the Rivers Harbors Act. Such a permit requires completion of an Application for Department of the Army Permit, construction drawings, site mapping and cross sections, aquatic resource assessments and quantification of impacts, avoidance/minimization summary, and proposed mitigation, if necessary.

Depending on the method required to install the new sewer line, permits may also be required under Sections 404 and 401 of the Clean Water Act if fill material will either be dredged or discharged into waters of the U.S., including Lake Erie. If dredging or filling activities are required for the project, it may qualify for a Nationwide 12 Permit (Utility Line Activities), if certain conditions are met, including the project resulting in less than a 0.5-acre loss in waters of the U.S. This permit requires disturbed site restoration to preconstruction conditions and USACE approval (sign-off) after construction completion. Nationwide Permits are less rigorous and typically result in a faster review period than an Individual Permit.

As a part of the ecological analysis for the project it is important to keep in mind that linear projects, such as a water line, are analyzed by USACE and/or Ohio EPA in their entirety. That means that if there will also be streams or wetlands, including isolated wetlands that will be crossed or impacted by the water line on land, that such impacts should also be included within the water quality certification package. Those additional impacts, if any, will also be included within the analysis of whether a Nationwide Permit or Individual Permit is warranted.

The USACE District Engineer will make a decision determining their degree of jurisdiction over the project and what permits may ultimately apply.

If Section 10, 404 and 401 permits are all required for this project, permitting costs are estimated to be between \$35,000 and \$50,000. This includes the cost to do the ecological assessments, but it does not include the costs to do specialized endangered species surveys, such as freshwater mussel surveys, if required and as further discussed below. The above cost range also does not include the cost to do species relocations or resource

mitigation of any type, if required by the regulatory agencies. Such estimates cannot be developed until the scale of the ecosystem impacts, if any, are determined.

9.2 UNITED STATES FISH AND WILDLIFE SERVICE

USACE will have to formally consult with the US Fish and Wildlife Service (USFWS) as a part of the permitting process, as required under the provisions of section 7(a)(2) of the Endangered Species Act (ESA), in order to determine that issuance of the permits will not lead to actions that are likely to jeopardize the continued existence of any listed species.

As a part of the Section 10 and 401/404 water quality certification package, the City will have to do a preliminary assessment of endangered species that could be affected by the project. These include, but are not limited to Indiana and Northern Long-Eared Bats, freshwater mussels, migratory birds and near-shore plant species. The terrestrial component of the project would definitely be within the area of the Indiana and Northern Long-Eared Bats. As such, any potential roost trees that could be affected by the project would be noted by the ecological consultant during field activities. The project is not located within the boundaries of the Lake Erie Water Snake (LEWS), which should not be of concern to the project. It is possible that USFWS may request additional field surveys if certain species, such as freshwater mussels, are believed to exist within the project area.

If listed species are present, the USFWS will ultimately determine if the water line development activities would affect them. If it is determined that the water line is not likely to adversely affect such species (e.g., the effects are beneficial, insignificant, or discountable), no further consultation is required.

If it is determined that the new sewer line is likely to adversely affect a listed species or designated critical habitat, a formal consultation is initiated. The ESA requires that consultation be completed within 90 days, and the regulations allow an additional 45 days for the USFWS to prepare a biological opinion. The analysis of whether or not the proposed action is likely to jeopardize the continued existence of the species or adversely modify designated critical habitat is contained within the biological opinion. If a jeopardy or adverse modification determination is made, the biological opinion must identify any reasonable and prudent alternatives that could allow the project to move forward, make a determination as to whether or not a permit will be required, or prohibit the project from taking place.

For example, if an endangered freshwater mussel species is present within the path of the proposed water line, USFWS may seek the relocation of the water line or, if that is not feasible, they may require the relocation of the mussel beds themselves. Additional, off-site mitigation is sometimes required in such circumstances. It is worthwhile to note that it is rare that USFWS would altogether prohibit the issuance of a permit for a project such as this.

It is also important to note that the ODNR Division of Wildlife (DOW) has established statewide in-water work exclusion dates, which vary across Lake Erie and which can be modified annually. It will be important to schedule in-water construction activities so as not to coincide with these exclusion dates.

The anticipated costs above include the cost to do a preliminary endangered species analysis of the project area. If such species are likely to be present and if USFWS requires additional and specialized surveys for them, such costs would have to be determined on an individual basis.

9.3 STATE OF OHIO, STATE HISTORIC PRESERVATION OFFICE (SHPO)

The SHPO will need to be notified because there are many nearby sites that have been designated historical by the National Park Service's National Register of Historic Places. One critical area to note is the Clifton Park Lakefront which is about one-mile down river. The SHPO is the state agency that oversees historic preservation efforts in Ohio.

The anticipated costs above include the cost to do a preliminary cultural resources review within the project area. If additional or more specialized cultural resources surveys or studies are required by SHPO in conjunction with this project, the cost estimates for those activities would need to be determined on a case by case basis.

9.4 OHIO ENVIRONMENTAL PROTECTION AGENCY (OEPA)

The OEPA, Division of Surface Water, has statutory authority requiring all construction plans for all public wastewater systems to be approved by their agency. An application package will need to be prepared and submitted for their review. The submittal will consist of an application fee, a completed "Permit to Install" (PTI) form, constructions plans, and technical specifications.

The package will then be submitted to the Northeast District Office in Twinsburg and upon plan approval the OEPA Director will issue a letter authorizing construction.

The WWTP's National Pollutant Discharge Elimination System (NPDES) permit will require modification because the HRT system will require an overflow discharge outfall to the Rocky River. This modification may be submitted concurrently with the PTI application or submitted separately at an early date.

The OEPA also has statutory authority requiring that all construction activities that disturb over one (1) acre of ground must get a permit to discharge storm water from the construction site. It has been estimated that construction activities to build the HRT system will disturb approximately 0.75 acres of ground so a discharge permit may not be needed. However, Lakewood's own ordinances may require a stormwater permit for disturbance of 8000 sq. ft.

To get permit coverage, if necessary, a Storm Water Pollution Prevention Plan (SWP3) will need to be developed for the construction site and a Notice of Intent (NOI) requesting coverage for discharges under the general permit will need to be completed and submitted to OEPA. Then the OEPA approval letter stating that construction activities are covered under the storm water general permit must be received before construction commences.

CHAPTER 10 - PLANNING LEVEL CONSTRUCTION COST ESTIMATE

10.1 COST ESTIMATE

A planning level cost estimate was developed for the two-train HRT system employing the ACTIFLO® process. The estimate includes all site work, tank and channel structural concrete, building masonry, grating and stairs metal fabrications, process equipment, electrical, mechanical, and plumbing costs. The costs for the various process equipment components were obtained directly from the manufacturers in the form of recommendations with budgetary costs.

The largest portion of the Site Construction cost is made up of the influent and effluent sewers. They account for about two-thirds of the total site work cost. The largest Concrete item cost is the ACTIFLO® process concrete tanks, accounting for over half of the total concrete cost. The ACTIFLO® process pumps and control room accounts for about one-third of the building Masonry costs. The largest Metal Fabrications cost is for all of the flooring plate and supporting structure that will be needed to cover most of all of the process tanks.

The largest portion of the Process cost is for the ACTIFLO® process equipment. It accounts for three-fourths of the equipment cost and is the largest single item cost for the project, approximately two-fifths of the total project cost.

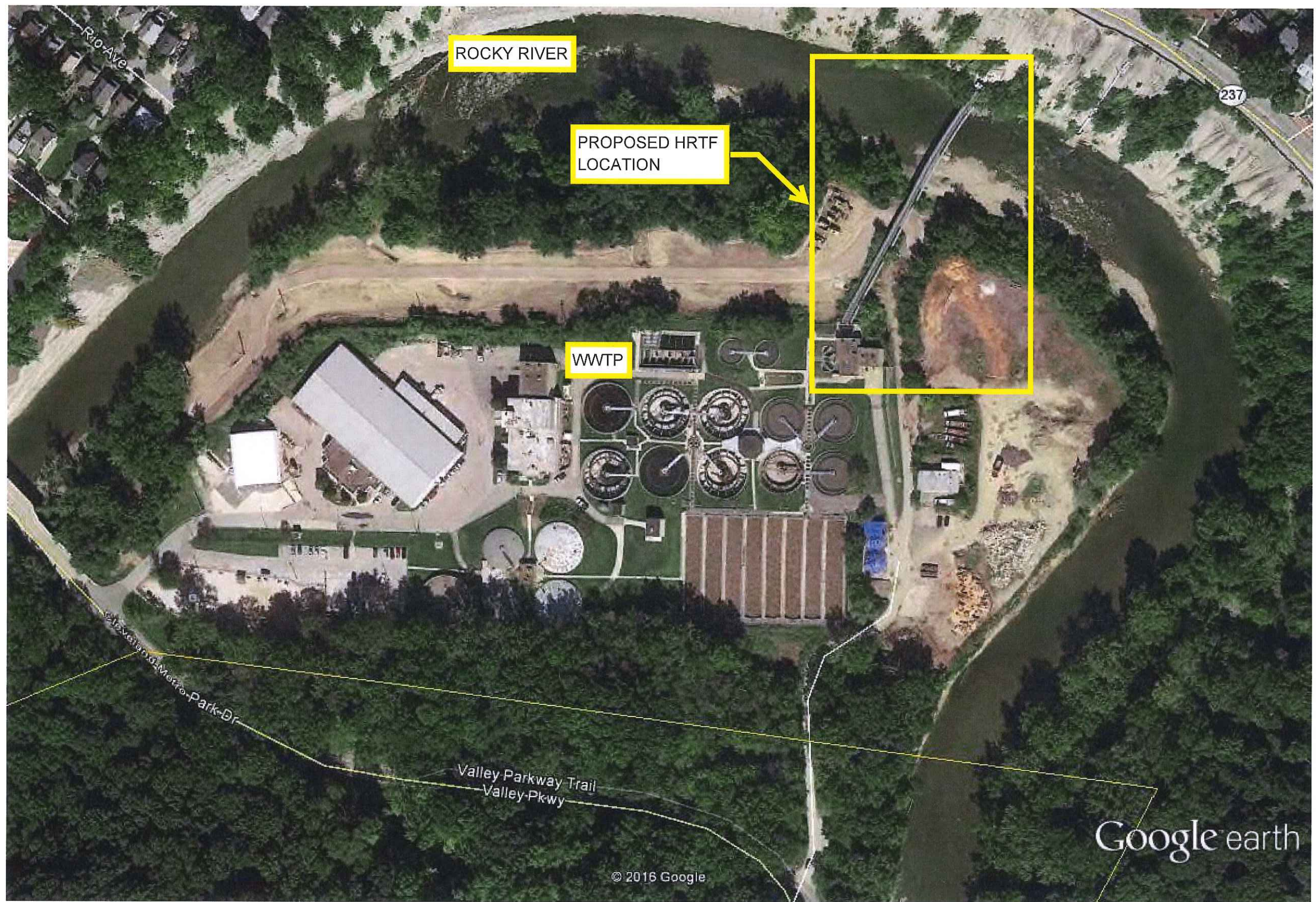
The table below summarizes the planning level construction cost estimate for the 35 MGD two-train ACTIFLO® HRT system. Itemized cost details can be found in the Appendix G.

Table 10-1: Planning Level Construction Cost

Description	Cost
Site Construction – Div. 02	\$ 970,580.00
Concrete – Div. 03	\$ 1,280,000.00
Masonry – Div. 04	\$ 1,176,000.00
Metal Fabrications – Div. 05	\$ 367,550.00
Process – Div. 11	\$ 7,948,800.00
Subtotal Divisions 15 & 16	\$ 2,055,030.00
Total Capital Cost	\$ 13,797,960.00
Contingency @ 10%	\$ 15,177,760.00

APPENDIX A

Project Site Map



Google earth

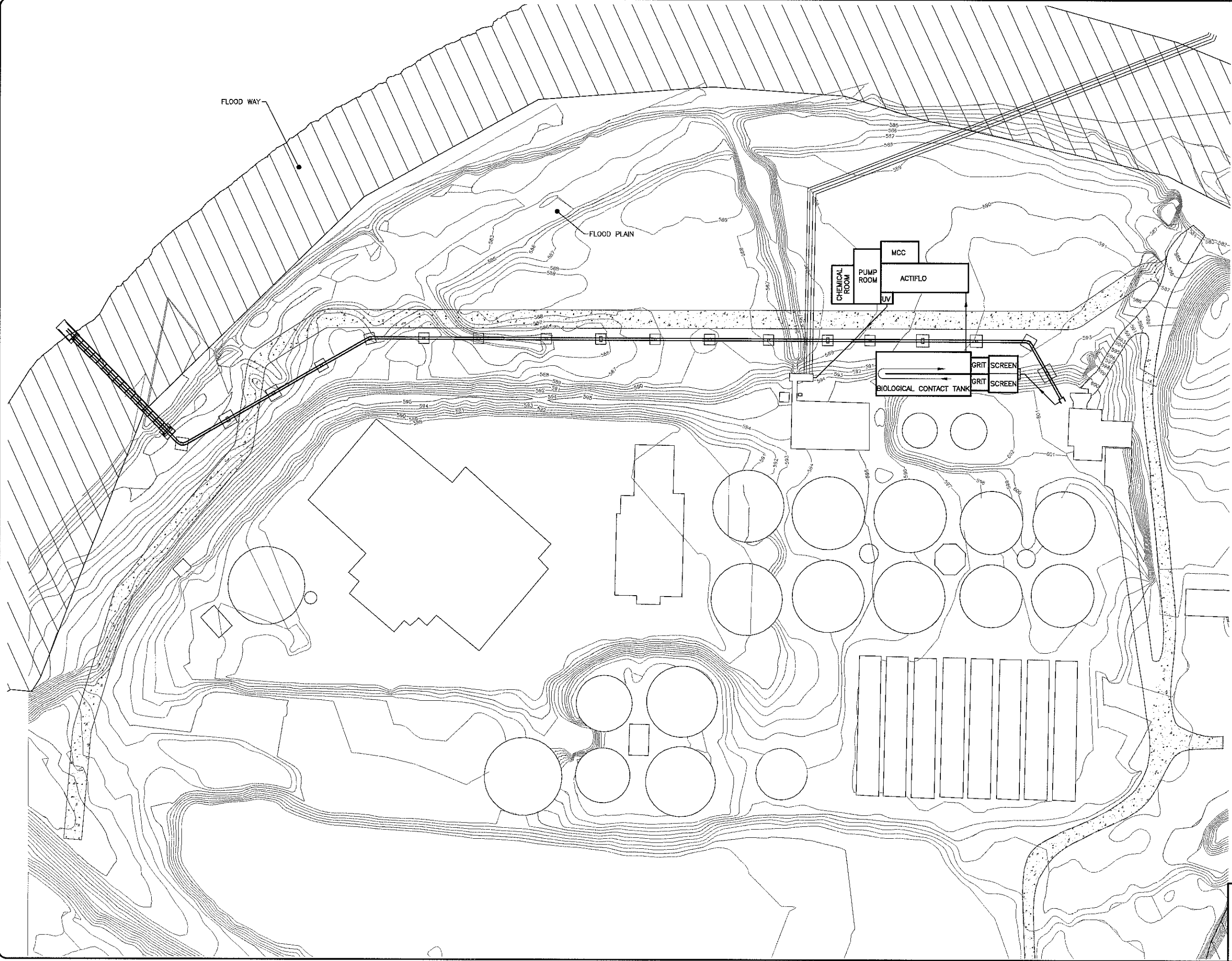
feet
meters



APPENDIX B

HRT Alternatives 1-6

H:\2014\14797\Drawings\Site\OPTION 1.DWG - 02/20/16 10:21:41 AM - ELMPT



Attachment B
Figure 1

CITY OF LAKEWOOD OHIO
WET WEATHER IMPROVEMENTS FOR
WWTP

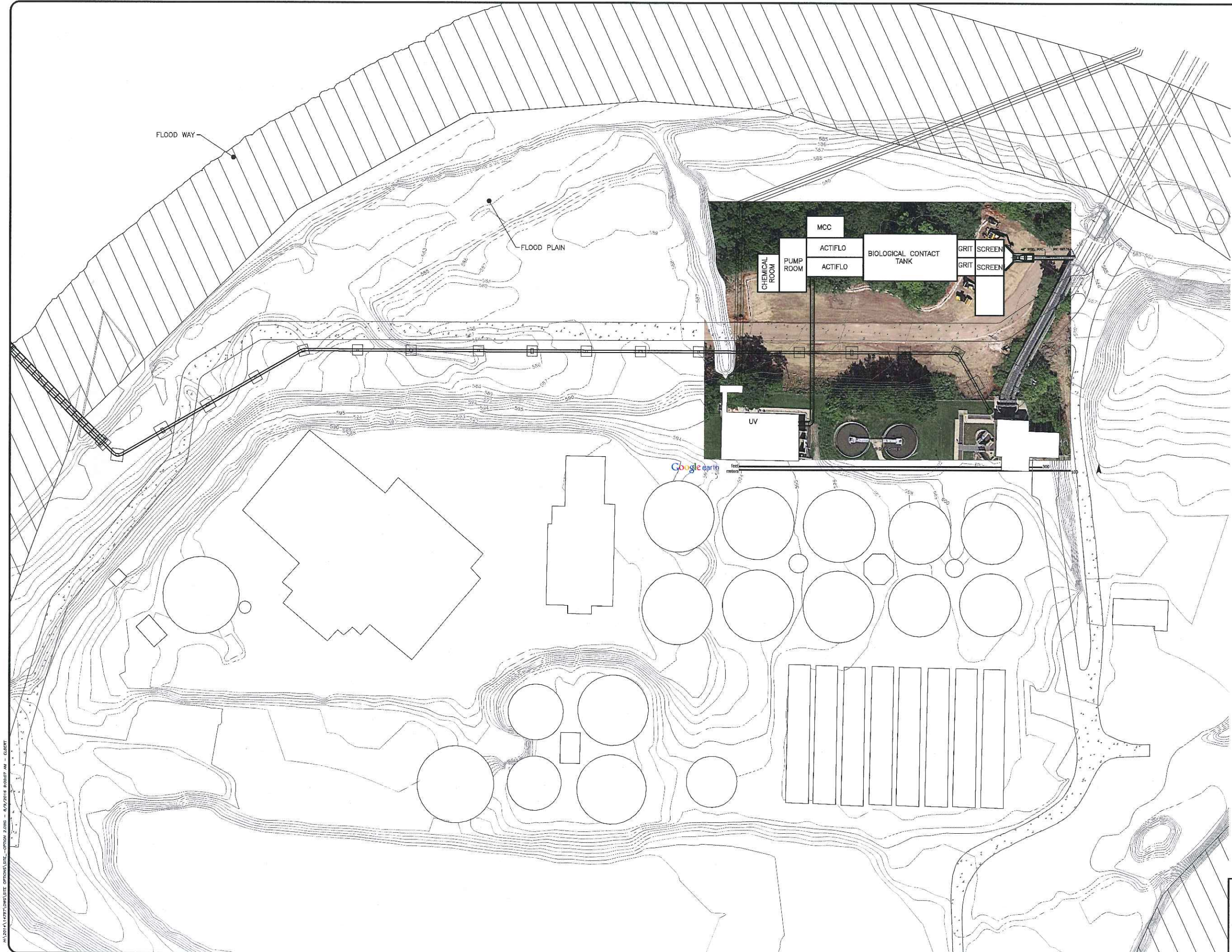
SITE LAYOUT OPTION 1

PROJECT NO: 14797	
DRAWING NAME C-1	
SHEET 1	OF 7

DRAWING SCALE:	NO.	REVISION	DATE
• HORIZ: 1" = 50'			
• VERT: N/A			
DATE: 08/02-2016			
DESIGNED BY: JZJ			
DRAWN BY: RE			
CHECKED BY: MAK			



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14797.DWG SITE - OPTION 2.DWG - 8/9/2016 8:00:07 AM - CLIENT

Attachment B
Figure 2

CITY OF LAKEWOOD OHIO
WET WEATHER IMPROVEMENTS FOR
WWTP

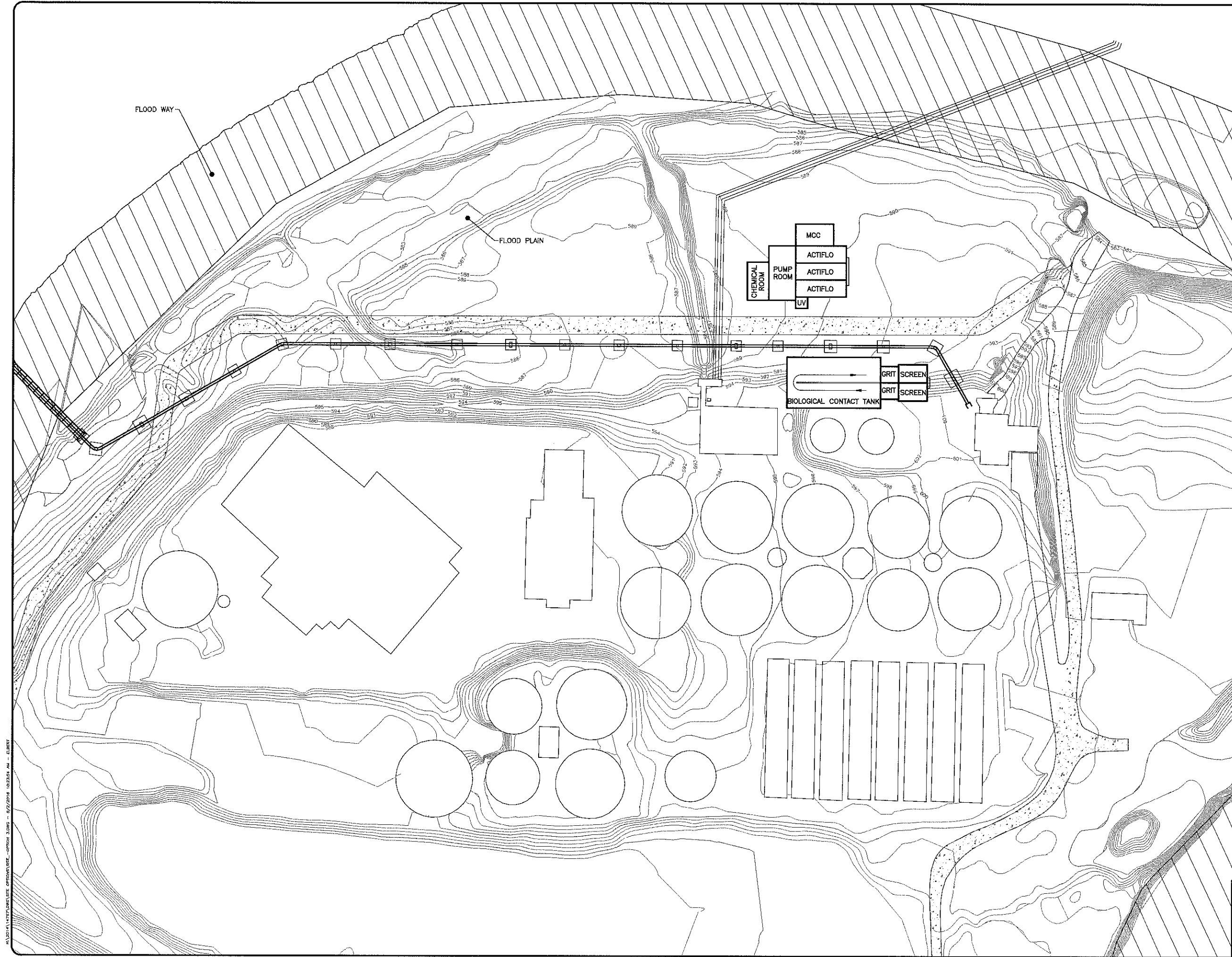
SITE LAYOUT OPTION 2

PROJECT NO:	
14797	
DRAWING NAME	
C-2	
SHEET	OF
2	7

DRAWING SCALE:	NO.	REVISION	DATE
• HORIZ: 1" = 50'			
• VERT: N/A			
DATE: 08/02-2016			
DESIGNED BY: JGZ			
DRAWN BY: RE			
CHECKED BY: MAK			



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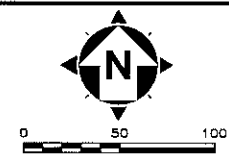
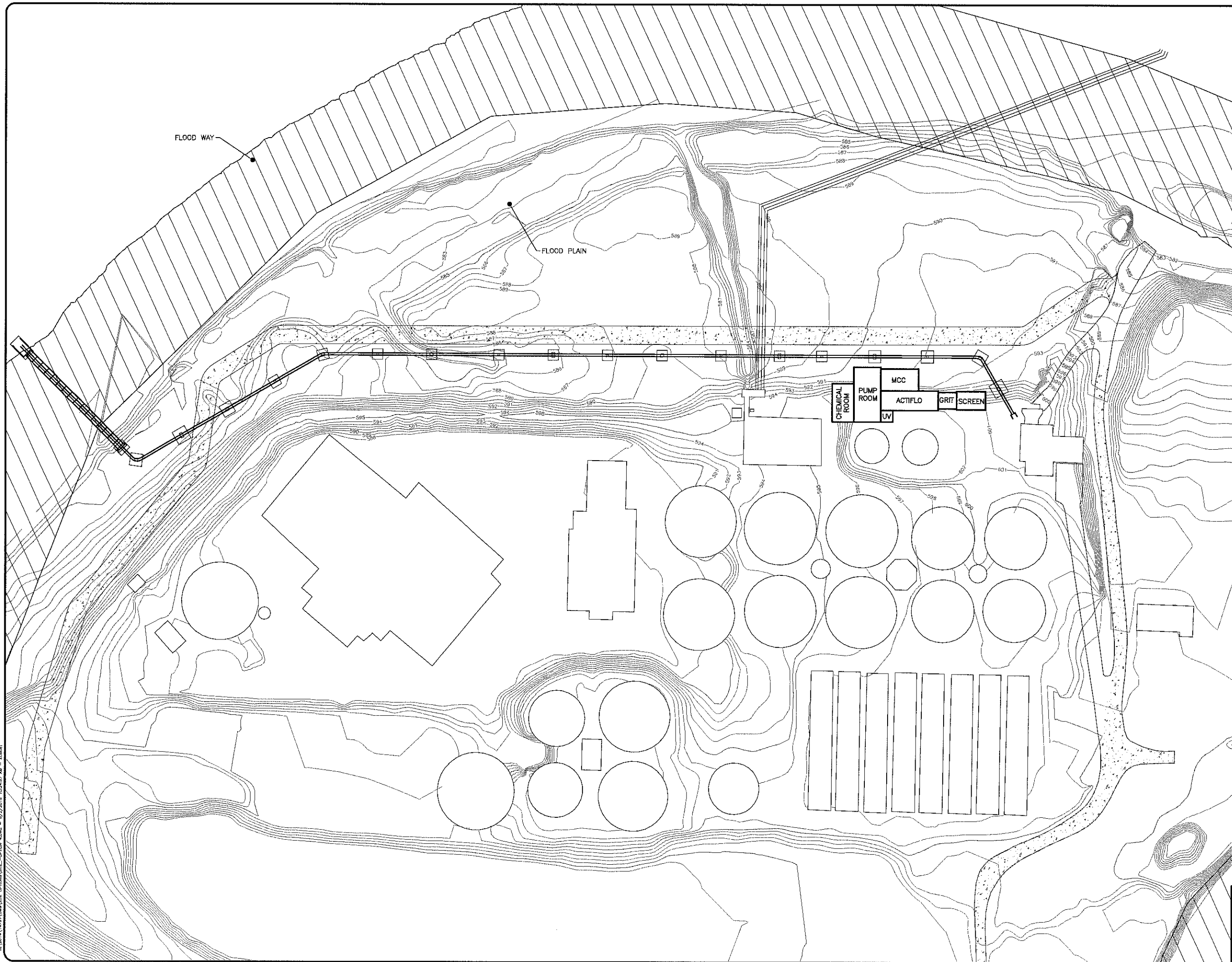


 CT Consultants engineers architects planners Northwoods / Building - 7905 N. High Street - Suite 340, Columbus, Ohio 43235 Phone: 614.885.1701 - Fax: 614.885.1701 - www.ctconsultants.com		PROJECT NO:		14797	
		DRAWING NAME:		C-3	
CITY OF LAKEWOOD OHIO		PROJECT NO:		14797	
WET WEATHER IMPROVEMENTS FOR		DRAWING NAME:		C-3	
WWTP		SHEET		OF	
SITE LAYOUT OPTION 3		3		7	
DRAWING SCALE:		NO.		REVISION	
• HORIZ: 1" = 50'					
• VERT: N/A					
DATE: 08/02-2016					
DESIGNED BY: JDZ					
DRAWN BY: RE					
CHECKED BY: MAK					

Attachment B
Figure 3

H:\2014\14797\WWTP\SITE OPTIONS\SITE_LAYOUT_OPTION_3.dwg - 8/2/2016 10:23:54 AM - ELMRT

14797.DWG SITE OPTION 4.DWG - 8/2/2016 10:24:57 AM - EUBERT



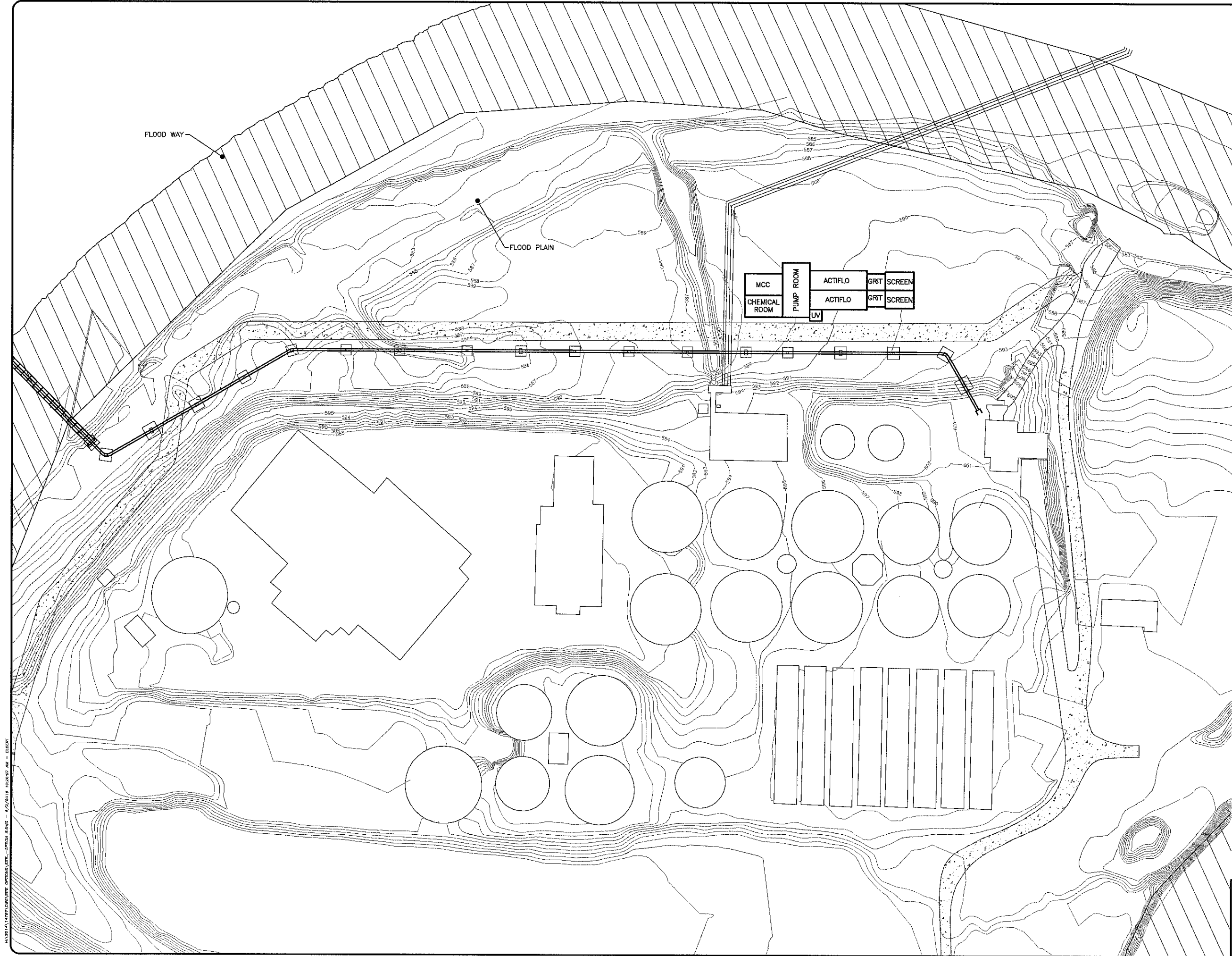
Attachment B
Figure 4

CITY OF LAKEWOOD OHIO
WET WEATHER IMPROVEMENTS FOR
WWTP

SITE LAYOUT OPTION 4

PROJECT NO: 14797	
DRAWING NAME C-4	
SHEET 4	OF 7

DRAWING SCALE:	NO.	REVISION	DATE
HORIZ: 1" = 50'			
VERT: N/A			
DATE: 05/04-2016			
DESIGNED BY: JGZ			
DRAWN BY: RE			
CHECKED BY: MAK			



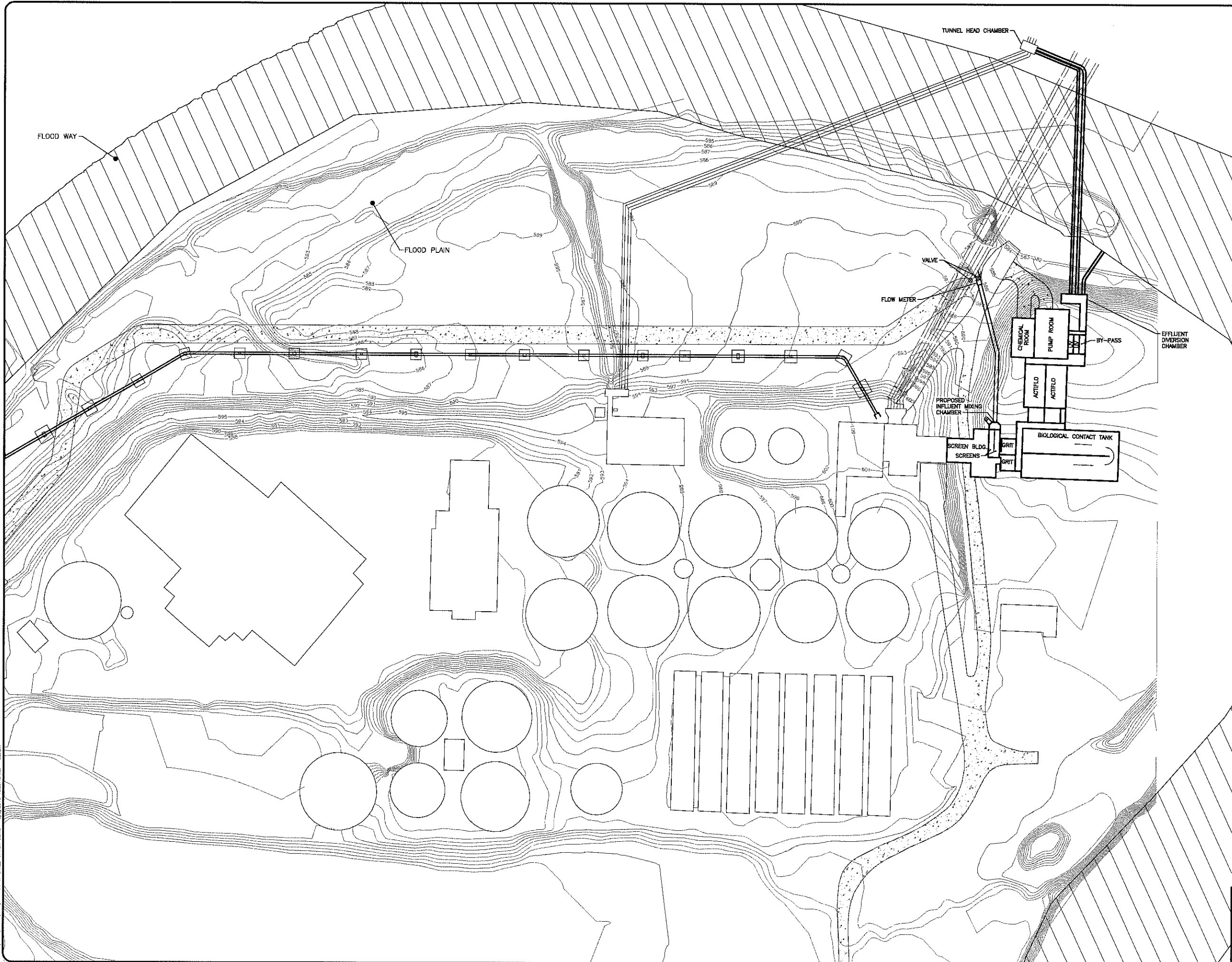
Attachment B
Figure 5

CITY OF LAKEWOOD OHIO
WET WEATHER IMPROVEMENTS FOR
WWTP

SITE LAYOUT OPTION 5

PROJECT NO:		14797	
DRAWING NAME		C-5	
SHEET	OF	5	7
DRAWING SCALE:	NO.	REVISION	DATE
• HORIZ: 1" = 50'			
• VERT: N/A			
DATE: 06/22-2016			
DESIGNED BY: JGZ			
DRAWN BY: RE			
CHECKED BY: MAK			

H:\2017\14797\DWG\SITE_OPTIONS\SITE_OPTION_6.DWG - 8/2/2016 10:28:12 AM - EURET



Attachment B
Figure 6

CITY OF LAKEWOOD OHIO
WET WEATHER IMPROVEMENTS FOR
WWTP

SITE LAYOUT OPTION 6

PROJECT NO: 14797	
DRAWING NAME C-6	
SHEET 6	OF 7

DRAWING SCALE:	NO.	REVISION	DATE
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• VERT: N/A			
DATE: 08/02-2016			
DESIGNED BY: JDZ			
DRAWN BY: RE			
CHECKED BY: MAK			

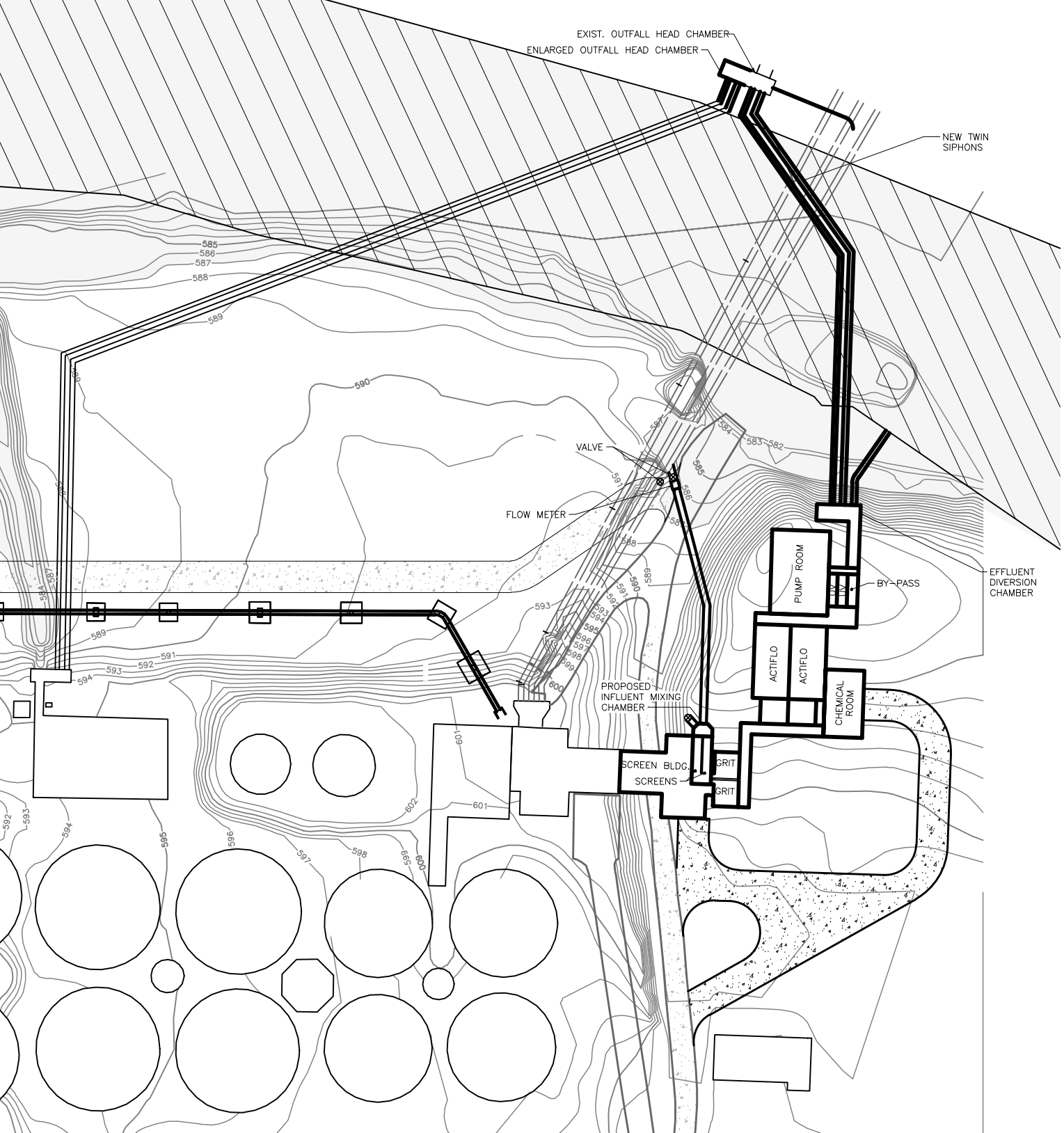


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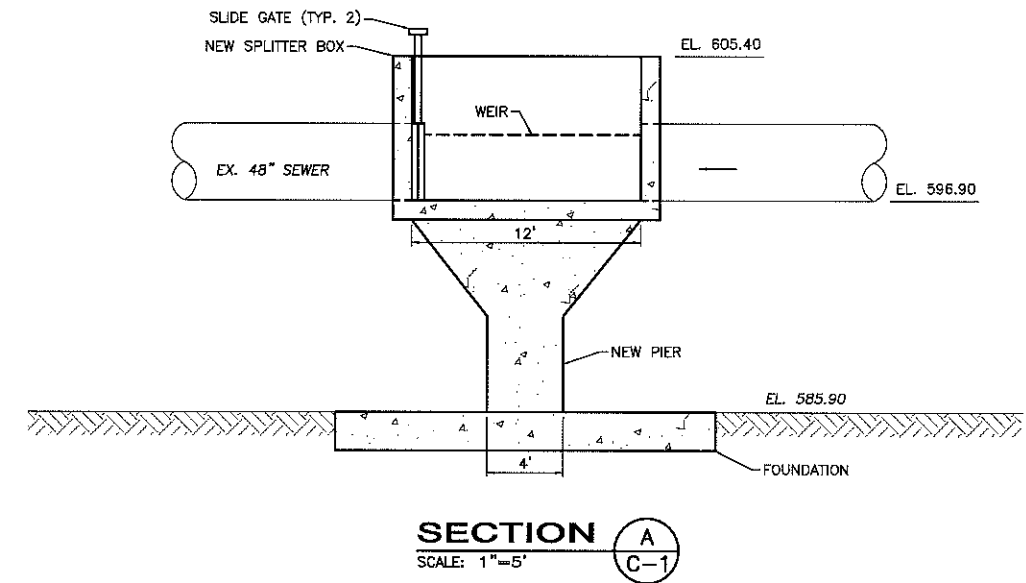
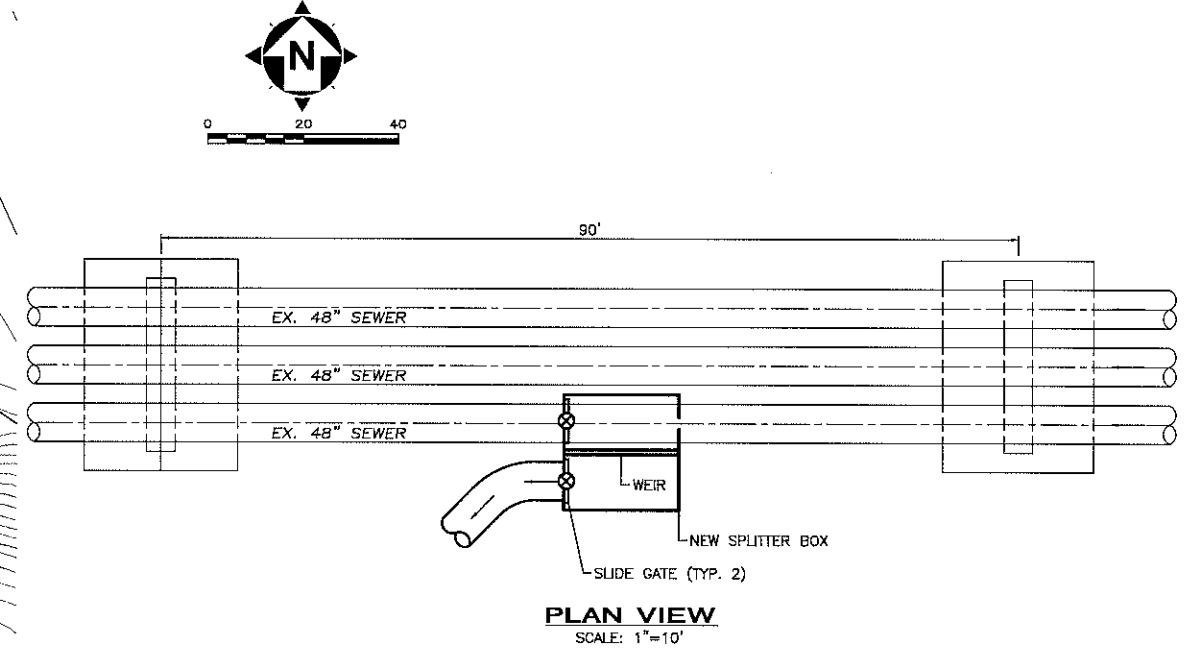
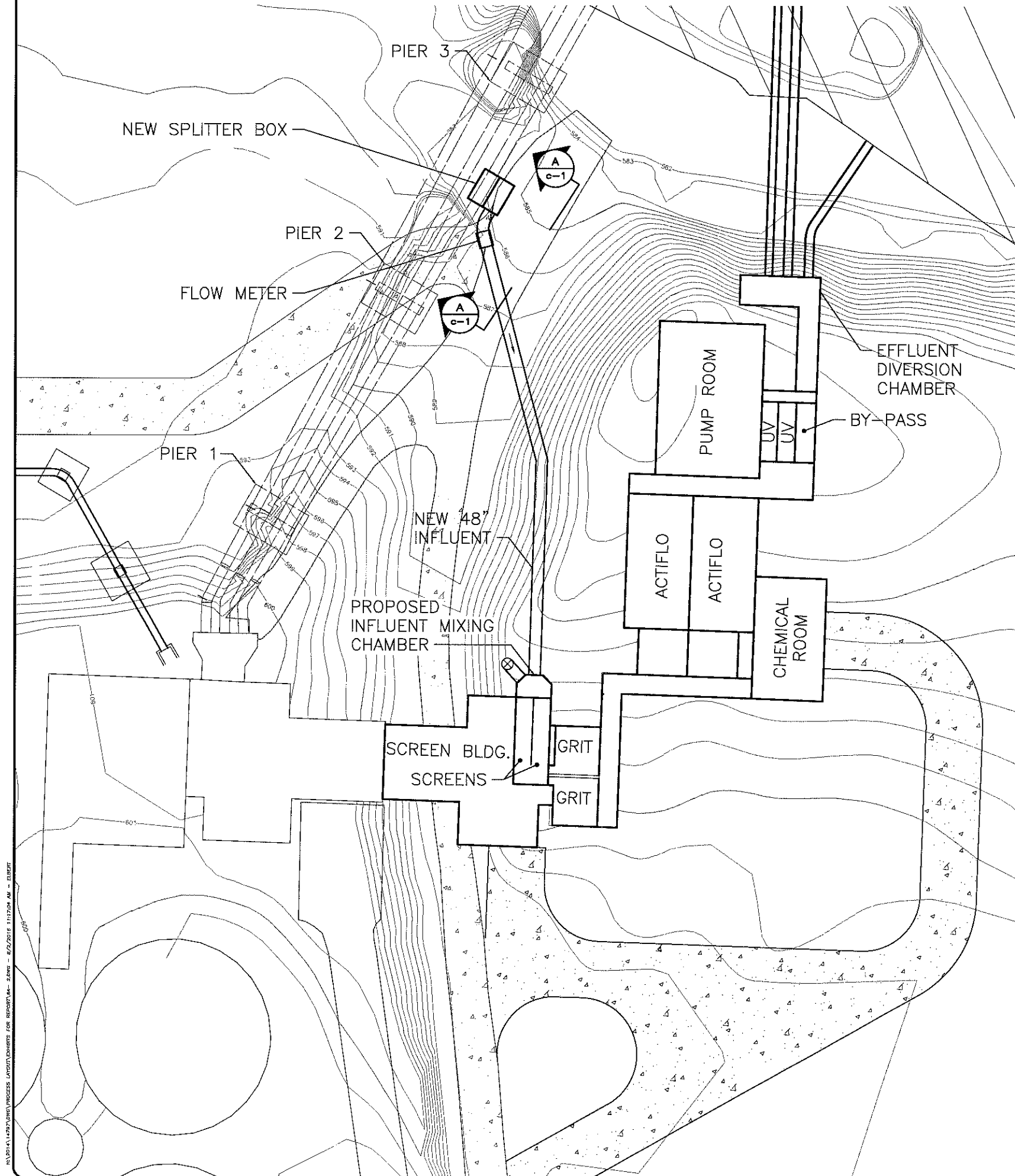
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APPENDIX C

Proposed Alternative 6A



15:20:11 1/25/2016 PROCESS LAYOUT/ENHANCE FOR REPORT 14797 - 2.000 - 8/2/2016 11:17:24 AM - EBS/ET



NOTES:

1. DIVERT FLOW FROM THE 48" ARIAL SEWER WITH AN ELEVATED CONCRETE SPLITTER BOX AND KEEP THE EXISTING SEWER TO THE PLANT.
- A. NEW SLIDE GATES FOR FLOW CONTROL OR,
- B. NEW WEIR AND GATE COMBINATION FOR FLOW CONTROL.
2. THE SPLITTER BOX SHOWN WITH 12" THICK WALLS. THE WALLS THICKNESS MAY BE DIFFERENT AFTER DESIGN.

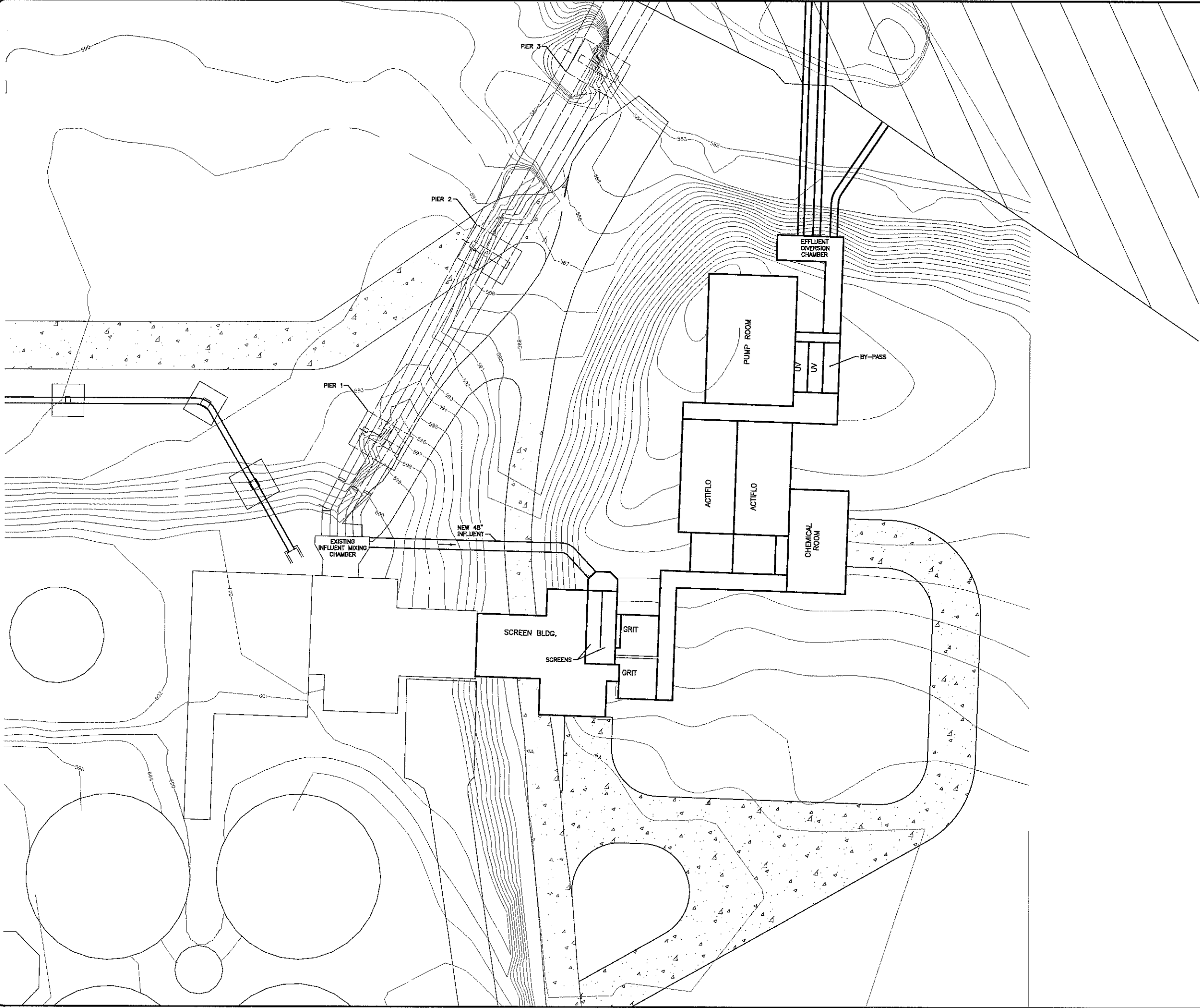
DATE	REVISION	NO.	DRAWING SCALE:	• HORZ: AS SHOWN	• VERT: N/A	DATE: 08/02/2016	DESIGNED BY: JGZ	DRAWN BY: RE	CHECKED BY: MAK

CITY OF LAKEWOOD OHIO
WET WEATHER IMPROVEMENTS FOR
WWTP

OPTION 6A - NEW SPLITTER
BOX FLOW CONTROL

PROJECT NO:	
14797	
DRAWING NAME	
C-6A	
SHEET	OF
2	3

\\201\1\1797\DWG\PROCESS\OPTION\CHAMBER FOR REPORT.MXD - 8/2/2016 11:22:54 AM - EBE:BT



CITY OF LAKEWOOD OHIO
WET WEATHER IMPROVEMENTS FOR
WWTP

OPTION 6A - CHANNEL OR PIPE
FROM EX. INFLUENT CHAMBER

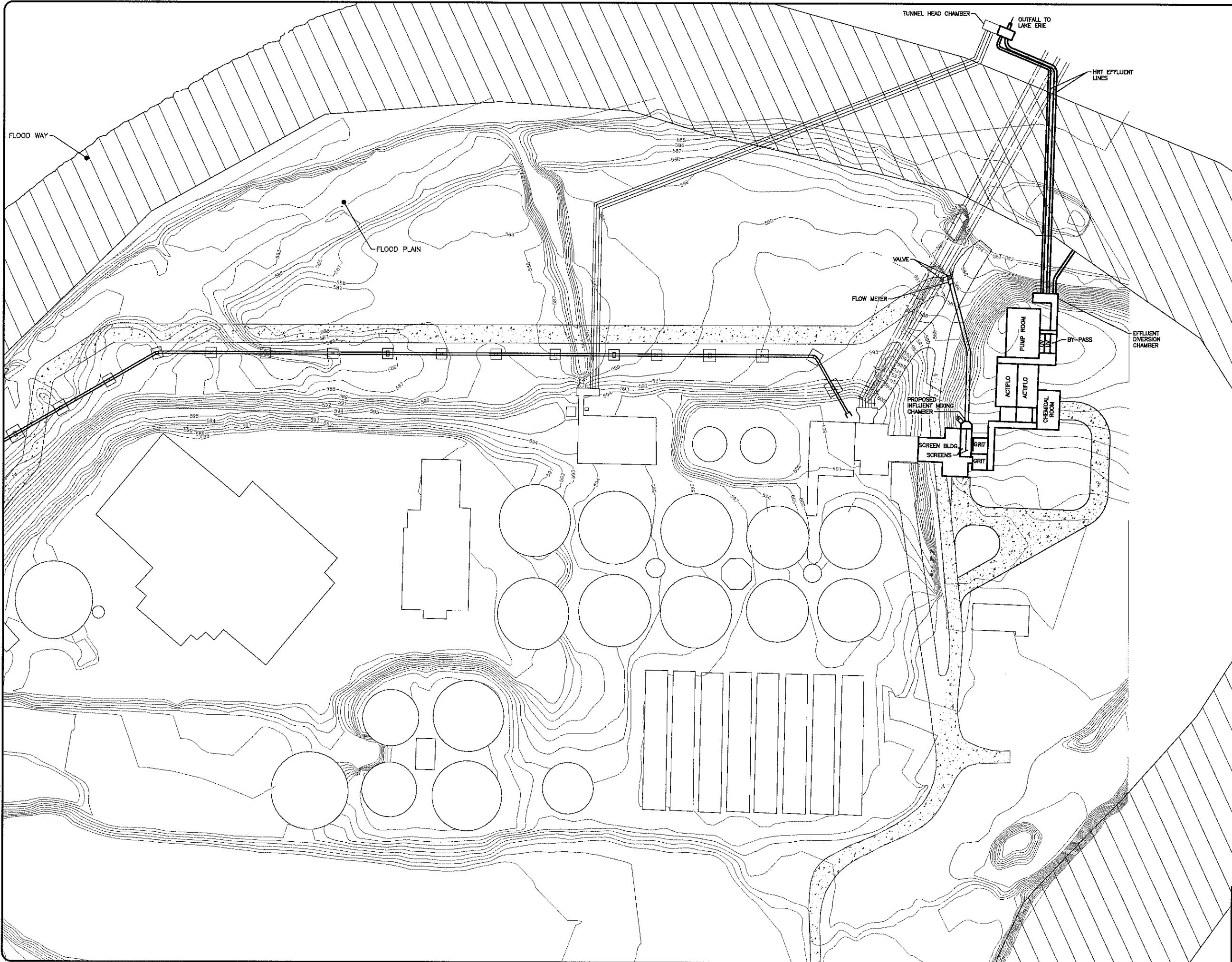
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14797	
DRAWING NAME	
C-6A	
SHEET	OF
3	3

DRAWING SCALE	NO.	REVISION	DATE
• HORIZ: 1" = 20'			
• VERT: N/A			
DATE: 08/02-2016			
DESIGNED BY: JGZ			
DRAWN BY: RE			
CHECKED BY: MAK			

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H:\2014\14797\000\PROCESS LAYOUT\SITE OPTION 6A- FINAL.DWG - 4/9/2016 5:23:20 AM - E.BERT



Attachment C
Figure 1

CITY OF LAKEWOOD OHIO
WET WEATHER IMPROVEMENTS FOR
WWTP

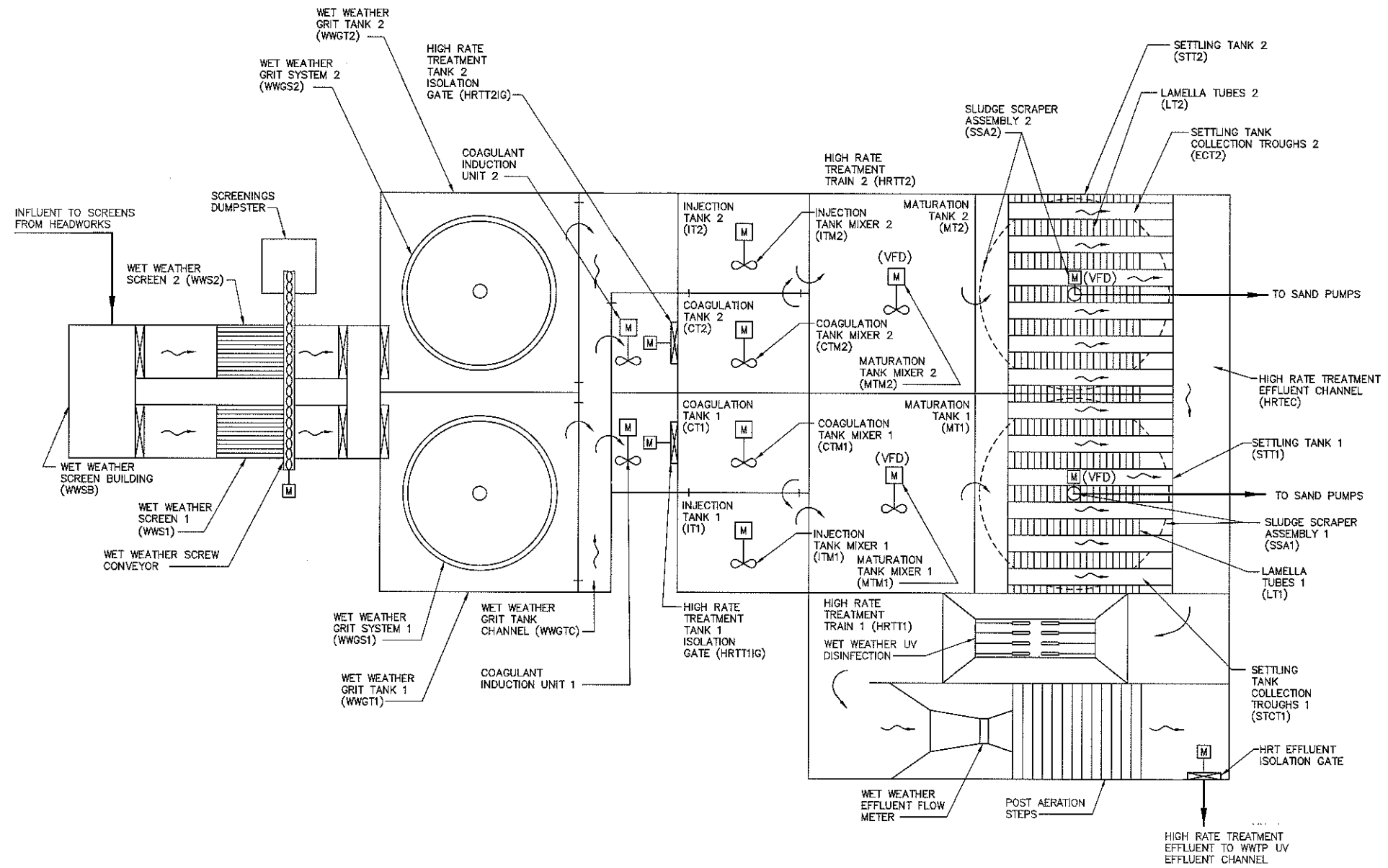
SITE LAYOUT OPTION 6A

PROJECT NO:	
14797	
DRAWING NAME	
C-6A	
SHEET	OF
7	7

DRAWING SCALE:	NO.	REVISION	DATE
HORIZ: 1" = 50'			
VERT: N/A			
DATE: 08-02-2016			
DESIGNED BY: JDZ			
DRAWN BY: RE			
CHECKED BY: MAK			



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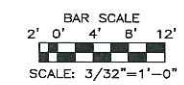
Attachment C
Figure 2

NO.	REVISION	DATE	BY	CHKD

DRAWING SCALE:	
• HORZ:	N/A
• VERT:	N/A
DATE: 08-01-2018	
DESIGNED BY:	JDZ
DRAWN BY:	RE
CHECKED BY:	MAK

PROJECT NO:	
14797	
DRAWING NAME	
G-1	
SHEET	OF
1	1

J:\2018\14797\DWG\FLOW SCHEMATIC_08-01-2018.dwg - 8/2/2018 4:45:30 PM - EBER



NOTE:
ASSUME 1 FOOT WIDE WALLS.

PRELIMINARY

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SCALE: AS SHOWN		NO	REVISION	DATE
DATE: 06-14-16				
DESIGNED BY: M/S				
DRAWN BY: RE				
CHECKED BY: MAK				

**CITY OF LAKEWOOD
OHIO WET WEATHER
IMPROVEMENTS FOR WWTP**

**PROCESS LAYOUT
OPTION 6A**

PROJECT NO:

14797

DRAWING N

P-1

SHEET	
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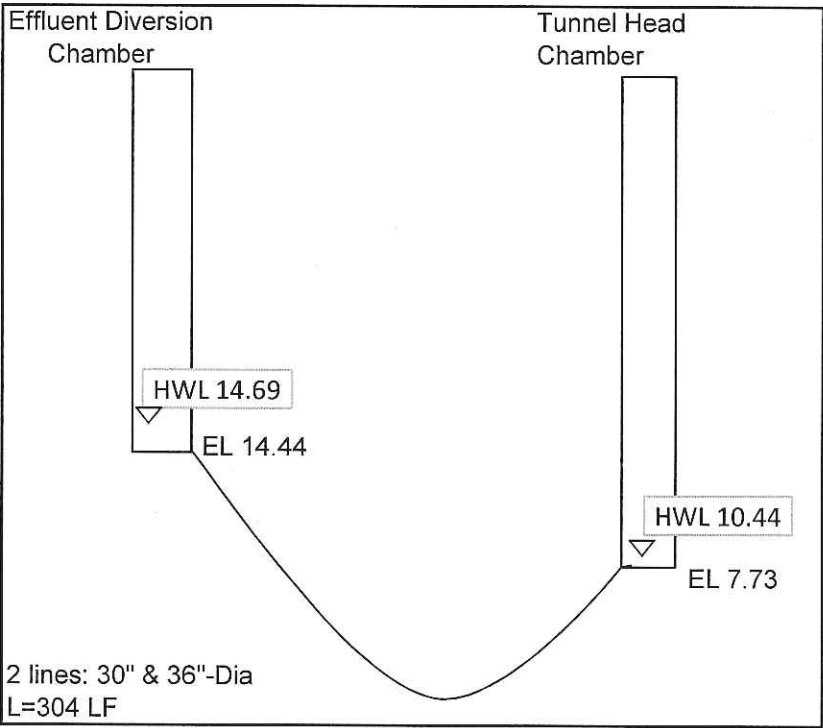
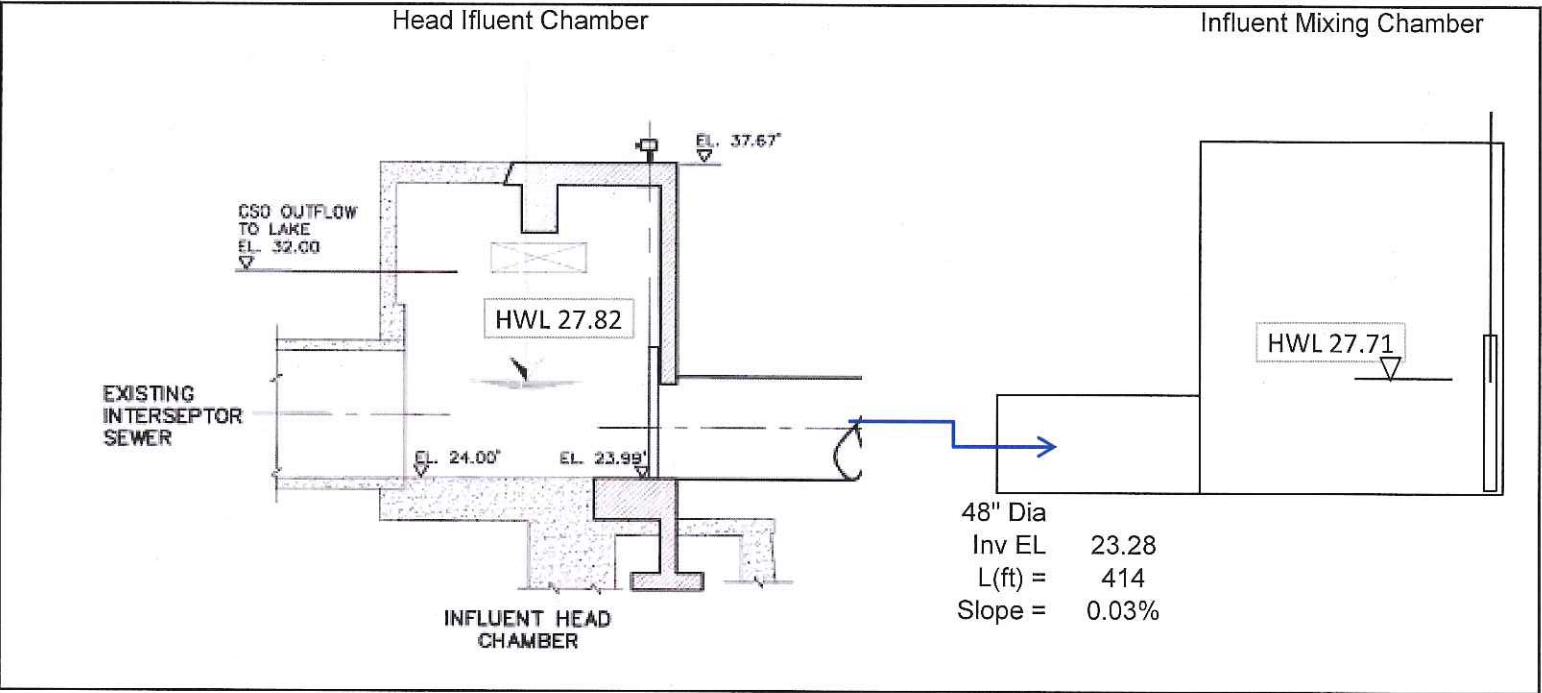
OF

APPENDIX D

Hydraulic Profile

LAKEWOOD WWTP
ACTIFLO HRT

EXISTING PLANT INFLUENT AND EFFLUENT



	Influent Head Chamber		Influent Mixing chamber		Effluent Diversion Chamber		Tunnel Head Channel	
	Relative	Absolute	Relative	Absolute	Relative	Absolute	Relative	Absolute
Inv EL	23.99	598.21	23.28	597.5	14.44	588.66	7.73	581.95

1980 Set, Sheet G5:	Bench Mark: Top of Slab of Influent Metering Vault	EL 28.99	Plant
		603.9	USGS EL
	Conversion Factor from Plant EL to USGS =	574.91	

URS 2001 23.28 = 597.5

Total L = 5344 from Treatment Plant to Lake Erie
L syphon = 675 from Treatment Plant to Tunnel Head Chamber

LAKEWOOD WWTP
ACTIFLO HRT

1) Pure water headloss calculated based on Hazen Williams equiation:

$$h_f = \frac{(10.44)(L)(Q)^{1.85}}{(C)^{1.85} (d)^{4.8655}}$$

where: L = pipe length or equivalent length (feet)
Q = flow (gpm)
C = Hazen Williams coefficient
C = 100
d = pipe dia (inches)

2) Minor head losses are calculated as follows:

$$h_m = k \frac{v^2}{2g}$$

where: k = factor
v = velocity (ft/s)
g = 32.2 ft/s/s

TOTAL PLANT FLOW			MGD	7.0	12.0	35.0	
			gpm	4,861	8,333	24,306	
			cfs	10.83	18.57	54.15	
Pipe Diameter	36		inch				
Pipe Diameter	30		inch				
Area (sft) of 36" dia pipe =	7.07		sft				
Area (sft) of 30" diam pipe =	4.91		sft				
Flow Split ration for 36" dia =	0.61	0	gpm	0,000	5,083	14,826	- Vary split value no. to obtain equal headloss in each pipe
			cfs	0.00	11.32	33.03	
Flow Split ration for 30" dia =	0.39	1	gpm	4,861	3,250	9,479	
			cfs	10.83	7.24	21.12	
Velocity in 36 " dia pipe =			fps	0.00	1.60	4.68	
Velocity in 30 " dia pipe =			fps	2.21	1.48	4.30	
V^2/(2g) for 36" pipe =			ft/s ²	0.00	0.04	0.34	
V^2/(2g) for 30" pipe =			ft/s ²	0.08	0.03	0.29	
h/100 in 36" dia pipe =			ft/100 ft	0.00	0.04	0.29	- Flow spilit Ratio is atjusted to obtain close headloss values
h/100 in 30" dia pipe =			ft/100 ft	0.09	0.04	0.31	
(Q,cfs/Area,sft) for 36" dia pipe =			cfs/sft	0.00	1.60	4.68	
(Q,cfs/Area,sft) for 30" dia pipe =			cfs/sft	2.21	1.48	4.30	
1. Calculate Friction Loss in the Syphon							
Dia = 30-in L = 400 ft C: 100			k				
Gravity Line				0.36	0.17	1.23	
90 degree bend (SR)	EA: 3		0.38	0.09	0.04	0.33	
entrance loss	EA: 1		1	0.08	0.03	0.29	
exit loss	EA: 1		0.75	0.06	0.03	0.22	
Total Friction Losses in 30-inch line				0.58	0.27	2.06	
Dia = 36-in L = 400 ft C: 100			k				
Gravity Line				0.00	0.16	1.16	
90 degree bend (SR)	EA: 3		0.38	0.00	0.05	0.39	
entrance loss	EA: 1		1	0.00	0.03	0.29	
exit loss	EA: 1		0.75	0.00	0.03	0.22	
Total Friction Losses in 36-inch line				0.00	0.26	2.05	
Static Head:				6.72 ft	6.72 ft	6.72 ft	
Syphon Head-available:				-6.72 ft	-6.46 ft	-4.67 ft	
72" dia outfall	Absolute	WL, ft		584.66			72"ø outfall to Lake Erie
WL in Diversion chamber:	Absolute	WL, ft		-	-	588.91	

LAKEWOOD WWTP
ACTIFLO HRT

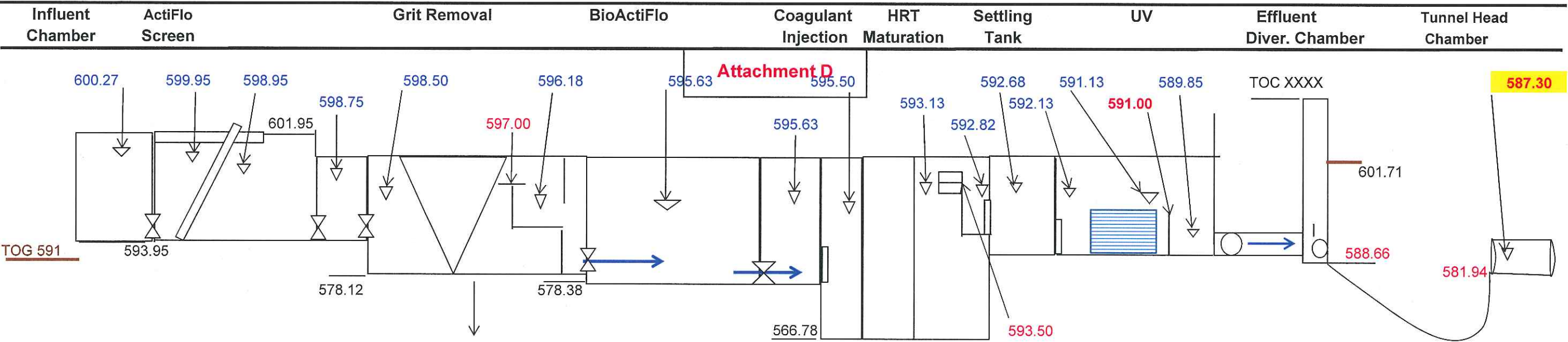
B. ELEVATIONS

	Existing		Proposed
	Relative	Absolute	Absolute
Tunnel Access Chamber Invert EL	5.00	579.22	
Tunnel Head Chamber-Siphon Pipe Invert EL	7.72	581.94	587.3
Tunnel Head Chamber WL	10.44	584.66	
Effluent Diversion Chamber Bottom Slab EL	14.44	588.66	588.66
Effluent Diversion Chamber WL EL @ 35 MGD	14.69	588.91	588.91
UV Effluent WL	14.82	589.04	
UV Effluent Wier Top EL	17.75	591.97	
Final Clarifier Effluent Weir EL	12.6	586.82	

at 63 MGD - SWMM Model

Existing relative elevations obtained from URS 1980 plan set.

URS 1980	CT 2015
23.28 =	597.5



Attachment D

LAKWOOD WWTP
ACTIFLO HRT

TOTAL PLANT FLOW				MGD	7.0	12.0	35.0	
				gpm	4,861	8,333	24,306	
No. of Trains				1	cfs	10.83	18.57	54.15
				2	cfs	5.41	9.28	27.07
Select Diameter for Proposed Piping:								
Assumed Pipe Diameter (inch) = 42								
Area (sft) = 9.62								
Velocity =				fps	1.13	1.93	5.63	
V^2/(2g) =				ft/s ²	0.02	0.06	0.49	
1. Effluent Diversion Chamber								
Effluent Weir	EA: 1	Length, ft =	4.5	ft	0.24	0.41	1.19	
	Slope	1.15%						
	Channel Length (ft) =	22						
	Channel Width, ft =	4.50 ft						
	Channel Depth (D), ft =	7.00						
	Hydraulic Depth (d), ft =	6	1.93					
	d/D =	0.86	0.28					
	n =	0.13						
	Wetted Perimeter, ft =	-	8.35					
	A/D ² =	0.70	2.34					
	Area of flow (A), sft	34.12	8.66					
	(R/D) =	0.297	0.539					
	Hydraulic Radius (R), ft	2.08	1.037					
Calculated Flow	cfs	68.53	10.91					
	MGD	44.30	7.05					
Ground Elevation, ft =								
Effluent Diversion Chamber Slab SET EL, ft =								
WL in the UV Effluent Channel =				ft	588.90	589.07	589.85	
2. UV								
Serpentine Weir SET EL, ft =								
Rectangular weir w/o end contractions K =				3.33				
Total Serpentine Weir Length, ft =				325				
H _f =				ft	0.05	0.07	0.13	
WL after UV modules =					591.05	591.07	591.13	
Assumed H _f thru UV (channel, UV modules) =				1				
WL in UV Channel =					592.05	592.07	592.13	
H _f - UV Influent Sluice Gate-015H	EA: 1	Dia (in) =	42	ft	0.02	0.06	0.55	
Flow thru Orifice		Area (sft) = 9.62						
WL in UV Inffluent Channel =					592.07	592.13	592.68	
UV Bottom EL =				4.00	587.13			

$Q = K \cdot L \cdot H^{1.5}$ Assume 2 parrallel Channels

$Q = \frac{1.49 \cdot A \cdot R^{2/3} \cdot S^{1/2}}{n}$

Isco Open Channel, p 130 and Table 6-2
page 141,

- Estimated EL based on URS Drawings

Orifice in Reservoir

$Q = C_d A \sqrt{2gh}$

LAKESWOOD WWTP
ACTIFLO HRT

3. Settling Tank Headloss				
TOTAL FLOW		MGD	7.0	12.0
		MGD	7.0	12
		gpm	4,861	8,333
		cfs		
H _f - ActiFlo Effluent Sluice Gate-013/14H EA: 1 Dia (in) = 42		ft	0.02	0.06
Flow thru Orifice Area (sft) = 9.62				
WL in ActiFlo Effluent Channel =			592.09	592.19
Rectangular Weir Nos. 1-6 EA: 1 Length, ft = 2.875		ft	0.32	0.47
ActiFlo Effluent WL at Rectangular Wier		ft	592.41	592.66
Bottom of Notch SET EL, ft = 593.50		ft		
HRT Bottom EL = 26.72 566.78		ft		
Settling Tank Headloss				
Settling Tank Influent Weir 29.67		ft		
HRT Maturation Tank Effluent Opening 5.9'H x 29.67'(W)				
Coagulation Injection Tank				
Assumed H _f thru Actiflo = 2			595.50	595.50
H _f - ActiFlo Influent Sluice Gate-011/12H EA: 1 Dia (in) = 42		ft	0.02	0.06
Flow thru Orifice Area (sft) = 9.62				
WL in ActiFlow Inffluent Channel =			595.52	595.56
4. Headloss from Actiflo to Bioactiflo				
BioAF Effluent Sluice Gate-010H EA: 0 Dia (in) = 42		ft	0.00	0.00
Flow thru Orifice Area (sft) = 9.62				
WL in BioActiflow Tank =			595.52	595.56
Tank Size: 104'x48'x17.25' (SWD) Tank Volume = 86,112		cft		
644,204		gal		
Detention Time =		min	132.52	77.30
Bottom of Tank EL = 17.25 578.38		ft		
5. Grit Removal				
BioAF Influent Sluice Gate-009H EA: 1 Dia (in) = 42		ft	0.02	0.06
Flow thru Orifice Area (sft) = 9.62				
WL in Grit Effluent Channel =			595.54	595.63
Effluent 5-ft Weir SET EL, ft = 597.00		ft		
Grit Efflt Weir, Slide Gates - 007/008H EA: 1 Length= 5			0.29	0.67
Total H _f - HeadCell Unit (inch) = 1.5			597.42	597.79
HeadCell Bottom EL = 20.375 578.12		ft		

Kruger, Sheet 6 of 9

Grit Removal Effluent Channel to BioActiflo
- Full flow

Q = Flow in cfs
C_d = Coefficient of Dischsrg = 0.95
A = Area of opening (ft²)
h = Differential Head (loss)

LAKESWOOD WWTP
ACTIFLO HRT

6. Screen						
Grit Influent Sluice Gate-005/006H Flow thru Orifice	EA: 1	Dia (in) = 36		0.01	0.03	0.25
		Area (sft) = 7.07				
Effluent Screen Channel WL =			ft	597.43	597.82	598.75
Screen Effluent Sluice Gates-003/004H Flow thru Orifice	EA: 1	Dia (in) = 54		0.01	0.02	0.20
		Area (sft) = 15.90				
Upstream of Screen		Downstream of Screen =		597.43	597.85	598.95
		Asumed Head Losses (ft) =	1	598.43	598.85	599.95
Screen Channel Top Slab		Freeboard (ft) = 2	ft			601.95
Screen Channel Bottom EL		Chennel Depth (ft) = 8	ft			593.95
Screen Influent Sluice Gates-001/002H Flow thru Orifice	EA: 1	Dia (in) = 48		0.01	0.04	0.32
		Area (sft) = 12.56				
WL in Influent Mixing Chamber				598.45	598.88	600.27
7. Headloss from Screen to HRT Influent Chamber						

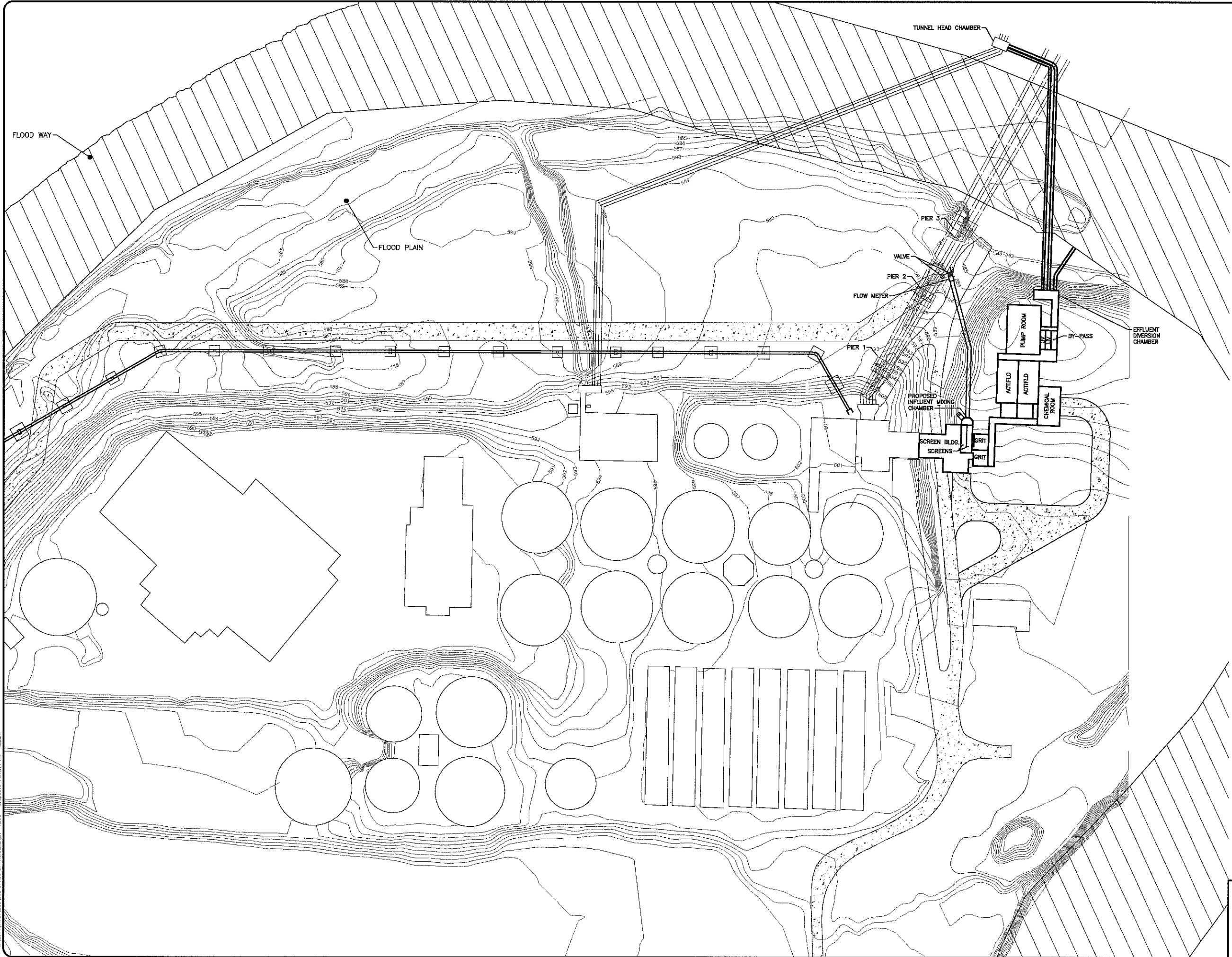
- One screen, Total flow

	Units	Total h _f
HRT, 35 MGD	ft	9.27
Existing Plant, 23 MGD, 1980	ft	12.21
Efluent Div. Chamber Bottom Slab EL	ft	588.66

APPENDIX E

Influent Sewer Options

\\N2014\14797\DWG\SITE OPTION 6A VERSIONS\6A-1.DWG - 9/2/2016 11:40:11 AM - ELSBRT



Attachment E
Figure 1

CITY OF LAKEWOOD OHIO
WET WEATHER IMPROVEMENTS FOR
WWTP

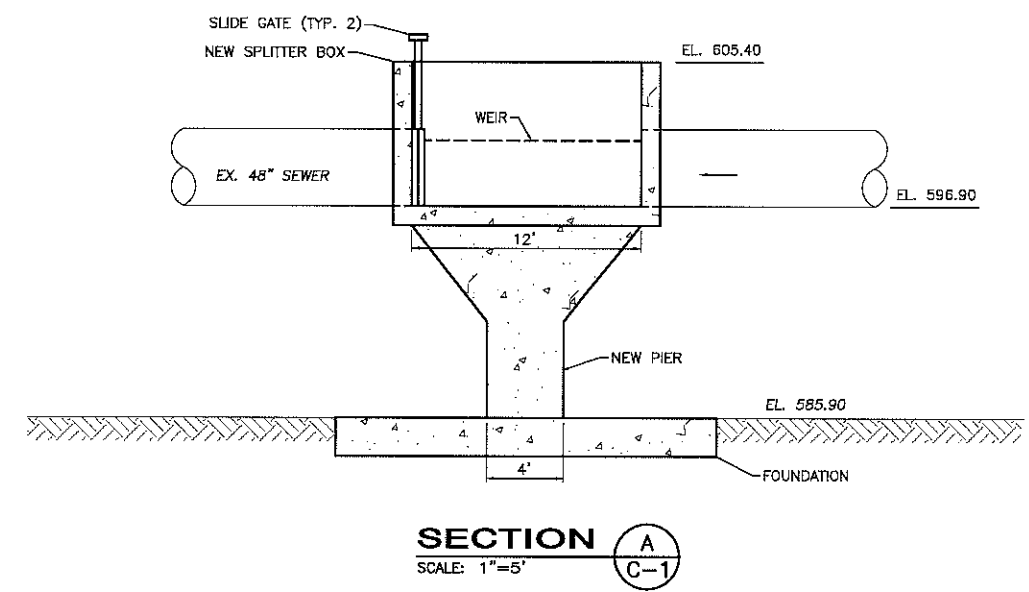
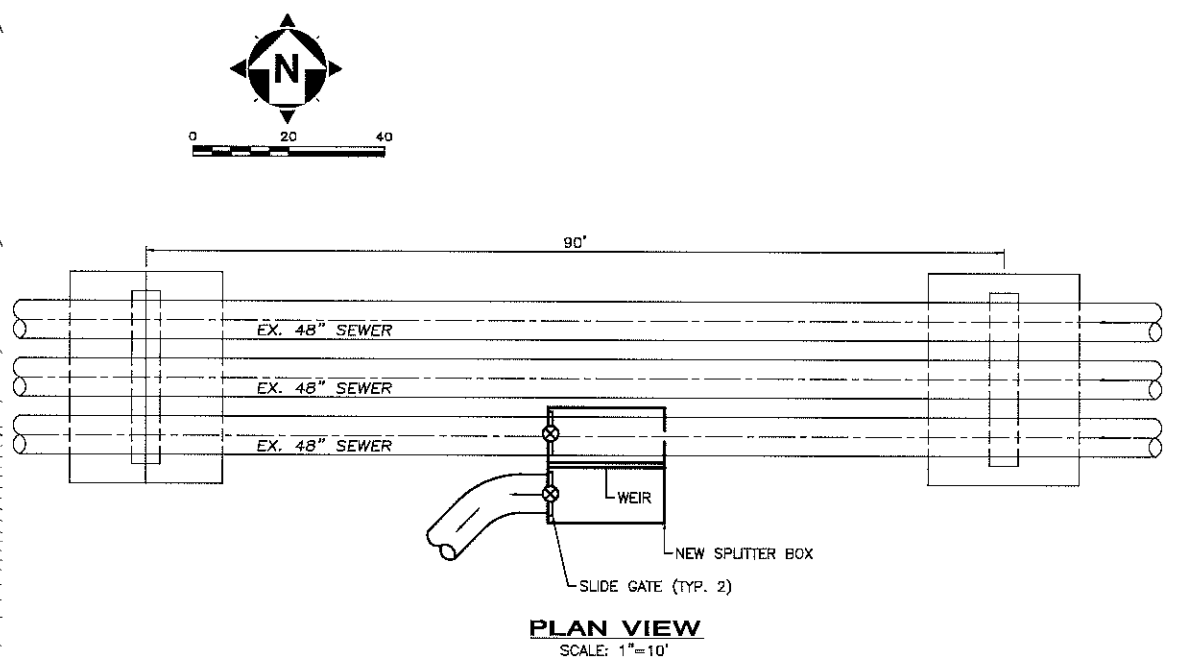
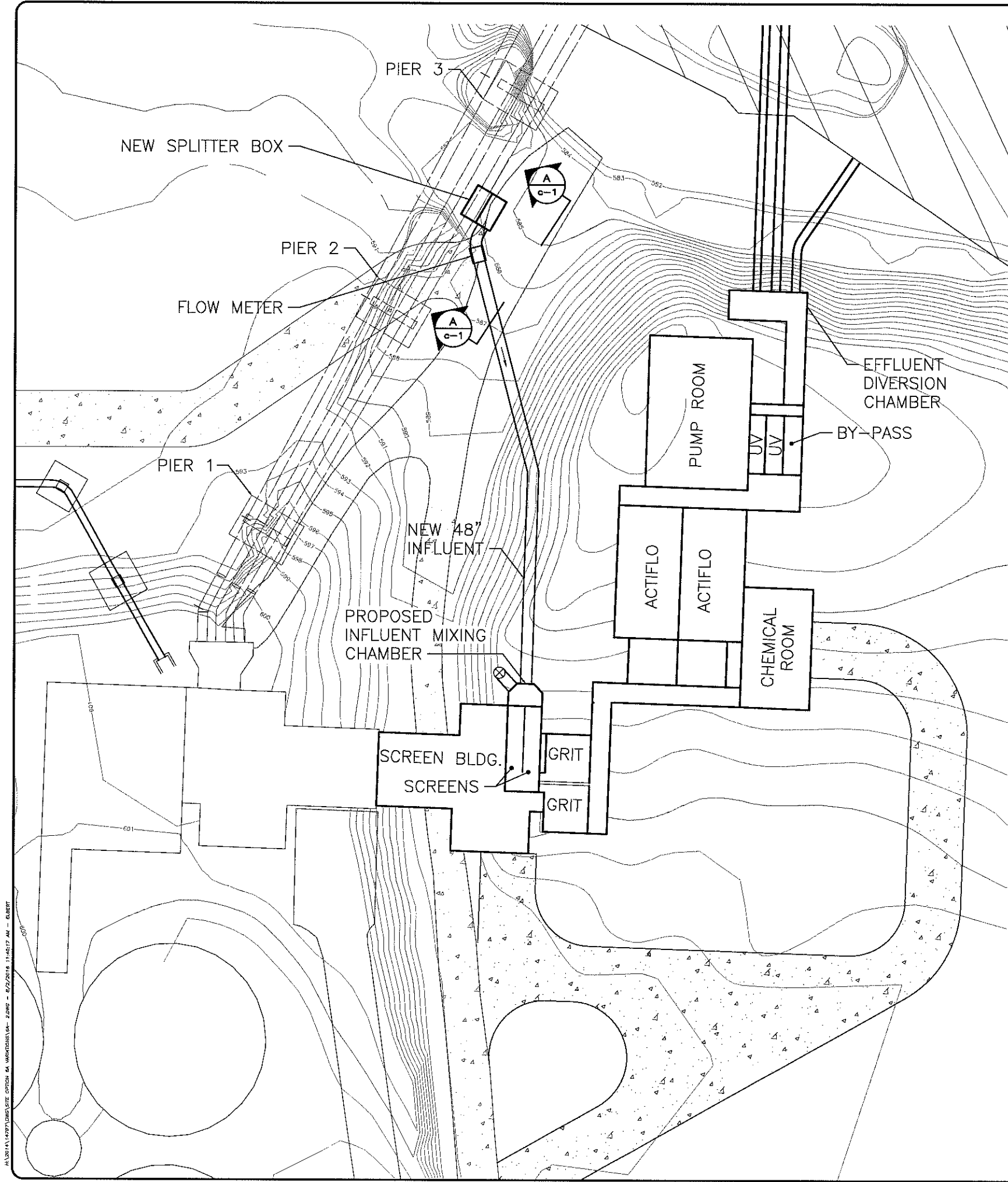
OPTION 6A - NEW AERIAL
SEWER WITH VALVES

PROJECT NO:	
14797	
DRAWING NAME	
C-6A	
SHEET	OF
1	3

DRAWING SCALE:	NO.	REVISION	DATE
• HORIZ: 1" = 50'			
• VERT: N/A			
DATE: 08-02-2016			
DESIGNED BY: JGZ			
DRAWN BY: RE			
CHECKED BY: MAK			



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- NOTES:**
- DIVERT FLOW FROM THE 48" ARIAL SEWER WITH AN ELEVATED CONCRETE SPLITTER BOX AND KEEP THE EXISTING SEWER TO THE PLANT.
 - NEW SLIDE GATES FOR FLOW CONTROL OR, NEW WEIR AND GATE COMBINATION FOR FLOW CONTROL.
 - THE SPLITTER BOX SHOWN WITH 12" THICK WALLS. THE WALLS THICKNESS MAY BE DIFFERENT AFTER DESIGN.

H:\2014\14797\DWG\SITE OPTION 6A WETWEATHER\6A-2.DWG - 6/2/2016 11:45:17 AM - EUBERT

Attachment E
Figure 2

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Phone: 614.485.1700 - Fax: 614.485.1701 - www.ctconsultants.com

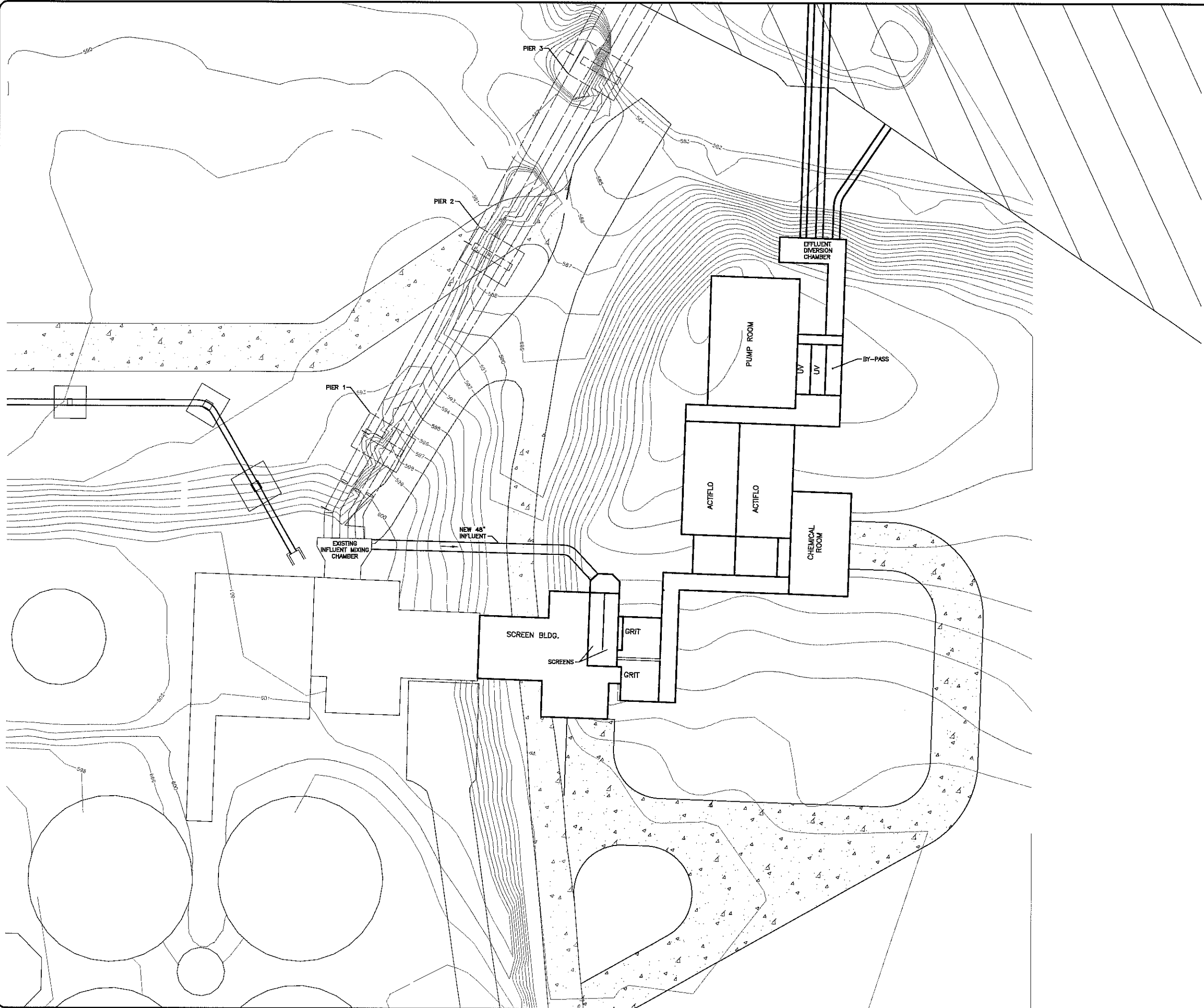
NO.	REVISION	DATE

CITY OF LAKEWOOD OHIO
WET WEATHER IMPROVEMENTS FOR WWTP

OPTION 6A - NEW SPLITTER BOX FLOW CONTROL

PROJECT NO: 14797	
DRAWING NAME: C-6A	
SHEET 2	OF 3

H:\2014\14797\DWG\SITE OPTION 6A WWTPLANS\14797-3290 - 07/2016 9:45:36 AM - EJBRT



Attachment E
Figure 3

CITY OF LAKEWOOD OHIO
WET WEATHER IMPROVEMENTS FOR
WWTP

OPTION 6A - CHANNEL OR PIPE
FROM EX. INFLUENT CHAMBER

PROJECT NO: 14797	
DRAWING NAME C-6A	
SHEET 3	OF 3

DRAWING SCALE:	NO.	REVISION	DATE
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• VERT: N/A			
DATE: 08/02-2016			
DESIGNED BY: JDZ			
DRAWN BY: RE			
CHECKED BY: MAK			



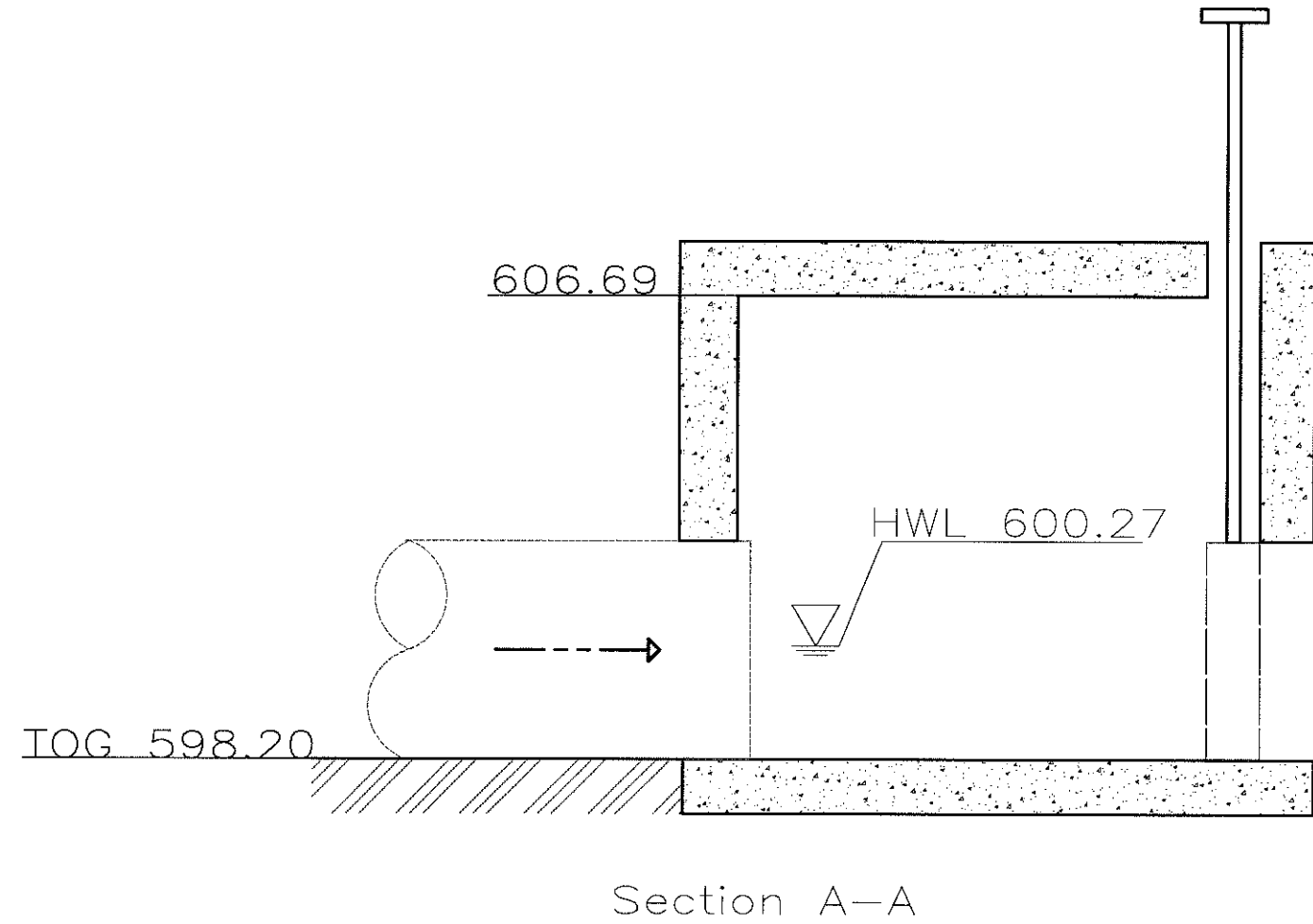
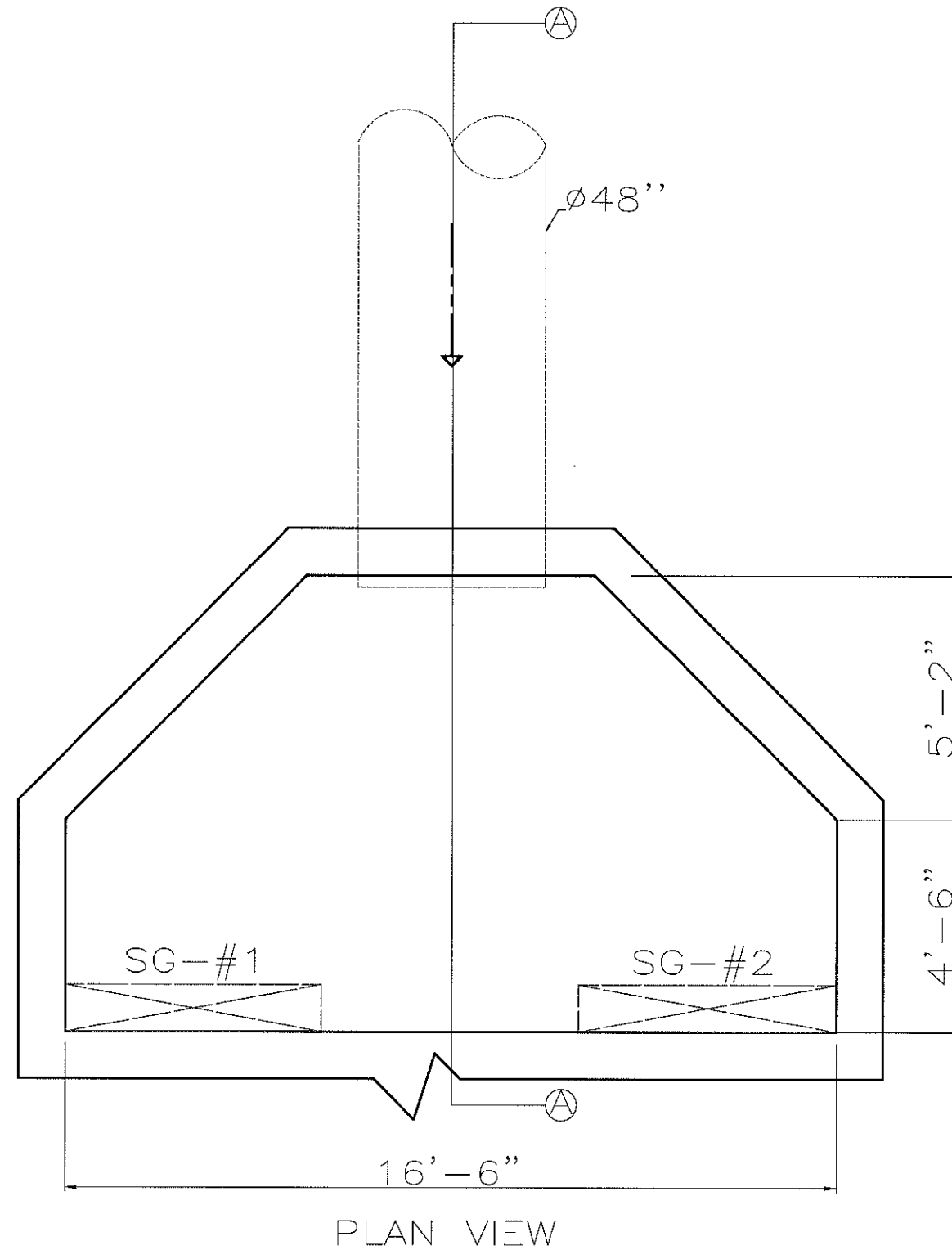
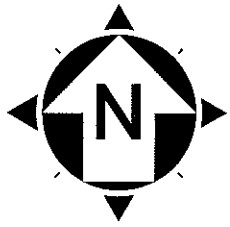
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APPENDIX F

Proposed HRT System Preliminary Layout

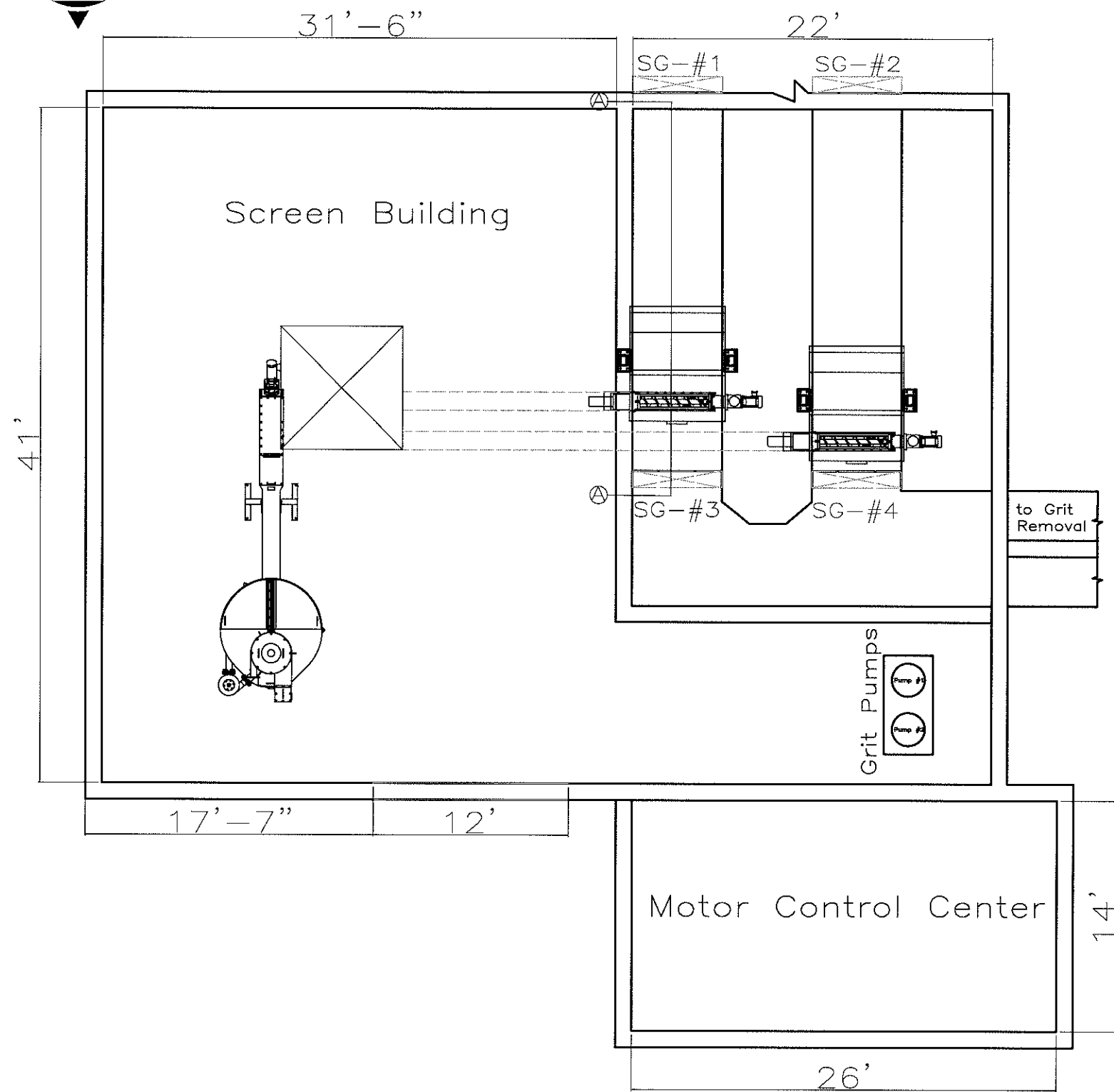
Figures 1-10



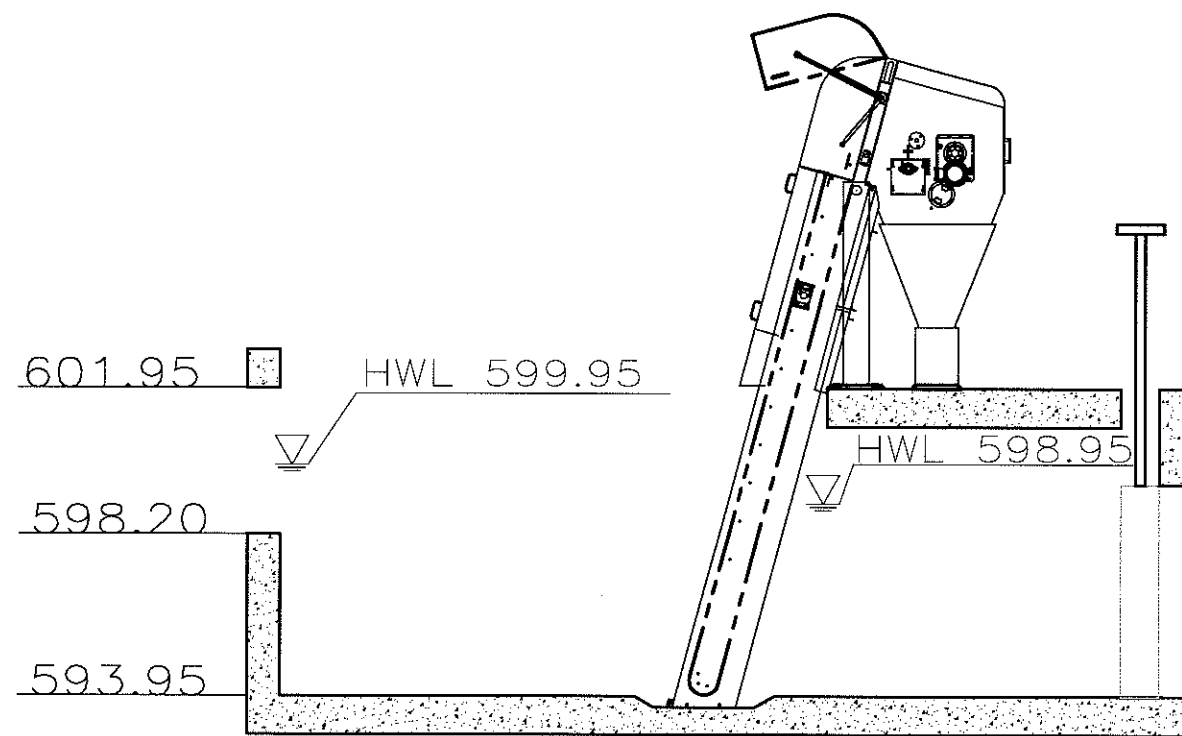
Attachment F
Figure 1

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14797							
CITY OF LAKEWOOD OHIO		WET WEATHER IMPROVEMENTS FOR		DESIGNED BY:		CHECKED BY:	
WWTP		Influent Mixing Chamber		DRAWN BY:		DATE:	
DRAWING SCALE:		NO.		REVISION		DATE	
• HORIZ: N/A							
• VERT: N/A							
DATE:							
DESIGNED BY:							
DRAWN BY:							
CHECKED BY:							

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PLAN VIEW



Section A-A

Attachment F
Figure 2A



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engineers architects planners
Northwood Building - 7065 N. High Street - Suite 340, Columbus, Ohio 43235
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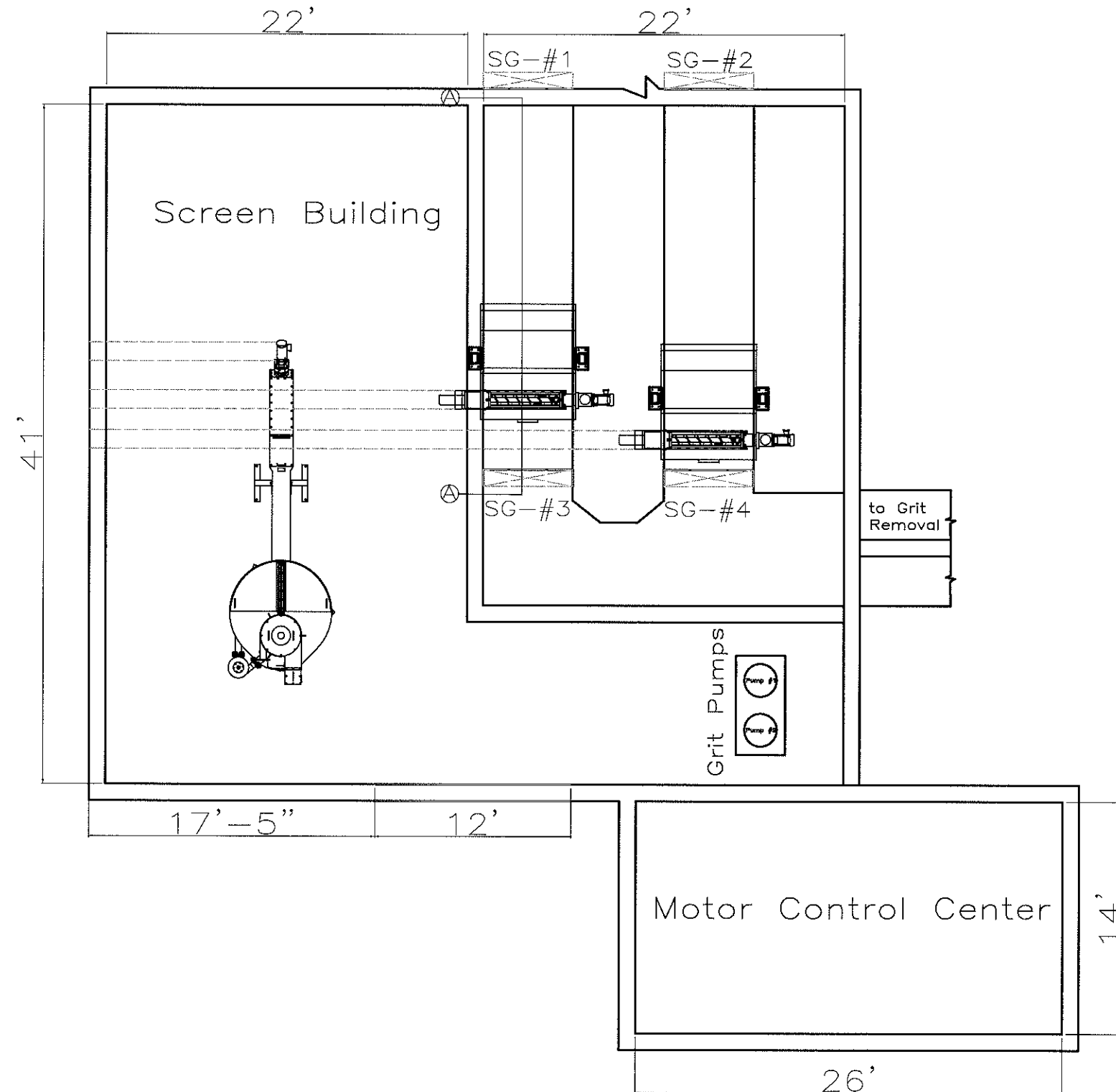
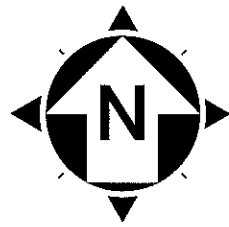
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DATE:	DESIGNED BY:
DRAWN BY:	CHECKED BY:

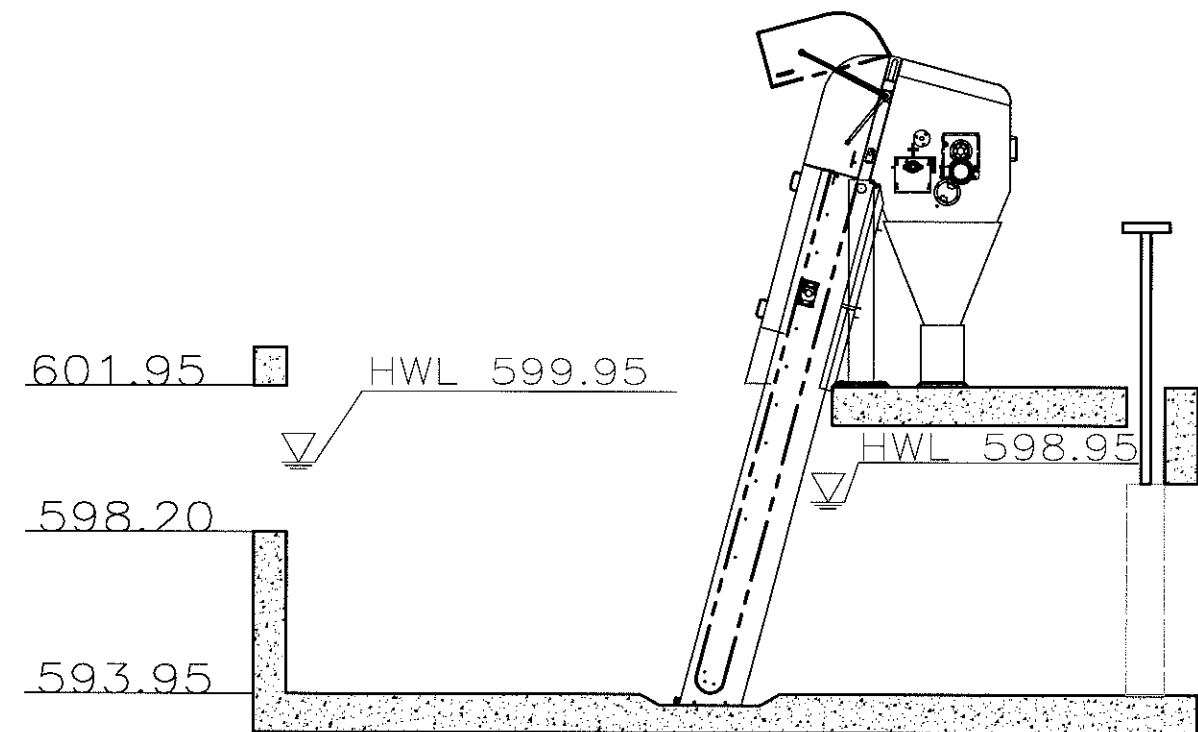
CITY OF LAKEWOOD OHIO
WET WEATHER IMPROVEMENTS FOR
WWTP

**Option 1 - Screen Building
& Solids Dumpster**

PROJECT NO:	
14797	
DRAWING NAME	
SHEET	OF



PLAN VIEW



Section A-A

Attachment F
Figure 2B

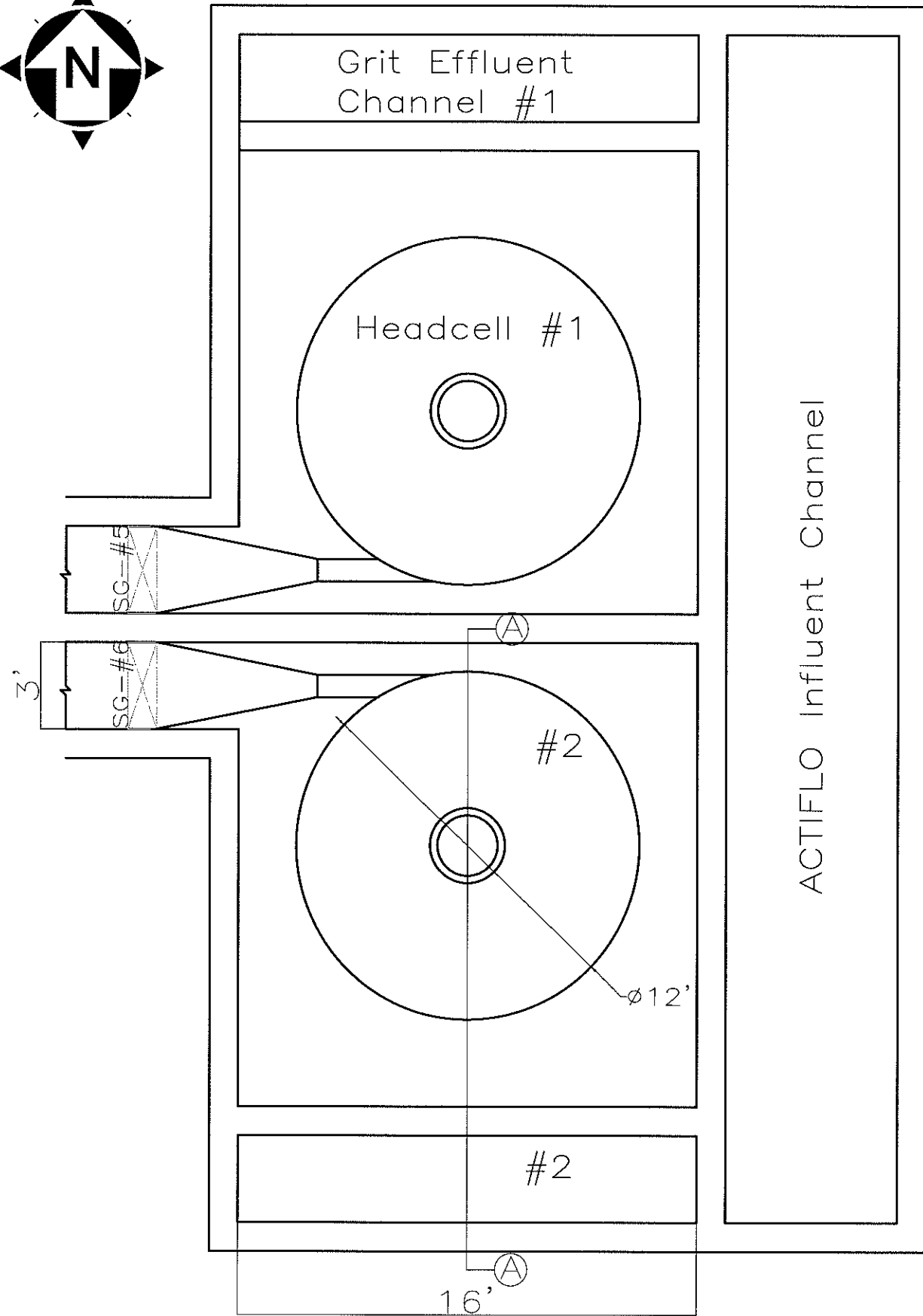
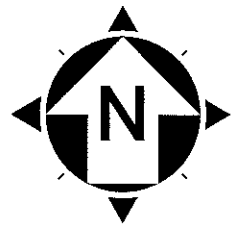
CT Consultants
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Northwood Building, 7063 N. High Street, Suite 140, Columbus, Ohio 43235
Phone: 614-883-1700 - Fax: 614-883-1701 - www.ctconsultants.com



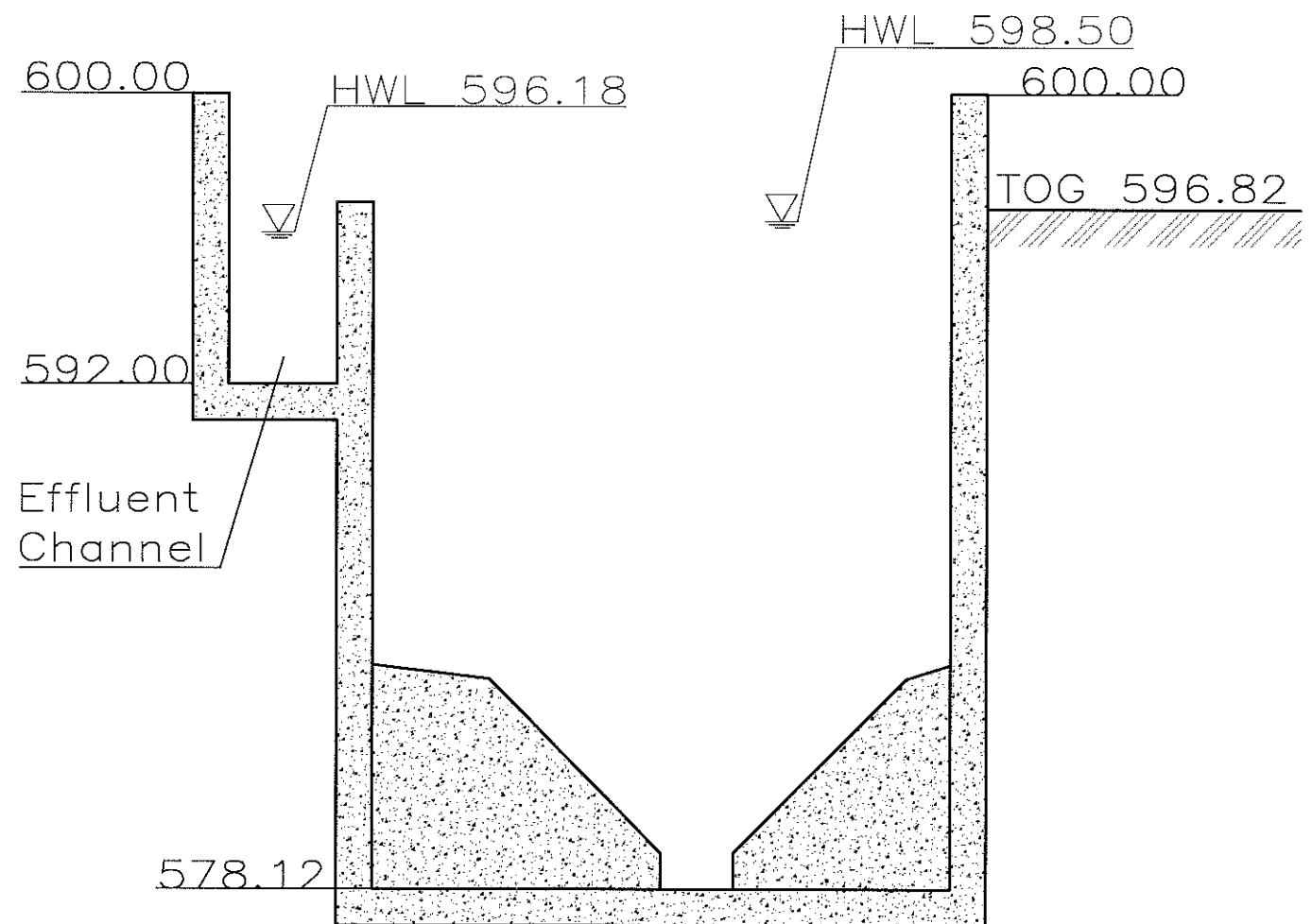
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DRAWING NAME		Option 2 - Screen Building & Utilization of Existing Dumpster	
SHEET		OF	
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• HORIZ:		DATE:	
• VERT:		DESIGNED BY:	
NO.		DRAWN BY:	
CHECKED BY:			

CITY OF LAKEWOOD OHIO
WET WEATHER IMPROVEMENTS FOR
WWTP

Option 2 - Screen Building &
Utilization of Existing Dumpster



PLAN VIEW

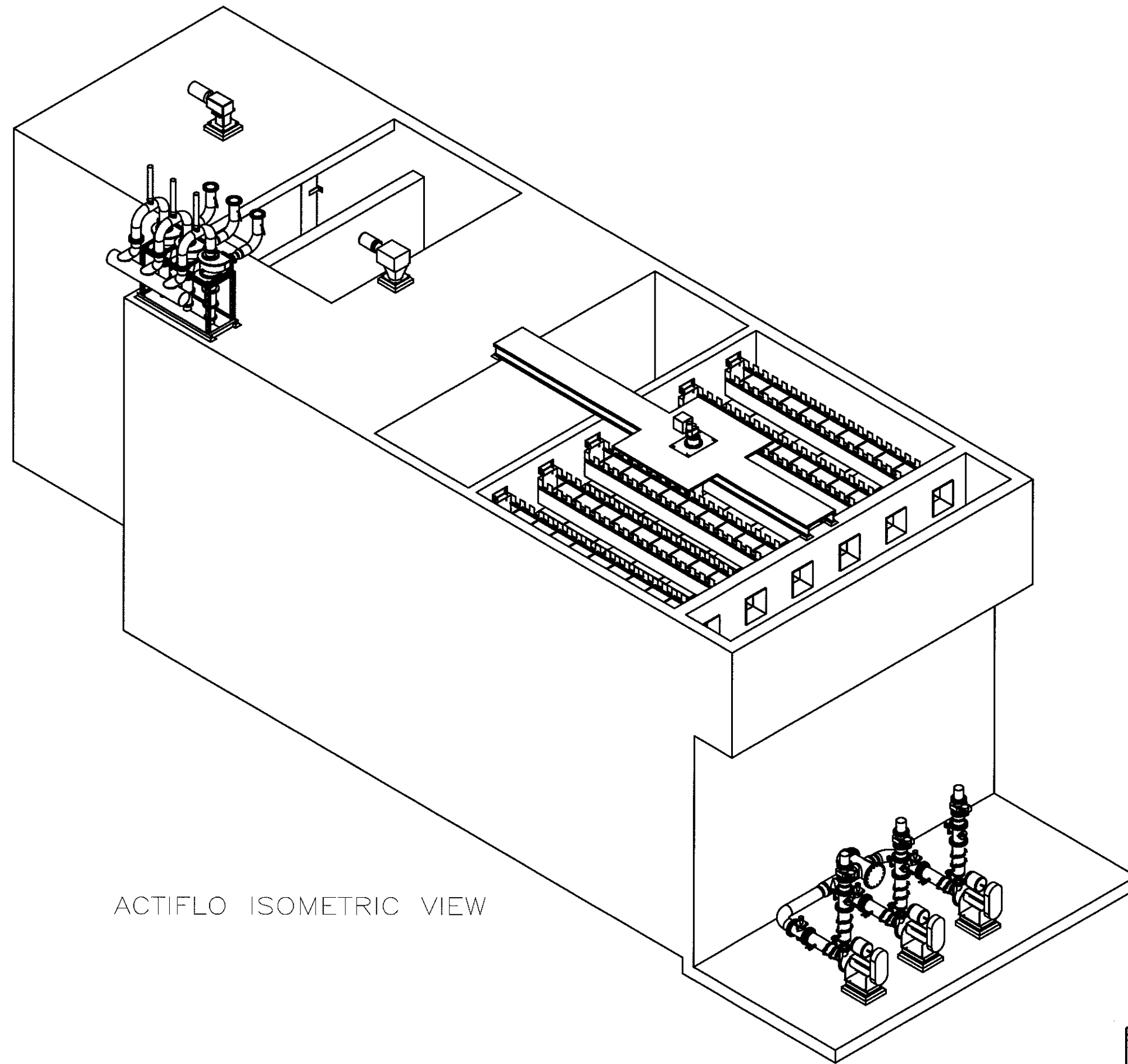


Section A-A

Attachment F
Figure 3



PROJECT NO.	14797
DRAWING NAME	Grit Tanks
SHEET	OF
DESIGNED BY:	
DRAWN BY:	
CHECKED BY:	
DATE	
DRAWING SCALE	N/A
HORIZ. VERT.	
NO.	



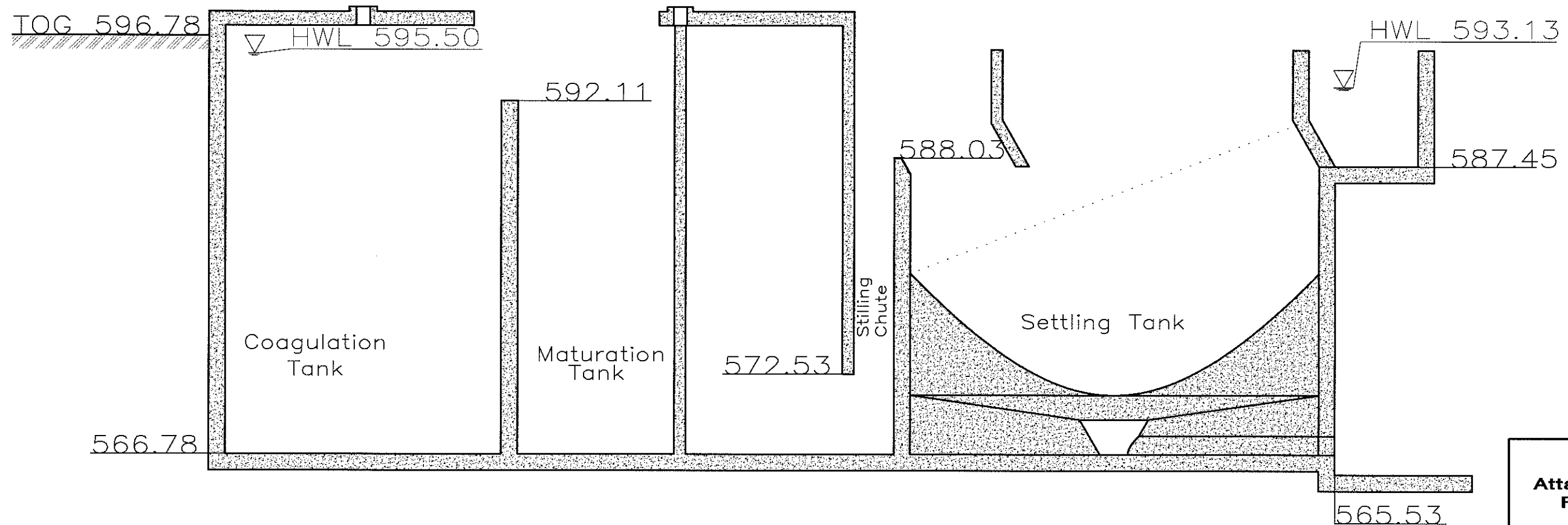
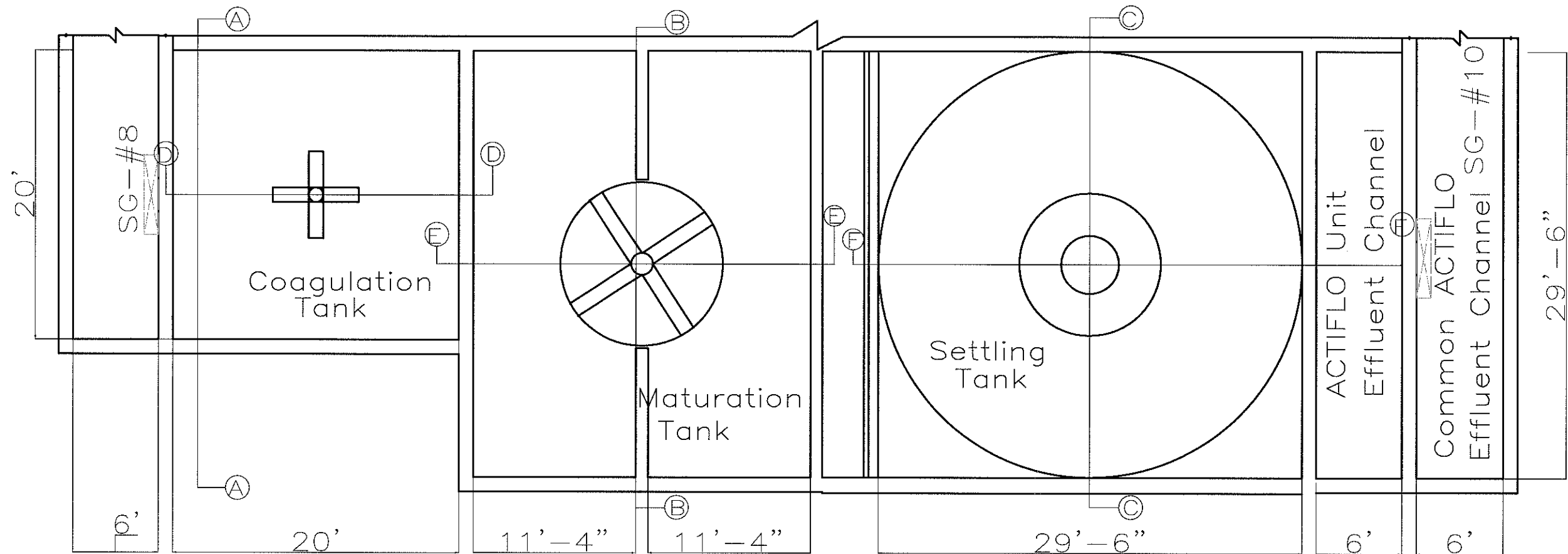
ACTIFLO ISOMETRIC VIEW

Attachment F
Figure 4

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DRAWING NAME		DATE:	
SHEET		DESIGNED BY:	
		DRAWN BY:	
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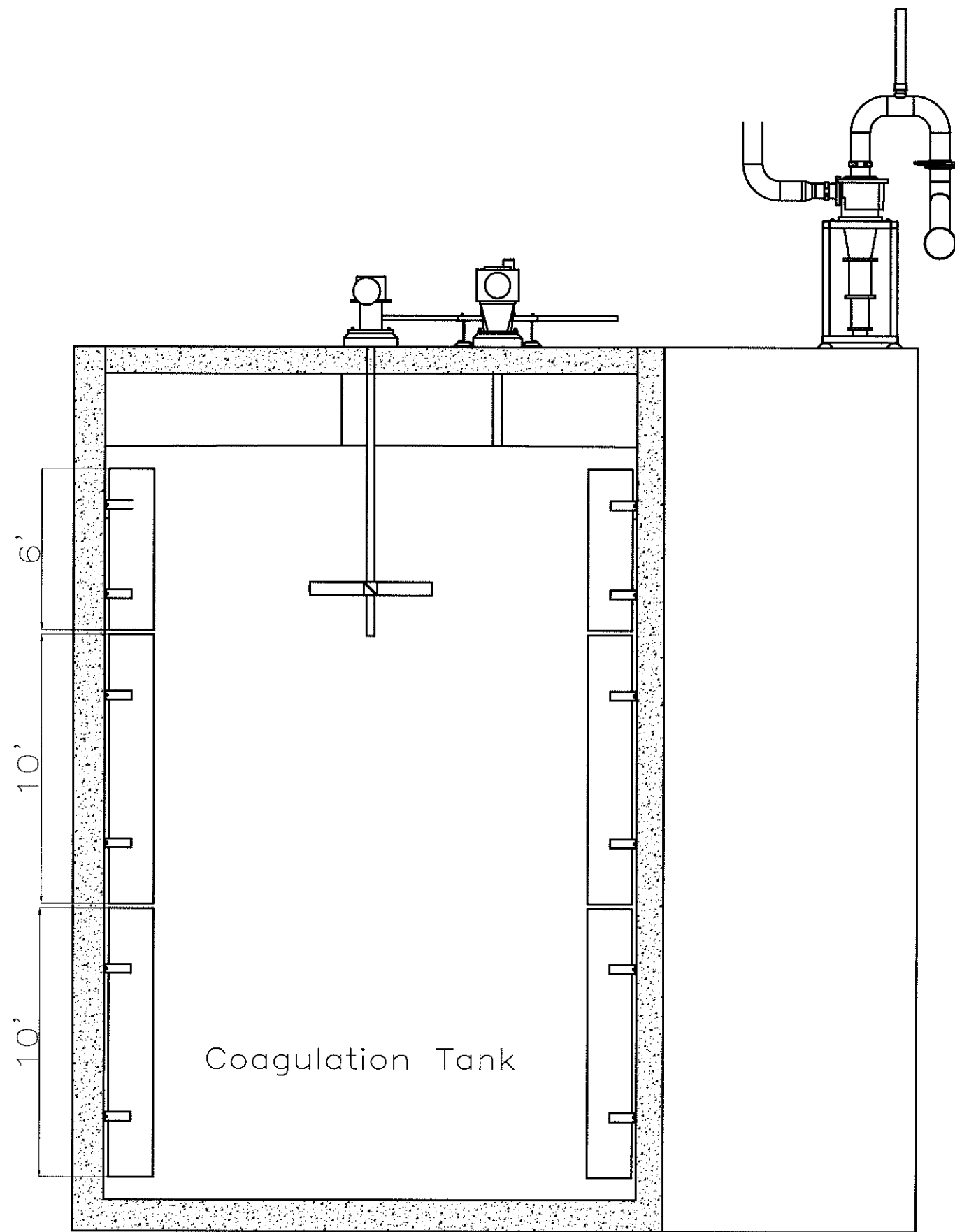
CITY OF LAKEWOOD OHIO
WET WEATHER IMPROVEMENTS FOR
WWTP

ACTIFLO Unit

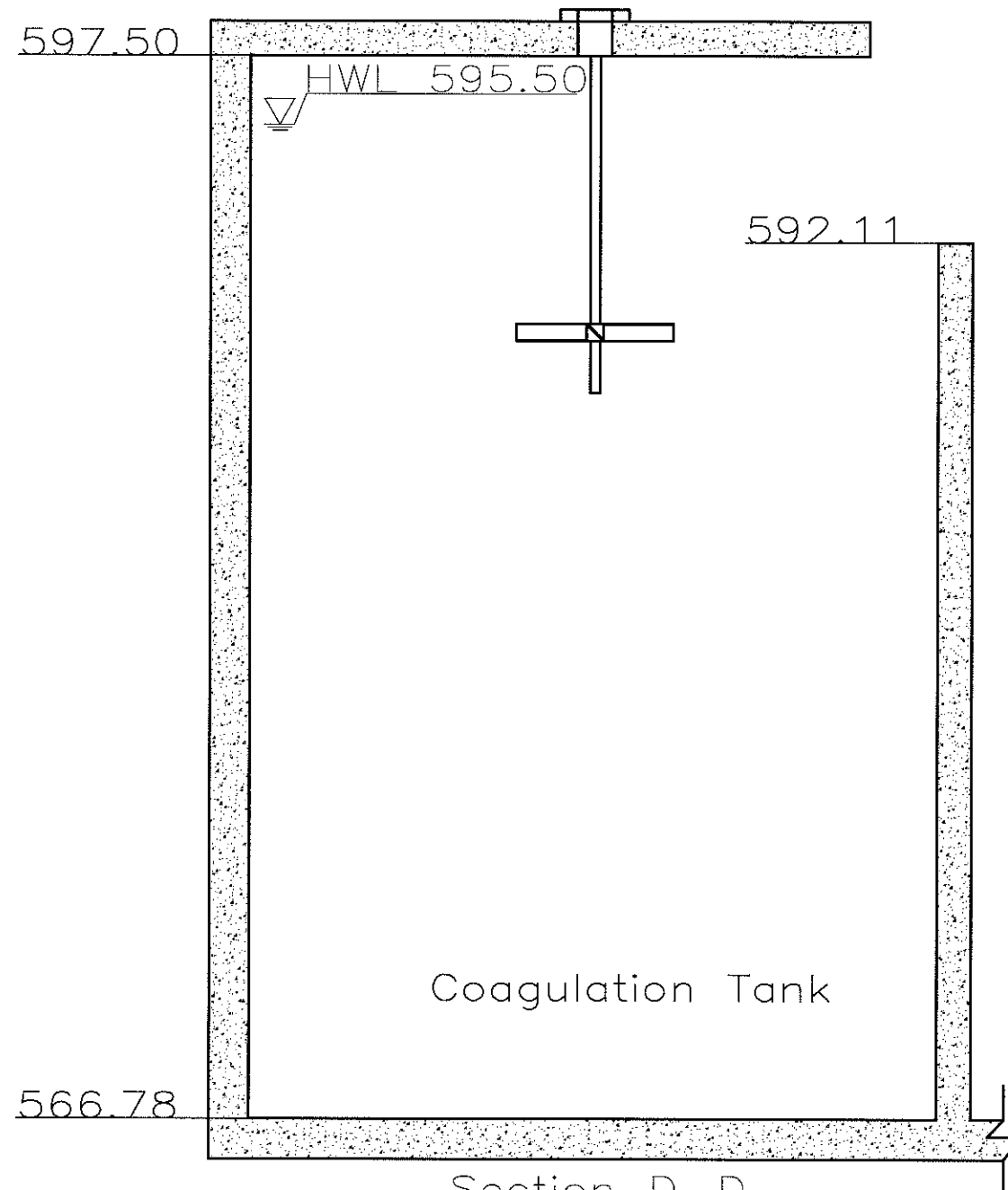


Attachment F
Figure 5

 CT Consultants engineers architects planners Northwood Building - 7905 N. High Street, Suite 400, Columbus, Ohio 43235 Phone: 614.863.1770 - Fax: 614.863.1771 - www.ctconsultants.com		NO.	
		DRAWING SCALE:	
CITY OF LAKEWOOD OHIO WET WEATHER IMPROVEMENTS FOR WWTP		HORIZ: N/A VERT: N/A DATE:	DESIGNED BY: DRAWN BY: CHECKED BY:
PROJECT NO:		PROJECT NO:	
DRAWING NAME		DRAWING NAME	
SHEET		OF	



Section A-A



Section D-D

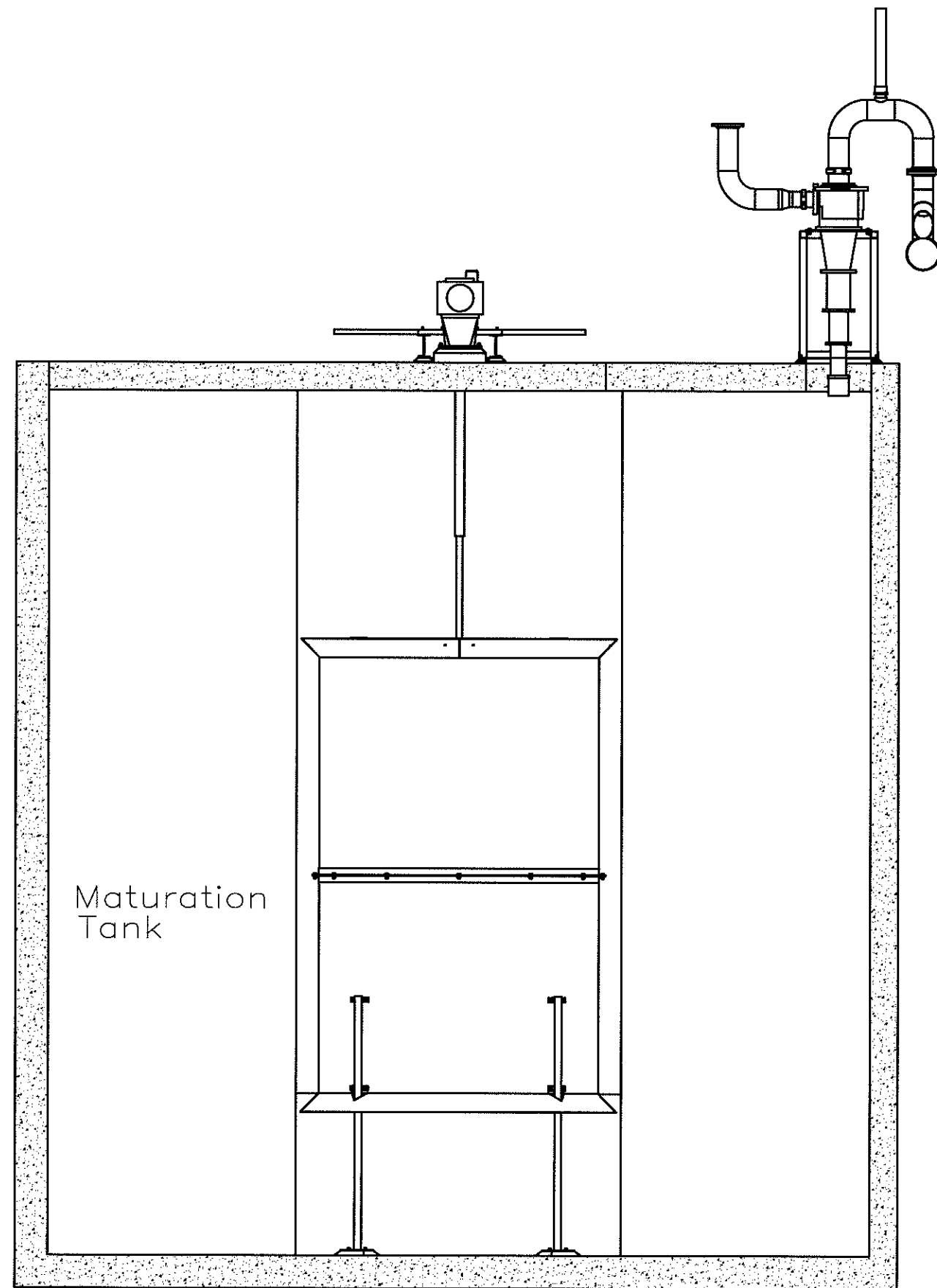
Attachment F
Figure 6

NO.	DATE	DESIGNED BY:	DRAWN BY:	CHECKED BY:

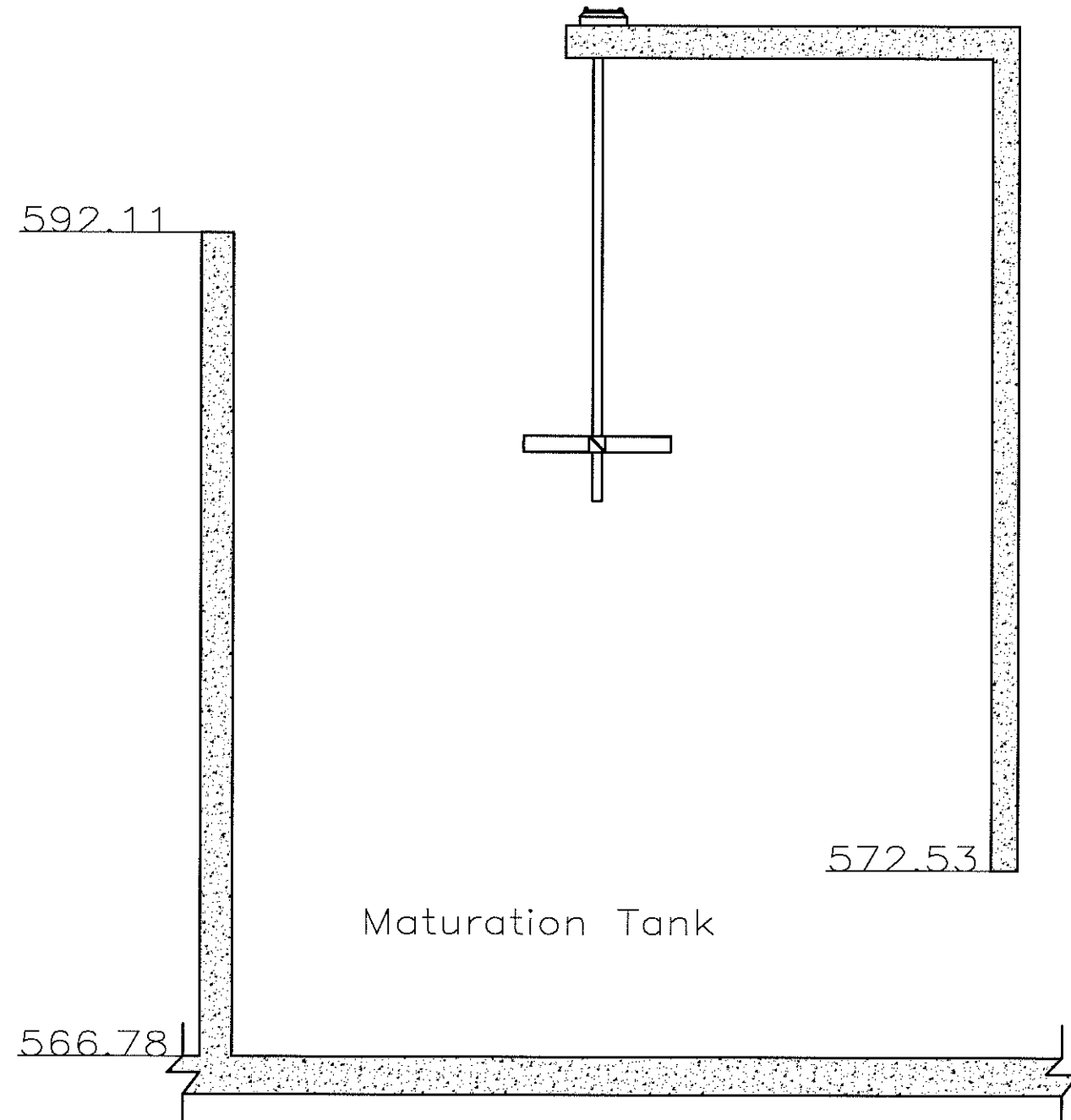
CITY OF LAKEWOOD OHIO
WET WEATHER IMPROVEMENTS FOR
WWTP

Coagulation Tank

PROJECT NO:	14797
DRAWING NAME	
SHEET	OF



Section B-B



Section E-E

Attachment F
Figure 7

CITY OF LAKEWOOD OHIO
WET WEATHER IMPROVEMENTS FOR
WWTP

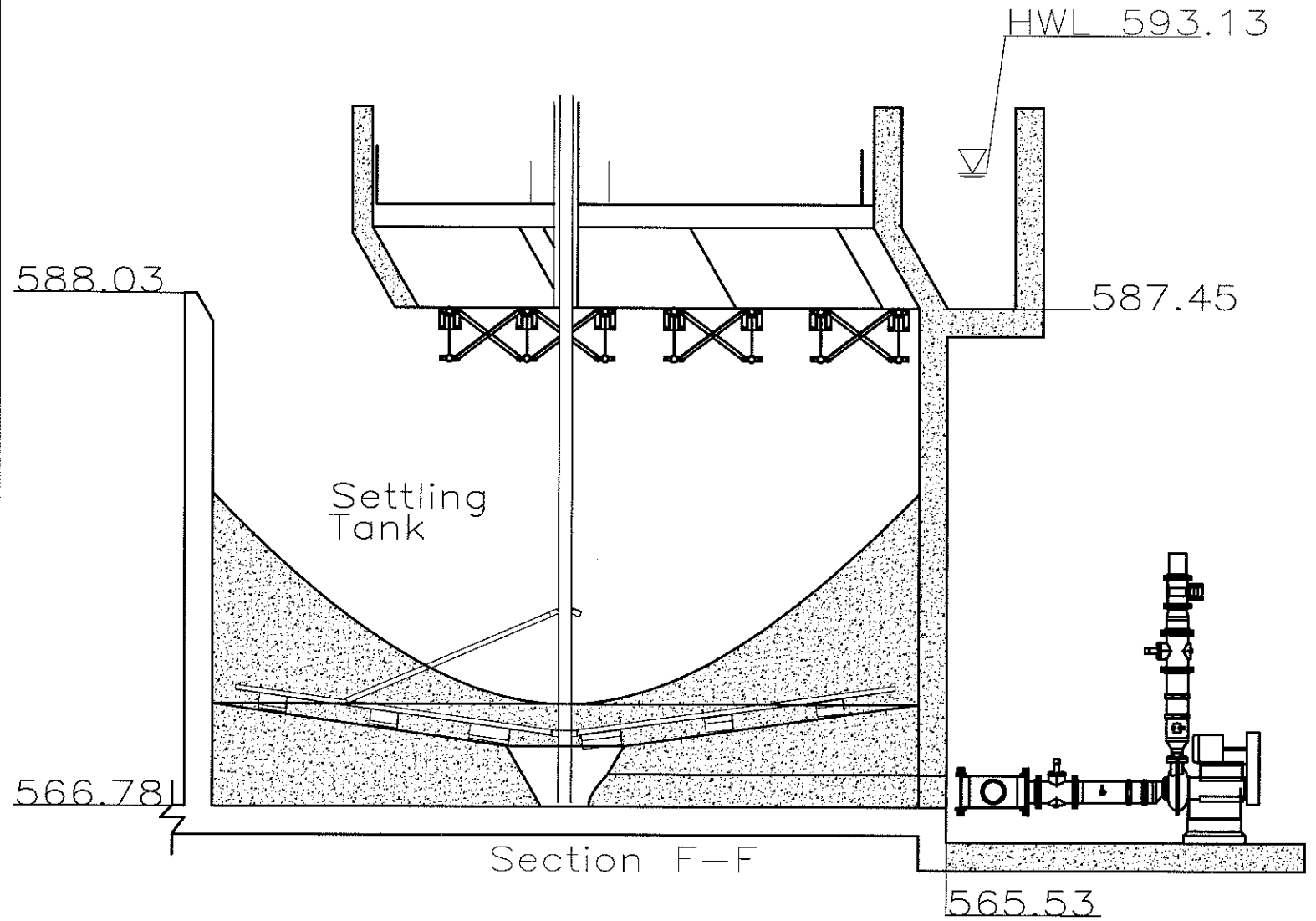
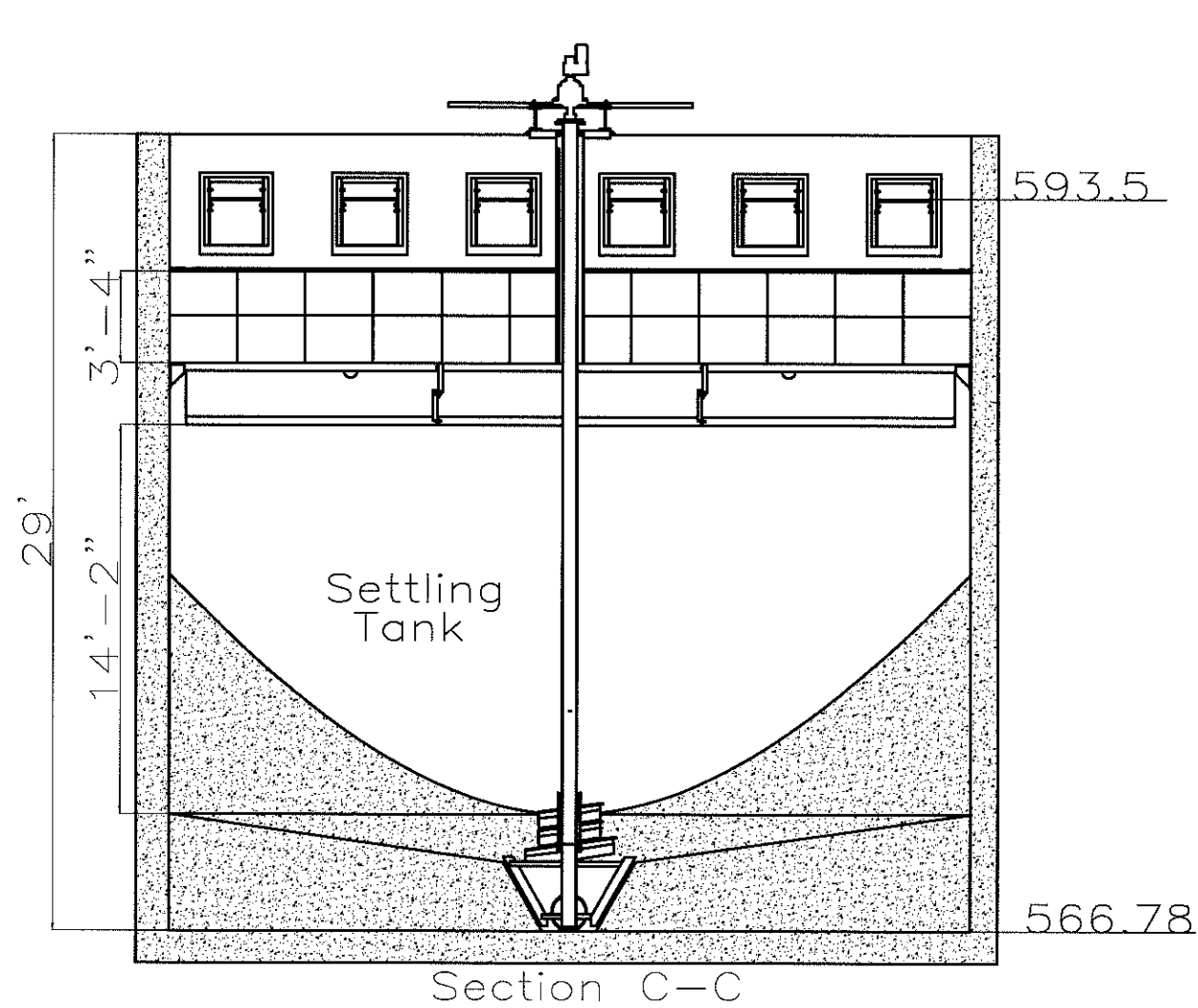
Maturation Tank

DRAWING SCALE:
* HORIZ: N/A
* VERT: N/A
DATE:
DESIGNED BY:
DRAWN BY:
CHECKED BY:

NO.	REVISION	DATE



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Phone: 614.853.1700 • Fax: 614.853.1701 • www.ctconsultants.com



Attachment F
Figure 8

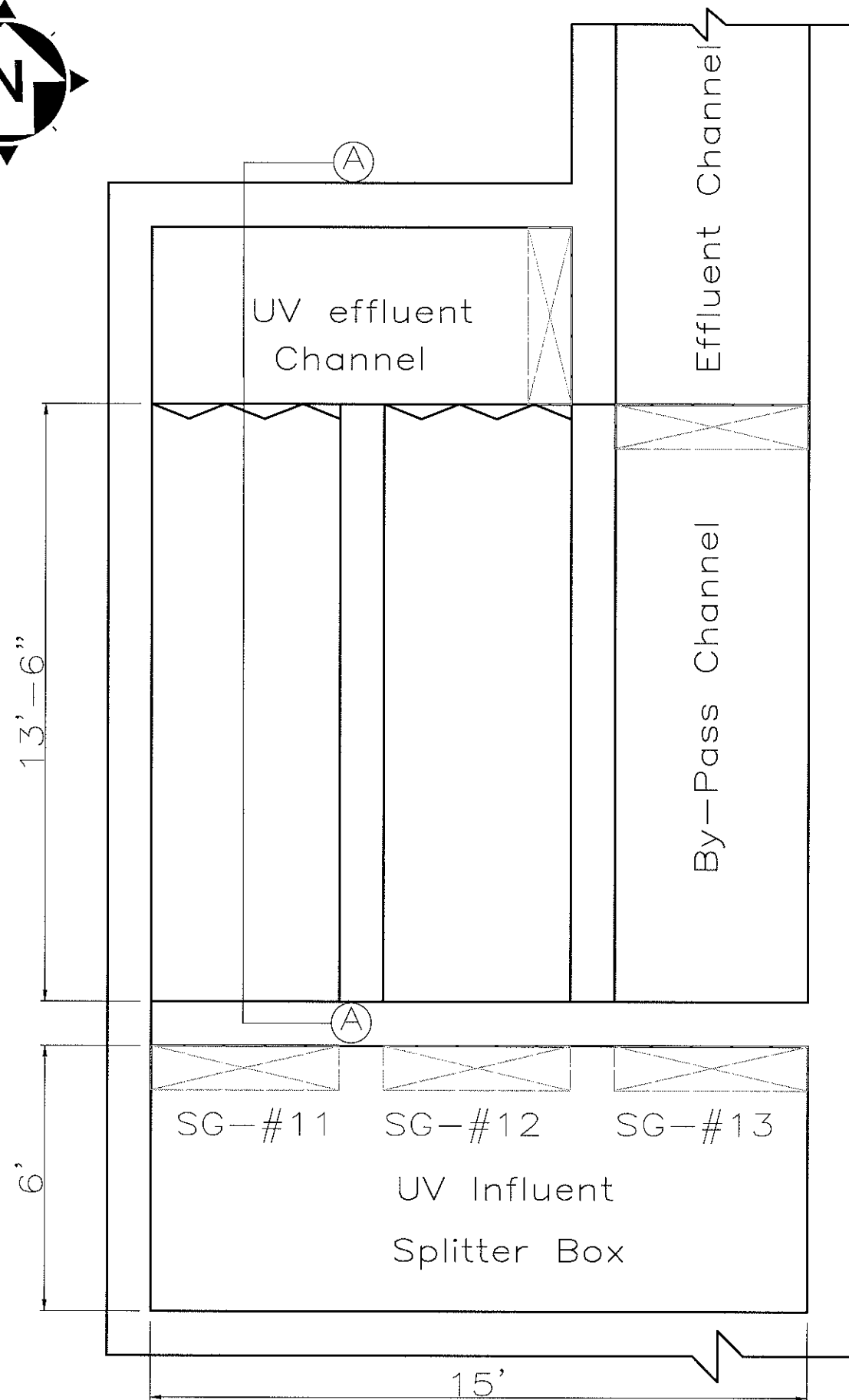
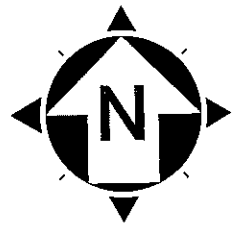
CITY OF LAKEWOOD OHIO
WET WEATHER IMPROVEMENTS FOR
WWTP

Settling Tank

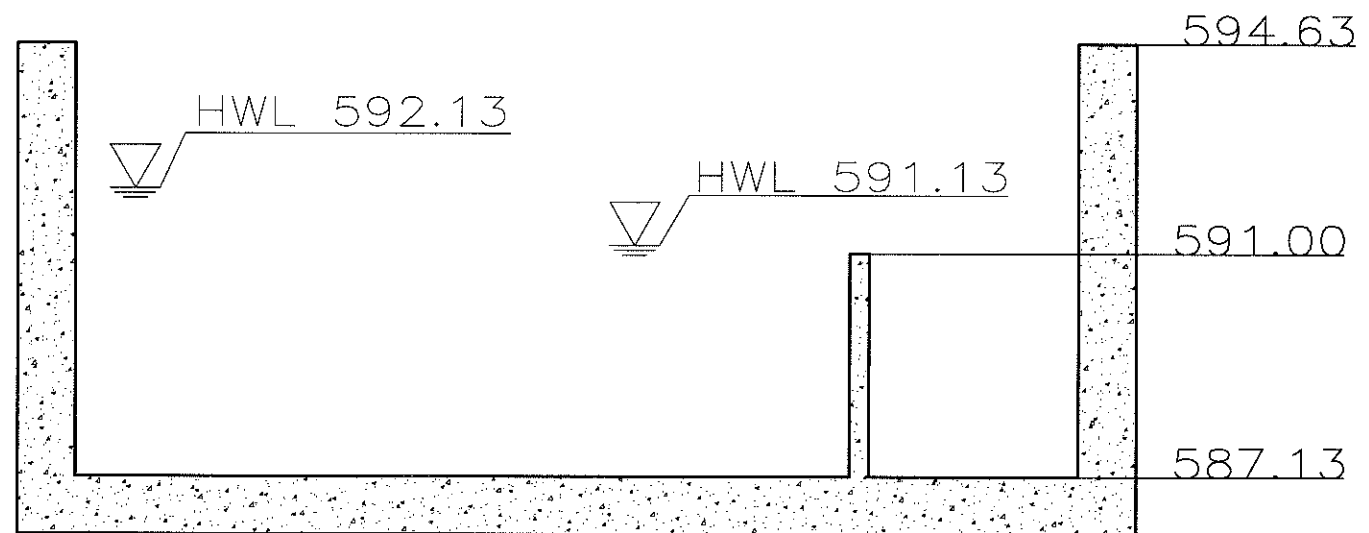
PROJECT NO:	
14797	
DRAWING NAME	
SHEET OF	

DRAWING SCALE:	N/A
HORIZ. VERT. DATE:	
DESIGNED BY:	
DRAWN BY:	
CHECKED BY:	

NO.	REVISION	DATE



PLAN VIEW



Section A-A

Attachment F
Figure 9

CITY OF LAKEWOOD OHIO
WET WEATHER IMPROVEMENTS FOR
WWTP

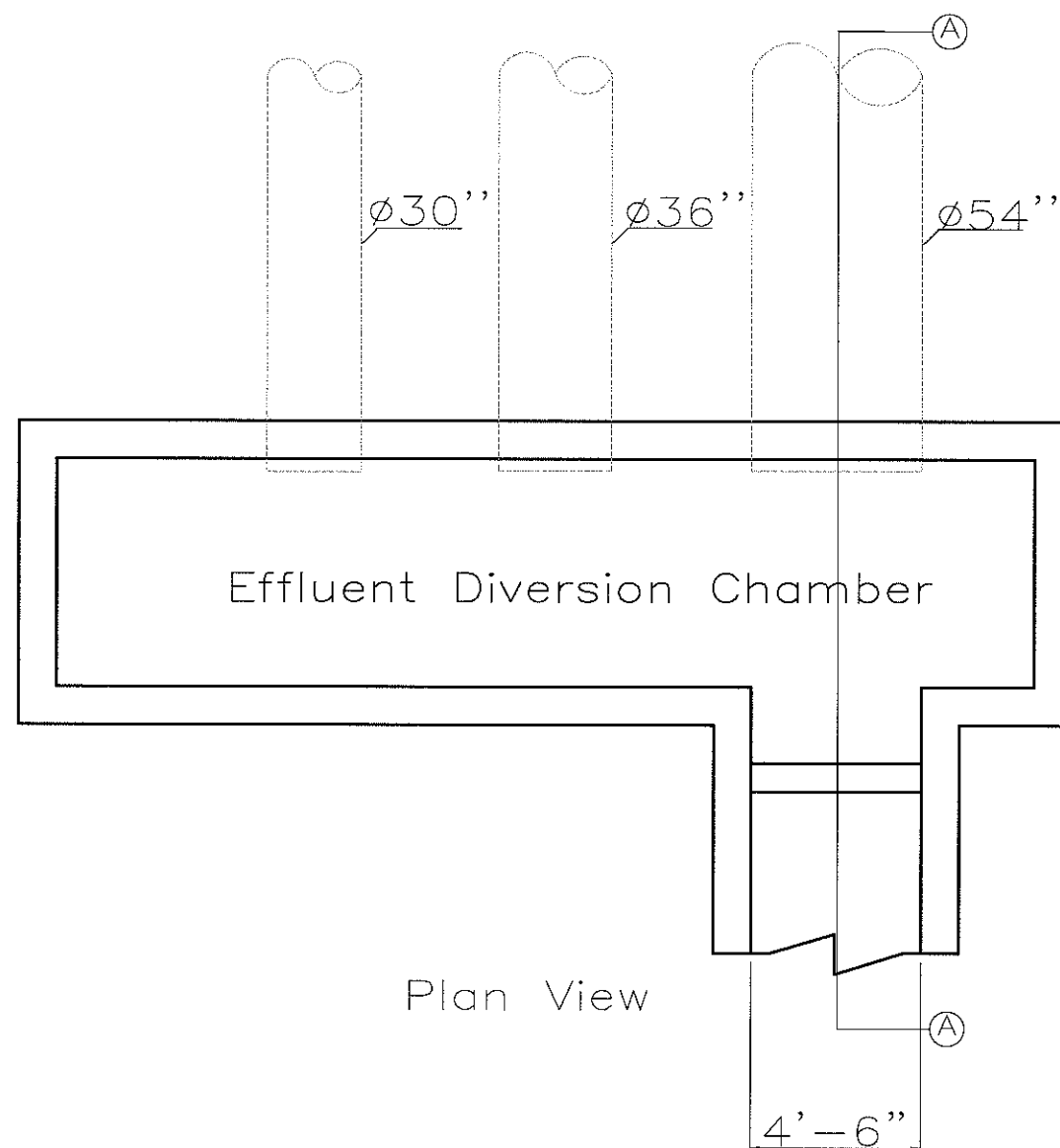
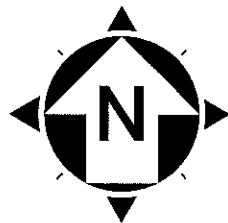
UV & By-Pass Channels

PROJECT NO:	
14797	
DRAWING NAME	
SHEET	OF

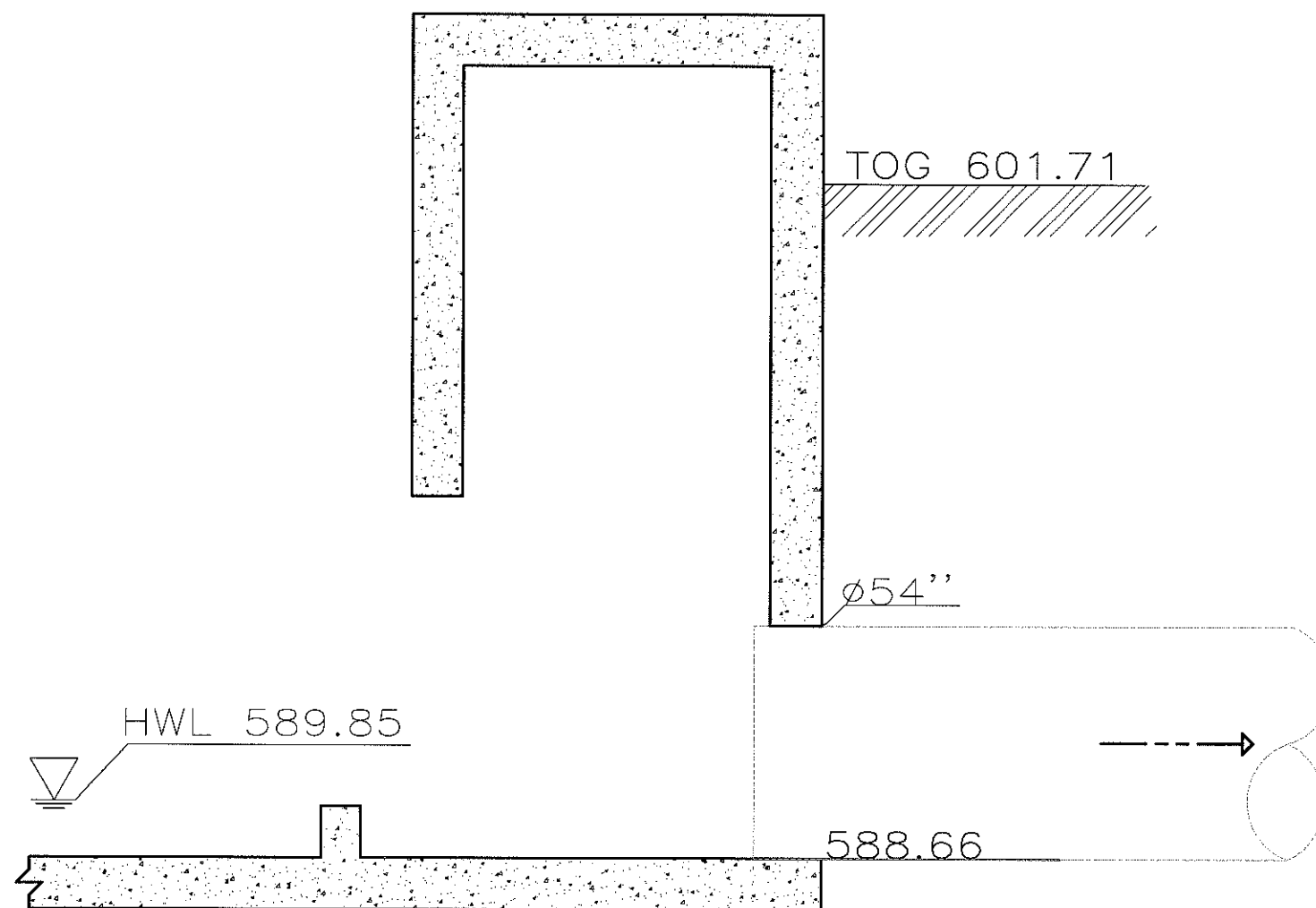
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• HORZ:	N/A			
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DATE:				
DESIGNED BY:				
DRAWN BY:				
CHECKED BY:				



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Plan View



Section A-A

Attachment F
Figure 10

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NO.	DRAWING SCALE:	HORIZ:	VERT:	DATE:	DESIGNED BY:	DRAWN BY:	CHECKED BY:
			N/A				

CITY OF LAKEWOOD OHIO
WET WEATHER IMPROVEMENTS FOR
WWTP

Effluent Diversion Chamber

PROJECT NO:	
14797	
DRAWING NAME	
SHEET	OF

APPENDIX G

Detailed Construction Cost Estimate

**CITY OF LAKEWOOD, OHIO
WWTP HIGH RATE TREATMENT (HRT) SYSTEM
CONSTRUCTION COST ESTIMATE**

08/01/2016

TWO TRAIN, 35 MGD ACTIFLOW SYSTEM

ITEM	QUANTITY	UNIT	MATERIAL COST		LABOR COST		TOTAL COST
			PER UNIT	TOTAL	PER UNIT	TOTAL	
SITE CONSTRUCTION - DIV 02							
MOBILIZATION	1	LS	\$ -	\$ -	\$ 40,000.00	\$ 40,000.00	\$ 40,000.00
EROSION CONTROL	1	LS	\$ 2,500.00	\$ 2,500.00	\$ 2,500.00	\$ 2,500.00	\$ 5,000.00
SITE DEWATERING	1	LS	\$ 900.00	\$ 900.00	\$ 9,100.00	\$ 9,100.00	\$ 10,000.00
PROCESS / SELECTIVE DEMO	1	LS	\$ 5,000.00	\$ 5,000.00	\$ 15,000.00	\$ 15,000.00	\$ 20,000.00
SITE CLEARING	1	LS	\$ -	\$ -	\$ 2,000.00	\$ 2,000.00	\$ 2,000.00
BOLLARDS	8	EA	\$ 330.00	\$ 2,640.00	\$ 165.00	\$ 1,320.00	\$ 3,960.00
CONCRETE SIDE WALK	800	SF	\$ 5.00	\$ 4,000.00	\$ 5.00	\$ 4,000.00	\$ 8,000.00
SOIL EXCAVATION, FILL & COMPACTION	5000	CY	\$ 3.00	\$ 15,000.00	\$ 6.00	\$ 30,000.00	\$ 45,000.00
MISC. PROCESS YARD PIPING, VALVES	1	LS	\$ 15,000.00	\$ 15,000.00	\$ 5,000.00	\$ 5,000.00	\$ 20,000.00
48" STEEL AERIAL INFLUENT SEWER ON PIERS	170	LF	\$ 1,000.00	\$ 170,000.00	\$ 500.00	\$ 85,000.00	\$ 255,000.00
30" RCP EFFLUENT SIPHON SEWER	400	LF	\$ 270.00	\$ 108,000.00	\$ 280.00	\$ 112,000.00	\$ 220,000.00
36" RCP EFFLUENT SIPHON SEWER	400	LF	\$ 290.00	\$ 116,000.00	\$ 280.00	\$ 112,000.00	\$ 228,000.00
54" RCP EFFLUENT OVERFLOW SEWER	125	LF	\$ 330.00	\$ 41,250.00	\$ 100.00	\$ 12,500.00	\$ 53,750.00
HAULING	4000	CY	\$ 0.75	\$ 3,000.00	\$ 1.78	\$ 7,120.00	\$ 10,120.00
BEDDING GRAVEL No. 57	175	CY	\$ 40.00	\$ 7,000.00	\$ 30.00	\$ 5,250.00	\$ 12,250.00
FINISH GRADING	10000	SF	\$ 0.50	\$ 5,000.00	\$ 0.50	\$ 5,000.00	\$ 10,000.00
SITE PAVING & IMPROVEMENTS	1	LS	\$ 10,000.00	\$ 10,000.00	\$ 10,000.00	\$ 10,000.00	\$ 20,000.00
LANDSCAPING (YARD PIPE, PUMP STA'S, FC)	500	SY	\$ 5.00	\$ 2,500.00	\$ 10.00	\$ 5,000.00	\$ 7,500.00
SUBTOTAL							\$ 970,580.00
CONCRETE - DIV 03							
SCREEN BUILDING	110	CY	\$ 600.00	\$ 66,000.00	\$ 400.00	\$ 44,000.00	\$ 110,000.00
GRIT TANKS (2)	300	CY	\$ 600.00	\$ 180,000.00	\$ 400.00	\$ 120,000.00	\$ 300,000.00
ACTIFLOW TANKS (2 TRAINS)	810	CY	\$ 600.00	\$ 486,000.00	\$ 400.00	\$ 324,000.00	\$ 810,000.00
UV DISINFECTION	60	CY	\$ 600.00	\$ 36,000.00	\$ 400.00	\$ 24,000.00	\$ 60,000.00
SUBTOTAL							\$ 1,280,000.00
MASONRY - DIV 04							
SCREEN BUILDING (FLOOR SF)	1440	SF	\$ 100.00	\$ 144,000.00	\$ 100.00	\$ 144,000.00	\$ 288,000.00
CHEMICAL ROOM (FLOOR SF)	1320	SF	\$ 100.00	\$ 132,000.00	\$ 100.00	\$ 132,000.00	\$ 264,000.00
PUMP ROOM (FLOOR SF)	1800	SF	\$ 100.00	\$ 180,000.00	\$ 100.00	\$ 180,000.00	\$ 360,000.00
MCC ROOM (FLOOR SF)	1320	SF	\$ 100.00	\$ 132,000.00	\$ 100.00	\$ 132,000.00	\$ 264,000.00
SUBTOTAL							\$ 1,176,000.00
METAL FABRICATIONS - DIV 05							
ALUMINUM GRATING AND SUPPORTS	400	SF	\$ 45.00	\$ 18,000.00	\$ 12.00	\$ 4,800.00	\$ 22,800.00
ALUMINUM DIAMOND PLATE AND SUPPORTS	4500	SF	\$ 50.00	\$ 225,000.00	\$ 12.00	\$ 54,000.00	\$ 279,000.00
ALUMINUM RAILING	300	LF	\$ 46.00	\$ 13,800.00	\$ 11.50	\$ 3,450.00	\$ 17,250.00
ALUMINUM STAIRS	40	TR	\$ 500.00	\$ 20,000.00	\$ 125.00	\$ 5,000.00	\$ 25,000.00
SLUDGE SCRAPER SUPPORT BRIDGE	1	LS	\$ 10,000.00	\$ 10,000.00	\$ 2,000.00	\$ 2,000.00	\$ 12,000.00
HATCHES	4	EA	\$ 2,500.00	\$ 10,000.00	\$ 375.00	\$ 1,500.00	\$ 11,500.00
SUBTOTAL							\$ 367,550.00
PROCESS - DIV 11							
SCREENS (2 UNITS) - PARKSON	2	EA	\$ 240,000.00	\$ 480,000.00	\$ 72,000.00	\$ 144,000.00	\$ 624,000.00
GRIT REMOVAL (2 UNITS) - HYDRO-INT'L	1	LS	\$ 315,000.00	\$ 315,000.00	\$ 94,500.00	\$ 94,500.00	\$ 409,500.00
GRIT PUMPS (3 PUMPS)	3	EA	\$ 10,000.00	\$ 30,000.00	\$ 3,000.00	\$ 9,000.00	\$ 39,000.00
ACTIFLOW SYSTEM (2 TRAIN2 X 17.5MGD) - KRUGER	1	LS	\$ 3,950,000.00	\$ 3,950,000.00	\$ 1,777,500.00	\$ 1,777,500.00	\$ 5,727,500.00
ACTIFLOW POLYMER TANK (1 - 4,000 GAL)	1	EA	\$ 10,000.00	\$ 10,000.00	\$ 1,500.00	\$ 1,500.00	\$ 11,500.00
UV DISINFECTION (2 BANKS) - TROJAN	1	LS	\$ 650,000.00	\$ 650,000.00	\$ 260,000.00	\$ 260,000.00	\$ 910,000.00
SLIDE GATES	12	EA	\$ 15,000.00	\$ 180,000.00	\$ 3,000.00	\$ 36,000.00	\$ 216,000.00
HYDROSTATIC PR VALVES - 4"	20	EA	\$ 200.00	\$ 4,000.00	\$ 40.00	\$ 800.00	\$ 4,800.00
FLOW METER (1 - ULTRASONIC CLAMP-ON)	1	EA	\$ 6,000.00	\$ 6,000.00	\$ 500.00	\$ 500.00	\$ 6,500.00
SUBTOTAL							\$ 7,948,800.00
SUBTOTAL DIVISIONS 02-11							\$ 11,742,930.00
ELECTRICAL - 10%	1	LS					\$ 1,174,300.00
HVAC - 2.5%	1	LS					\$ 293,580.00
PLUMBING - 5%	1	LS					\$ 587,150.00
SUBTOTAL DIVISIONS 15 & 16							\$ 2,055,030.00
TOTAL CAPITAL COST							\$ 13,797,960.00
CONTINGENCY @ 10%							\$ 1,377,760.00

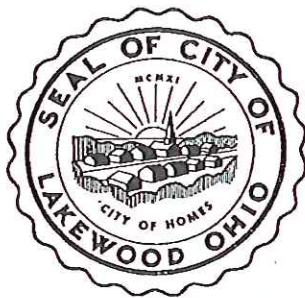
Appendix H

Vendor Information

Attachment F
Source Control Pilot Study Supporting Documents

ATTACHMENT F- SOURCE CONTROL PILOT STUDY

This attachment contains all of the public meeting notices, letters to residents, legislation, program guides, and Design/Build contracts that the City created for this project.



12650 DETROIT AVENUE • 44107 • 216/529-6600 • fax 216/529-5652
Website: www.onelakewood.com

MICHAEL P. SUMMERS
MAYOR

February 12, 2014

Re: Important community meeting; EPA storm water pilot study (including your house)

Dear Neighbor:

I invite you to attend a community meeting on Wednesday, **February 26, 2014, at 7 p.m.** in the Harding Middle School Cafetorium, 16601 Madison Ave. This meeting will provide information and an opportunity to discuss a proposed storm water management pilot study in your neighborhood. The pilot study area includes 272 homes located within the boundaries of Hilliard Road and McKinley, Delaware and Eldred Avenues. I have included a map on the back to better describe this pilot study area.

This is an important meeting for you, your neighborhood and the City of Lakewood. This pilot study will involve testing and investigations of water movement from your house into the Lakewood storm and sanitary sewer systems. Work undertaken as a result of the pilot study might include digging, correcting and adding sewer connections from your house to the street.

The purpose of this study is to evaluate cost-effective compliance with the federal Clean Water Act by correctly connecting every house in a small section of Lakewood to the proper sewer pipes in the street. Investigations to date across Lakewood have shown that a significant percentage of properties may have connections that allow storm water to enter the sanitary sewer system, which causes overflows of sanitary sewage into our watershed. The storm water reaches the sanitary sewer through aged leaky sewer pipes, blockages or improper connections. When the connections are remediated in the study area, we will then measure storm-water-versus-sanitary-water volumes in varying conditions and compare it to pre-correction measurements.

The information gained from this study will permit the city to determine whether managing water movement from the house to the street presents a cost-effective improvement measure that will enable Lakewood to comply with modern requirements. Lakewood remains consistently engaged with U.S. EPA and Ohio EPA to identify the best measures to improve our century-old sewer systems. Lakewood has been actively advancing a holistic approach that looks at cost-effective measures tied to other community goals, what EPA now calls "Integrated Municipal Storm water and Wastewater Planning Framework." For more information on this framework, see [HTTP://TINYURL.COM/7STQZP9](http://TINYURL.COM/7STQZP9).

I hope you can attend this important meeting at Harding Middle School on February 26. If you can't, know that we will schedule additional opportunities to discuss this pilot study at later dates, and you are also welcome to contact the Division of Engineering at (216) 529-6807.

Sincerely,

Michael P. Summers, Mayor



Harding Middle School

Hilliard Rd.

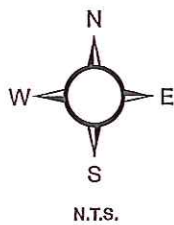
McKinley Ave.

Glenbury Ave.

Atkins Ave.

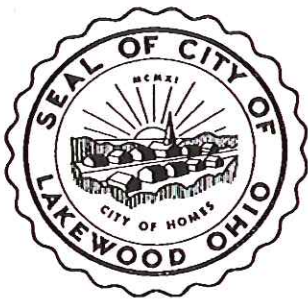
Eldred Ave.

Delaware Ave.



Sewer Pilot Study Area





12650 DETROIT AVENUE • 44107 • 216/529-6600 • fax 216/529-5652
Website: www.onelakewood.com

MICHAEL P. SUMMERS
MAYOR

March 26, 2014

Re: Clean Water Pilot Project

Dear Neighbor,

I wish to recap our February 26 neighborhood meeting at Harding School. At this meeting we reviewed the following:

- Our challenges as a city to meet the regulatory obligations of the 1972 Clean Water Act.
- The challenges presented by our 100-year-old sewer system designs.
- Our need to improve the management of storm water that cannot be handled by our sewer system resulting in overflows to the Rocky River, particularly during big storms.
- Our \$23 million spent since 2003 to address these events and their behavior in these high-volume storms.
- Our plans to invest \$4.7 million this year in sewer modifications.
- Our plans to begin a pilot study in your neighborhood, including (a) our goal, in Phase One of this pilot study, to study and map how storm water moves off of each of the 270 private parcels and the streets in the pilot area; and (b) the unique and isolated nature of sewer flows in this neighborhood that make it optimal for studying the "before" and ultimately "after" of design changes.

Enclosed with this letter is the handout of key slides we used at our February 26 meeting. While we covered all aspects of this project, this handout provides a foundation of important information. Here are our next steps:

1. Beginning in May, city representatives will begin to set up appointments to gain access to your basement in order to map existing sewer designs and flows. (If you wish to have us communicate with you electronically, which we encourage, please send your contact information to us at engineering@lakewoodoh.net.)
2. We will schedule another neighborhood update and discussion in a few months, after we have experienced a few tests, in order to share methodology and lessons learned.
3. If you are contemplating any major construction project in the next year, such as basement waterproofing, driveway replacement, major porch renovation or construction of a new addition or garage, we ask that you contact us as soon as possible to discuss how that may relate to the study.

In the meantime, we request that you contact the Lakewood Division of Engineering & Construction at (216) 529-6692 or by email at engineering@lakewoodoh.net to provide your contact information so that we can schedule the required testing and keep you updated as the pilot study progresses.

Sincerely,

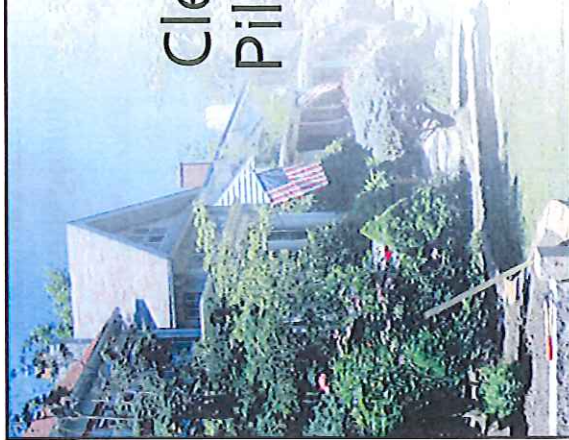

Michael P. Summers, Mayor



Selected Slides from Presentation
February 26, 2014

Clean Water Pilot Project

City of Lakewood
Division of Engineering
(216) 529-6692
engineering@lakewoodoh.net
www.one.lakewood.com



Our sewer system performance



What's working well:

- ☐ Conveyance of sewage to treatment plant
- ☐ Conveyance of storm water from small storms
- ☐ Treatment of sewage at treatment plant

What must be improved to meet EPA requirements:

- ☐ Management of storm water
- ☐ Removal, storage or conveyance of water from large or intense storms to treatment plant

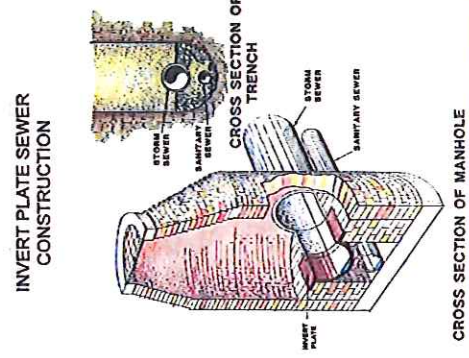
Our progress

- ☐ \$23 million of planning and mitigation work since 2003; years of work still ahead
- ☐ All residents contribute through water, sewer rates
- ☐ Ongoing mapping, modeling
- ☐ West End overflow elimination (\$4.284 million)
- ☐ Edgewater sewer separation (\$1.844 million)
- ☐ Regulator modifications (\$192,000)
- ☐ Redesign of 4 city parking lots to collect storm water (\$470,000)

Our objectives

- ☐ Separate storm water from sewage
 - ☐ Will allow us to determine actual amount of sewage flow
 - ☐ This actual volume will determine if wastewater plant must be expanded or redesigned
- ☐ Receive new 5-year permit for our wastewater treatment plant
- ☐ Complete this pilot study: Will prove or disprove that source control corrections (storm water and sewage from house to street) will cost-effectively reduce sanitary volume

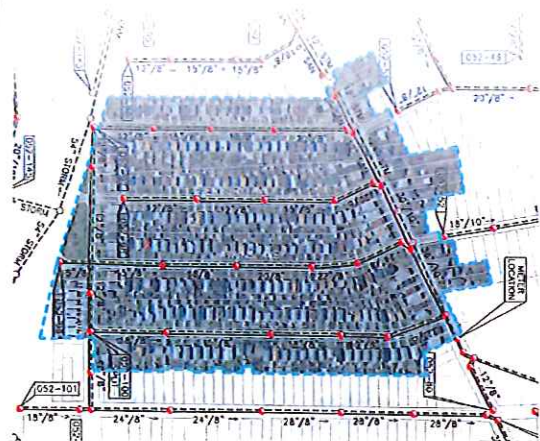
Typical sewer pipes beneath Lakewood's streets



- ☐ Shifted or missing invert plates can often lead to increased water in the sanitary sewer
- ☐ Adjustments among plumbing, engineering work vary over decades

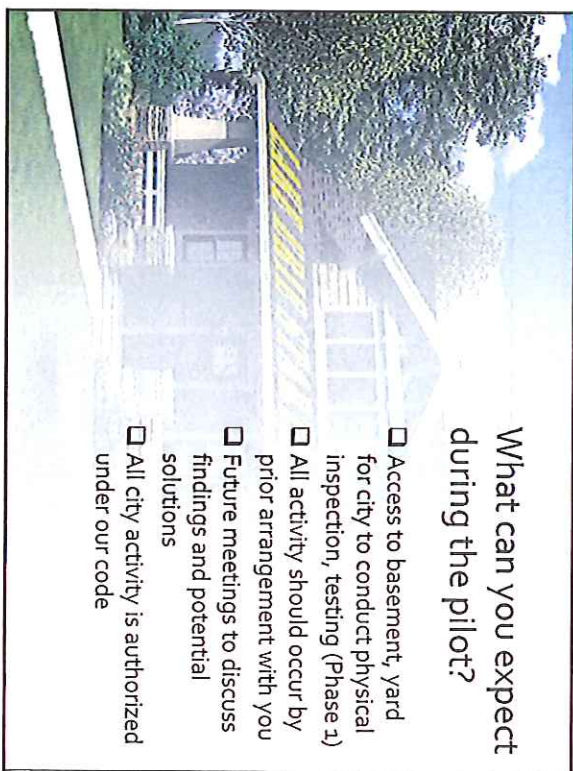
The pilot study neighborhood

Area bounded by McKinley to the west, Hilliard to the north, Eldred to the east and Delaware to the south



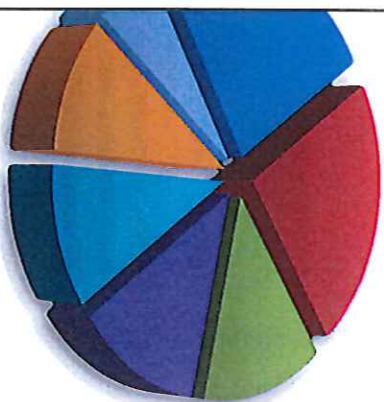
What can you expect during the pilot?

- ☐ Access to basement, yard for city to conduct physical inspection, testing (Phase 1)
- ☐ All activity should occur by prior arrangement with you
- ☐ Future meetings to discuss findings and potential solutions
- ☐ All city activity is authorized under our code



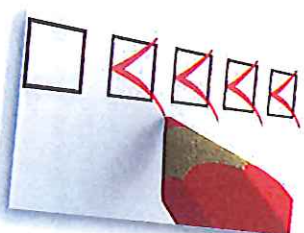
What will Phase 1 of the pilot cost you?

- ☐ The cost to homeowners and the neighborhood is **personal inconvenience and disruption** this year for the testing and study
- ☐ As part of a pilot program to help the City evaluate this effort citywide, we are exploring options to fund this program in the future



What are the city's next steps in Phase 1 (public and private)?

- ☐ Schedule each house for inspection starting in May
- ☐ Video existing conditions in pipes
- ☐ Inventory issues found, public and private
- ☐ Identify design options
- ☐ Analyze process improvement and opportunities to reduce cost
- ☐ Prepare for Phase 2
- ☐ Keep you fully informed of our activity each step along the way

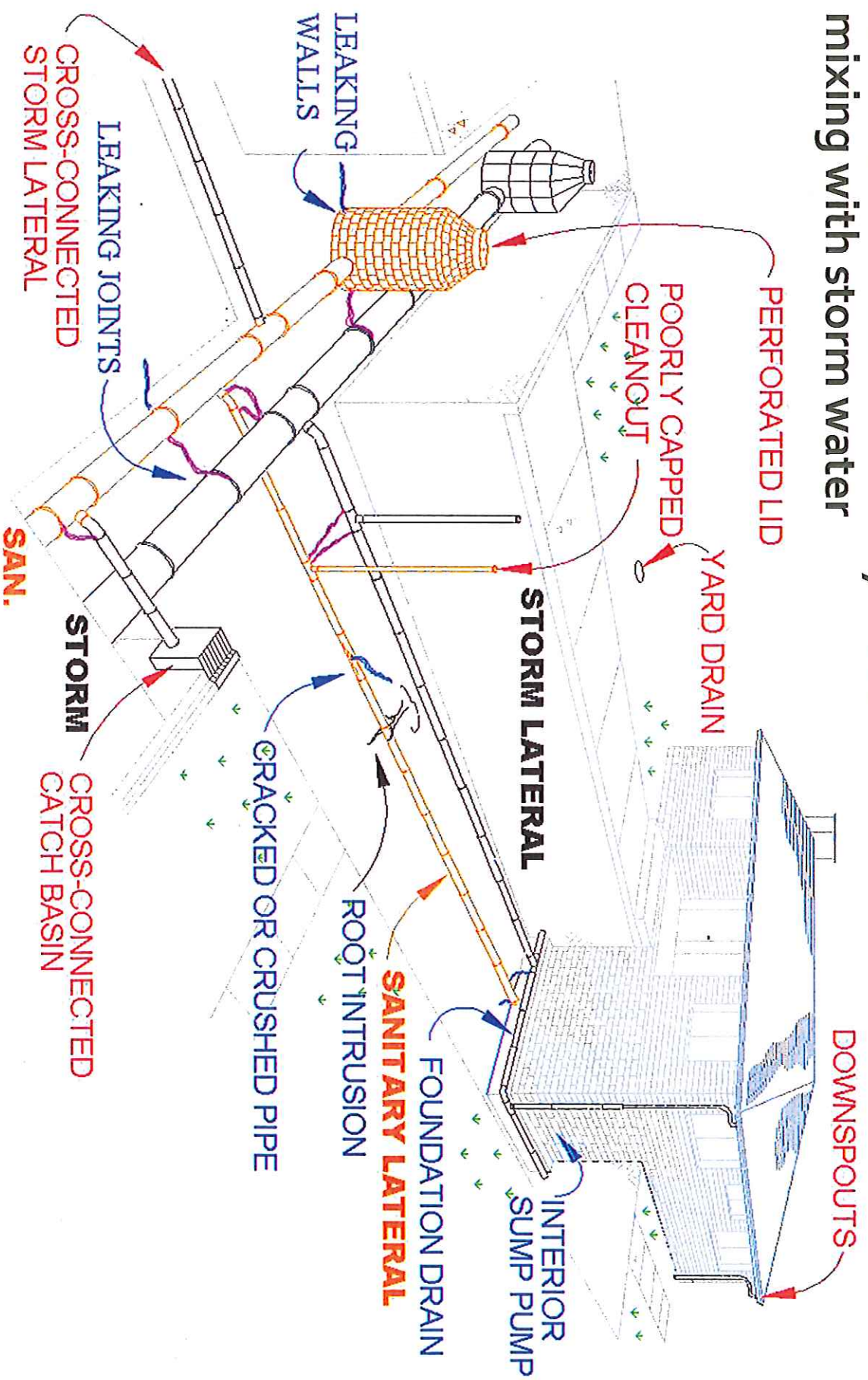


Why this neighborhood?

- ❑ 270 structures (of 17,000 citywide)
- ❑ Unique situation where all houses flow into a single point (sewer interceptor by Harding Middle School)
- ❑ We have very good data of current state
- ❑ Dry weather and wet weather
- ❑ Allows us to measure before and after flow volumes in a variety of dry weather and wet (storm) weather conditions
- ❑ All houses in area were built in the same time period and are of similar design



Common sources of sanitary water mixing with storm water





DEPARTMENT OF PUBLIC WORKS
12650 DETROIT AVENUE • 44107 • (216) 529-6692

JOSEPH J. BENO, PE
Director of Public Works

MARK K. PAPKE, PE, CPESC
City Engineer

August 19, 2015

«First_Name» «Last_Name»
«Mail_Num» «Mail_Street»
«Mail_CSZ»

NOTIFICATION OF ENTRY REQUIRED AT YOUR PROPERTY

Dear «First_Name» «Last_Name»:

In accordance with the past communications, meetings and investigations performed at your property, the City of Lakewood is entering into contract Underground Connections (UC) to perform the necessary rehabilitation to separate the storm and sanitary flows within your property. All UC employees working on the project have undergone a background check with Lakewood Police Department. UC will begin to prepare specific scopes of work and cost estimates for each individual property. In order to prepare these estimates, UC will be contacting you to arrange an appointment to perform their own assessment of your property utilizing the City's documents along with their findings to determine the most cost effective approach. Upon completion of the cost estimate, the City will review and approve the plan. The City will then provide you a report of the findings from the investigations, and the proposed work and cost estimate. Under the program guidelines (visit http://www.onelakewood.com/wp-content/uploads/2015/06/2015_EPACleanWaterPilotPrg.pdf), the cost will be split with the City funding 90% and the property owner funding 10% (payment plans are available). You will be given 30 days to opt-in and have UC perform the work at the 90/10 split or you can opt-out and perform the repairs at 100% property owner responsibility within 90 days. There is also an appeals process if you disagree with the required repairs (see the program guidelines).

UC will begin scheduling individual appointments starting Monday, August 24, 2015. The City will monitor the work performed by UC to ensure it is completed to the satisfaction of the City and the individual property owners. The City of Lakewood representative is Brian Shields, PE and can be contacted at (216) 529-6869 or brian.shields@lakewoodoh.net.

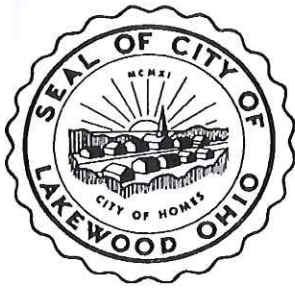
Underground Connections contact information is as follows:

UC Pilot Study Project Phone	(330) 462-3679
Office Number:	(330) 410-4638
Project Site Superintendent:	Tom Carlisle, Jr.
Office Manager:	Janet Carlisle
Project Scheduler:	Meghan McGroder

The Clean Water Pilot Study is required per our National Pollutant Discharge Elimination System (NPDES) agreement with the Ohio EPA. The City and UC is committed to making this program a success. We appreciate your cooperation in this matter.

Respectfully,

Mark Papke, PE, CPESC
City Engineer



DEPARTMENT OF PUBLIC WORKS
12650 DETROIT AVENUE • 44107 • (216) 529-6692

JOSEPH J. BENO, PE
Director of Public Works

MARK K. PAPKE, PE, CPESC
City Engineer

October 20, 2015

Property Owner
Xxxx
Lakewood, Ohio 44107

SECOND NOTICE

NOTIFICATION OF ENTRY REQUIRED AT YOUR PROPERTY

Dear Property Owner:

As of the date of this letter, you have not scheduled your appointment with Underground Connections (UC) or the phone number we have on file is disconnected. The appointment is necessary for a scope of work and cost estimate to be prepared for your property. Please schedule your appointment by **October 27, 2015**.

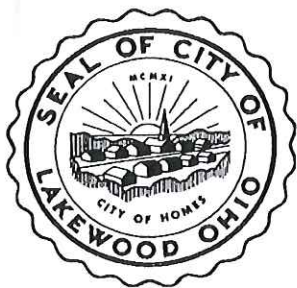
Underground Connections contact information is as follows:

UC Pilot Study Project Phone	(330) 462-3679
Office Number:	(330) 410-4638
Project Site Superintendent:	Tom Carlisle, Jr.
Office Manager:	Janet Carlisle
Project Scheduler:	Meghan McGroder

The Clean Water Pilot Study is required per our National Pollutant Discharge Elimination System (NPDES) agreement with the Ohio EPA. The City and UC is committed to making this program a success. We appreciate your cooperation in this matter. **Failure to comply with this notice may result in a disruption of your water service.**

Respectfully,

Mark Papke, PE, CPESC
City Engineer



DEPARTMENT OF PUBLIC WORKS
12650 DETROIT AVENUE • 44107 • (216) 529-6692

JOSEPH J. BENO, PE
Director of Public Works

MARK K. PAPKE, PE, CPESC
City Engineer

January 11, 2016

Property Owner and Occupant
Xxxx
Lakewood, Ohio 44107

FINAL NOTICE

NOTIFICATION OF ENTRY REQUIRED AT YOUR PROPERTY

Dear Property Owner and Occupant:

As of the date of this letter, the property owner has not scheduled the required appointment with Underground Connections (UC) or the phone number we have on file is disconnected. The appointment is necessary for a scope of work and cost estimate to be prepared for your property. Please schedule your appointment by **JANUARY 20, 2016**.

Underground Connections contact information is as follows:

UC Pilot Study Project Phone	(330) 462-3679
Office Number:	(330) 410-4638
Project Site Superintendent:	Tom Carlisle, Jr.
Office Manager:	Janet Carlisle
Project Scheduler:	Meghan McGroder

The Clean Water Pilot Study is required per our National Pollutant Discharge Elimination System (NPDES) agreement with the Ohio EPA. The City and UC is committed to making this program a success. We appreciate your cooperation in this matter.

Failure to comply with this notice will result in a disruption of your water service in which the water SHUT-OFF process is scheduled to begin on JANUARY 21, 2016 for the property.

Respectfully,

Mark Papke, PE, CPESC
City Engineer



DEPARTMENT OF PUBLIC WORKS
12650 DETROIT AVENUE • 44107 • (216) 529-6692

JOSEPH J. BENO, PE
Director of Public Works

MARK K. PAPKE, PE, CPESC
City Engineer

date

Property Owner
mailing address
Lakewood, Ohio 44107

Re: site address

NOTICE OF THE COST OF CORRECTION - CLEAN WATER PILOT PROGRAM
YOUR ACTION IS REQUIRED 30 DAYS FROM RECEIPT TO EITHER:
OPT-IN, OPT-OUT, OR APPEAL

Dear Property Owner(s):

The evaluation for the above referenced property is complete and corrective measures are required on your private property to remove clean water from the sanitary sewer system. **YOU ARE REQUIRED TO RESPOND TO THIS NOTICE WITHIN 30 DAYS OF RECEIPT.**

Problems Found – See attached our consulting engineer's (AECOM) summary of findings. The results indicate that the property's sanitary sewer lateral is infiltrating clean water from the surface into the sanitary sewer lateral and the structure's foundation drains may be directly tied into the sanitary lateral, which contribute clean water. In the early 1900's construction period, the common practice was to drill small diameter holes atop the sanitary lateral at the foundation to permit footing clean water to enter into the sanitary lateral. The televising performed within the sanitary lateral is unable to detect these small holes. As such, confirmation of the presence of footing drains at your property will be made through interior excavation and exposing the footing. Should the excavation reveal that a foundation drain is not present then that portion of the work will be non-performed and the final amount due reduced.

Corrective Action Required – See attached our contractor's (Underground Connections) quote. Generally, the scope of work provided in the quote will result in removing the clean water from the property's sanitary lateral by any or all of the following: 1) lining the private property portion of the sewer pipe lateral to stop infiltration; 2) installing new storm and sanitary sewer Test-Tees; 3) unblocking the front left downspout; 4) installing a larger pipe from the front downspout to the storm lateral; 5) installing a sump and pump in the basement to collect the foundation drains and pump it up to the storm sewer lateral via the front downspout; 6) required electrical panel upgrades with a new common service added (see the enclosed Electrical Meter Form for further details); and 7) site restoration.

(continued)

Response Required - Per the Program Guide, you have the following three options:

- 1) **OPT IN** - Within 30 days from receipt of this letter, you may “opt in” which authorizes the City and Underground Connections to proceed with the work. Enclosed are the following three (3) forms that must be returned to opt in: 1) Clean Water Pilot Program Form; 2) Right of Entry Form; and 3) Electrical Meter Form. Upon your approval, Underground Connections will contact you to coordinate a time to begin the work.

90/10 Split Cost if you “opt in”

The total estimated cost for the work is \$7,964 which includes a 10% contingency for unforeseen conditions if they are encountered. This amount will not be exceeded unless authorized by you.

City Pays = \$7,167.60

You Pay = \$796.40*

***Opt in Billing:** The property owner will be billed the full amount when the following is completed: work, site restoration, acceptance of the work by the City and the property owner, and payment to the contractor. At the time of billing, an option will be provided to permit the property owner’s portion to be financed at zero percent interest over a period of 10 years which will be added to the water/sewer bill.

- 2) **OPT OUT** – If the opt-out box is checked and returned or you do not send back the attached form within 30 days of receiving this notice, the City will assume that you have chosen to OPT OUT. If you Opt out OR do not return the forms, you are then required to have a contractor of your choice who is registered with the City begin corrective action within 90 days at 100% your cost. Your contractor will need to obtain a building permit and schedule/pass City inspections. Your contractor will need to perform dye tests in the presence of the City to prove that the clean water sources to the sanitary no longer exist.
- 3) **CONTEST THE NECESSITY OF THE CORRECTIONS** - If you contest the necessity of the corrections contemplated by the city, you will have 30 days from the date you receive notice within which to appeal to the city’s Board of Building Standards and Building Appeals. Applications for appeals to the board cost \$25 and must be submitted with the City of Lakewood’s Division of Housing and Building and the board will hear your appeal in accordance with Article XIV of the city’s charter and any applicable rules and regulations.

WITHIN 30 DAYS of receipt, please fill out the enclosed “**CLEAN WATER PILOT PROGRAM FORM**” and return it as indicated. Also, please return the Right of Entry and Electrical Meter forms for property owners selecting the “OPT IN” option.

For program details, please refer to the Clean Water Pilot Program Guide located at http://www.onelakewood.com/wp-content/uploads/2015/06/2015_EPACleanWaterPilotPrg.pdf. Should you have any questions regarding the program, please contact Mark Papke, PE CPESC 216.529.6807 or email mark.papke@lakewoodoh.net.

(continued)

www.onelakewood.com

Should you have any questions regarding the test results and corrective techniques, please contact Brian Shields, PE at 216.529.6869 or brian.shields@lakewoodoh.net.

Should you have any questions regarding the installation of the electrical service meter, please contact Joseph Meyers Lakewood Assistant Building Commissioner at 216.529.6293 or via email joseph.meyers@lakewoodoh.net.

We appreciate your cooperation with this program.

Respectfully,

THE CITY OF LAKEWOOD

Mark Papke, PE, CPESC
City Engineer

Enclosures: Summary of test results
 Underground Connections Quote
 Clean Water Pilot Program Form
 Right of Entry Form
 Electrical Meter Form
 Prepaid Postage Envelope to return forms to the City of Lakewood

CLEAN WATER PILOT PROGRAM FORM

PLEASE PRINT

PROPERTY OWNER NAME(S):

ADDRESS:

PHONE:

EMAIL:

CHOOSE ONE BY CHECKING THE BOX:

- ☐ OPT IN – Proceed with work and the undersigned property owner(s) share shall not exceed \$796.40.
- ☐ OPT OUT – The undersigned property owner(s) shall hire their own Contractor to make repairs and the undersigned property owner will pay 100% of the costs. The corrections work shall begin within 90 days.
- ☐ CONTEST – Within 30 days, the undersigned property owner(s) will file an application to appeal at the Lakewood City Hall Division of Housing and Building.

PROPERTY OWNER – NAME PRINT

PROPERTY OWNER – SIGNATURE

DATE: _____

PROPERTY OWNER – NAME PRINT

PROPERTY OWNER – SIGNATURE

DATE: _____

Return Form to: City of Lakewood
Attn: Mark Papke, City Engineer
12650 Detroit Ave
Lakewood, Ohio 44107

OR

Scan and email to: mark.papke@lakewoodoh.net

RIGHT – OF – ENTRY FORM

In consideration of the City of Lakewood, Underground Connections or its duly designated representatives doing the work described herein, I do hereby agree as follows:

I, _____ (property owner), do hereby authorize the City of Lakewood to enter upon my land located at _____ (address), Lakewood, Ohio 44107 with such workers and equipment as may be reasonably required to:

PERFORM CLEAN WATER CORRECTIVE WORK PER THE QUOTE

It is understood that upon completion, the City of Lakewood, Underground Connections, or its duly designated representative shall return the property as nearly as practicable to its original condition, taking into consideration the nature of the work performed.

I have read and understand this Right-Of-Entry.

AUTHORIZED AND SIGNED BY:

PROPERTY OWNER – NAME PRINT

PROPERTY OWNER – SIGNATURE

DATE: _____

PROPERTY OWNER – NAME PRINT

PROPERTY OWNER – SIGNATURE

DATE: _____

Return Form to: City of Lakewood
Attn: Mark Papke, City Engineer
12650 Detroit Ave
Lakewood, Ohio 44107

OR

Scan and email to: mark.papke@lakewoodoh.net

ELECTRICAL METER FORM

- **Electric Code**

The sump pump will be constructed in a “common” area of the dwelling. As such, for two-family dwellings and multi-family dwellings, the National Electric Code (NEC) does NOT permit the sump pump to be connected to any service that supplies power to a dwelling unit or tenant space (see code excerpt below). This includes dwellings that are owner occupied. Therefore, a new electric service meter will be installed to power the sump pump at your property. The construction costs for the new meter install and power supply lines for the sump pump only are included in your quote. No other electrical work will be required to separate common area power. This is also an insurance that the sump pump will continue to operate even if the tenant has their power interrupted. Please contact Joseph Meyers Lakewood Assistant Building Commissioner with any questions regarding the electrical service at 216.529.6293 or via email joseph.meyers@lakewoodoh.net.

NFPA 70 National Electric Code 2011 Article 210.25(B) Common Area Branch Circuits.

Branch circuits installed for the purpose of lighting, central alarm, signal, communications, or other purposes for public or common areas of a two-family dwelling, a multifamily dwelling, or a multi-occupancy building shall not be supplied from equipment that supplies an individual dwelling unit or tenant space.

From the commentary: Not only does 210.25 prohibit branch circuits from feeding more than one dwelling unit, it also prohibits the sharing of systems, equipment, or common lighting if that equipment is fed from any of the dwelling units. In addition, common area circuits in occupancies other than dwelling units are subject to this requirement, and “house load” branch circuits must be supplied from equipment that does not directly supply branch circuits for an individual occupancy or tenant space. The systems, equipment, and lighting for public or common areas are required to be supplied from a separate “house load” panelboard. This requirement permits access to the branch-circuit disconnecting means without the need to enter the space of any tenants. The requirement also prevents a tenant from turning off important circuits that may affect other tenants.

- **First Energy**

In order to get the power connected at your property, we need you to provide the information below to set up the new meter service. According to First Energy, because your residence has existing services they cannot be billed at the Residential rate. The new meter will be at the Commercial rate with an estimated monthly charge of \$25 to \$28 per month. Please contact Tim Denzler at First Energy with any questions regarding the electrical billing 440.546.8711 or via email tjdenzler@firstenergycorp.com.

Property Address: _____ - Lakewood, OH 44107

Property Owner Name: _____

Billing Address: _____

Property Owner Phone No.: _____

PLEASE FILL OUT THIS FORM AND RETURN WITH THE OTHER FORMS.

www.onelakewood.com



DEPARTMENT OF PUBLIC WORKS
12650 DETROIT AVENUE • 44107 • (216) 529-6692

JOSEPH J. BENO, PE
Director of Public Works

MARK K. PAPKE, PE, CPESC
City Engineer

Date

Property Owner
mailing address
Lakewood, Ohio 44107

Re: site address

NOTICE OF EXPIRED OPT-IN PERIOD CLEAN WATER PILOT PROGRAM

Dear Property Owner(s):

On *(date)*, we met with you at the above referenced property to prepare a quote for the removal of property's storm water from the sanitary sewer system. On December 18, 2015, we sent you (via certified mail) the proposal for the work needing to be completed at your property which came back to our office unclaimed. On *(date)*, we performed Residential Service, as required by law, by adhering the letter to the property's entrance door. The letter has been removed since then.

We have not received any communication from you opting in, out or contesting. The 30 day opt-in period has expired. If we have made an error and you wish to opt-in, please contact us by *(date)*.

Otherwise, it is assumed that you have "opted-out" and will be performing the repairs at 100% your costs. Your contractor will need to obtain a building permit for the corrections by *(date)*. ***Failure to begin work by this date will result in a disruption of your water service in which the water SHUT-OFF process is scheduled to begin on (date) for the property.***

We appreciate your cooperation with this program.

Respectfully,
THE CITY OF LAKEWOOD

Mark Papke, PE, CPESC
City Engineer

RESOLUTION NO. 8794-15

BY: Anderson, Bullock, Juris,
Madigan, Marx, O'Leary.

A RESOLUTION to take effect immediately provided it receives the affirmative vote of at least five members of Council, or otherwise to take effect and be in force after the earliest period allowed by law, establishing a pilot program in western Lakewood to remove clean water sources from the City's sanitary sewer system in the furtherance of the City's permitting under the Ohio Environmental Protection Agency; authorizing the Mayor (Director of Public Safety), the Director of Public Works, the Director of Law, the Director of Finance and/or the Purchasing Manager to enter into contracts for professional services for the pilot program, and to advertise for bids and enter into contracts for the purchase of repair, maintenance and operating supplies, services and equipment for the pilot program as authorized by the Administrative Code of the City of Lakewood with the lowest and best bidder or bidders or as otherwise provided by law in an amount not to exceed \$900,000.00; declaring a nuisance; and identifying resident payment options under the pilot program.

WHEREAS, the City of Lakewood was issued a renewal of the Ohio Environmental Protection Agency (Ohio EPA) NPDES Permit dated September 1, 2014 that requires the development of a plan to reduce and eliminate sewage discharges to the environment; and

WHEREAS, to timely meet its legal requirements, the City is undertaking a pilot study to remove clean water sources from the City's sanitary sewer system as one of the measures critical to the evaluation and development of an integrated plan; and

WHEREAS, the City strategically chose specific properties within the area bordered by Hilliard Road, Atkins Avenue, Eldred Avenue and Delaware Avenue in western Lakewood to undertake the pilot study; and

WHEREAS, the City of Lakewood, in order to properly evaluate the effectiveness of removing clean water sources on private property within the compliance schedule contained in the Ohio EPA NPDES Permit conditions, has determined the use of public funds, partially to be reimbursed to the City by the pilot project participants, to be in the best interests of the public; and

WHEREAS, Chapter 913 of the Codified Ordinances prohibits persons from discharging sewage, industrial waste or other waste into the City's wastewater disposal system contrary to the provisions of that chapter, federal or state pretreatment requirements, or any order of Council; and

WHEREAS, Chapter 913 of the Code prohibits persons from discharging or causing to be discharged any storm water, surface water, groundwater, roof runoff, subsurface drainage, un-contaminated cooling water or unpolluted industrial process waters to any sanitary sewer, and contemplates that doing so constitutes a public nuisance; and

WHEREAS, this Council desires to provide the authorization to the Mayor (Director of Public Safety), the Director of Public Works, the Director of Law, the Director of Finance, and/or the Purchasing Manager to enter into contracts for professional services for the pilot program, and to advertise for bids and enter into contracts for the purchase of repair, maintenance and operating supplies, services and equipment for the pilot program as authorized by the Administrative Code of the City of Lakewood with the lowest and best bidder or bidders or as otherwise provided by law in an amount not to exceed \$900,000.00; and

WHEREAS, the City of Lakewood makes this determination solely and expressly for the aforementioned purpose and only for this specific pilot study area; and

WHEREAS, the City of Lakewood has determined it is in the best interest of the public; to protect the public health and welfare, that it is necessary to fund the correction and rehabilitation necessary on private property in the pilot study area as a critical and key element to the proper development of a comprehensive plan to reduce and eliminate sewage discharges to the environment; and

WHEREAS, pursuant to the Constitution of the State of Ohio and the Ohio Revised Code, municipalities have the power of local self-government, and the power to enact laws that are for the health, safety, welfare; and

WHEREAS, this Council by a vote of at least five of its members determines that this resolution is an emergency measure and that it shall take effect immediately, as set forth in Article III, Sections 10 and 13 of the Second Amended Charter of the City of Lakewood, and that it is necessary for the immediate preservation of the public property, health, and safety and to provide for the usual daily operation of municipal departments, in that the City must proceed to investigate and correct improper inflow and infiltration of stormwater into the sanitary system under the Ohio EPA NPDES permit immediately; now, therefore

BE IT RESOLVED BY THE CITY OF LAKEWOOD, OHIO:

Section 1. The City hereby establishes a pilot project in western Lakewood, within the area bounded by Hilliard Road to the north, Atkins Avenue to the west, Eldred Avenue to the east and Delaware Avenue to the south, to remove clean water sources from the City's sanitary sewer system in the furtherance of the City's permitting under the Ohio EPA, substantially under the conditions and specifications identified in the pilot project program guide attached hereto as **Exhibit A**.

Section 2. The Mayor (Director of Public Safety), the Director of Public Works, the Director of Law, the Director of Finance, and/or the Purchasing Manager be and are hereby authorized and directed to enter into contracts for professional services for the pilot program, and to advertise for bids and enter into contracts for the purchase of repair, maintenance and operating supplies, services and equipment for the pilot program as authorized by the Administrative Code of the City of Lakewood with the lowest and best bidder or bidders or as otherwise provided by law in an amount not to exceed \$900,000.00.

Section 3. Within the pilot program area, any discharge of sewage, industrial waste or other waste into the City's wastewater disposal system contrary to the provisions Chapter 913, federal or state pretreatment requirements, or any order of Council; and any discharge or the causing of any discharge of any storm water, surface water, groundwater, roof runoff, subsurface drainage, uncontaminated cooling water or unpolluted industrial process waters to any sanitary sewer constitute and are hereby declared to be public nuisances.

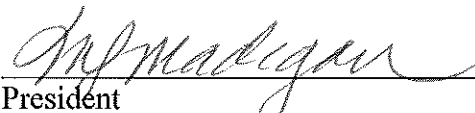
Section 4. Owners of property included within the pilot program are required to participate in the program in accordance with the authority granted to the City, and under penalty imposed by, Chapters 901, 913 and 917 of the Codified Ordinances and all applicable code. Owners shall have the option to test and correct their sewer connections at their own expense using their own contractors, subject to the City's approval and inspection, and in accordance with the terms of the program, but in any event not later than December 1, 2015. For those corrections undertaken on private property by the City, the City is expected initially to bear the full cost of the corrections, and participants must repay the City 10 percent of such costs. The Director of Finance is authorized and directed to establish payment options available to those property owners who participate in order to lessen the financial impact of the corrections upon owners.

Section 5. The pilot program established in this resolution shall not cease except upon further action by Council.

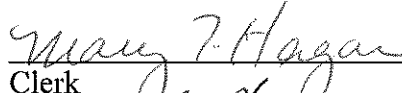
Section 6. It is found and determined that all formal actions of this Council concerning and relating to the passage of this resolution were adopted in an open meeting of this Council and that all such deliberations of this Council and of any of its committees that resulted in such formal action were in meetings open to the public in compliance with all legal requirements.

Section 7. This resolution is hereby declared to be an emergency measure necessary for the immediate preservation of the public peace, property, health, safety and welfare in the City and for the usual daily operation of the City for the reasons set forth and defined in its preamble, and provided it receives the affirmative vote of at least five members of Council this resolution shall take effect and be in force immediately, or otherwise shall take effect and be in force after the earliest period allowed by law.

Adopted: March 16, 2015



President

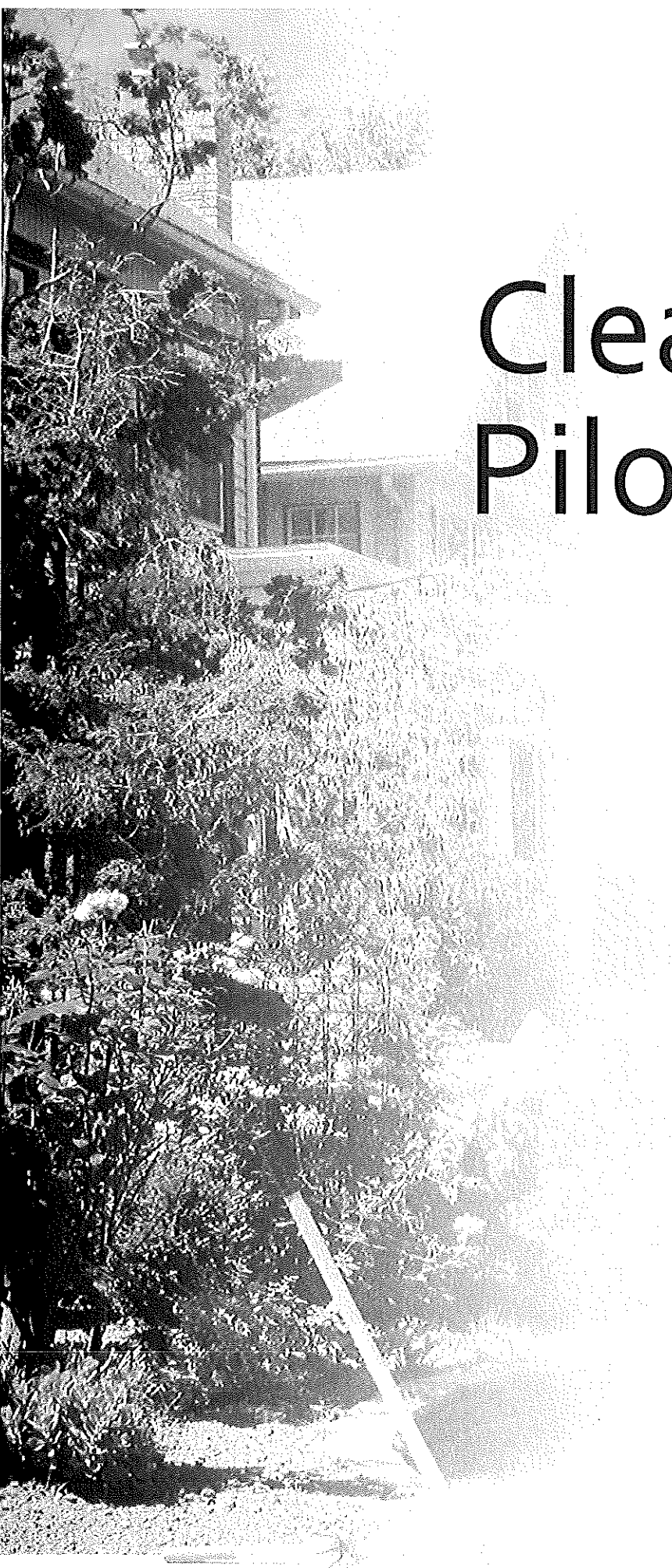


Clerk

Approved: March 20, 2015



Mayor



Clean Water Pilot Project

Program Guide

City of Lakewood
www.onelakewood.com





City of Lakewood

Clean Water Pilot Project

Program Guide

A. Pilot Project Area. The pilot project area will be bordered by Hilliard Road to the north, Atkins Avenue to the west, Eldred Avenue to the east and Delaware Avenue to the south, and will include the following residential properties:

Parcel No.	Address	Street
313-11-018	2122	Atkins Ave.
313-12-044	2123	Atkins Ave.
313-11-019	2124	Atkins Ave.
313-12-043	2127	Atkins Ave.
313-11-020	2128	Atkins Ave.
313-12-042	2131	Atkins Ave.
313-11-021	2132	Atkins Ave.
313-11-022	2134	Atkins Ave.
313-12-041	2135	Atkins Ave.
313-13-001	2139	Atkins Ave.
313-11-023	2140-42	Atkins Ave.
313-13-002	2143-45	Atkins Ave.
313-11-024	2144	Atkins Ave.
313-13-003	2147-49	Atkins Ave.
313-11-025	2148	Atkins Ave.
313-13-004	2151-53	Atkins Ave.
313-11-026	2152	Atkins Ave.
313-13-005	2155-57	Atkins Ave.
313-11-027	2156	Atkins Ave.
313-11-029	2160	Atkins Ave.
313-13-006	2159-61	Atkins Ave.
313-11-030	2162	Atkins Ave.
313-13-007	2163-65	Atkins Ave.
313-11-031	2166	Atkins Ave.
313-13-008	2167	Atkins Ave.
313-11-032	2170	Atkins Ave.
313-13-009	2171-73	Atkins Ave.
313-13-010	2175	Atkins Ave.

Parcel No.	Address	Street
313-11-033	2176	Atkins Ave.
313-11-034	2178	Atkins Ave.
313-13-011	2179-81	Atkins Ave.
313-11-035	2180	Atkins Ave.
313-13-012	2183	Atkins Ave.
313-11-036	2184-86	Atkins Ave.
313-13-013	2185-87	Atkins Ave.
313-11-037	2188-90	Atkins Ave.
313-13-014	2191	Atkins Ave.
313-11-038	2192	Atkins Ave.
313-13-015	2193	Atkins Ave.
313-11-039	2196-98	Atkins Ave.
313-13-016	2197-99	Atkins Ave.
313-11-040	2200	Atkins Ave.
313-13-017	2203	Atkins Ave.
313-11-041	2204	Atkins Ave.
313-13-018	2205-07	Atkins Ave.
313-11-042	2208-10	Atkins Ave.
313-13-019	2209-11	Atkins Ave.
313-11-043	2212	Atkins Ave.
313-11-044	2214-16	Atkins Ave.
313-13-020	2215	Atkins Ave.
313-13-021	2217-19	Atkins Ave.
313-11-045	2218-20	Atkins Ave.
313-13-022	2221	Atkins Ave.
313-13-074	16611-13	Delaware Ave.
313-13-075	16615-17	Delaware Ave.
313-13-076	16619-21	Delaware Ave.

Parcel No.	Address	Street
313-13-077	16701-03	Delaware Ave.
313-13-025	16706	Delaware Ave.
313-13-078	16707	Delaware Ave.
313-13-024	16708	Delaware Ave.
313-13-079	16711	Delaware Ave.
313-13-023	16712-14	Delaware Ave.
313-11-046	16800	Delaware Ave.
313-11-047	16802-04	Delaware Ave.
313-11-048	16806-08	Delaware Ave.
313-11-049	16810-12	Delaware Ave.
313-11-050	16900-02	Delaware Ave.
313-11-051	16906-08	Delaware Ave.
313-11-052	16914	Delaware Ave.
313-11-053	17002	Delaware Ave.
313-13-042	2178	Eldred Ave.
313-13-055	2183	Eldred Ave.
313-13-041	2184-86	Eldred Ave.
313-13-056	2187	Eldred Ave.
313-13-040	2188-90	Eldred Ave.
313-13-057	2191	Eldred Ave.
313-13-058	2193-95	Eldred Ave.
313-13-039	2194-96	Eldred Ave.
313-13-038	2198-2200	Eldred Ave.

Parcel No.	Address	Street
313-13-059	2199-2201	Eldred Ave.
313-13-037	2202-04	Eldred Ave.
313-13-060	2203-05	Eldred Ave.
313-13-036	2206-08	Eldred Ave.
313-13-061	2207-09	Eldred Ave.
313-13-035	2210	Eldred Ave.
313-13-062	2211	Eldred Ave.
313-13-063	2215	Eldred Ave.
313-13-034	2216	Eldred Ave.
313-13-033	2220-22	Eldred Ave.
313-13-064	2221	Eldred Ave.
313-13-065	2223	Eldred Ave.
313-13-032	2224-26	Eldred Ave.
313-13-031	2230	Eldred Ave.
313-13-066	2231	Eldred Ave.
313-13-030	2233-35	Eldred Ave.
313-13-029	2234	Eldred Ave.
313-13-068	2238	Eldred Ave.
313-13-028	2239	Eldred Ave.
313-13-069	2242-44	Eldred Ave.
313-13-070	2245	Eldred Ave.
313-13-026	2249	Eldred Ave.
313-13-067	2250	Eldred Ave.

If your property is not listed above, you are not a part of the pilot project, although work may be occurring near your property and at your neighbors' property.

This area was chosen because it features a unique situation where all houses flow into a single point (the sewer interceptor by Harding Middle School); the homes were built in the same time period and are of similar design; we have very good data of the current state of sewer flows during dry and wet weather; and we can measure before and after flow volumes in a variety of dry weather and wet (storm) weather conditions.

B. Rationale. The rationale for the pilot project is as follows:

- The city's sewer system is plagued with significant inflow and infiltration, complicated by a complex network of separate and combined sewers. This results in sewage overflows to the Rocky River and Lake Erie.
- Lakewood recently entered into an administrative consent order with the U.S. EPA that stipulates the city eliminate all sanitary sewer overflows and basement backups.
- Lakewood recently was issued a renewal of its Ohio EPA NPDES permit dated September 1, 2014 that requires the development of a plan to reduce and eliminate sewage discharges to the environment.
- The majority of rainfall that enters the sanitary sewer system comes from sources on private property. These sources must be systematically removed. Each source is a small portion

of the enormous volume of water that enters the system, so it will take time before the removal of each source will produce a noticeable effect.

- Rain water enters the public sanitary sewer due to the age of the overall system and development in the city. The city needs to find and eliminate as many sources of rain water in its sanitary sewer system as possible.

- The city's sanitary sewers are properly sized for conveying sewage during dry weather. It is only during significant rainfall events that the sanitary and/or combined sewers become overloaded.

- Financing for rehabilitation and corrections on private property is worth analyzing. Costs often exceed normal expectations of what homeowners can absorb.

C. Goals of the Program. The goals of the pilot project are as follows:

- to improve water quality and achieve compliance with the federal Clean Water Act and Ohio law;

- to reduce the volume of surface and subsurface water entering the city's sanitary sewer system;

- to reduce overflows into the Rocky River and Lake Erie;

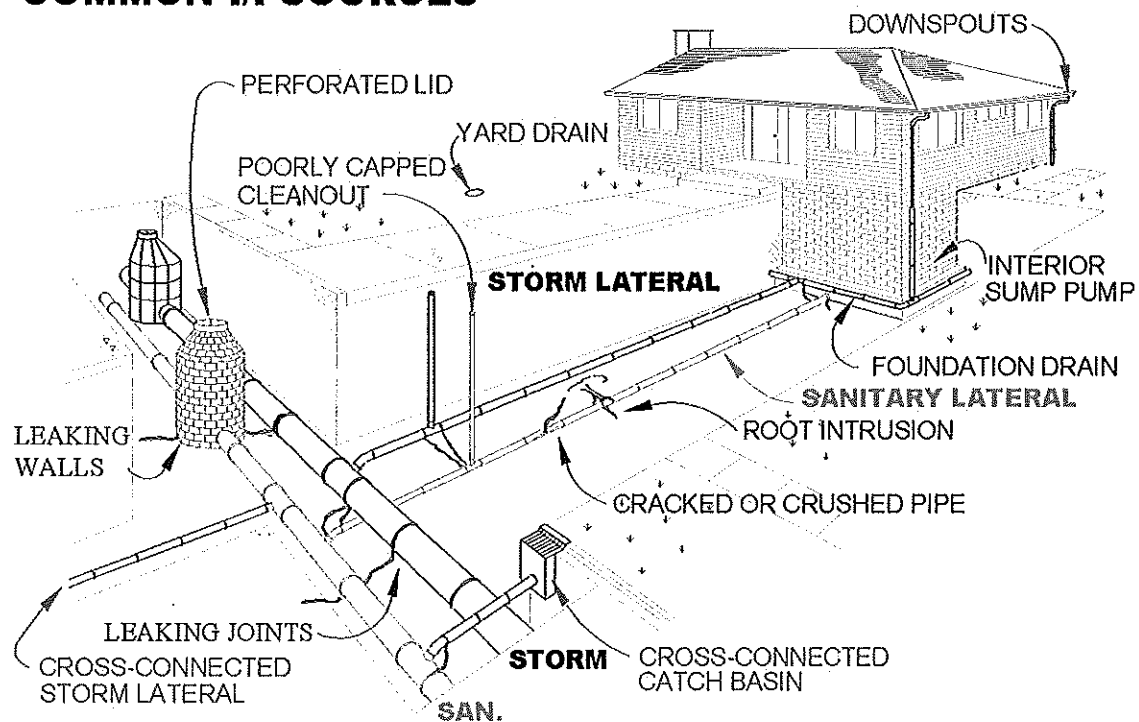
- to reduce the occurrence of basement flooding; and

- to develop a source-control program that considers the financial impact on the residents and technical effectiveness as the city looks toward future citywide programs, corrections and compliance initiatives.

D. Authority for the Program. The city is operating under the resolution establishing the pilot program in 2015. Under Chapters 901, 913 and 917 of the Codified Ordinances, the city may inspect, sample, test and order correction of all instances of improper sewer connections from private property to the city's sewer system, and the infiltration of storm water into the sanitary sewers on private property. The city may also require that all storm water goes from homes to the storm system, and all sanitary water goes from homes to the sanitary system. The pilot program will permit the city and homeowners to make necessary corrections on private property without having to impose some of the more difficult penalty provisions, such as injunctive relief, prosecution and the like, upon affected homeowners.

E. Scope of the Program. The city has engaged its own employees and contractors to conduct physical inspection and testing of sewer connections on properties included in the pilot program. They will access each basement and yard after arranging a time with you. They will attempt to video existing conditions in the pipes leading to and from your home. They will inventory all sewer connections, identify design options for the correction of any violations, and arrange for and conduct corrections of those violations. Some common inflow and infiltration sources to be addressed in the pilot program are illustrated in the following diagram:

COMMON I/I SOURCES



The correction work includes activities that are directly attributable to the removal of clean water sources to the sanitary sewers and may include removal of dirty water to storm sewers. *Examples of correction work* may include installation of:

- a sump pump receptacle (sometimes referred to as a crock) to act as a storage well for water from the foundation (footer) drain;
- a sump pump or ejector pump in sumps or crocks located in the basement or exterior of the house;
- a water-pressure-driven backup sump pump or battery powered backup sump pump;
- downspout diverters or splash pads;
- sanitary and storm lateral pipes to replace existing pipes or to reconnect clean water sources to the storm sewer;
- liners in existing pipes to stop leaking into the pipe;
- upgrades to the house electrical system to support installation of pumps including wiring of a receptacle for the sump pump;
- revisions to the house plumbing system to support installation of a sump pump including installation of new sump-pump discharge piping;

- hangers, braces, supports, staples and other systems for routing and securing plumbing and electrical systems;
- redirecting floor drains to sanitary connection; and/or
- other corrections required to properly complete the project performed at the discretion of the city.

Corrections may require:

- open trenching or where feasible, trenchless construction methods;
- exterior excavation around selected portions of the house foundation;
- cutting and removal of concrete basement slabs and any associated floor covering;
- cutting and removal of sidewalks, driveways, patios, and other exterior hard surfaces;
- removal of plant materials and salvaging (where feasible) or replacing same with like plant materials;
- temporary alterations to irrigation systems;
- drilling, cutting or otherwise creating openings for electrical and plumbing work;
- cutting and repair of exterior foundation walls to allow redirection of foundation (footer) drains to the sump pump receptacle, and redirection of lateral sewer lines;
- localized water proofing of new exterior foundation walls;
- surveying, isolating and removing asbestos containing floor covering or insulation if there is the potential for creating air born asbestos fibers;
- air quality testing; and/or
- other appropriate industry standard methods of construction required to properly complete the project performed at the discretion of the city.

Corrections will not include improving any system, surface, structure, object, or facility not necessary to remove sources of clean water from the sanitary sewer system including:

- waterproofing old construction;
- replacing floor coverings other than those directly disturbed by construction;
- wall coatings and/or paint other than required to attempt to match new work with old construction;
- upgrading facilities not associated with the intent of the program;
- replacing dead, diseased or dangerously rotted plant material; or
- any activity considered purely decorative.

If your property is within the original pilot-study area and you have already made, at your expense, corrections to your sewer system after notice of the pilot study was provided in February 2014, the city may consider, on a case-by-case basis depending on a number of factors, awarding a credit against your water and sewer charges. This would be determined after the city has had an opportunity to determine a scope of work at your property.

F. Ownership of Corrections. When work is completed, you will own all property, devices and materials used to correct problems. Any general or specific warranties or other benefits owned by the city will be transferred, to the extent possible, to you. You will be responsible for future operation and maintenance including but not limited to all necessary electrical and power supply costs. The city will not be responsible for the corrections or any property, devices and materials used for the corrections. The payment of financial assistance by the city under this program shall not be deemed to give rise to any liability on the part of the city for work performed by a contractor or any other person.

G. Payment for Corrections; Financing. Once the evaluations are complete, and scope of work per property is determined, the following is the city's financial participation in the corrections to be made on your property:

- The city will provide you, as the homeowner, notice of the cost of correction with an itemized list of the corrections to be made. The notice will be made either by certified mail or residence service at the affected property. You can opt in and use the city's contractor for the corrections to be made after the notice is made. You will have 30 days to opt in, on a form approved by the city, after receipt of the notice.

- *If you opt in*, the city will pay for 100 percent for initial property correction at your home. It is estimated the total cost of correction at most parcels will not exceed \$7,500. Work at some homes may cost much less; work at others may cost much more.

- If you opt in, you will be responsible to repay the city just 10 percent of the cost of any correction per parcel. You will have the opportunity to set up a payment plan for no more than 10 years at 0 percent interest. Amounts due under the payment plan will be added to your water and sewer bill. Your failure to make a scheduled payment will result in the balance being assessed to your property tax bill. The city may consider, on a case-by-case basis depending on a number of factors, awarding a full or partial credit for any repayment obligation or against your water and sewer charges based upon sewer corrections you may have already made, at your expense, after notice of this pilot study was provided in February 2014.

- If you contest the necessity of the corrections contemplated by the city, you will have 30 days from the date you receive notice within which to appeal to the city's Board of Building Standards and Building Appeals. Applications for appeals to the board cost \$25 and must be submitted with the city's Division of Housing and Building and the board will hear your appeal in accordance with Article XIV of the city's charter and any applicable rules and regulations.

- *If you fail to opt in* within 30 days of receiving notice of the corrections, you must begin to correct the identified sewer connection issues within 90 days, failing which the city may enforce the penalty provisions of Chapters 901, 913 and 917 of the Codified Ordinances or take

other actions allowable by any applicable code. All necessary permits must be pulled for such work and you must bear the full expense of the corrections. If you fail to opt in, you must complete the work undertaken be completed by December 1, 2015, failing which the city may enforce the penalty provisions of Chapters 901, 913 and 917 of the Codified Ordinances or take other actions allowable by any applicable code, including abating the nuisance conditions on your property and assessing the cost to the property.

H. Conditions of Financial Assistance. Any sanitary sewer customer participating in this program must be the owner of the property, and as a condition to receiving the assistance, you must agree on the opt-in form to the following:

- ***Inspection.*** The city, on reasonable notice, may inspect the corrections at any time.
- ***Maintenance and Repair.*** You will operate and maintain the corrections and timely complete any repairs or replacement of the corrections.
- ***Discharge Modifications Prohibited.*** You will not modify the sump pump discharge (if applicable) in any manner that would directly or indirectly contribute foundation drain flow and clear water flow to the sanitary sewer system.
- ***Agreement Runs with the Land.*** You will agree that these conditions run with the property and may be recorded by the city; and that the city may maintain a record or database of properties governed by the agreement.

I. After the Project is Completed. Without written permission of the city, you will not be permitted to alter the plumbing or connection to the sanitary sewer system after the corrections are made, subject to the penalty provisions found within Chapters 901, 913 and 917 of the Codified Ordinances or other applicable law. If the city determines after the project is completed there is a modification of the system that permits clean water to enter the sanitary sewer, or a failure to maintain or replace a failed sump pump or other equipment that would allow an indirect or direct connection to the sanitary sewer system, or such other cause may allow a direct or indirect connection, the city may require further corrections by the property owner.

J. Contact Information. For more information, please contact the city's Division of Engineering at (216) 529-6692 or engineering@lakewoodoh.net.

Clean Water Pilot Project

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City of Lakewood
www.onelakewood.com



Parcel No.	Address	Street
313-13-077	16701-03	Delaware Ave.
313-13-025	16706	Delaware Ave.
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313-13-024	16708	Delaware Ave.
313-13-079	16711	Delaware Ave.
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313-13-034	2216	Eldred Ave.
313-13-033	2220-22	Eldred Ave.
313-13-064	2221	Eldred Ave.
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313-13-031	2230	Eldred Ave.
313-13-066	2231	Eldred Ave.
313-13-030	2233-35	Eldred Ave.
313-13-029	2234	Eldred Ave.
313-13-068	2238	Eldred Ave.
313-13-028	2239	Eldred Ave.
313-13-069	2242-44	Eldred Ave.
313-13-070	2245	Eldred Ave.
313-13-026	2249	Eldred Ave.
313-13-067	2250	Eldred Ave.

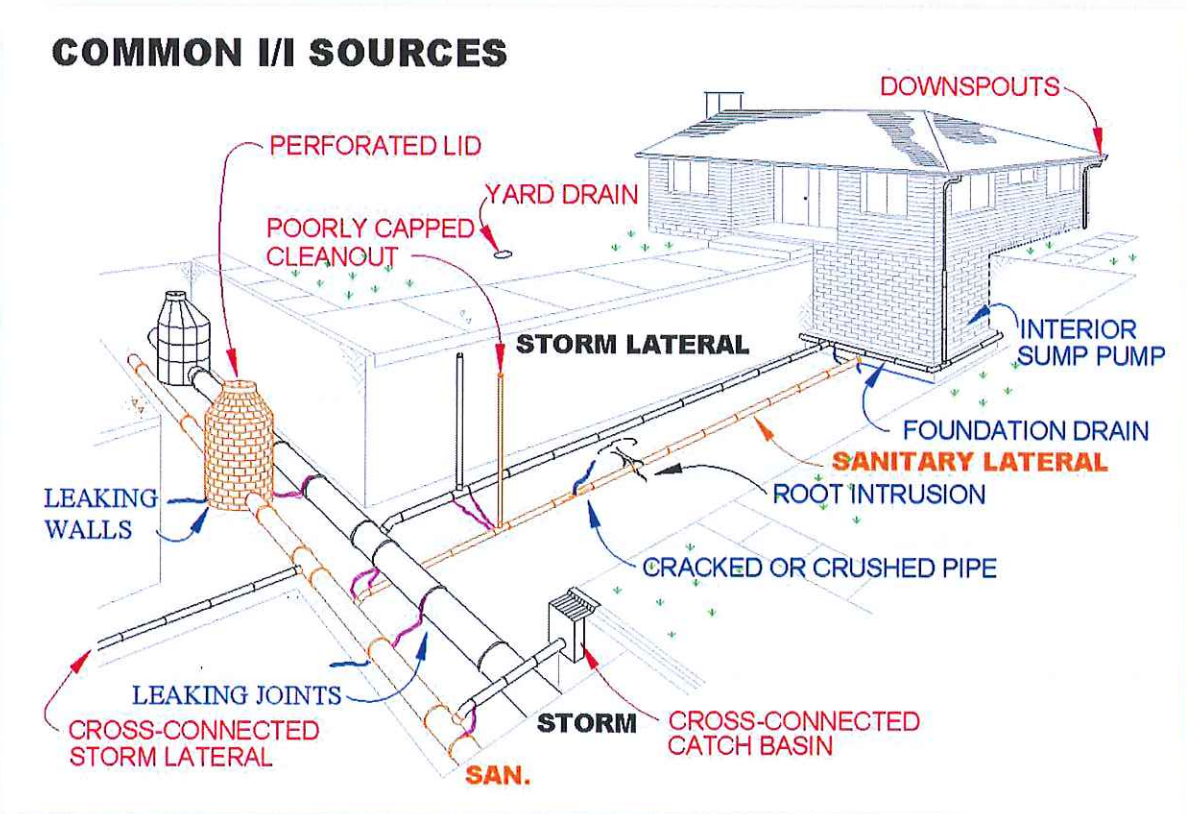
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B. Rationale. The rationale for the pilot project is as follows:

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- Lakewood recently entered into an administrative consent order with the U.S. EPA that stipulates the city eliminate all sanitary sewer overflows and basement backups.
- Lakewood recently was issued a renewal of its Ohio EPA NPDES permit dated September 1, 2014 that requires the development of a plan to reduce and eliminate sewage discharges to the environment.
- The majority of rainfall that enters the sanitary sewer system comes from sources on private property. These sources must be systematically removed. Each source is a small portion

and conduct corrections of those violations. Some of the violations expected to be encountered are illustrated in the following diagram:



The correction work includes activities that are directly attributable to the removal of clean water sources to the sanitary sewers. *Examples of correction work* may include installation of:

- a sump pump receptacle (sometimes referred to as a crock) to act as a storage well for water from the foundation (footer) drain;
- a sump pump or ejector pumps in sumps or crocks located in the basement or exterior of the house;
- a water pressure driven backup sump pumps or battery powered backup sump pumps;
- downspout diverters or splash pads;
- sanitary and storm lateral pipes to replace existing pipes or to reconnect clean water sources to the storm sewer;
- liners in existing pipes to stop leaking into the pipe;

- replacing floor coverings other than those directly disturbed by construction;
- wall coatings and/or paint other than required to attempt to match new work with old construction;
- upgrading facilities not associated with the intent of the program;
- replacing dead, diseased or dangerously rotted plant material; or
- any activity considered purely decorative.

F. Ownership of Corrections. When work is completed, you will own all property, devices and materials used to correct problems. Any general or specific warranties or other benefits owned by the city will be transferred, to the extent possible, to you. You will be responsible for future maintenance including but not limited to all necessary electrical and power supply costs. The city will not be responsible for the corrections or any property, devices and materials used for the corrections. The payment of financial assistance by the city under this program shall not be deemed to give rise to any liability on the part of the city for work performed by a contractor or any other person.

G. Payment for Corrections; Financing. Once the evaluations are complete, and scope of work per property is determined, the following is the city's financial participation in the corrections to be made on your property:

- The city will provide you, as the homeowner, notice of the cost of correction with an itemized list of the corrections to be made. The notice will be made either by certified mail or residence service at the affected property. You can opt in and use the city's contractor for the corrections to be made after the notice is made. You will have 30 days to opt in, on a form approved by the city, after receipt of the notice.

- ***If you opt in***, the city will pay for 100 percent for initial property correction at your home. It is estimated the cost of correction at most parcels will not exceed \$7,500. Work at some homes may cost much less; work at others may cost much more.

- If you opt in, you will be responsible to repay the city just 10 percent of the cost of any correction per parcel. You will have the opportunity to set up a payment plan for no more than 10 years at 0 percent interest. Amounts due under the payment plan will be added to your water and sewer bill. Your failure to make a scheduled payment will result in the balance being assessed to your property tax bill.

- If you contest the necessity of the corrections contemplated by the city, you will have 30 days from the date you receive notice within which to appeal to the city's Board of Building Standards and Building Appeals. Applications for appeals to the board cost \$25 and must be submitted with the city's Division of Housing and Building and the board will hear your appeal in accordance with Article XIV of the city's charter and any applicable rules and regulations.

- ***If you fail to opt in*** within 30 days of receiving notice of the corrections, you must begin to correct the identified sewer connection issues within 90 days, failing which the city may enforce the penalty provisions of Chapters 901, 913 and 917 of the Codified Ordinances or take other actions allowable by any applicable code. All necessary permits must be pulled for such work and you must bear the full expense of the corrections. If you fail to opt in, you must complete the work undertaken be completed by December 1, 2015, failing which the city may enforce the penalty provisions of Chapters 901, 913 and 917 of the Codified Ordinances or take other actions allowable by any applicable code, including abating the nuisance conditions on your property and assessing the cost to the property.

H. Conditions of Financial Assistance. Any sanitary sewer customer participating in this program must be the owner of the property, and as a condition to receiving the assistance, you must agree on the opt-in form to the following:

- ***Inspection.*** The city, on reasonable notice, may inspect the foundation drain connection at any time.

- ***Maintenance and Repair.*** You will maintain the sump pump system (if applicable) and timely complete any repairs or replacement of the sump pump system.

- ***Discharge Modifications Prohibited.*** You will not modify the sump pump discharge (if applicable) in any manner that would directly or indirectly contribute foundation drain flow to the sanitary sewer system.

- ***Agreement Runs with the Land.*** You will agree that these conditions run with the property and may be recorded by the city; and that the city may maintain a record or database of properties governed by the agreement.

I. After the Project is Completed. Without written permission of the city, you will not be permitted to alter the plumbing or connection to the sanitary sewer system after the corrections are made, subject to the penalty provisions found within Chapters 901, 913 and 917 of the Codified Ordinances or other applicable law. If the city determines after the project is completed there is a modification of the system that permits clean water to enter the sanitary sewer, or a failure to maintain or replace a failed sump pump or other equipment that would allow an indirect or direct connection to the sanitary sewer system, or such other cause may allow a direct or indirect connection, the city may require further corrections by the property owner.

J. Contact Information. For more information, please contact the city's Division of Engineering at (216) 529-6692 or engineering@lakewoodoh.net.

RESOLUTION NO. 8800-15

BY: **Anderson, Bullock, Juris, Madigan,
Marx, Nowlin, O'Leary.**

A RESOLUTION to take effect immediately provided it receives the vote of at least five members of Council, or otherwise to take effect at the earliest period allowed by law, authorizing the Mayor (Director of Public Safety), the Director of Public Works, the Director of Law, the Director of Finance, and /or the Purchasing Manager to establish procedures for and engage in the process of letting of one or more contracts with one or more qualified entities for design and construction of corrections to the sewer system under the western Lakewood clean water pilot project without the necessity of competitive bidding; and exempting the City from certain provisions within the Ohio Revised Code related to design-build contracting for the purposes of this project.

WHEREAS, Lakewood has traditionally contracted for public works improvements using the design-bid-build project delivery system, with construction contracts let under the City's competitive-bidding regulations; and

WHEREAS, Ohio law changed substantially in 2011 and 2012, and many new project delivery systems, such as design-build, are now available to cities; and

WHEREAS, newer project delivery models may result in efficiencies in the contracting process and substantial cost savings, but cannot be used by following traditional competitive-bidding regulations; and

WHEREAS, Section 111.04 of the Codified Ordinances permits exceptions to competitive bidding under certain circumstances, including for contracts involving professional or technical services; contracts with construction managers; contracts which may be awarded without competitive bidding under state statutes; and contracts where Council determines that it is either impractical to award the contract under competitive bidding procedures, or cost-effective and in the best interests of the City to award the contract without competitive bidding; and

WHEREAS, it is in the City's best financial interest to employ the design-build project delivery system for corrections to the sewer system under the western Lakewood clean water pilot project (which project is further described in Resolution 8794-15), and to exempt the City from state design-build statutes and rules using its home-rule authority; and

WHEREAS, all contracts not specifically excepted by ordinance must be approved by Council pursuant to Section 111.02 of the Codified Ordinances; and

WHEREAS, pursuant to the Constitution of the State of Ohio and the Ohio Revised Code, municipalities have the power of local self-government; and

WHEREAS, pursuant to the Constitution of the State of Ohio and the Ohio Revised Code, municipalities have the power to enact laws that are for the health, safety, welfare, comfort and peace of the citizens of the municipality; and

WHEREAS, this Council by a vote of at least five of its members determines that this resolution is an emergency measure and that it shall take effect at the earliest date possible as set forth in Article III, Sections 10 and 13 of the Second Amended Charter of the City of Lakewood and that it is necessary for the immediate preservation of the public property, health, and safety and to provide for the usual daily operation of municipal departments in that the City wishes to create the design-build delivery model for this project so it may occur in 2015; now, therefore,

BE IT RESOLVED BY THE CITY OF LAKEWOOD, OHIO:

Section 1. The Mayor (Director of Public Safety), the Director of Public Works, the Director of Law, the Director of Finance, and /or the Purchasing Manager may establish procedures for and engage in the process of letting of one or more contracts with one or more qualified entities for the design and construction of corrections to the sewer system under the western Lakewood clean water pilot project (which project is further described in Resolution 8794-15) under the design-build project delivery system without the necessity of competitive bidding.

Section 2. Council shall approve the final award of contract(s) related to this project and the final form of the contract(s).

Section 3. As a home-rule charter City, the City shall not be obligated to follow Ohio statutory procedures regarding contracting for this project including, but not limited to, R.C. §§ 7.12, 9.31, 9.311, 9.312, 9.313, 9.315, 9.32, 9.33 through 9.335, 153.12-.14, 153.50-.52, 153.54, 153.56, 153.57, 153.571, 153.63, 153.67-.71, 153.80, 735.05-.09, 735.074, and other applicable sections within the Revised Code and its Chapter 153.

Section 4. It is found and determined that all formal actions of this Council concerning and relating to the passage of this resolution were adopted in an open meeting of this council, and that all such deliberations of this Council and any of its committees that resulted in such formal action, were in meetings open to the public, in compliance with all legal requirements.

Section 5. This resolution is hereby declared to be an emergency measure necessary for the immediate preservation of the public peace, property, health, safety and welfare in the City and for the usual daily operation of the City for the reasons set forth and defined in the preamble to this resolution, and provided it receives the affirmative vote of at least five members of Council this resolution shall take effect and be in force immediately upon its adoption by the Council and approval by the Mayor, or otherwise it shall take effect and be in force after the earliest period allowed by law.

Adopted: April 20, 2015

Jeff Madigan
President

Mary T. Hagan
Clerk

Approved: April 22, 2015

Michael S. Simon
Mayor

**REQUEST FOR QUALIFICATIONS
FOR
DESIGN/BUILDER**

Issued May 11, 2015

As Requested By

The City of Lakewood, Ohio

For

**2015 CLEAN WATER PILOT PROJECT
SANITARY SEWER LATERALS
REHABILITATION & REPAIR**

**RFQ Submittal due date: May 26, 2015
4:00 PM**

Request for Qualifications (Design/Builder Provision of Services and Materials by Design/Build Contractor)

Project Name:	City of Lakewood 2015 Pilot Study Area Rehabilitation & Repair
Project Location:	City of Lakewood – Eldred Avenue; Atkins Avenue & Delaware Avenue
Engineer:	CT Consultants, Inc.

No. of paper copies requested (stamped, not bound)	5
No. of electronic copies requested on CD or flash drive (PDF)	1

Submit the requested number of Statements of Qualifications (and the attached forms) directly to:
Mr. Mark Papke, P.E., City Engineer; Lakewood City Hall, 12650 Detroit Avenue, Lakewood, OH 44107.

Project Overview

A. Project Description

The City of Lakewood is executing a pilot study with an objective to eliminate the sources of clean water on private property from entering the City's sanitary sewer system and evaluate the cost and benefits of such a program citywide. The City has conducted a physical inspection program of private properties on Eldred, Delaware and Atkins Avenue that are a part of a pilot study to reduce infiltration and inflow. The City intends to engage the services of a Design/Builder (DB) to thoroughly assess the City's inspection reports of approximately 102 properties; develop a plan of repair and rehabilitation for each property; and, execute the approved repair/rehabilitation work to the satisfaction of the City and the individual property owners.

The Program of Requirements will be developed and other design-related services will be provided by the DB based upon criteria established by the City and Engineer under a contract between the City and DB. ("City/DB Contract.")

This Design Build Project will utilize the Design/Build Contractor project delivery method. The project will be funded by the City locally. State Prevailing Wages apply to this Project.

B. Scope of Services

The selected Design/Build Contractor (DB), as a component of its required Scope of Services ("Work"), will discuss and clarify with the City and/or the Engineer (as the City directs), the breakdown of the Project's detailed cost components, address the City's Project requirements and refine the Project schedules associated with the performance and completion of work as to each of the individual homeowner properties.

As properly authorized, the DB will provide, among other things, the following categories of services: constructability review; comments on inspection reports and other documents produced by the City and/or the Engineer associated with the physical inspections undertaken by the City and/or the Engineer, CCTV video and logs; development and maintenance of project and construction schedules and estimates of probable construction cost and labor availability; value engineering; performance of rehabilitation and repair; selection of subcontractors and material suppliers; an overall direction and control leading to completion of construction and close out of the scope of work associated with each individual property.

The preconstruction and construction services are generally described herein and are subject to modification as project goals and objectives may be or are further clarified. The DB shall proceed to

self-perform its Work and/or may enter into individual subcontracts (as necessary) associated with the following scopes of work: excavation, landscaping, material and equipment supply, plumbing and electrical with qualified subcontractors, utilizing "Open Book" pricing such that all subcontracted work shall be based upon pricing open to review and audit by the City and the Engineer. The City and individuals and entities authorized by it shall have access to all books, records, documents and other data in the DB's possession related to itself, its subcontractors and material suppliers pertaining to bidding, pricing or performance of the Work as shall be more fully defined and set forth in the contract between the City/DB Contract.

Preconstruction Services: The DB will work cooperatively with the City and Engineer, and will provide (among other services), cost and labor estimating, budgeting, constructability review, scheduling and preconstruction planning throughout the preconstruction stages. The DB shall prepare a Basis Document for each homeowner property subject to review and approval of the City and/or Engineer. The Basis Document shall include a written description, sketch (as applicable or directed by the City) and specifications for each homeowner property for the City and/or Engineer's approval prior to initiating any work. The DB shall submit to the City a firm price (the "Firm Price") for each individual property together with individual specifications, qualifications and assumptions based upon the Basis Documents. The DB, the City and/or the Engineer shall meet to reconcile any questions, discrepancies or disagreements relating to the specifications, qualifications and assumptions and the Basis Documents. The reconciliation shall be documented by an addendum to the specifications, qualifications and assumptions that may be set forth in writing by the City and the DB as to each individual homeowner property. The DB shall then submit to the City, for approval, the DB's final Firm Price based upon the Basis Documents and the approved specifications, qualifications and assumptions. Contingent upon the City's approval of the each final Firm Price the City shall deduct each Firm Price from the Guaranteed Maximum Price ("GMP") addressed in the City/DB Contract. In respect to the completion of the individual scopes of work relative to each of the proposed approximately 103 individual homeowner properties, the maximum, total amount which the City may agree upon shall not exceed the City's budget established for the entirety of the Work to be provided by the DB in the monetary amount of \$800,000 ("Budgeted Amount.") If, during the course of the Project, the individual proposed Budgeted Amount exceeds the amount of \$800,000 or for such other reasons as the City deems appropriate, then the City may terminate the agreement with the DB; elect to proceed with the performance of some of the DB Work as to some but not all of the individual homeowner properties; modify the GMP ("GMP Amendment") and/or seek proposals from other firms for completion of some or all of the work related to individual homeowner properties.. Further the City reserves the right of add or delete any and all items from the DB Work, including converting to a typical bid process.

Construction Services: The DB shall schedule and construct the Project pursuant to the construction documents and in accordance with the schedule requirements. The DB shall hold all subcontracts and shall be fully responsible for the means and methods of construction, project safety, project completion within the schedule agreed upon in the preconstruction phase, compliance with all applicable laws and regulations (including monitoring compliance with all equal employment, and prevailing wage requirements), and submitting monthly reports of these activities to the City. All subcontracts shall be on the subcontract form pre-approved by the City. The City reserves the right to approve the DB's selection of subcontractors and any supplemental terms to the form subcontract as shall be presented to the City and Engineer prior to DB entering into such subcontracts. Each subcontract shall, in any event, contain provisions associated with indemnifying the City from any and all claims as may be asserted associated with each individual homeowner property together with provisions requiring that the DB and each of its subcontractors maintain adequate casualty and liability insurance. Further subcontract provisions shall include, but shall not be limited to, clauses associated with liquidated damages, two (2) year warranties upon final completion of DB Work as to each individual homeowner property; the method and manner of communications and dealings with individual homeowners, including restrictions and conditions as to access to the interior of

homeowners' residences; retainage; and other provisions as may additionally be included within the City/DB Contract.

For purposes of providing relevant project experience for the Statement of Qualifications, below is a preliminary list of relevant scope of work requirements for this RFQ:

1. Review of CCTV and inspection reports.
2. Development of plans for repair, rehabilitation and improvements for each homeowner property in the Pilot Study Area.
3. Sanitary sewer lateral lining
4. Sanitary sewer lateral replacement
5. Sump Pump installation and redirection of footer drains
6. Yard drains – redirection and re-piping.
7. Downspouts – divert/convert to splash pad
8. Internal home plumbing modifications.
9. Home electrical upgrades to support sump pump installations

C. Informational Meeting:

A mandatory meeting will be held at Lakewood City Hall; 12650 Detroit Avenue – 2nd Floor on Tuesday, May 19, 2015 at 10 am for all prospective D/B Contractors. The purpose of the meeting will be a brief overview of the project and provide a forum to address questions from D/B Contractors.

D. Funding / Estimated Budget

Construction Cost \$800,000

E. Anticipated Schedule

DB Services Start	<u>06/29/15</u>
Construction Stage Start	<u>07/15</u>
Construction Stage Completed	<u>03/16</u>
DB Services Completed	<u>07/16</u>

F. Evaluation Criteria for Selection

Selection Criteria:

The DB will be selected using (i) a qualification-based selection process during the initial Request for Qualifications ("RFQ") stage to develop a short list and (ii) a best value selection process during the final Request for Proposal stage for the final DB selection. The qualifications-based selection criteria for the RFQ are included in this RFQ. The best value criteria used in evaluating proposals from the Short Listed Firms will include such factors that are determined to derive or offer the greatest value to the City, combining both qualifications and fee as well as other factors which the City may take in consideration during the course of its review of the qualifications of those selected to present Requests for Proposal.

Short Listed Firms:

Each firm responding to this RFQ will be evaluated based on its qualifications and the qualifications and experience of the particular individuals and entities identified as the firm's proposed team for the Project. After evaluating the responses to this RFQ, the City can select a short list of no less than three candidates that it considers to be the most qualified. Provided however, if the City determines that fewer than three firms are qualified, it will only select the qualified firms (the "Short-Listed Firms"). The Short-Listed Firms will receive (i) a form of the Agreement with the City containing the contract terms and conditions, (ii) General Conditions, (iii) Bid Forms for each property, (v) a copy of the rating form, (vi) a form of performance bond, (vii) a form of payment bond, (viii) a set of

the design criteria documents, (ix) a proposed Project schedule, and such other documents as the City may determine to be applicable to the information it requires to be contained in the Request for Proposal.

Interview:

The Short-Listed Firms will be interviewed by the City; if the City deems necessary. The purpose of the interview will be to review pricing information, meet the proposed Project team, become familiar with key personnel, and understand the project approach and ability to meet the stated objectives for the Project. Each Short-Listed Firm must be prepared to discuss with specificity the firm's capacity to conduct the Work in compliance with the schedule and budget expectations. The City will notify each Short-Listed Firm to schedule individual times for the interviews.

Other Meetings:

The City reserves the right to call additional meetings of the Short- Listed Firms, which meetings may be undertaken individually or may include some or all of those entities identified as the Short-Listed Firms

Selection Schedule:

The following tentative schedule is subject to change.

RFQ Posted and Advertised	05/07/15
Informational Meeting	05/19/15
Qualifications Due	05/26/15
Select/Notify Short-Listed Firms	06/04/15
Interviews	06/11/25 to 06/16/15
Selection of DB	06/22/15

Cancellation, Rejection and Alteration:

The City reserves the right to reject all submittals and Proposals and may cancel at any time for any reason this solicitation, any portion of this solicitation or any phase of the Project. The City shall have no liability to any submitter or Proposer arising out of such cancellation or rejection. The City reserves the right to waive minor variations in the selection process and to alter all or any portion of the RFQ and the selection process.

F. Submittal Instructions

Paper copies of the Statement of Qualifications, if requested, should be stapled only. Do not use special bindings or coverings of any type. Cover letters and transmittals are not necessary.

[Electronic submittals should be combined into one PDF file named with the project number listed on the RFQ and your firm's name. Use the "print" feature of Adobe Acrobat Professional or similar software for creating a PDF rather than using a scanner. If possible, please reduce the file size of the PDF. In Adobe Acrobat Professional, go to Advanced, then PDF Optimizer. Also, please label the CD and the CD cover with the project number and firm name.]

Facsimile or e-mailed copies of the Statement of Qualifications will not be accepted.

Submit all questions regarding this RFQ in writing to Mr. Mark Papke, P.E., City Engineer, Lakewood City Hall, 12650 Detroit Avenue, Lakewood, Ohio 44107/mark.papke@lakewoodoh.net, with a copy to Richard Iafelice, P.E., P.S./riafelice@ctconsultants.com (No phone calls please). Questions will be answered in writing and copies will be provided to all firms. The name of the party submitting a question will not be included on the Q&A document.

Unless otherwise noted or exempt, all documents submitted to the City in response to the RFQ or the RFP are public and will be available for inspection and copying in accordance with ORC 149.43 at the conclusion of the selection process. The following information shall remain confidential and will not be released: (1) Proposal Form(s), except for cost category subtotals which will be transferred to any rating form or the Agreement; (2) Financial Statements; (3) Surety Letters showing Bonding Capacity; and (4) Insurance Certificates.

Proposers are requested to submit the following information in response to this RFQ of the Statement of Qualifications.

1. Summary: Provide a summary, on one page or less, describing why the firm is the most qualified for the Project. As an attachment, please provide a listing of proposed field personnel including resumes of project superintendent and support staff.
2. Bonding/Insurance: Provide evidence of capacity to provide bonding in the amount of the project budget and a copy of the firm's certificate of insurance showing the firm's current limits of liability for commercial general liability, employer's liability, business automobile liability and professional liability.
3. Management Systems: Describe the scheduling and cost control systems the firm would propose to use for the Project
4. Self-Performed Work: Indicate whether the firm intends to self-perform any work on the Project and, if so, the nature of the work and capability to self-perform. The City reserves the right to limit or prohibit self-performed work.
5. Estimating: Demonstrated track record of performance of in-house labor and cost estimating on projects comparable to the Project.
6. Scheduling: Demonstrated track record of performance of managing projects to the original schedule.

STATEMENT OF QUALIFICATIONS FOR DESIGN/BUILDER

PART I – CONTRACT SPECIFIC QUALIFICATIONS

A. CONTRACT INFORMATION

1. PROJECT TITLE AND LOCATION (City and County)

2. ANNOUNCEMENT DATE

3.

B. FIRM POINT OF CONTACT

4. PROJECT REPRESENTATIVE NAME AND TITLE

5. PRESIDENT / CEO

6. NAME OF FIRM (LEGAL NAME ON FILE WITH THE OHIO SECRETARY OF STATE)

7. TELEPHONE NUMBER

8. FAX NUMBER

9. E-MAIL ADDRESS

10. COUNTY

11. FTID NUMBER

12. WEB ADDRESS

1. SUMMARY

Provide a summary, on one page or less, describing why the firm is the most qualified for the Project. As an attachment, please provide a listing of proposed field personnel including resumes of project superintendent and support staff.

1. SUMMARY (Continued)

2. BONDING / INSURANCE

Provide evidence of capacity to provide bonding in the amount of the project budget and a copy of the firm's certificate of insurance showing the firm's current limits of liability for commercial general liability, employer's liability, business automobile liability and professional liability.

3. MANAGEMENT SYSTEMS

Describe the scheduling and cost control systems the firm would propose to use for the Project.

4. SELF-PERFORMED WORK

Include whether the firm intends to self-perform any work on the Project and, if so, the nature of the work and capability to self-perform. The City reserves the right to limit or prohibit self-performed work.

5. ESTIMATING

Demonstrated track record of performance of in-house labor and cost estimating on project comparable to the Project.

6. SCHEDULING

Demonstrate track record of performance of managing projects to the original schedule.

Design/Builder Selection Rating

Project Name

**City of Lakewood
Clean Water Pilot Project**

Proposer Firm

City, State, Zip

Value	Score
-------	-------

Selection Criteria

1. PRIMARY D/B/ QUALIFICATIONS

- | | | | |
|----|--|--|--------|
| a. | Construction / Field Personnel | Experience / ability of Superintendent to identify / solve issues during construction | 0 - 10 |
| b. | Preconstruction Experience of D/B Firm | Similar projects completed by D/B Firm | 0 – 10 |
| c. | Management Experience of D/B Firm | D/B Firm's experience with repair and rehabilitation of sanitary sewer | 0 – 15 |
| d. | Availability to accomplish the project | Availability of qualified personnel, equipment, and facilities, to accomplish the work | 0 - 10 |

2. BONDING / INSURANCE

Furnished

5

3. MANAGEMENT

- | | | | |
|----|--------------------------------|--|-------|
| a. | Budget and Schedule Management | Performance in completing projects with original budget and schedule limitations | 0 - 5 |
| b. | Team Organization | Clarity of responsibility / communication demonstrated by table of organization | 0 - 5 |

4. SELF-PERFORMED WORK

- a. Experience with Similar Projects 0 - 10

5. ESTIMATING

- | | | |
|---------------------|--|--------|
| a. Past Performance | Level of performance as indicated by past evaluations / letter of reference / reference checks | 0 – 15 |
|---------------------|--|--------|

6. SCHEDULING

- | | | |
|---------------------|--|--------|
| a. Past Performance | Level of performance as indicated by past evaluations / letter of reference / reference checks | 0 – 15 |
|---------------------|--|--------|

Subtotal (100 max)

Notes

Evaluator:

Name

Signature

Date _____

RESOLUTION NO. 8813-15

BY: Anderson, Bullock, Juris, Madigan,
Marx, Nowlin, O'Leary.

A RESOLUTION to take effect immediately provided it receives the vote of at least five members of Council, or otherwise to take effect at the earliest period allowed by law, authorizing the Director of Public Works to enter into a design-build form of agreement for the design and construction of corrections to the sewer system under the western Lakewood clean water pilot project with Underground Connections, Inc. in an amount not to exceed \$800,000.

WHEREAS, Lakewood identified Underground Connections, Inc. through a request for qualification process as the most qualified of the two qualifications received; and

WHEREAS, this Council by a vote of at least five of its members determines that this resolution is an emergency measure and that it shall take effect at the earliest date possible as set forth in Article III, Sections 10 and 13 of the Second Amended Charter of the City of Lakewood and that it is necessary for the immediate preservation of the public property, health, and safety and to provide for the usual daily operation of municipal departments in that the City wishes to create the design-build delivery model for this project so it may occur in 2015; now, therefore,

BE IT RESOLVED BY THE CITY OF LAKEWOOD, OHIO:

Section 1. The Director of Public Works to enter into a design-build form of agreement for the design and construction of corrections to the sewer system under the western Lakewood clean water pilot project with Underground Connections, Inc. in an amount not to exceed \$800,000.

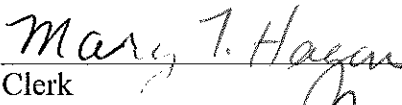
Section 2. Council hereby specifically approves the contract between the city of Lakewood and Underground Connections, Inc. in substantial form as is attached as Exhibit A.

Section 3. It is found and determined that all formal actions of this Council concerning and relating to the passage of this resolution were adopted in an open meeting of this council, and that all such deliberations of this Council and any of its committees that resulted in such formal action, were in meetings open to the public, in compliance with all legal requirements.

Section 4. This resolution is hereby declared to be an emergency measure necessary for the immediate preservation of the public peace, property, health, safety and welfare in the City and for the usual daily operation of the City for the reasons set forth and defined in the preamble to this resolution, and provided it receives the affirmative vote of at least five members of Council this resolution shall take effect and be in force immediately upon its adoption by the Council and approval by the Mayor, or otherwise it shall take effect and be in force after the earliest period allowed by law.

Adopted: July 6, 2015


President


Clerk

Approved: July 8, 2015


Mayor

Exhibit A

DESIGN/BUILD AGREEMENT

Effective Date of Agreement: _____, 2015

THIS AGREEMENT ("Agreement") is made and entered into on the dates so noted below with the Effective Date above note, by and between:

_____ (the "DB"), and

The City of Lakewood (the "City").

Owner Name:	City of Lakewood, Ohio
City address for notices is:	Division of Engineering and Construction 12650 Detroit Avenue Lakewood, OH 44107 Attn: Mark K. Papke
The Design-Builder:	_____
Design-Builder address for notices is:	_____ _____, Ohio _____
For the Project:	Pilot Project for the elimination of water intrusion into City sanitary storm sewer system.
City's Responsible Administrator:	Mark K. Papke City Engineer
City's Authorized Representative is:	Mark K. Papke, City Engineer (or others designated by him)
City Representative address for notices is:	Division of Engineering and Construction 12650 Detroit Avenue Lakewood, Ohio 44107
Consulting Engineer	CT Consultants Attn: Richard Iafelice Vice-President

Attachment G
Modeling Methods Technical Memorandum

Source Control Pilot Study
Enhanced Model Method Development

CLEAN WATER LAKEWOOD



Rebuilding the Pipeline for Our Future

September, 2016

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**CITY OF LAKEWOOD
SOURCE CONTROL PILOT STUDY**

1.0 Introduction

This technical memorandum is to present the results and findings for developing a small (102 parcel) model calibrated to flow metering data. The development identifies methodologies that can be utilized to replicate small area sewershed characteristics that are more sensitive to runoff characteristics and sanitary sewer impacts due to individualized parcel response to dry and wet weather event flows.

1.1 STUDY AREA

The study area includes 102 parcels serviced by sewers on Atkins, Delaware and Eldred Avenues between Hilliard Road and North Marginal Drive. The study only included the portion of Eldred Avenue draining south to Delaware Avenue. There is a connection to the northern draining sewer on Eldred Avenue that was isolated at a high point manhole with sandbags for the study purposes. Another cross connection was identified at the intersection of Delaware and Eldred Avenues that allowed for capacity relief of sewers east of Eldred through the Delaware and Atkins sewers. This cross connection was also isolated with sandbags for the purposes of this study. The pilot study area and existing sewer utilities are provided in Figure 1-1.

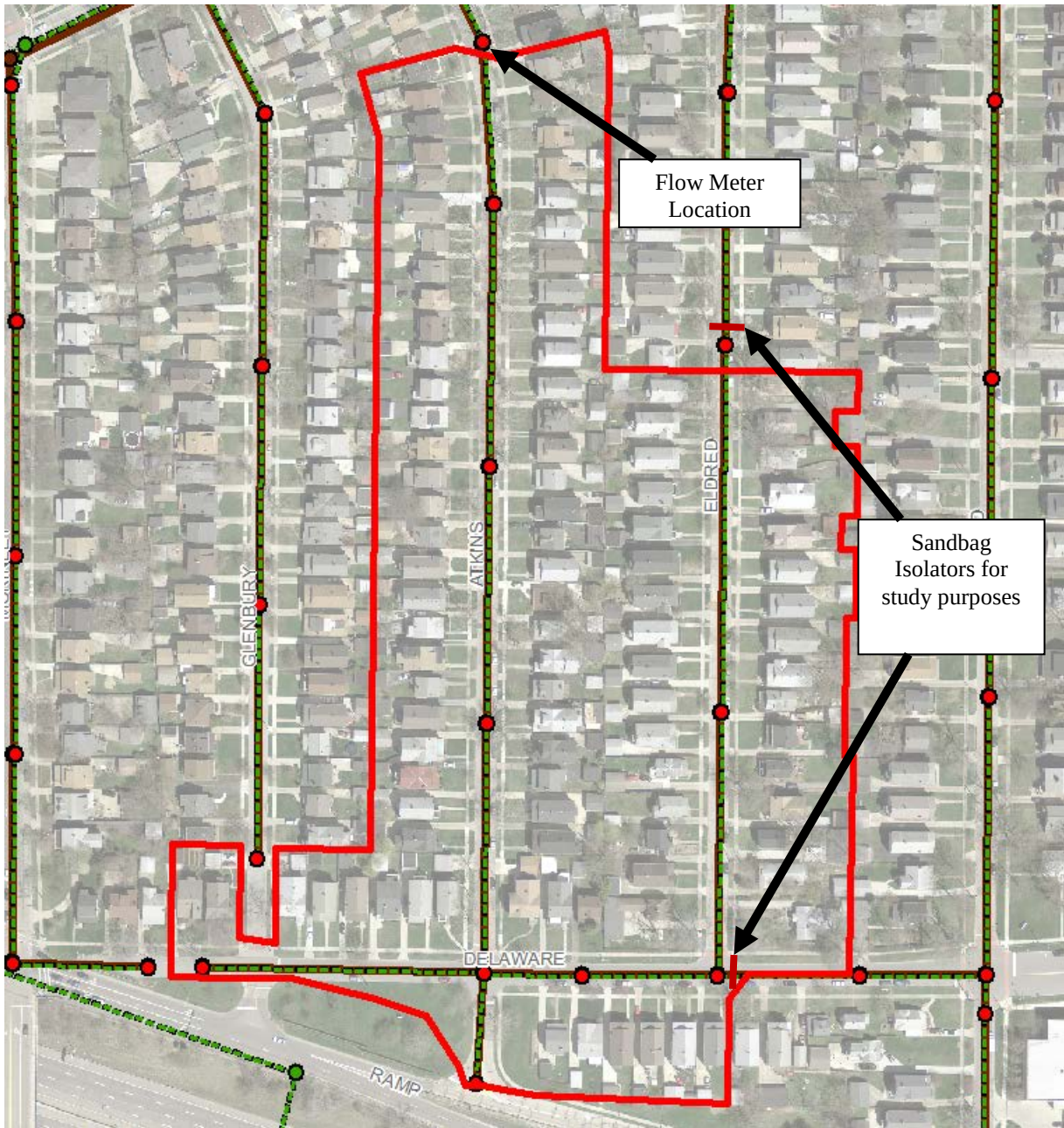


Figure 1-1
Pilot Study Area

2.0 Existing Conditions

2.1 COLLECTION SYSTEM

The study area sewer construction consists of over/under (O/U) sewers with the storm sewer directly above the sanitary and shared manholes to access both pipe. The City performed sewer televising of the storm sewer and then the sanitary sewer to develop an understanding of existing sewer conditions. Figure 2-1 illustrates the typical configuration of the O/U sewers. An invert plate in the “over” sewer allows access to the “under” sewer. O/U sewers were built predominantly during the 1920s and 30s although invert plate sewers were installed until the 1950s.

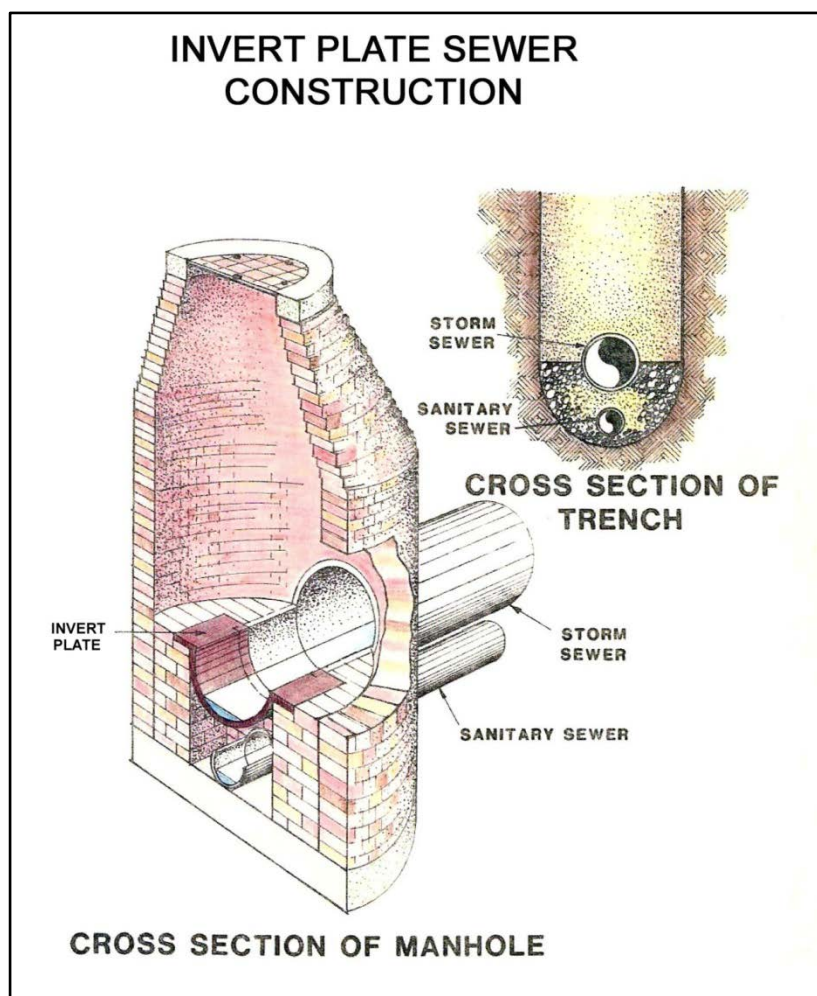


Figure 2-1
Sketch of Over/Under Sewer Configuration

2.1.1 Manholes

In O/U manholes, a trough shaped plate is laid across the storm sewer invert from the upstream conduit to the downstream conduit to convey stormwater. The invert plate is grouted into place so stormwater cannot enter the sanitary sewer below. In order to access the sanitary sewer, the invert plate has to be physically pried open, breaking the concrete grout. Maintenance crews leaving the manhole must re-grout the invert plate or it becomes a large inflow source during subsequent precipitation events. The following Figure 2-2 shows a tight invert plate installation (left) and the view when removed (right).

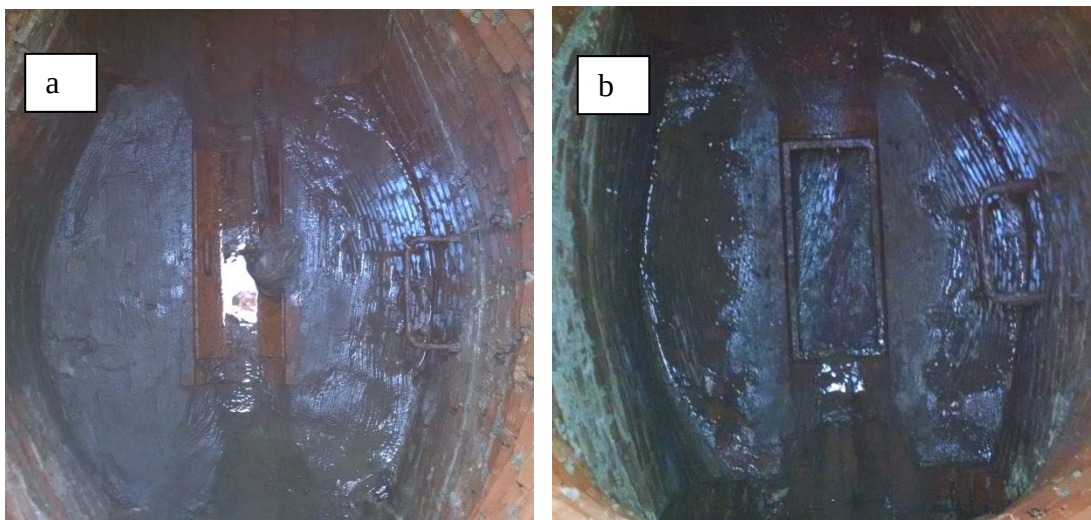


Figure 2-2
Invert Plate Installation (a) and Removal (b)

Sewer televising of the pilot study area sewers indicated that the invert plates are not properly seated in almost every manhole. It appears that over the years, the plates are no longer grouted in place and are in varying conditions of displacement that range from allowing crack intrusion between sewers to full displacement. Figure 2-3 shows examples of varying conditions of invert plate displacement.



Figure 2-3
Invert Plate Conditions

2.1.2 Sewers

During construction of the sanitary sewer (generally 8 to 12-inches in diameter) two-foot sections of vitrified clay pipe (VCP) were laid on a bed of granular sand. Then the trench was backfilled with more granular sand to a depth of approximately six-inches above the crown of the sanitary sewer. The storm sewer was laid directly above the sanitary on that bedding. Backfilling with granular material continued to the springline of the storm sewer, (also generally built with two-foot VCP sections), and finally the trench was filled in with premium (granular) backfill. Cement joints were used during construction of both sewers. The O/U configuration of the sewer collection systems leaves the “under” sewer extremely susceptible to infiltration and inflow (I/I). Whatever joint sealing compound was originally used has deteriorated, so today, stormwater can leak out of joints in the storm sewer, through the permeable backfill, and infiltrate the sanitary sewer joints.

It should be noted that there are instances in the City that the sanitary sewer was constructed encased in concrete. It is inconclusive as to whether any of these instances occurred within the pilot study area.

Sewer sizes and locations are shown on Figure 2-4. The modeled O/U sewers are shown as side by side with duplicate manholes for graphical purposes. Connections between the manholes are represented by orifices whose size is adjusted to achieve calibration. The orifices represent the separation plates between the O/U sewers.

Error! Reference source not found.
Existing Conditions
August 22, 2016



**Figure 2-4
Modeled Sewer Utilities**

2.2 PRIVATE PROPERTY

A City-led investigation of the individual properties was performed to review drainage routes on the property to the storm sewer system as well as possible cross connections, illicit connections, or infiltration to sanitary sewers.

2.2.1 Lakewood Historical Development Conditions

Properties within the study area were constructed with similar methods to each other. Based on data provided by the Cuyahoga County Planning Commission, the construction era of the homes within the study area is assumed to be 1920s. Almost 36% of the homes in Lakewood were built during this decade with 86% built before 1930. During this time period each home in the pilot area was constructed with a storm lateral and a sanitary lateral on private property that is connected to its respective public utility at the street. A historical private sewer connection would be assumed to look like Figure 2-5.

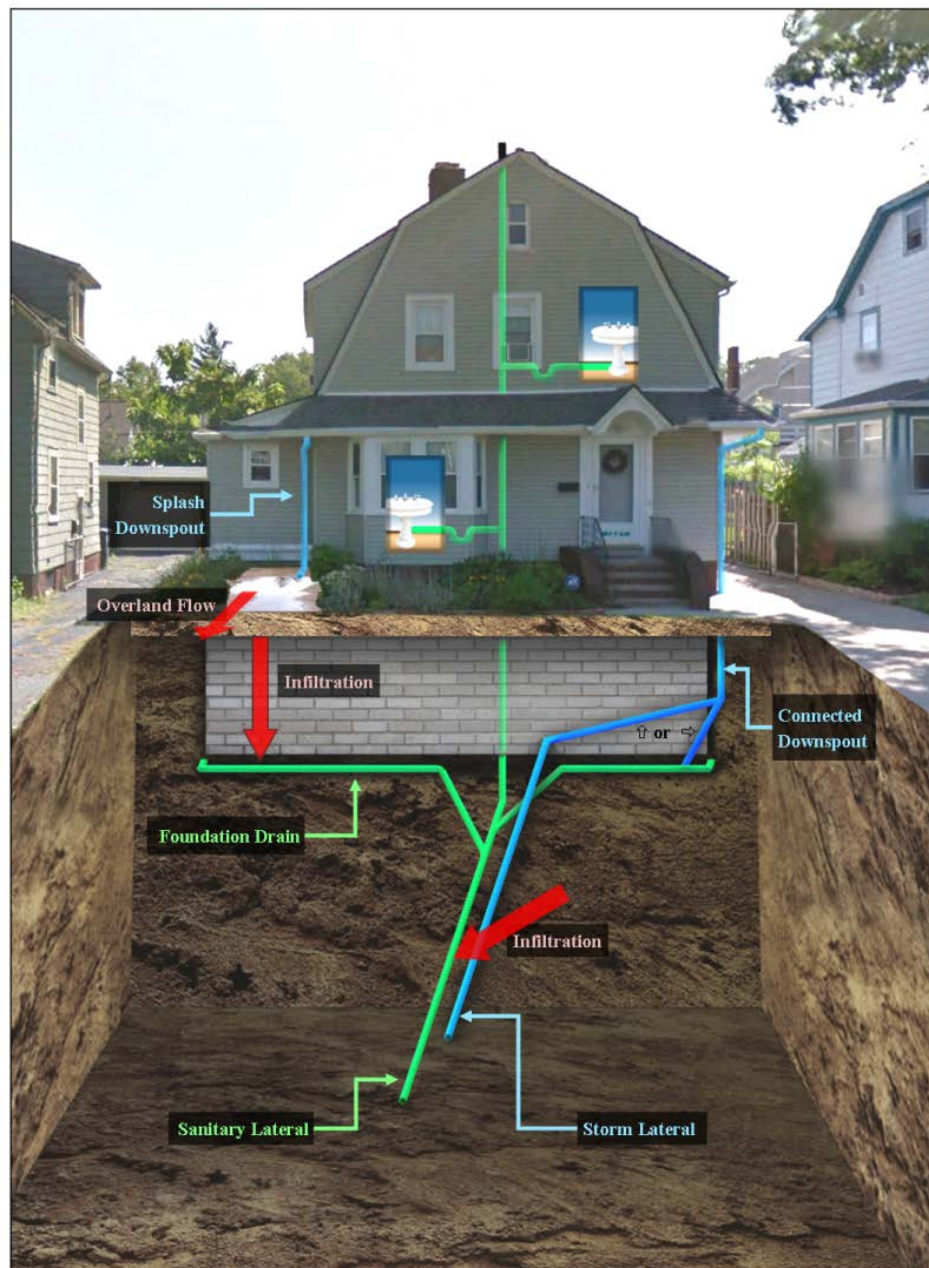


Figure 2-5
Assumed Private Parcel Connections

Typical construction assumes that downspouts and foundation drains would be connected to the storm lateral and interior household drains would connect to the sanitary lateral. However, actual construction may have tied services to the closest lateral or maintenance/repair/home improvement projects by the private owner may have changed these connections based on connection convenience or lack of knowledge that both types of laterals existed on the property.

2.2.2 Site Investigation Summary

The City televised the sanitary lateral of several properties and determined that most sanitary laterals were in disrepair with joint offsets, cracked pipe, and root intrusion which allow for infiltration. Some of the worst infiltration points were noted to be near the foundation of the structure or at the point of connection to the sewer at the street. Some of the inspections did note tie-ins to the sanitary lateral that could be from downspouts or a foundation drain. Dye testing to verify connections was not performed during the televising of the sanitary laterals. However, separate investigations by the City did perform dye testing in the study area at a later date.

The City performed site investigations to identify downspout discharge points, lateral type connections, and possible foundation drain connections. Dye testing of the downspouts and along the foundation wall was performed a few months after the televising. A review of the testing reports indicated dye in both the storm and sanitary laterals, with the sanitary lateral showing dye 96% of the time, the storm showing dye 47%, and the foundation showing dye 5%. Figure 2-5 illustrates the assumptions in how downspouts and foundation drains could be connected to the storm and/or sanitary laterals. Dye testing of the foundation soils to determine if the foundation drains were connected to either lateral was generally inconclusive; however, 5% of homes showed a dye response in the sanitary laterals. It was not determined how much of the test flow rate was split between laterals or the dye response time from the start of inflow to outflow in a lateral.

3.0 Flow Metering

3.1 LOCATION

Flow metering was performed prior to construction of the proposed improvements to document existing conditions. Additional flow metering will be performed upon completion of the proposed improvements. The basis of the pre- and post- flow metering was to understand the reduction in I/I to the sanitary sewer resulting from system improvements. Existing conditions sanitary I/I was assumed to be from illicit storm, downspout, foundation drain, and groundwater connections. Therefore, it was only necessary to meter the sanitary sewer system. Flow metering was performed on Atkins at the first manhole south of Hilliard. The upstream system was isolated from connections to other systems at Eldred and Delaware and Eldred midway between Delaware and Hilliard. Figure 1-1 provides these locations.

3.2 RESULTS

Flow metering occurred from March 27, 2015 to May 2, 2015 and June 4, 2015 to June 29, 2015 and captured approximately 14 wet weather events of 0.1 inches or greater. The break in metering was due to access issues from May to June. The flow meter data is shown in Figure 3-1 and Figure 3-2. The June rain events were significantly larger than those in March and May.

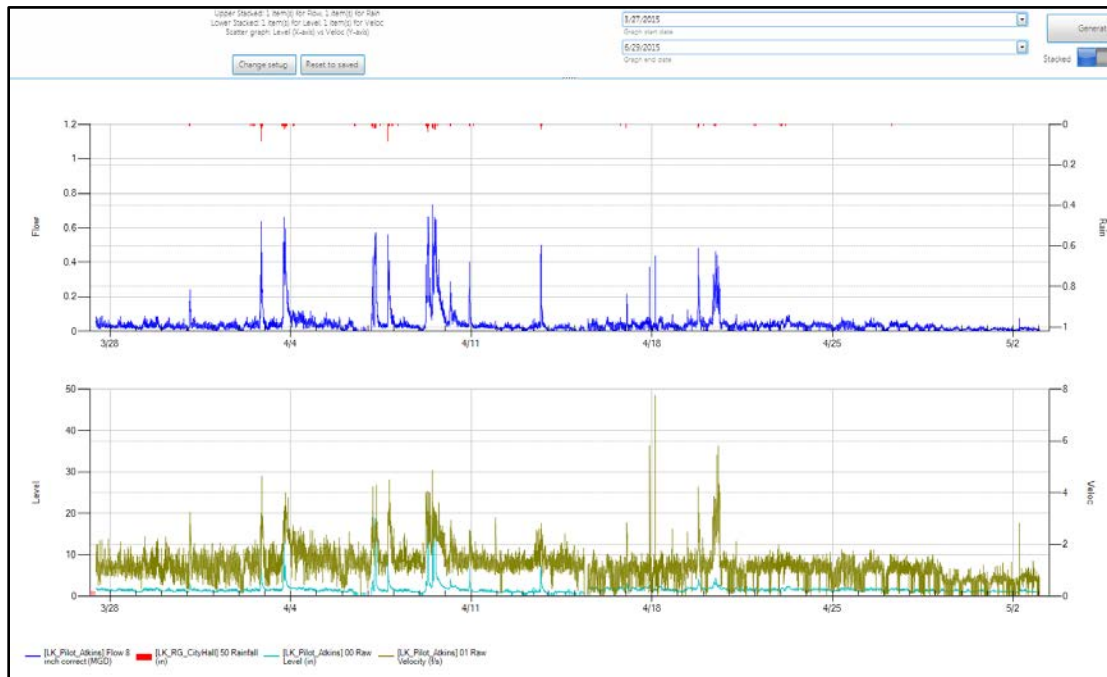


Figure 3-1
March to May 2015 Sanitary Flow Meter Data

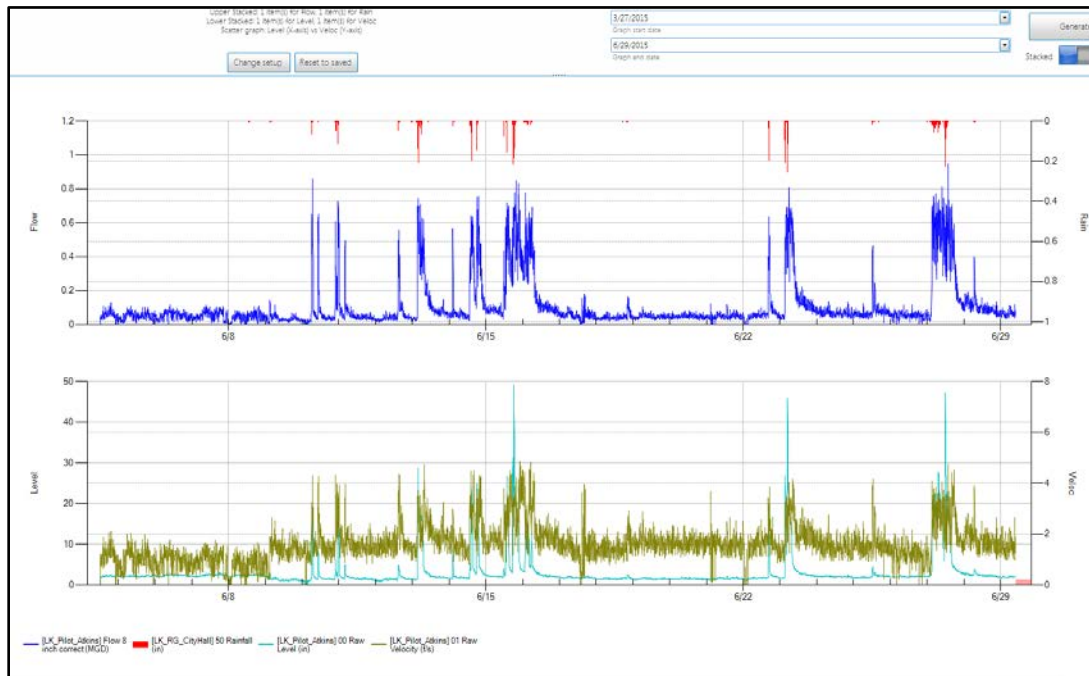


Figure 3-2
June, 2015 Sanitary Flow Meter Data

3.2.1 Dry Weather

The flow meter data was used to analyze dry weather flows. From the meter data, a total of 20 days were selected by hand as days during which wet weather was not influencing the meter flows. The data from those days was analyzed to provide a daily average dry weather flow (ADWF). ADWF was then broken down into Ground Water Infiltration (GWI) and Average Daily Sewage Flow (ADSF).

$$\text{ADWF} = \text{GWI} + \text{ADSF}$$

The dry weather analysis had the following results:

$$\text{ADWF} = 0.035 \text{ MGD}$$

$$\text{GWI} = 0.020 \text{ MGD}$$

$$\text{ADSF} = 0.014 \text{ MGD}$$

3.2.2 Storm Events

There are approximately 25 events in which there was an increase in sewer flows that coincide with rainfall. Of these, approximately 14 were significant enough to be considered during model development and calibration. The events are listed in Table 3-1.

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Flow Metering
August 22, 2016

Table 3-1

Atkins Flow Meter									
Storm Events Considered for Modeling Calibration									
Date	Duration (h)	Maximum Rainfall (in/hr)	Minimum Rainfall (in/hr)	Mean Rainfall (in/hr)	Total Rainfall (in)	Maximum Flow (MGD)	Minimum Flow (MGD)	Mean Flow (MGD)	Total Flow (Mg)
3/31/2015 0:30	6.5	0.1	0	0.006923	0.045	0.2434	0.003923	0.05535	0.01499
4/2/2015 18:20	8.17	0.8	0	0.02265	0.185	0.6376	0.01075	0.1132	0.03851
4/3/2015 15:30	10.67	0.2	0	0.01594	0.17	0.6196	0.02314	0.1827	0.0812
4/7/2015 2:05	10.5	0.2	0	0.02667	0.28	0.5736	0	0.1431	0.06259
4/7/2015 16:40	8.33	0.9	0	0.0222	0.185	0.5017	0.0232	0.1203	0.04176
4/9/2015 4:05	21.17	0.4	0	0.02102	0.445	0.7335	0.01311	0.2308	0.2036
4/10/2015 2:30	7.33	0.1	0	0.003409	0.025	0.2874	0.03397	0.09782	0.02989
4/10/2015 20:25	6.83	0.1	0	0.007317	0.05	0.4008	0.02008	0.0701	0.01996
4/13/2015 14:55	6.67	0.2	0	0.009	0.06	0.5014	0.01434	0.07321	0.02034
4/16/2015 22:50	6.33	0.1	0	0.003158	0.02	0.2058	0.002474	0.03926	0.01036
4/19/2015 17:10	7.33	0.2	0	0.01023	0.075	0.398	0.006816	0.09406	0.02874
4/20/2015 7:30	12.08	0.1	0	0.003724	0.045	0.4651	0.01427	0.1447	0.07284
6/10/2015 4:20	10.92	0.65	0	0.01649	0.18	0.8595	0.0156	0.1218	0.05542
6/10/2015 19:45	12.75	0.6	0	0.01922	0.245	0.7276	0.02483	0.133	0.07064
6/12/2015 12:45	7.25	0.5	0	0.01793	0.13	0.5579	0.01846	0.1164	0.03516
6/13/2015 1:25	14.25	1.3	0	0.05509	0.785	0.6996	0.0218	0.2252	0.1337
6/14/2015 0:20	6.5	0.3	0	0.008462	0.055	0.5677	0.0363	0.08375	0.02268
6/14/2015 11:35	15.58	2	0	0.0462	0.72	0.7555	0.02249	0.2465	0.1601
6/15/2015 9:40	29.5	2.2	0	0.06288	1.855	0.7775	0.03182	0.3347	0.4113
6/18/2015 18:40	6.67	0.1	0	0.00525	0.035	0.1657	0.02712	0.0625	0.01736
6/22/2015 14:30	7.25	2	0	0.04138	0.3	0.6336	0.04121	0.1309	0.03955
6/23/2015 1:15	19	2.6	0	0.07447	1.415	0.8075	0.02814	0.2635	0.2086
6/25/2015 10:25	7.92	0.2	0	0.007579	0.06	0.4648	0.03811	0.1119	0.03693
6/27/2015 1:10	35	2.1	0	0.06214	2.175	0.9494	0.01778	0.3017	0.4399

4.0 Hydraulic Model

The City of Lakewood (City) has previously completed and submitted a citywide existing conditions hydraulic model for EPA review and comment. The model included all storm, sanitary, and combined sewers and was calibrated utilizing sewershed meter data from permanent and temporary meters. The report is entitled “Integrated Wet-Weather Improvement Plan Technical Memorandum” dated November 2014. This existing conditions model is the base model for developing enhanced modeling methods to analyze the impacts of private property source control implementation. This model utilizes a commercial software program, PCSWMM, which includes the USEPA Stormwater Management Model (SWMM) hydrologic and hydraulic program as its computation engine.

4.1 LARGE AREA PRACTICES

4.1.1 Surface Influences

Sewershed combined sewer or storm sewer models typically contain subcatchments that are large enough to include many landuse types such as industrial, commercial, residential, and open land. A typical sewershed flow meter may include many subcatchments and register flows that are a merging of all the various subcatchments and their land use types, slopes and infiltration parameters. Model calibration will include adjustment of subcatchment parameters to develop runoff characteristics that when combined and routed through the sewers, generally replicate the flow meter data. Some of the various adjustments may include:

- Subcatchment storage to remove initial volume and flow at the beginning of an event
- Infiltration rates to modify the flow and volume during an event
- Slope or runoff coefficients to modify the timing of flow events
- Amount of imperviousness to modify flow and volume during an event
- Routing between impervious and pervious areas to modify timing and volume of flow events

4.1.2 Infiltration Influences

Sewershed sanitary sewer models identify sub-sewershed areas that provide an inflow and infiltration (I/I) response in the sanitary sewers. The infiltration parameters in the model are developed based upon wet weather response data recorded by the flow meter.

SWMM accounts for sewer I/I by allowing a constant baseline I/I and/or an I/I unit hydrograph to be added at a manhole. I/I unit hydrographs (also known as RTK hydrographs) are developed

from the combining of 3 triangular unit hydrographs that are characteristic of various types of I/I response. Typically these 3 hydrographs represent the following:

1. Short term I/I – this typically includes direct connections such as downspouts and illicit catchbasin connections to the sanitary sewer.
2. Medium term I/I – this typically includes a combination of ground infiltration and downspouts connected to foundation drains and sump pumps that may be connected to the sanitary system.
3. Long term I/I – this typically includes ground infiltration that finds its way to the laterals and trench backfill and enters the sanitary sewer at poor joint conditions.

The hydrographs are built based on the percent of rainfall (R) estimated to be captured over the sewershed, the time to peak flow (T), and a multiplier (K) that sets how long it takes for the flow to taper off.

4.2 PILOT AREA CONDITIONS

The pilot area is very small for trying to utilize sewershed modeling techniques. The 102 parcel pilot study area is represented by 6 subcatchments in the existing conditions model. However, those 6 subcatchments were part of a larger 25 catchment sewershed when calibrated in the existing conditions model. Due to the more sensitive meter response to the individual parcel runoff or infiltration characteristics over a small area, the flow meter data from the pilot area requires a more refined approach. Therefore, the pilot model subcatchments were developed and calibrated on an individual parcel basis, in order to provide a more refined model and better mimic the pilot meter data.

4.2.1 Parcel Infiltration components

The pilot area consists of 102 private parcels that were reviewed for their connection to the sanitary sewer in the O/U sewer. Each parcel was reviewed to determine at which manhole its infiltration responses would be loaded. It is assumed from some of the dye testing that there would be some short term inflows due to downspout connections along with medium and long term inflow reactions. It was expected that the groundwater or leaking storm sewer response to the sanitary sewer would be a part of the medium or long term I/I reactions since the invert plates were reinstalled after the televising inspection.

4.2.2 Parcel runoff components

The individual parcel subcatchments were developed based upon land slope, percent impervious, pervious and impervious runoff coefficients, and pervious infiltration parameters. These were routed to the storm sewer manholes. The parameters were generally based upon the original sewershed model since the storm sewer was not metered for calibration purposes. It was assumed that any I/I from storm runoff that was removed from the sanitary during pilot

study system improvements was returned to the storm sewer. The storm sewer is assumed to have been designed for these flows, and therefore, storm sewer calibration was not considered necessary since it was not required to update storm sewer capacities.

4.2.3 Initial Calibration

The initial model setup based on calibrating RTK values to flow meter data was quickly determined to have issues due to the volume, flow and length of wet weather response to the sanitary sewer. It became apparent that the sanitary sewers were being directly impacted by storm runoff through downspouts or direct storm sewer connections.

Understanding how the invert plates impact the system, a field inspection of the manholes was completed during calibration to determine the installation condition of the plates. The results of the inspections found that almost every invert plate was not seated properly in the opening between the storm and sanitary sewer. Figure 4-1 shows various conditions of the plates during the field inspections.



Figure 4-1



Post Televising Invert Plate Conditions

In addition to the invert plate review, the original sewer inspection tapes were reviewed. It was determined that although there were many joint separations, one major joint separation which was directly connected from the storm sewer to the sanitary sewer was identified. Figure 4-2 shows a) the storm sewer active flow that ends at the joint and b) calcification from infiltration in

the nearest sanitary sewer joint below.

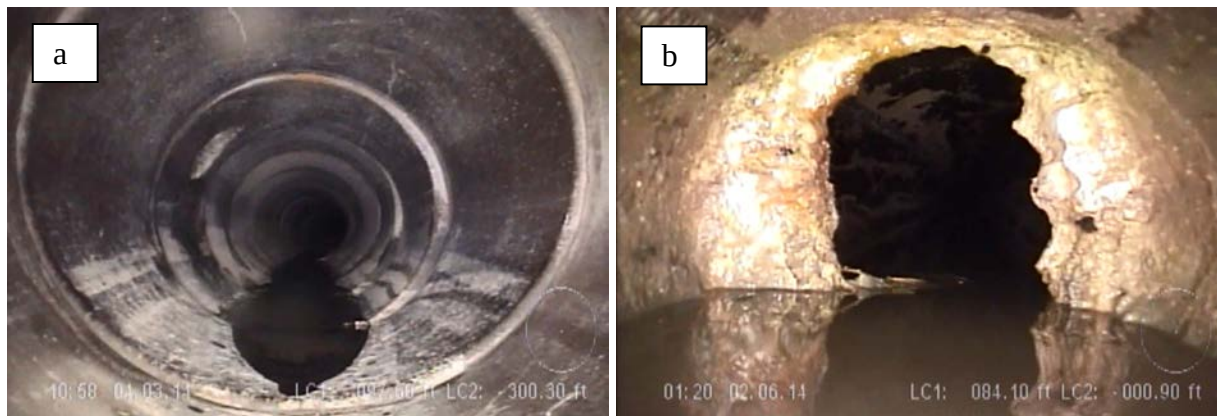


Figure 4-2
Storm Sewer Leak (a) to Sanitary Sewer (b)

Based on the field findings it was necessary to include the subcatchment runoff as a part of the sanitary calibration with connections at the manholes through the invert plates.

4.3 METHODOLOGY

The parcel runoff characteristics utilizing the sewershed values were determined to not be sensitive enough to replicate flow meter wet weather interactions with the sanitary sewer. Since the storm sewer flows have a direct impact on the sanitary flows, it became important to enhance the model by developing parcel runoff in a detailed manner. Due to the small size of the study area, the runoff hydrograph from each parcel should recognize the difference in runoff characteristics of roof drainage, pavement drainage, foundation drains, and yards.

Tools recently added to SWMM were investigated to determine if they could be utilized for enhanced model analysis at the individual parcel level. SWMM now includes Low Impact Development (LID) tools. These tools were developed to allow the analysis of rooftop disconnection, green roofs, infiltration trenches, permeable pavement, rain barrels, rain gardens, bio-retention cells, and vegetated swales. The tools allow a runoff subcatchment to be subdivided into LIDs without splitting the original subcatchment into multiple children subcatchments. The LIDs have additional control of the runoff characteristics that override the overall subcatchment values and allow for more choices in the outlet of the LID other than the original subcatchment outlet.

Further investigation determined that the LID tools could be utilized to replicate existing conditions runoff characteristics as well as proposed LID impacts. For example, permeable pavement could replicate existing conditions of an impervious pavement since the tools utilize surface runoff hydraulics similar to those of a subcatchment impervious runoff area. The difference is setting the permeable pavement subsurface storage, soil and underdrain

conditions to zero values so that they are ignored.

The control of where an LID discharges allows for enhancing the model to better replicate what portion of a subcatchment may directly drain to another subcatchment, a storm sewer, or sanitary sewer.

The LID tools were originally developed for Low Impact Development Best Management Practice analysis of proposed alternatives. The hydraulic theory behind their development also allows them to be utilized as Runoff Characterization tools (RC) for existing conditions calibration and analysis. Being able to utilize these tools for runoff characterization for smaller study areas that required enhanced detailed models becomes essential to modeling the various parcel runoff types.

In an effort to develop a model with better response to local parcel types of runoff, two methods were reviewed to develop the enhanced parcel subcatchment runoff characterization.

1. Subdividing each parcel into children subcatchments that represent a different runoff characterization for each runoff type. Since the model already consists of 102 parcels, and each parcel would have approximately four children to represent various types of runoff, this method was determined to be too tedious to develop and manage on an individual parcel basis.
2. Review of the RCs determined that a single parcel could be subdivided into several RCs without redevelopment of individual catchment areas. Further testing determined that the RCs could be utilized to replicate existing conditions scenarios by zeroing out specific parameters. The RCs were utilized to develop the existing conditions runoff characterization of each parcel.

4.4 SUBCATCHMENT DEVELOPMENT

The initial concept was to create RCs for impervious surface areas and foundation drains. Each would be routed to the storm sewer if they were directly connected to the storm lateral, otherwise, they were routed to the yard or sanitary lateral as appropriate. Figure 4-3 illustrates the assumed private parcel connections for the parcel runoff modeling.

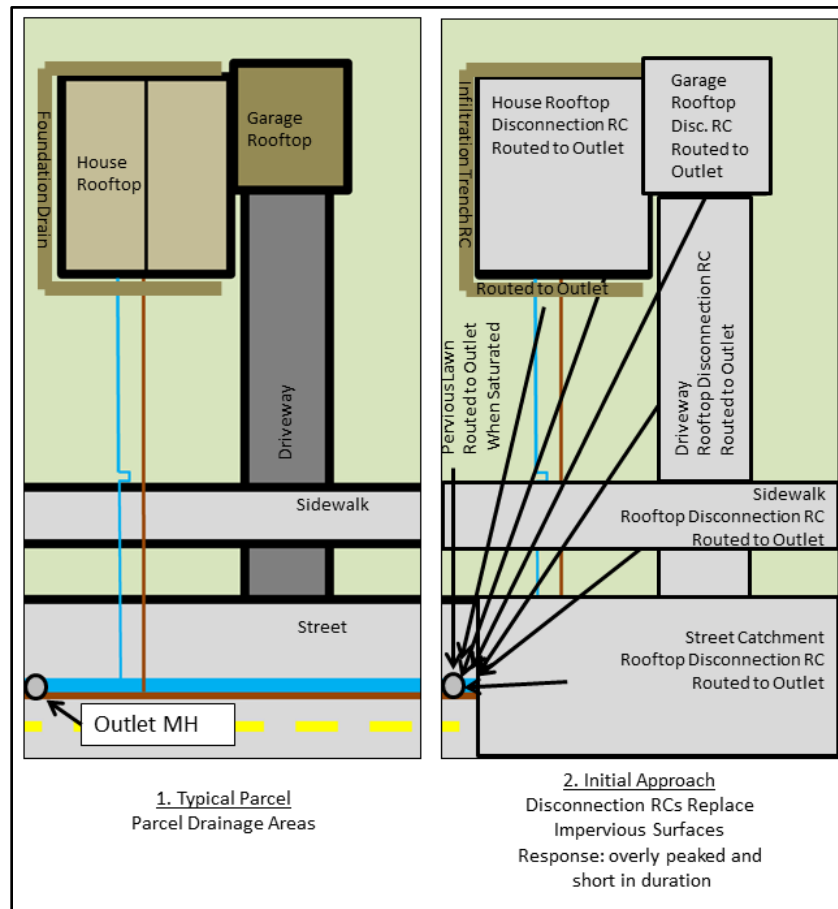


Figure 4-3
Initial Parcel Model Development

4.4.1 RC Types

The preferred modeling approach resulted in each subcatchment being treated as a pervious lawn (Imperv % = 0), and each impervious surface developed upon the property represented by an RC. This allows the user to continue to treat each property as a single catchment. Explaining further, each catchment is imagined to have started out as a lawn, but has at least 3 impervious RCs associated to the base catchment representing: (1) the house, (2) the garage, and (3) the driveway plus any walkways made of concrete/asphalt. This allows the user to include RCs to represent both existing condition connections and potential modifications. For example, an RC can be used to send connected downspouts to the sanitary lateral, and a second RC to route splashed downspouts to the lawn for the same property.

In order to achieve calibration to existing conditions flow data, two of the available eight RC types were chosen.

1. Infiltration Trenches
2. Rooftop Disconnections

These RCs were chosen not for their names at face value, but for the variables provided through their modeling configuration and the ability to modify those variables to achieve the desired flow responses. For example, using an “Infiltration Trench” RC does not mean that there are infiltration trenches currently existing on the properties, but it means that the response recognized at the flow meter reflects how the network of foundation drains and laterals act in concert such that their effect on the system is best mirrored by the variables available through the “Infiltration Trench” RC type.

Upon review of the individual site investigations it was determined that the 102 parcels could be categorized into 9 typical scenarios that accounted for the portion of rooftops connected to the storm lateral versus splashing to the yard, driveway drain connections, garage roof connection, etc. Figure 4-4 shows some typical downspout configurations. The following RC profiles were developed for use within a subcatchment:

Name	LID Type	Routed To
1/2ConnectedDrive	Rooftop Disconnection	Storm Manhole
1/2ConnectedGarage	Rooftop Disconnection	Storm Manhole
1/2ConnectedHouse	Rooftop Disconnection	Storm Manhole
1/2DisconnectedDrive	Rooftop Disconnection	Pervious Yard
1/2DisconnectedGarage	Rooftop Disconnection	Pervious Yard
1/2DisconnectedHouse	Rooftop Disconnection	Pervious Yard
1/4DisconnectedHouse	Rooftop Disconnection	Pervious Yard
3/4ConnectedHouseRooftop	Rooftop Disconnection	Storm Manhole
ConnectedGarageRooftop	Rooftop Disconnection	Storm Manhole
ConnectedHouseRooftop	Rooftop Disconnection	Storm Manhole
DisconnectedGarage	Rooftop Disconnection	Pervious Yard
DisconnectedHouse	Rooftop Disconnection	Pervious Yard
OtherPavedSurfaces	Rooftop Disconnection	Storm Manhole
Foundation Drain	Infiltration Trench	Sanitary Manhole

The profiles and RC types were used to simplify the model configuration process to be concise yet as diverse and realistic as project boundaries would allow. The result is that each property is identified as one of the 9 typical parcel runoff scenarios and has the appropriate RCs applied to it. The characteristics were obtained from the individual property connectivity assessments provided by the City. Impervious area average sizes were applied to each catchment after taking measurements using GIS.



Figure 4-4
Typical Downspout Configurations

4.5 MODEL CALIBRATION

4.5.1 Dry Weather Flow

After the dry weather flow was extracted from the pilot data, weekday hourly, weekend hourly, and monthly time patterns were applied to the data at each loading node. The patterns were extracted from the calibration of CSO 052 area within the context of the greater Existing Conditions SWMM Model. The patterns are represented in Figure 4-5, and a few modeled days of dry weather flow are shown in Figure 4-6 during the study period.

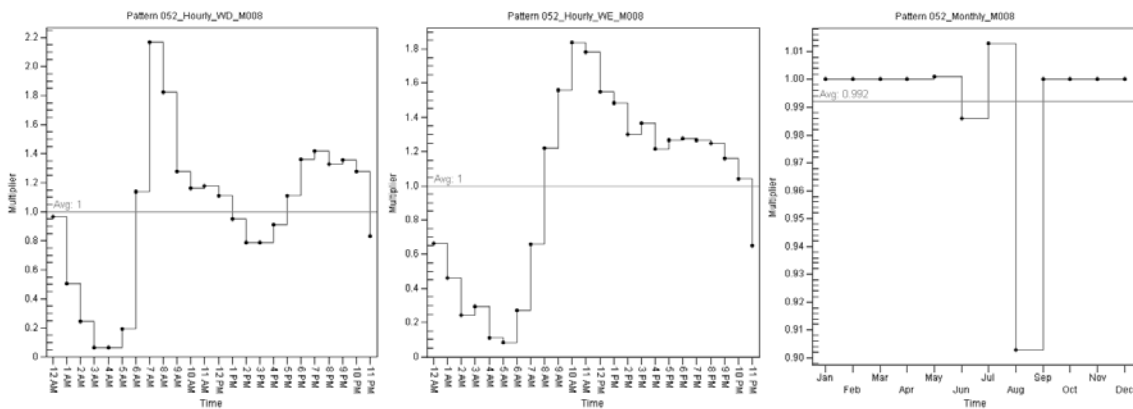


Figure 4-5
Weekday Hourly (left), Weekend Hourly (center),
& Monthly (right) DWF time patterns

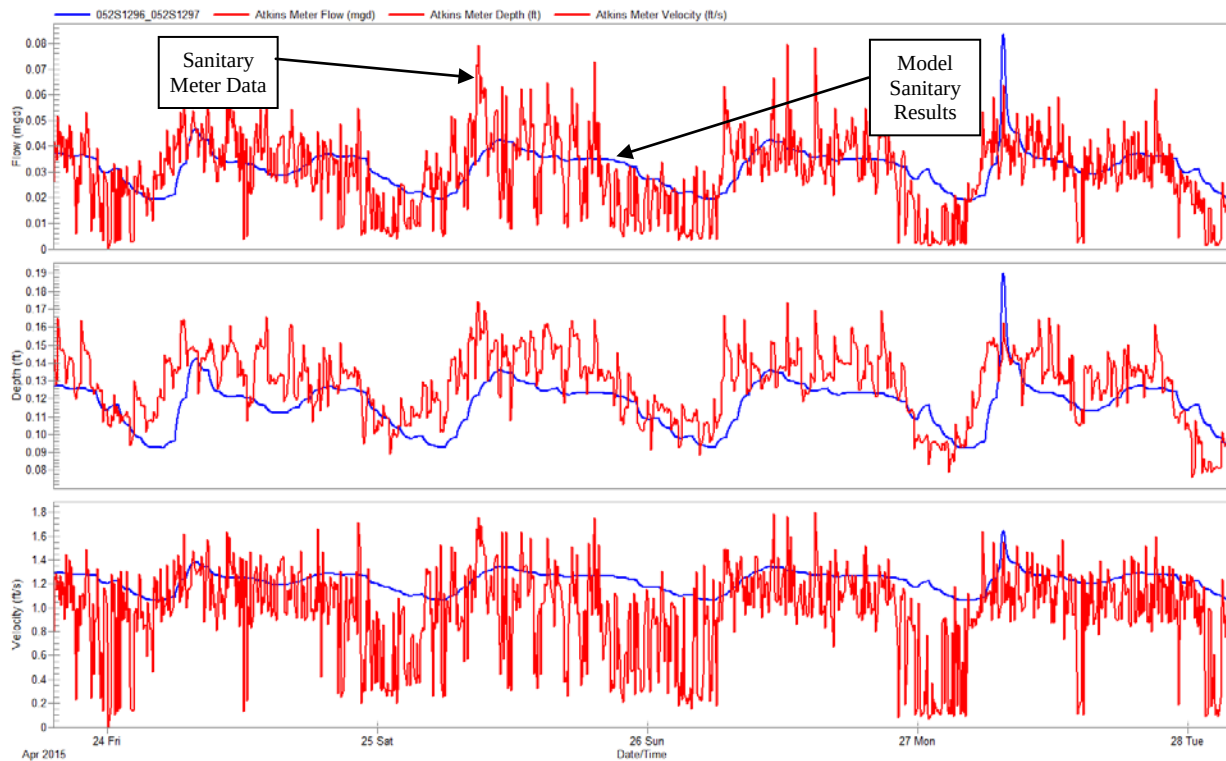


Figure 4-6
Calibrated Dry Weather Flow

4.5.2 Wet Weather Flow

Review of the wet weather events indicates that the sanitary sewer response relates to how long the storm sewer is reacting to the storm event. The current RC assumptions route the water quickly to the storm sewer which then routes to the sanitary through the invert plate connections, but once the rain is gone, the storm sewer impact goes away. The meter data indicates that the sanitary wet weather impact correlates for small events, but for larger events, should be more prolonged. Figure 4-7 shows the model versus meter data and Figure 4-8 shows the modeled storm flow correlation to the sanitary sewer.

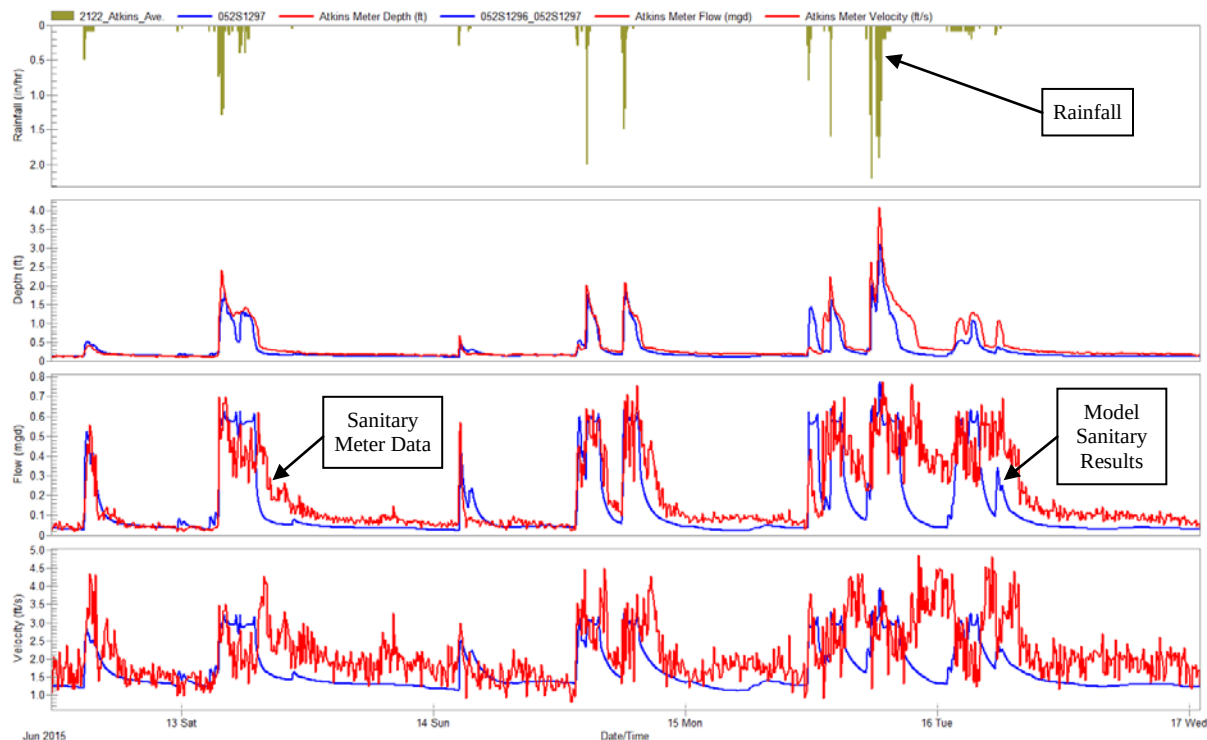


Figure 4-7
Initial Wet Weather Calibration

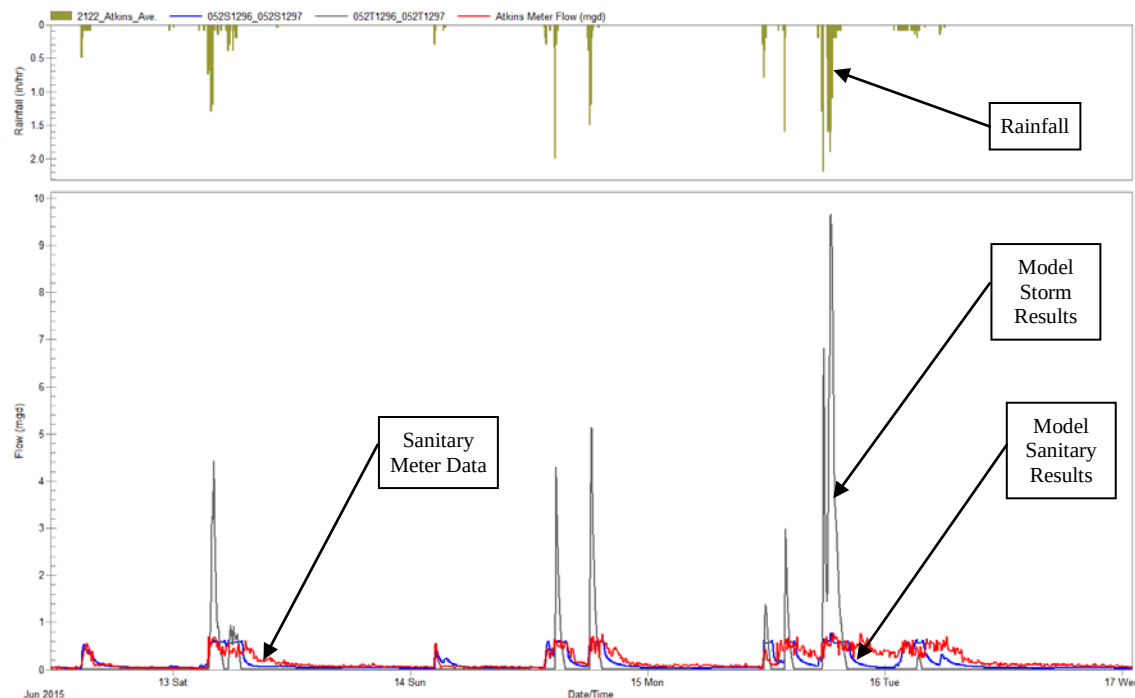


Figure 4-8
Storm Flow Correlation to Wet Weather Calibration

Based upon the model reaction versus flow meter data, it was assumed that the wet weather impact runoff characteristics were similar to those seen when a detention system is involved. This would extend the time of impact of the storm sewers on the sanitary sewers.

The original RC assumptions were reviewed to develop an updated method to reflect these findings. During the televising of the sanitary laterals, it was determined that laterals were generally in disrepair with evidence of settling, root intrusion, and debris. It was assumed that the storm laterals were in similar or worse condition than the sanitary laterals. Storm sewer laterals are impacted by additional debris, like leaves and dirt, build up in the gutters, downspouts over time, unless individuals were regularly cleaning these features. This seemed uncommon based on conversations with the City and given the difficulty involved in performing the cleaning. If enough debris builds up in these elements, then capacity is lost. As capacity is lost, the private property storm lateral collections system begins to store wet weather volumes. This causes some of the individual components of runoff types to the storm sewer to begin to act as a single system. Due to the storm lateral conditions, the stored wet weather volumes can cross infiltrate into the sanitary lateral system. It is difficult to determine how much cross infiltration may occur between the separate storm and sanitary lateral systems. The updated methodology assumed that the foundation drains and rooftop connections were acting as a single system that was best represented as an infiltration trench with detention storage and outlet to the storm sewer system.

The RC profiles were updated as follows:

Name	LID Type	Routed To
1/2ConnectedDrive	Infiltration Trench	Storm Manhole
1/2ConnectedGarage	Infiltration Trench	Storm Manhole
1/2ConnectedHouse	Infiltration Trench	Storm Manhole
1/2DisconnectedDrive	Rooftop Disconnection	Pervious Yard
1/2DisconnectedGarage	Rooftop Disconnection	Pervious Yard
1/2DisconnectedHouse	Rooftop Disconnection	Pervious Yard
1/4DisconnectedHouse	Rooftop Disconnection	Pervious Yard
3/4ConnectedHouseRooftop	Infiltration Trench	Storm Manhole
ConnectedGarageRooftop	Infiltration Trench	Storm Manhole
ConnectedHouseRooftop	Infiltration Trench	Storm Manhole
DisconnectedGarage	Rooftop Disconnection	Pervious Yard
DisconnectedHouse	Rooftop Disconnection	Pervious Yard
OtherPavedSurfaces	Rooftop Disconnection	Storm Manhole

The resulting impact was that the RC infiltration trench has a controlled outflow on the backside of the rain event until empty. Figure 4-9 is a result of this method. This did not replicate the meter flow and volumes of the larger events after the rain event ended. The sanitary sewer was still being impacted by high flow volumes after the rainfall events have ended that gradually taper off rather than the constant outflow until empty bench pattern from the model.

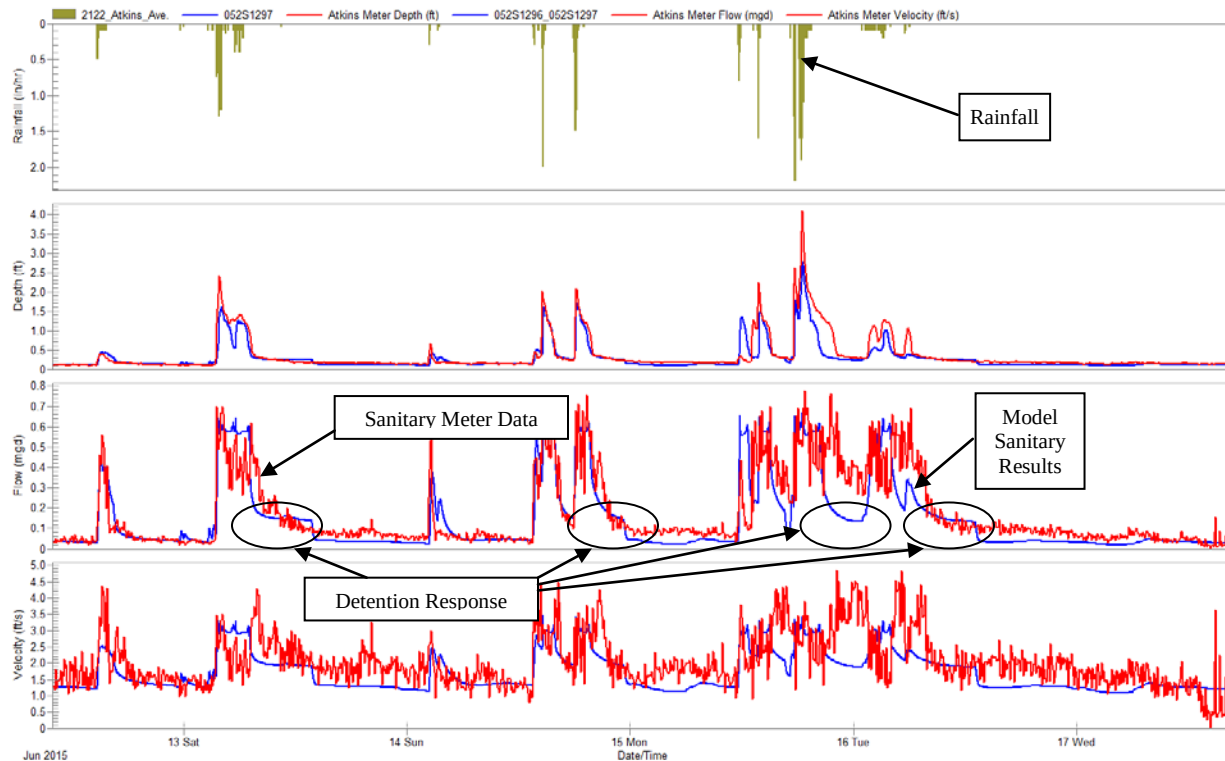


Figure 4-9
Detention Wet Weather Calibration

It was determined that to better replicate the flow meter data more runoff needed to reach the storm sewer in an extended time response during larger events. The RC for infiltration trenches allows for storage to a limited depth before overflowing onto the pervious area of the subcatchment. Use of this option and a sensitivity analysis of the storage depth and outlet parameters provided a better pattern fit during the larger or multiple storm events. The configuration assumes that the storm downspout/foundation drain detention system fills up during larger events and overflows across the lawn to the storm sewer. The impact of overflow across the lawn before reaching the storm sewer extends the response time of the wet weather impact to the sanitary sewer. Figure 4-10 illustrates the revised private parcel connections for the parcel runoff modeling.

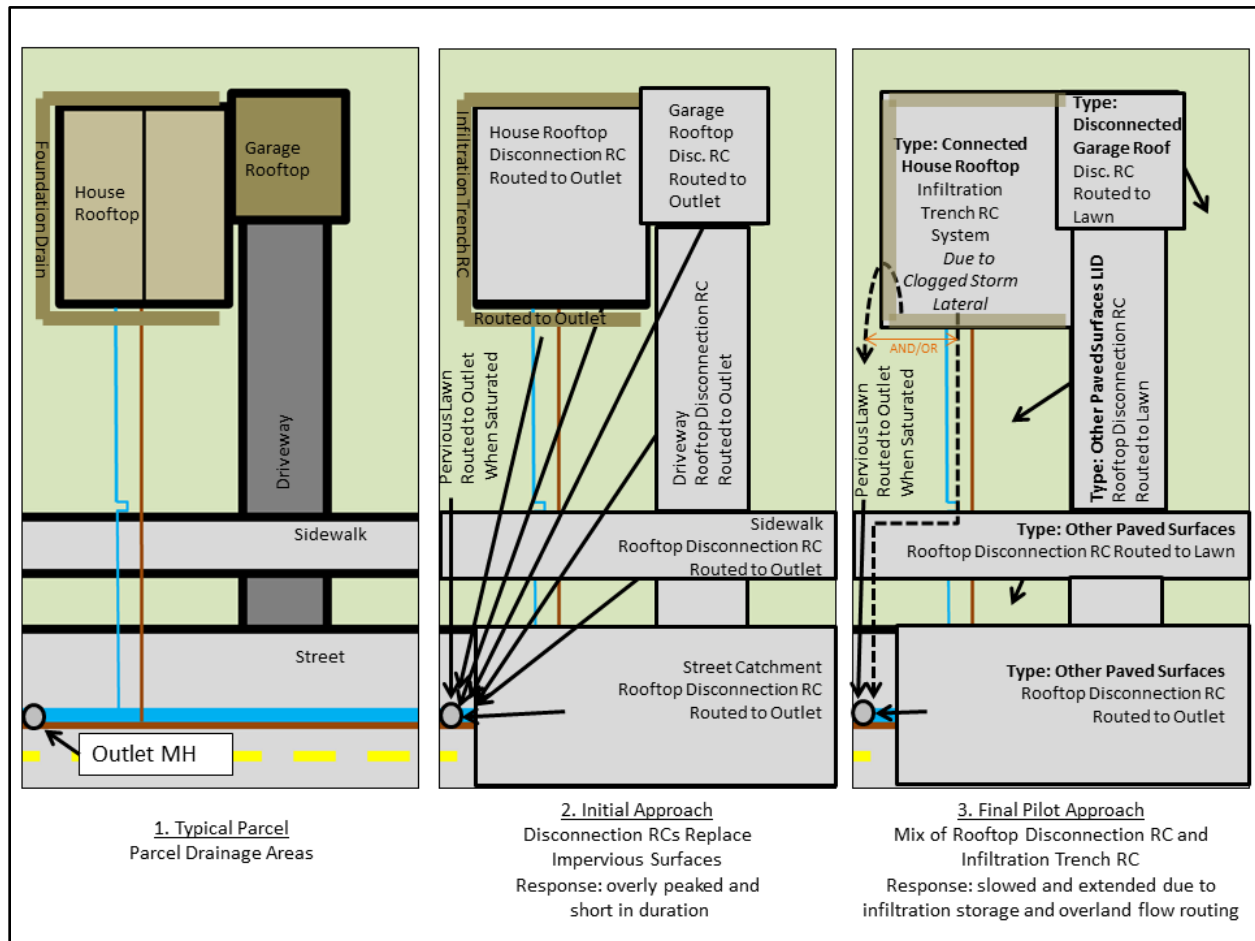


Figure 4-10
Final Parcel Model Development

Figure 4-11 provides results of developing runoff detention for clogged storm laterals with an overflow option to the pervious area.

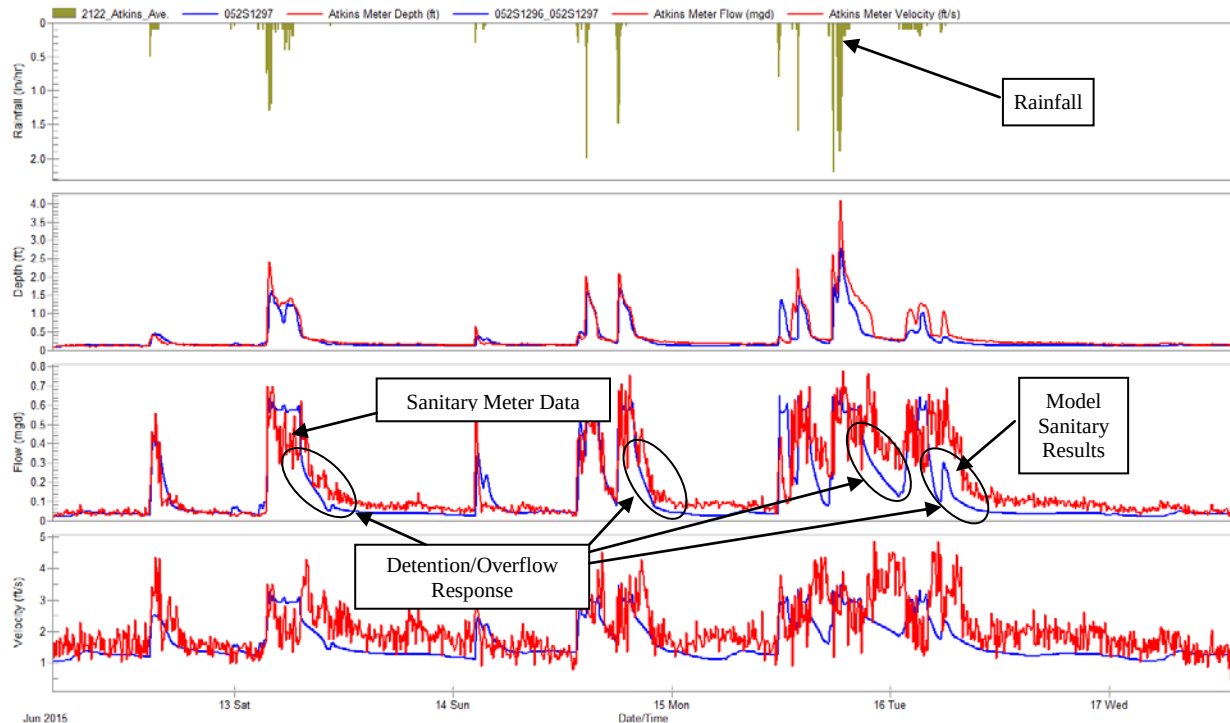


Figure 4-11
Detention with Overflow Wet Weather Calibration

At this point it appears that the flow differences may be due to sanitary I/I influences rather than runoff. A long term RTK was developed based on the assumption that there are I/I influences on the private sanitary laterals from clogged storm lateral cross infiltration and public storm to sanitary sewer I/I. The final calibration is shown in Figure 4-12 and extended period continuous calibration shown in Figure 4-13.

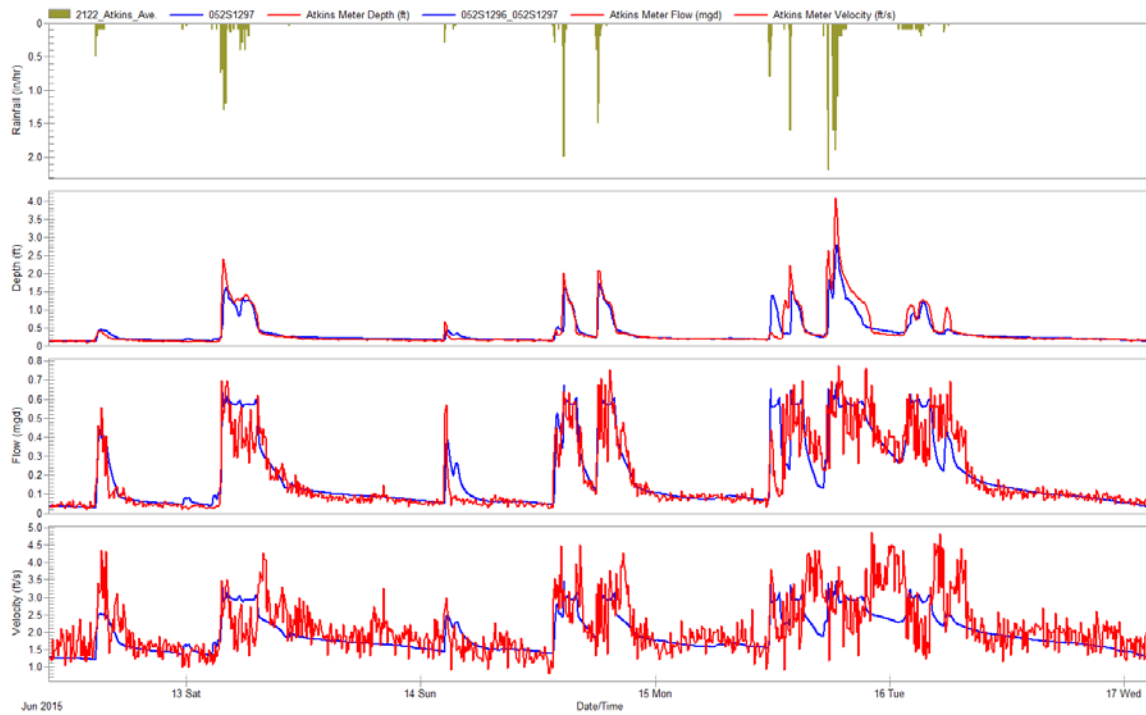


Figure 4-12
Final Wet Weather Calibration

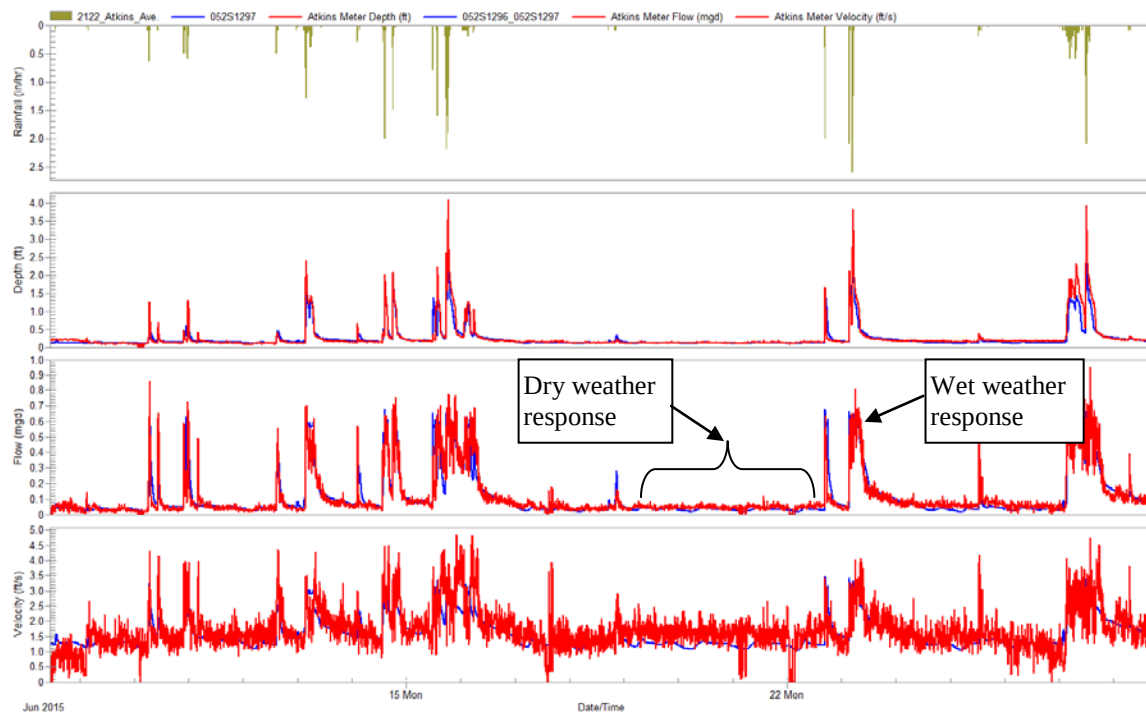


Figure 4-13
Continuous Wet Weather Calibration

5.0 Model Validation

5.1 PILOT STUDY CONSTRUCTION OBSERVATIONS

The pilot study included separating manholes, lining sanitary sewers and laterals on each property, and routing foundation drains/sump pumps to the storm sewer or lateral. While total construction was not yet complete at the time of this technical memo, the private work was complete enough to validate some of the modeling assumptions.

Construction work on private property revealed the following issues:

1. Less than 10% of the properties had foundation drains.
2. The storm and sanitary laterals are in the same trench.
3. The storm lateral has a trap that was usually filled with sediment, validating the modelers' hypothesis that laterals were clogged.
4. Migration of flow from the clogged storm lateral to the sanitary lateral appeared to be significant.

Construction findings are illustrated in Figure 5-1 and an example of a typical clogged trap is shown in Figure 5-2.

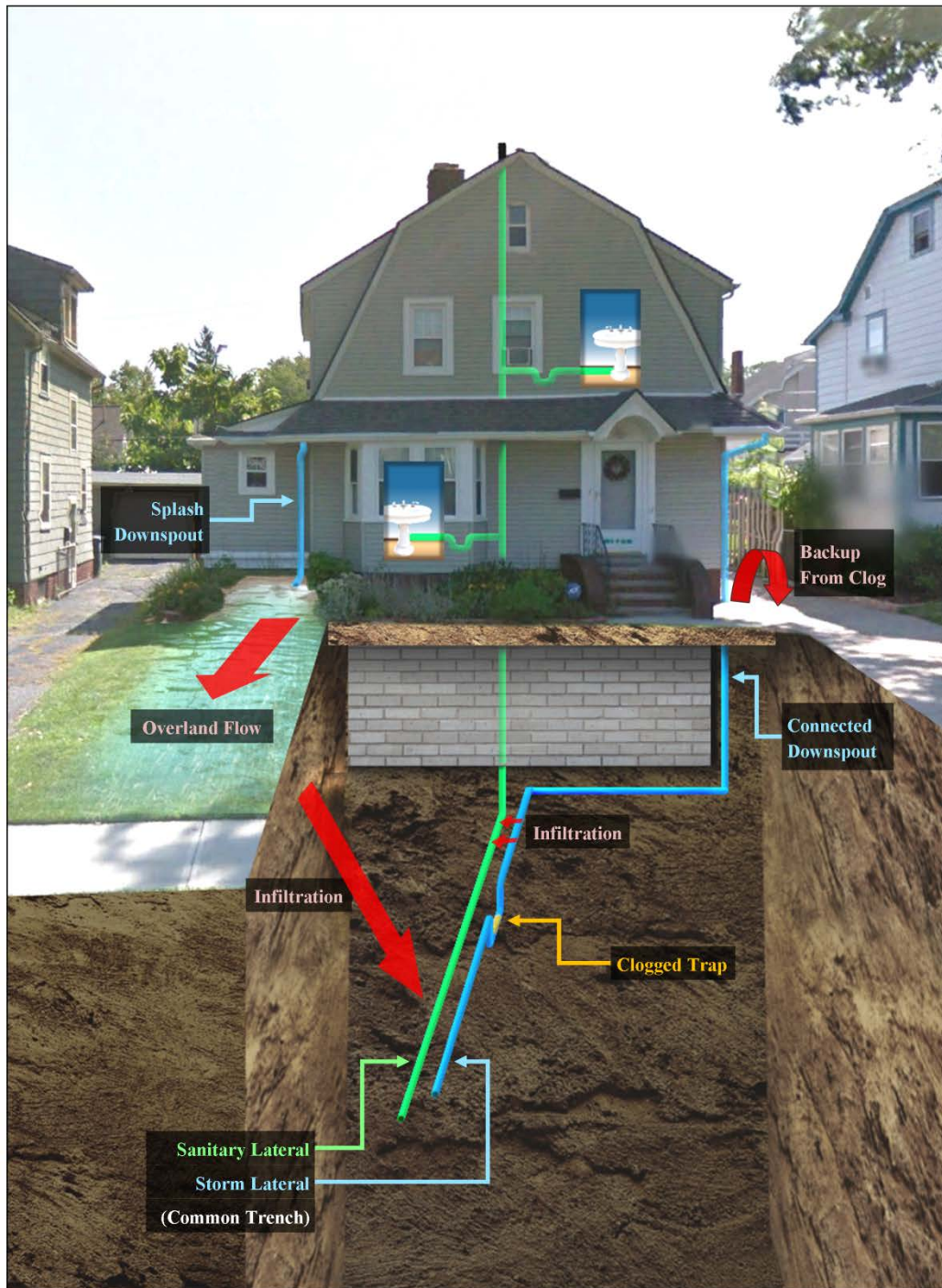


Figure 5-1
Private Parcel Connections – Existing Conditions



Figure 5-2
Trap Clogged With Sediment

6.0 Pilot Study Modeling Summary

The pilot study required a review of modeling techniques due to its small size and sensitivity to the individual runoff types (roofs, driveways, yards) on an individual parcel basis. Due to the study being limited to 102 parcels around 1/8 acre in size and the majority of the parcel having rooftop, driveway, and sidewalk imperviousness, it was assumed that a flow meter in the sanitary sewer would register data that may be recognizable as a high slope rooftop connection versus flatter driveway and sidewalk connections that may be inadvertently connected to the sanitary sewer. Unfortunately, the findings in the data showed that the storm sewers and sanitary sewers were directly connected to each other at the manholes and that model calibration would require calibration of storm sewer impacts to the sanitary sewer.

Since dividing each parcel into multiple subcatchment children for each runoff type would be too tedious to develop and manage, a different technique was developed utilizing LID tools for subcatchments. It was determined that LID tools could be utilized as RCs for existing conditions. The parameters within the LID tools allowed for characterizing different areas of a subcatchment into individual runoff types that could be reasonably managed. An additional feature of utilizing an RC tool was that they provide additional options for where drainage could outlet to. RC areas within a subcatchment do not have to outlet to the same location as the overall subcatchment outlet. While RCs are generally utilized for analyzing proposed condition improvements, several of them can be utilized to replicate existing conditions by setting certain parameters to zero so that they are ignored.

Utilizing RCs and logical assumptions, runoff from the parcels to the storm sewers was extended to replicate the storm sewer connection impacts to the sanitary sewer registered by the sanitary flow meter. The technique appears to be acceptable in calibrating existing conditions of small area studies where storm runoff and meter data are sensitive to the localized runoff types. It was considered validated when the assumptions of storm lateral clogging were later observed in the field during construction.

The technique will be utilized for post construction analysis in the future. Due to the storm/sanitary connection findings discussed in previous sections, post construction flow metering and modeling will include both storm and sanitary in an effort to analyze both sanitary reduction impacts and better understand the sensitivity of localized runoff types to storm sewers versus the original existing conditions subcatchment methods. The better understanding of the RC tools gives a better understanding in their use as proposed condition tools for large area subcatchments.

Attachment H
Public Input Documents

ATTACHMENT H
PUBLIC ENGAGEMENT DOCUMENTS

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H.1 SOCIAL MEDIA POSTS

The following posts are listed in chronological order, starting with the most recent posts. All posts were cross-posted on Facebook and Twitter.



City of Lakewood @LakewoodOhio - May 17

Dozens of residents braved the rain Saturday for a special tour of the Waste Water Treatment Plant #CleanWaterLKWD



← ↻ 2 ❤️ 7 ⋮



City of Lakewood @LakewoodOhio - Apr 29

Bioretention, like the new gardens in Madison and Lakewood Park, are helpful to fish habitat news.wsu.edu/2016/04/12/hop ... #1LKWD #cleanwaterLKWD



Hope for saving salmon lies in reducing stormwa...

SEATTLE, Wash. — Salmon exposed to toxic stormwater can die in a matter of hours. But preliminary new findings by Washington State University researchers suggest t...
news.wsu.edu

← ↻ 3 ❤️ 3 ⋮



City of Lakewood @LakewoodOhio · Apr 19
What's this Clean Water LKWD you keep hearing about? Here's the recent flyer & FAQ explaining more. #1LKWD

CLEAN WATER LAKEWOOD
Rebuilding the Pipeline for Our Future

LAKWOOD OHIO

What is Clean Water Lakewood? Clean Water Lakewood is an ongoing program aiming to better manage our combined sewer overflows and continue efforts to protect our important natural resources.	It is rainwater mixed with raw sewage from residential properties that overflows into Lake Erie and the Rocky River.
When do these overflows happen?	Overflows occur during rain events when the stormwater exceeds the capacity of the pipes and the sewage treatment plant.
Why do we need to fix this problem?	The city is looking for proactive ways to eliminate overflows in Lakewood in order to protect our important natural resources. Also, it is a federal requirement to become compliant with the Clean Water Act of 1972.
Who needs to be involved? Everyone.	A major source of the overflows start at the household level. Residents need to be educated and engaged on this matter as it will require financial investment in sewer upgrades. We need public input and participation.

DYE TEST FAQ'S
March 2016

What is a dye test?
Dye is injected into each exterior storm connection (downspouts and drains), and flushed through with water. A city representative will visually inspect the ground water point in the street. If the water enters the storm sewer the test passes, if it fails in the sanitary sewer, connections will be needed.

Why is a dye test required?
Sanitary connections to storm sewers are prohibited by law. The Clean Water Act, enforced by US EPA and Ohio EPA, requires the City and property owners to mitigate storm water discharge into the sanitary sewer system to prevent effluent from entering waterways during heavy storm conditions. Read more about this on the reverse side.

When is a dye test required?
Prior to any work on the underground storm system: new construction, additions, alterations, drains, waterproofing, water controlling, etc. A dye test is also currently required for aboveground work on gutters and downspouts.

What if incorrect connections are found?
If a sanitary connection to the storm system is found, the problem must be corrected within 90 days. If a storm connection to the sanitary system is found, ALL new work must be properly connected. It is likely that eventually every property in Lakewood will be required to remediate incorrect connections. Therefore, HOA A-W-646 that while you are digging or doing planned sewer work can be the most economical time to address any incorrect connections.

What if I have a combined sewer system?
If major work is to be done we strongly recommend making the separation at this time, while the excavation is open.

How do I order the dye test, and what is the cost?
Call the Building Department at 214-579-6270, provide your name, phone number, the address where the work is to be performed, and a brief description of the work. The average lead time is two weeks and there is no cost for the initial test.

What else do I need to know?
1) After the work is complete, but before covering, you or your contractor will be responsible for performing a verification test to confirm the work has been properly connected to the city sewer system. This must be performed in the presence of a city representative who can be coordinated with your building inspector.
2) Sprinkling of downspouts is an acceptable solution as long as water is carried away from the foundation and no resistance is created.
3) Your town can call for 3 cones.



City of Lakewood @LakewoodOhio · Apr 19

Clean Water Lakewood results to be discussed tonight @ 7pm in the City Hall Auditorium #1LKWD #CleanWaterLKWD

🔄 1 ❤️ 1 ⋮



City of Lakewood @LakewoodOhio · Apr 12

This is the 39th consecutive year LKWD has received 'Tree City USA' status — the 2nd-longest streak in Ohio. bit.ly/1qGq0SL #1LKWD

🔄 5 ❤️ 6 ⋮



City of Lakewood @LakewoodOhio · Apr 10

Lakewood's got NOTHING on Rio's overflow problems. read.bi/1NNO6F6 #1LKWD #CleanWaterLKWD



A 2016 Rio Olympics waterway has levels of viruses akin to raw se...

A bombshell Associated Press report detailed just how badly polluted Rio's waterways, which will host the 2016 Olympics, are.

businessinsider.com

🔄 1 ❤️ 1 ⋮



City of Lakewood @LakewoodOhio · Apr 4

Reduce your runoff footprint: Rain Barrel Workshop set for April 6. bit.ly/24MOucE #1LKWD



City of Lakewood @LakewoodOhio · Mar 16

Can't wait to see Public Square with green infrastructure; maybe LKWD can get some ideas here #1LKWD
[#CleanWaterLKWD](#)



City of Lakewood @LakewoodOhio · Mar 10

Copenhagen turning parks into ponds. LKWD's not looking at this idea, but still interesting. bit.ly/1SHcFVo #1LKWD [#CleanWaterLKWD](#)



[View summary](#)

 **City of Lakewood** @LakewoodOhio · Mar 8
While @OhioEPA is encouraging urban tree canopy in Cleveland area, LKWD has planted more than 600 in past 2 years. bit.ly/1YtihCR

🔄 4 ❤️ 5 ... [View summary](#)

 **City of Lakewood** @LakewoodOhio · Mar 8
Reduce your runoff footprint: Rain Barrel Workshop set for April 8. bit.ly/24MOucE #1LKWD #CleanWaterLKWD

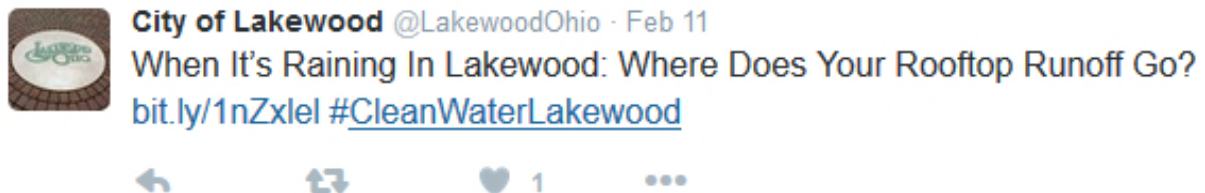
🔄 1 ❤️ ...

 **City of Lakewood** @LakewoodOhio · Mar 1
California no longer looking at stormwater as a nuisance, maybe we shouldn't either. #cleanwaterlakewood #1LKWD nyti.ms/1UcwJ1E

🔄 1 ❤️ 1 ... [View summary](#)

 **City of Lakewood** @LakewoodOhio · Feb 25
Thinking about planting a tree in your yard? Get a reduced rate. bit.ly/1LHPwuU #1LKWD

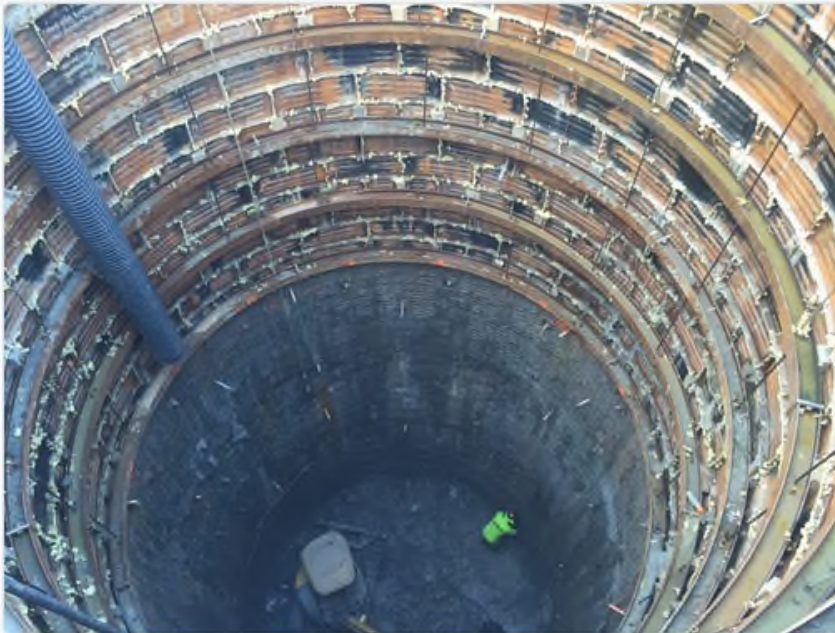
🔄 4 ❤️ 1 ...





City of Lakewood @LakewoodOhio · Feb 8

This giant hole is part of the West End CSO Elimination Project, addressing LKWD's overflow into Rocky River.
#1LKWD



4 7



City of Lakewood @LakewoodOhio · Feb 5

.@CLE_State Urban Affairs is hosting a water photo contest titled:
What does water mean to you? bit.ly/1Qg07yq #CleanWaterLKWD

1 1





City of Lakewood @LakewoodOhio · Jan 13

Investment in sewer projects spurs rate hike. bit.ly/1P8NF2L #1LKWD



City of Lakewood @LakewoodOhio · 17 Nov 2015

City of Lakewood planted hundreds of trees this fall. bit.ly/1NAgmVO #1LKWD



City of Lakewood @LakewoodOhio · 12 Sep 2015

From rustbelt to bluebelt. econ.st/1LX6Mic #CleanWaterLKWD #1LKWD



[View summary](#)



City of Lakewood @LakewoodOhio · 6 Sep 2015

The new environmentally friendly roof at LKWD City Hall. One of many "green" investments in your LKWD government.





City of Lakewood @LakewoodOhio · 29 Aug 2015

The Clean Water LKWD task force toured Green Infrastructure options in Parma earlier this week. [#cleanwaterlakewood](#)



City of Lakewood @LakewoodOhio · 2h

Clean Water Lakewood volunteers: Educated and engaged on overflows. bit.ly/1OnqrbV [#1LKWD](#)





City of Lakewood @LakewoodOhio · 27 Aug 2015

Clean Water LKWD group recently toured the Treatment Plant to better understand obstacles ahead #cleanwaterlakewood



← ↻ ❤️ 3 ⋮



City of Lakewood @LakewoodOhio · Apr 19

Clean Water Lakewood results to be discussed tonight @ 7pm in the City Hall Auditorium #1LKWD #CleanWaterLKWD

← ↻ ❤️ 1 ⋮



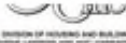
City of Lakewood @LakewoodOhio · Apr 19

What's this Clean Water LKWD you keep hearing about? Here's the recent flyer & FAQ explaining more. #1LKWD




Clean Water Lakewood is an ongoing program aiming to better manage our combined sewer overflows and continue efforts to protect our important natural resources.

What are combined sewer overflows?	It is rainwater mixed with raw sewage from residential properties that overflows into Lake Erie and the Rocky River.
When does this happen?	Overflows occur during rain events when the stormwater exceeds the capacity of the pipes and the sewage treatment plant.
Why do we need to fix this problem?	The city is looking for proactive ways to eliminate overflows in Lakewood in order to protect our important natural resources. Also, it is a federal requirement to become compliant with the Clean Water Act of 1972.
Who needs to be involved?	Everyone. A major source of the overflows start at the household level. Residents strive to be educated and engaged on this matter as it will require financial investment in sewer upgrades. We need public input and


DYE TEST FAQ'S
March 2019

What is a dye test?
Dye is injected into each exterior storm connection (downspouts and drains), and flushed through with water. A city representative will visually inspect the dyed water path in the street. If the water enters the storm sewer the test passes, if it enters the sanitary sewer, corrections will be needed.

Who is a dye test required?
Sanitary connections to storm sewers are prohibited by law. The Clean Water Act, enforced by US EPA and Ohio EPA, requires the City and property owners to mitigate storm water drainage into the sanitary sewer system to prevent effluent from entering waterways during heavy storm conditions. [Read more about this on the reverse side.](#)

When is a dye test required?
Prior to any work on the underground storm system: new construction, additions, lateral, drains, re-piping, water conditioning, etc. A dye test is **not** currently required for aboveground work on gutters and downspouts.

What if incorrect connections are found?
If a sanitary connection to the storm system is found, the problem must be corrected within 90 days. If a storm connection to the sanitary system is found, **ALL new work must be properly connected**. It is likely that eventually every property in Lakewood will be required to remediate incorrect connections. Therefore, BE AWARE that while you are digging or doing planned sewer work can be the most economical time to address any incorrect connections.

What if I have a combined sewer system?
If major work is to be done we strongly recommend making the separation at this time, while the excavation is open.

How do I order the dye test, and what is the cost?
Call the Building Department at 216-529-6270, provide your name, phone number, the address where the work is to be performed, and a brief description of the work. The average lead time is two weeks and there is no cost for the initial test.

What else do I need to know?

- 1) After the work is complete, but before covering, you or your contractor will be responsible for performing a verification test to confirm the work has been properly connected to the city sewer system. This must be performed in the presence of a city representative and can be coordinated with your building inspection.
- 2) Spreading of downspouts is an acceptable solution as long as water is carried away from the foundation and no nuisance is created.
- 3) Dye tests are valid for 6 years.

H.2 NEWSPAPER ARTICLES

Reduce Your Runoff Footprint: Rain Barrel Workshop Set for April 8

March 06, 2016
Colin McEwen

According to the Environmental Protection Agency, rain barrels save an average homeowner about 1,300 gallons of water during the peak summer months. Rain barrels can help capture some of that water — saving residents money and helping us all become better stewards of the environment.

The Cuyahoga County Soil and Water Conservation District and the city of Lakewood are hosting a rain barrel workshop at the Women’s Pavilion at Lakewood Park at 6:30 p.m. Wednesday, April 6.

The workshop is designed to teach residents how to harvest rainwater for gardening and combatting storm water pollution.

Rain barrels are containers used to collect and store rainwater that would otherwise be lost to runoff and likely diverted to a storm drain. Collected water may then be used to water lawns and gardens.

“There are many ways that residents can be better stewards of the environment,” said city engineer Mark Papke. “These rain barrels are just one very effective and affordable avenue for residents to make an impact.”

A \$60 fee includes instruction and all materials, including a 55-gallon barrel and a downspout diverter. With a large crowd expected, residents are required to register for the seminar, by calling the Cuyahoga County Soil and Water Conservation District at 216-524-6580, or registering online at www.cuyahogawcd.org/events.

Registration is required by April 1.

For more information — or to register directly — call Rocky River Watershed Coordinator Jared Bartley at 216-524-6580, ext. 14, or [check out the Clean Water Lakewood webpage](#).

It's Raining In Lakewood: Where Does Your Rooftop Runoff Go?

February 10, 2016
Colin McEwen

Lakewood, a city of homes with very little undeveloped property, may find the key to sewer improvements in our own backyards, driveways and roof drains.

When homes have roof drains or foundation drains connected to a sanitary sewer line, groundwater and rainwater add unnecessary water volume to the sewer system. Additionally, when sewer pipes on the individual's property are cracked, ground water leaches in, adding another source of unnecessary water to Lakewood wastewater treatment plant's load.

A significant volume of water in Lakewood's sanitary sewer system comes from private property. The sources include leaking house laterals and improperly connected roof and foundation drains. The city of Ann Arbor found that 70 to 90 percent of total sanitary sewer flow, in some portions of their system, was coming from footing drains during storm events, according to the city's 2001 Sanitary Sewer Overflow Prevention Study.

To quantify flow from private property, 102 homes in a pilot area on Delaware, Atkins and Eldred Avenues have been investigated to see if their homes are improperly connected, and if their pipes are cracked and broken. Nearly all of the homes in this pilot study had some broken or improperly connected pipes. After the homes are properly connected by this spring, flows going into storm and sewer drains will be re-measured and compared to pre-construction flows, to determine how significant of a reduction has occurred.

There are several overflow locations throughout the city.

Some of Lakewood's sewer overflows might be nearly eliminated if each property was connected so that their roofs and foundation drains were connected to the storm pipe, not the sanitary, and the property had sewer lines that weren't cracked. When planning home renovations you may also consider understanding the stormwater flow off of your property and ensuring proper connections.

Other ways homeowners can reduce the volume of water going into sanitary sewer lines is by:

- Installing low-flow showers, washers, dishwashers, and toilets
- During a rain event, don't add additional water into the sewer system; refrain from running dishwasher, clothes washer, or shower
- Add practices to your home where rain can infiltrate or be stored for later use (i.e. rain barrels, bio-swales and pervious pavement)

Residents interested in more information can [visit the webpage](#) or contact the Mayor's office: 529-6600; mayor@lakewood.oh.net.

Clean Water Lakewood Volunteers: Educated and Engaged On Overflows

January 15, 2016

Colin McEwen

Clean Water Lakewood: Rebuilding the Pipeline for Our Future, is a group of citizen volunteers committed to understanding Lakewood's sewer infrastructure to continue improvements and reduce wastewater overflows.

Lakewood's sewer system is a unique collection of types of pipes linked together over several decades. The system performs well in most conditions and Lakewood has been making sustained progress in implementing updates and new projects. Lakewood's unique system requires additional assessment and planning to select further improvements, which will include significant municipal investments over many years.

"Clean Water Lakewood volunteers bring a variety of perspective's and expertise to this important issue," said Shannon Strachan, Executive Assistant to the Mayor. "The group has met monthly since July, working toward suggesting infrastructure ideas to be considered for Lakewood."

Possibilities include combinations of increasing perviousness through green infrastructure, increasing retention via storage, eliminating cross-connections between storm and sanitary sewers, and increasing capacity at [the waste water treatment plant](#).

The questions confronting Clean Water Lakewood are intricate, and connected to issues of development, land use, building codes and affordability. Consequently, meeting topics have included: the Clean Water Act of 1972, Lakewood's discharge permit requirements, EPA's Integrated Planning Framework, how private property can affect sewer overflows, and advantages & disadvantages of various infrastructure options.

Two field trips offered useful perspectives. First, the group toured Lakewood's Water Pollution Control Facility, and learned about Lakewood's high-performing treatment plant, as well as nearby combined sewer overflows, and the intended high rate treatment plant coming in the next 5-10 years. Led by William Crute, Division Manager of Lakewood's treatment plant, the field trip underscored the challenges of dealing with wet weather flow.

The second field trip was an interactive tour of the Watershed Stewardship Center in Parma. Jennifer Grieser, Area Manager of Urban Watersheds at the Cleveland Metroparks, led a tour of the green infrastructure installed around the premises to reduce stormwater runoff from impervious surfaces. Additionally, she spoke of maintenance required and pros and cons of the various options experienced during the few years it has been installed at the Center.

The work of this citizen group, as well as the City of Lakewood, is part of the development of Lakewood's Integrated Wet Weather Plan under Ohio EPA issued permit that is working to

reduce wastewater overflows into Rocky River and Lake Erie. All meeting handouts and summaries are available at: <http://www.onelakewood.com/cleanwaterlakewood> under the sub heading “[Meeting Summaries](#).” The general public can offer comments by emailing the Mayor’s Office at mayor@lakewoodoh.net or calling 529-6600.

<http://www.onelakewood.com/clean-water-lakewood-volunteers-educated-and-engaged-on-overflows/>

Clean Water Lakewood's Citizen Volunteers Tour 'Green and Gray' Infrastructure

September 25, 2015

Colin McEwen



A group of volunteer citizens committed to understanding Lakewood's water infrastructure in relation to wastewater overflows took a couple of evening field trips this summer.

The citizens are members of the city initiative Clean Water Lakewood: Rebuilding the Pipeline for Our Future, who also hosted their kickoff meeting in July.

William Crute, division manager of Lakewood's Waste Water Treatment Plant, and Mirko Kucinic, unit manager, led an Aug. 11 complete tour of the treatment plant, the nearby combined sewer overflows, and the intended high-rate treatment plant coming in the next five to 10 years.

The goal of the meeting was to understand how the treatment plant works, and when the facility has difficulty treating all of the water flowing through the sewer system.

A couple weeks later, the group toured the Watershed Stewardship Center in Parma. Jennifer Grieser, area manager of Urban Watersheds at the Cleveland Metroparks, led a tour of the green

infrastructure installed around the premises to reduce stormwater runoff from impervious surfaces. Additionally, she talked about the maintenance required and pros and cons of the various options during the few years it has been installed at the Center.

The next several meetings will take place indoors, where the participants will discuss the issues with clean water entering our sanitary sewers, as well as compare various green and grey infrastructure options and what they see as advantages and disadvantages of each.

The city of Lakewood is working on a multi-year, multi-million-dollar plan to continue the city's progress under the 1972 Clean Water Act. [The Ohio EPA approved a permit last year](#) that will enable the city to improve the city's stormwater management and reduce wastewater overflows into the Rocky River and Lake Erie.

For some guidance in the process, the city established a volunteer-driven working group Clean Water Lakewood to help transform water infrastructure in Lakewood. The resident group will focus on facilitating best-practice solutions for wastewater overflows.

Lakewood's combined sewers are designed to take all wastewater to the treatment plant, which can process more than 30 million gallons per day. However, during storms, the volume of rainwater entering the combined sewer system can exceed both the capacity of the combined sewers and the treatment plant. The new agreement includes plans for sewer separation projects and wastewater treatment investments.

"No one more than the city of Lakewood desires to do our part to improve the cleanliness of our local watershed, especially our wonderful Lake Erie," said Lakewood Mayor Michael Summers.

New Study Begins At Waste Water Treatment Plant

Colin McEwen
Volume 11, Issue 14 06.23.2015
The Lakewood Observer



City of Lakewood officials are looking to increase capacity at the Lakewood wastewater treatment facility to treat a higher volume of flows during rain events.

Lakewood's combined sewers are designed to take all wastewater to the treatment plant, which can process a maximum hydraulic volume of 40 million gallons per day. However, during storms, the volume of rainwater entering the combined sewer system can exceed both the capacity of the combined sewers and the treatment plant, leading to overflows into Lake Erie and Rocky River.

Working to protect the city's water resources, Lakewood has implemented a pilot study of a high-rate treatment system. The high-rate system would be activated during storms when flows exceed treatment plant capacities. The high-rate system would reduce the quantity of untreated water being discharged to the river and lake.

The City of Lakewood selected Veolia's Actiflo, with technology that separates solids out of high volumes of water and settles them quickly into a sludge that can be properly disposed of.

If the pilot study is successful at cleaning Lakewood's wet weather flows to meet permit requirements, the system may be phased into the treatment plant in the next five years.

"Our goal is to decrease overflows that occur into the river and lake," said William Crute, division manager of the Lakewood Waste Water Treatment Plant. "This may be the most cost effective solution, as we look to stretch our treatment dollars while dramatically reducing pollution levels and achieving better water quality."

This pilot study is in a self-contained trailer that will be stationed on treatment plant grounds during the month of June for testing.

<http://lakewoodobserver.com/read/2015/06/23/new-study-begins-at-waste-water-treatment-plant>

City Of Lakewood Seeks Members For New ‘Clean Water Lakewood’ Advisory Group

Colin McEwen

06.23.2015

Volume 11, Issue 14, The Lakewood Observer



The city of Lakewood is working on a multi-year, multi-million-dollar plan to continue the city’s progress under the 1972 Clean Water Act. [The Ohio EPA approved a permit last year](#) that will enable the city to improve the city’s stormwater management and reduce wastewater overflows into the Rocky River and Lake Erie.

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“No one more than the city of Lakewood desires to do our part to improve the cleanliness of our local watershed, especially our wonderful Lake Erie,” said Lakewood Mayor Michael Summers.

“We hope to receive some guidance from our community’s strong and diverse group of residents, business owners and thought leaders in Lakewood.”

Anyone interested in participating in the Clean Water Lakewood working group is encouraged to call the mayor’s office at 216-529-6093. The first meeting is slated to take place July 16.

<http://lakewoodobserver.com/read/2015/06/23/city-of-lakewood-seeks-members-for-new-clean-water-lakewood>

Work Wrapping Up On Madison Park ‘Green Street’ Project

Colin McEwen

5/26/2015

Volume 11, Issue 11, The Lakewood Observer

The project to enhance the entrance to Madison Park is coming to a close. Crews are expected to finish the work by June 1.

"Madison Park Green Street" includes the addition of decorative concrete pavement, plantings and benches that will also be installed near the pool entrance of Madison Park.

The comprehensive effort includes planting 18 trees, 69 shrubs, 649 perennials and ornamental grasses, 1,475 ground-cover plants, and 700 bulbs.

One of the ideas behind the "Madison Park Green Street" project is to improve the city's stormwater management and reduce combined sewer overflows into Rocky River and Lake Erie.

During storms, the volume of rainwater entering the combined sewer system can exceed both the capacity of the combined sewers and the treatment plant. Bio-retention catch basins — like those installed at Madison Park's entrance — will help infiltrate stormwater into the ground rather than into a pipe.

"This project achieves a few very important objectives," said the city's public works director Joe Beno. "We're continuing our effort to be excellent stewards of the environment, while beautifying our park spaces and adding to the vibrancy of this important commercial corridor."

Once the project to resurface Madison Avenue is completed, designated bike lanes will be installed for each direction of traffic. To ensure the safety of bicyclists, the 28 angled spaces were removed and replaced with 14 parallel parking spaces.

Lakewood Continues Tree City USA Tradition

Colin McEwen

4.01.2015

Volume 11, Issue 7, The Lakewood Observer



For the 38th year, the Arbor Day Foundation has named the city of Lakewood a "Tree City USA" to honor the city's "commitment to effective urban forest management."

The Arbor Day Foundation — in cooperation with the National Association of State Foresters and the USDA Forest Service — sponsors the Tree City USA program.

"Trees clean the air, shade our homes, reduce energy costs, beautify our neighborhoods, improve storm water management and increase property values," said Mayor Michael Summers.

A long-standing Tree City USA award recipient in Northeast Ohio, Lakewood has consistently met the national standards required for the prestigious award.

The four standards of a Tree City USA include:

- A Tree Board or Department: Someone must be legally responsible for the care and management of the community's trees. This may be a volunteer tree board, a forestry department, or a professional forester or arborist.
- A Tree Care Ordinance: The tree ordinance must designate the establishment of a tree board or forestry department and give this body the responsibility for writing and implementing an annual community forestry work plan.
- A Community Forestry Program with an annual budget of at least \$2 per capita.
- An Arbor Day Observance and Proclamation will take place this year, at a time/date to be determined.

According to the National Arbor Foundation, meeting the four standards for becoming a Tree City USA "tells visitors that here is a community that cares about its environment, and is also an indication to prospective businesses that the quality of life may be better in that community."

Summers said the city is proud to accept the recognition but added that there is still work ahead.

“A lot of our at-risk trees are in our backyards,” he said. “The city has an opportunity to contribute, but residents and business owners can also help us grow our tree canopy; we’ve all got a role to play.”

Among the city’s goals is to increase the tree canopy by 10 percent, to 38.5 percent by the year 2035.

The city’s forestry department and Lakewood Tree Task Force have developed a comprehensive strategy to improve the tree canopy and add diversity to the variety of species around the city.

In just two years, the organization has already helped plant dozens of trees at Madison and Lakewood parks, presented 19 recommendations to Lakewood City Council supporting tree legislation and worked with the city’s forestry department to plant nearly 600 trees around Lakewood.

The city’s strategy also includes an effort to prepare the city for climate change, add diversity to the urban forest, withstand pest infestations and storms, and add in trees with more fall colors. More trees also means less storm water runoff.

“Everyone benefits when elected officials, volunteers and committed citizens in communities like Lakewood make smart investments in urban forests,” said Matt Harris, chief executive of the Arbor Day Foundation. “Trees bring shade to our homes and beauty to our neighborhoods, along with numerous economic, social and environmental benefits.”

Investment in Sewer Projects Spurs Rate Hike

Colin McEwen

01.06.2015

Volume 11, Issue 1, The Lakewood Observer

Increases in water and sewer rates are expected to be the norm around Northeast Ohio this year — and during the next several years — as municipalities attempt to meet the challenges of an aging water and sewer infrastructure, while complying with EPA mandates. Lakewood is no different. On December 15, 2014, the city administration and Lakewood City Council agreed to increase water and sewer rates effective January 1, 2015. Customers will begin receiving bills with the new rates starting mid-January to early February.

Water rates will increase 10 cents, or 1.5%, over 2014 rates—from \$6.24 per ccf to \$6.34 per ccf, where one **ccf** is equal to 100 cubic feet or approximately 748 gallons.

- This slight increase is to support an automatic meter reading system that will be completed in 2015. The project has been completed in the eastern two thirds of the city, with approximately 6,000 residential meters remaining to be installed in the western third of the city.
- The \$3.8 million project mentioned above is a new, wireless system which will not only replace the current outdated system, but will also result in more accurate measuring and real-time monitoring of water usage. This means that leaks can be detected and repaired faster for the City's water customers.
- Sections of Blossom Park, St. Charles, Summit, Athens and Woodward will be having new water mains installed during 2015.

Sewer rates will increase 5% over 2014 rates—from \$4.72 per ccf to \$4.96 per ccf.

- The sewer bill increase is required for the City of Lakewood to continue to develop and implement strategies for compliance with the regulations required by the Federal Clean Water Act of 1972.
- Lakewood's continued work with the EPA to develop an integrated wet weather improvement plan to eliminate combined sanitary and storm sewer overflows into Lake Erie and the Rocky River involves the City's measuring and modeling of its sewer system to develop appropriate, cost-effective and environmentally sound solutions to problems created by overflows.
- Projects underway in 2015 include West End Sewer Improvements, Edgewater Ave. Sewer Separation, and a Clean Water Pilot Study (southwestern section of Lakewood from Delaware to Hilliard and from Woodward to McKinley).

There is a special homestead exemption that reduces water and sewer bill charges for any homeowner who is 65 years of age or older—or is permanently disabled—with an income below \$35,000 per year.

If you feel you may qualify, if you would like to set up monthly ACH payments, or if you have any other questions, please contact the **City of Lakewood's Division of Utility Billing at (216) 529-6820**.

You can now pay your water and sewer bill online at: www.onelakewood.com.

New Downtown Parking Lots Part of an Effort to Improve Stormwater Management

Colin McEwen

9.30.2014

Volume 10, Issue 20, The Lakewood Observer

The recently finished parking lots in downtown Lakewood provide more than spaces for vehicles to park. They're also good for the environment.

The idea behind the improvements — at the two lots between St. Charles and Cook just north of Detroit Avenue — was to reduce stormwater runoff from the parking lot to the storm sewer.

“We wanted to capture the water, allow it to slowly drain into the ground instead of going into a catch basin and possibly affect the combined sewer overflow,” said Joe Beno, the city’s director of public works.

The city obtained a \$150,000 storm-water improvement grant from the Ohio EPA’s Surface Water Improvement Fund to help pay for the \$400,000 project.

The concrete medians separating the lines of cars were ripped out, and replaced with a pervious paver drainage system. The project also included planting about a dozen new trees, as well as the addition of two bio-swales at the corners of the lots.

“This has a direct impact on the amount of water that goes into the overflow,” added Beno. “This will reduce the amount of combined sewer overflow — and that’s a good thing.”

Most of the work was completed last year, but the contractor recently applied a final seal to the asphalt and raised a few of the pavers that settled during the past year.

In addition to new pavement, the two parking lots now have kiosks allowing motorists to pay for parking with a credit card, or by using an app on their cell phones. Additional signs will be added to aid with the visibility of the space numbers in the winter.

Improvements to the sidewalks and adjacent drive aprons are expected by the end of 2014; 10 additional lights are also being added to the lots.

H.3 MEDIA MONITORING EMAILS TO CLEAN WATER LAKEWOOD TASK FORCE

Below are the three separate media monitoring emails sent to the Clean Water Lakewood Task Force.

The goal of sending these emails was to get the Task Force engaged on the issue and understanding its context outside of Lakewood.

The first media monitoring email was sent on 8/4/2015 from Julia Lazar.

Hello Clean Water Lakewood Working Group,

Approximately every 2 weeks for the next 6 weeks you will get an email with recent news articles in regards to either stormwater, green and grey infrastructure, sewage treatment plant upgrades, or combined sewer overflows. This is the first email.

Our next meeting starts at 7pm, August 11th at Lakewood's Waste Water Treatment Plant ([1699 Cleveland Metro Park Drive](#)).

Here are a few recent articles that may be of interest:

- 1) [AP Investigation: Filthy Rio Water a Threat to 2016 Olympics](#). This article states how the lack of sewage treatment affects Olympians training in Rio for next summer's games.*
- 2) [Northeast Ohio Regional Sewer District \(NEORS D\) posted a series of photos showing the waste water treatment network under our feet heading to the plant](#)*
- 3) [Lakewood's Waste Water Treatment Plant launches pilot study to better manage overflows](#)*
- 4) [Toronto and Calgary were hit with heavy flooding in 2013, forcing them to react with a new strategy](#)*

Photos below are from twitter and may give you a good idea of some grey infrastructure before our tour of Lakewood's waste water treatment plant on August 11th.

- 1) NEORS D shows a photo of their crew in one of their sewer tunnels. This gives you an idea of scale.*



- 2) Here is a photo that NEORSD tweeted of their sewer crews working on the Edgewater CSO flap gate:



Media Monitoring email sent to Clean Water Lakewood Volunteers on 8/17/2015 from Julia Lazar

Hello Clean Water Lakewood Working Group,

Here is the 2nd installment of media monitoring. There are many varieties of green infrastructure that we will be learning about next Wednesday, August 26th at 7pm. We are meeting at the Watershed Stewardship Center in Parma ([2277 W. Ridgewood Drive](#)).

The first two articles detail two green infrastructure ideas other cities are working on.

- 1) [A New Playground in the Bronx Soaks Up the City's Problematic Storm Water](#)
- 2) [D.C.'s Polluted Rivers Are Getting a Green Makeover](#)
- 3) [Citizens Share Ideas for Lakewood's Downtown Development](#): Any redevelopment in Lakewood should consider opportunities of redeveloping in a way that also helps us meet our OEPA permit requirements through reducing: stormwater runoff, stress on Lakewood's sewer system, and/or combined sewer overflows. Make sure to click on the link to a pdf in this article, showcasing 3 development options up for discussion 6:30PM on Wednesday, August 19th at Univ of Akron, Lakewood campus.
- 4) In case you wanted to see another sewage treatment plant, NEORS is hosting an open house on [Saturday, September 19th](#) which includes a plant and lab tour and several educational exhibitors to talk about water-related issues in Cleveland.

Below is a photo from Twitter showing some green infrastructure installed in San Francisco.



Media Monitoring email sent to Clean Water Lakewood Volunteers on 9/10/2015 from Julia Lazar

Hello Clean Water Lakewood Working Group,

Below is the 3rd and final media monitoring email. Our goal was to start off the working group with a few recent articles every two weeks to keep us all informed of water news that relates either to this project or region. We hope you enjoyed them.

Here are three recent articles that emphasize the value of our water:

[From rustbelt to bluebelt: Could water be the Midwest's ticket to economic rebirth?](#) The Economist, Aug. 1, 2015. While this article doesn't specifically mention Cleveland, it certainly applies to this region.

[Waukesha Plan for Lake Michigan Water Raises Worries.](#) New York Times, Aug. 25, 2015. The 2008 Great Lakes Compact is being tested by a suburb of Milwaukee that hopes to divert water from Lake Michigan due to their aquifer being contaminated and running low.

[Underground man-made cavern being turned into giant pump station to help clean Lake Erie.](#) The Akron Beacon Journal, June 15, 2015. This article notes tunnels that Cleveland and Akron are working on in regards to their combined sewer overflow challenges.

*We look forward to seeing you at our next meeting on **September 15, at 7pm** at the University of Akron, Lakewood campus. I may be on maternity leave by that time; please note that Jennifer Brown (jbrown@ctconsultants.com) will be taking my place as email communicator for the next few meetings.*

H.4 INFORMATIONAL FLYER

This flyer was included with everyone's water bill during the spring of 2016. It was two-sided and its intended purpose was to help the community understand the Clean Water Lakewood initiative as well as to introduce them to the new dye-testing policy.



DIVISION OF HOUSING AND BUILDING
12860 DETROIT AVENUE • LAKEWOOD, OHIO 44107 • 216/529-6270 • FAX 216/529-6800
Website: www.one.lakewood.com

DRU SILEY
DIRECTOR OF PLANNING & DEVELOPMENT
216/529-6634
MICHAEL J. MOLINSKI, R.A.
CITY ARCHITECT
216/529-6272
JOSEPH A. MEYER
ASSISTANT BUILDING COMMISSIONER
216/529-6223

DYE TEST FAQ'S

February 2016

What is a dye test?

Dye is injected into each exterior storm connection (downspouts and drains), and flushed through with water. A city representative will verify which sewer the dyed water exits in the street. If the water exits the storm sewer the test passes, if it exits in the sanitary sewer, corrections will be needed.

Why is a dye test required?

The Environmental Protection Agency has mandated that the City mitigate storm water drainage into the sanitary sewer system to prevent effluent from entering waterways during heavy storm conditions. Sanitary connections to storm sewers are likewise prohibited. [Read more about this on the reverse side.](#)

When is a dye test required?

Prior to **any** work on the *underground* storm system: new construction, additions, laterals, drains, waterproofing, water controlling, etc. A dye test is **not** currently required for *aboveground* work on gutters and downspouts.

What if incorrect connections are found?

If a sanitary connection to the storm system is found, the problem must be corrected within 90 days. If a storm connection to the sanitary system is found, only **new work must be properly connected.** The homeowner is encouraged to remediate all incorrect connections. Improper connections outside of the planned work area may be required to be capped or splashed at the direction of the City.

What if I have a combined sewer system?

If major work is to be done we strongly recommend making the separation at this time, while the excavation is open.

How do I order the dye test, and what is the cost?

Call the Building Department at 216-529-6270, provide your name, phone number, the address where the work is to be performed, and a brief description of the work. The average lead time is two weeks and there is no cost for the initial test.

What else do I need to know?

- 1) After the work is complete, but before covering, you or your contractor will be responsible for performing a verification test to confirm the work has been properly connected to the city sewer system. This must be performed in the presence of a city representative and can be coordinated with your Building Inspector.
- 2) Splashing of downspouts is an acceptable solution as long as water is carried away from the foundation and no nuisance is created.
- 3) Dye Tests are valid for 5 years.



Clean Water Lakewood is an ongoing program aiming to better manage our combined sewer overflows and continue efforts to protect our important natural resources.

What are combined sewer overflows?

It is rainwater mixed with raw sewage from residential properties that overflows into Lake Erie and the Rocky River.

Why does this happen?

Overflows occur during rain events when the stormwater exceeds the capacity of the pipes and the sewage treatment plant.

Why do we need to fix this problem?

The city is looking for proactive ways to eliminate overflows in Lakewood in order to protect our important natural resources. Also, it is a federal mandate to become compliant with the Clean Water Act of 1972.

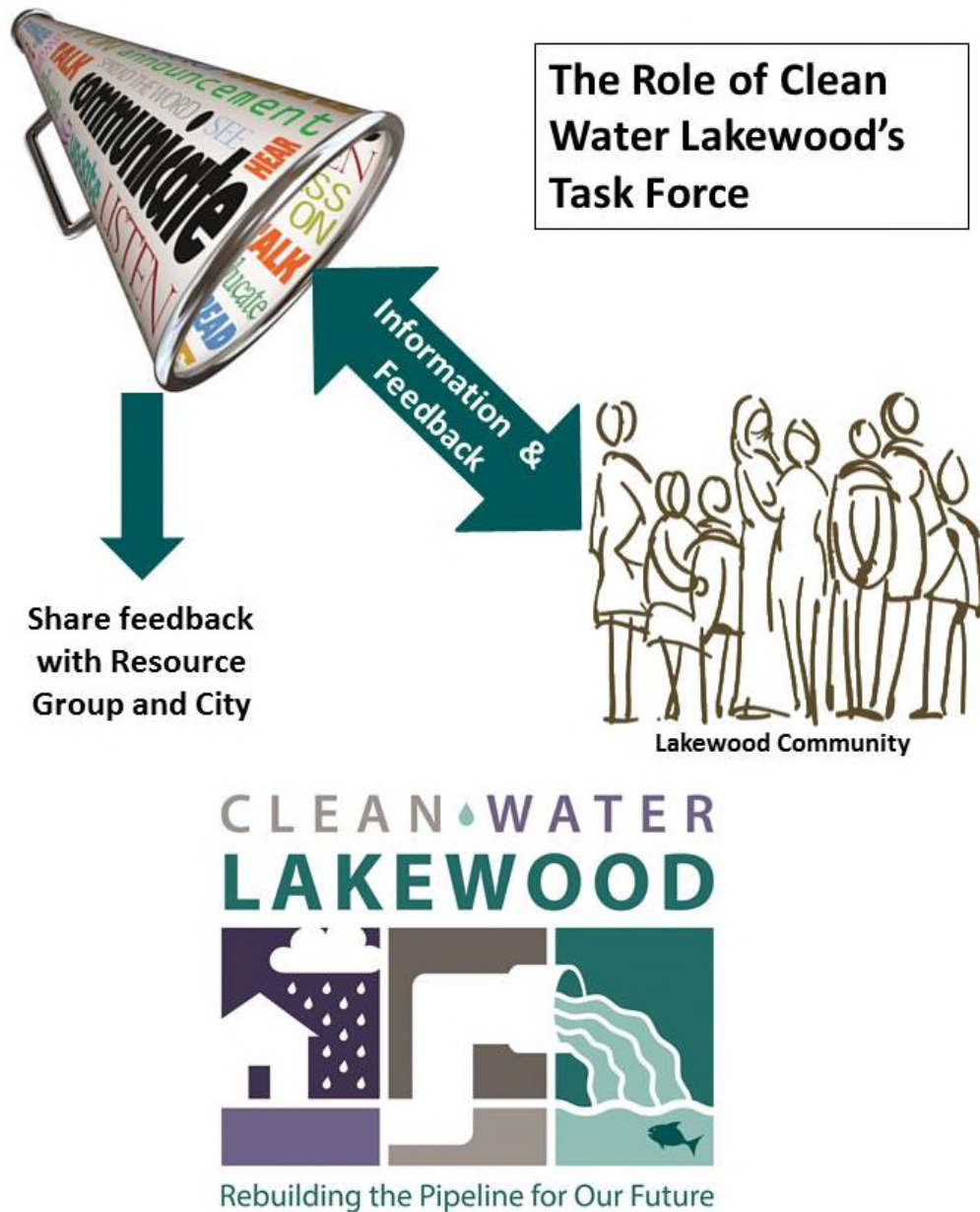
Who needs to be involved? Everyone.

A major source of the overflows start at the household level. Residents should strive to be educated and engaged on this matter as it will require a sizable financial investment in sewer upgrades. We need public input and support.

You can learn more by visiting www.onelakewood.com/cleanwaterlakewood, calling the Mayor's office at 216-529-6093 or following the city of Lakewood on Twitter or Facebook.

H.5 HANDOUTS GIVEN AT PUBLIC MEETINGS

The following are copies of the handouts provided during public meetings.



2016 Integrated Wet Weather Improvement Plan; Resource Binder

Figure H-1: Cover of Clean Water Lakewood Resource Binder, all members had their own binder.

This calendar represents meeting dates for first four meetings.

August 2015						
Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
						1
2	3	4	5	6	7	8
9	10	11 7PM WWTP Tour 1699 Cleveland Metro Park Dr	12	13	14	15
16	17	18	19	20	21	22
23	24	25	26 *7PM Green Infrastructure Tour Parma, 6:30 at City Hall for	27	28	29

September 2015						
Sunday	Monday	Tuesday	Wednesda	Thursday	Friday	Saturday
		1	2	3	4	5
6	7 Labor Day	8	9	10	11	12
13	14	15 7PM U of Akron; Policy intro and Grey&Green Discussion	16	17	18	19
20	21	22	23	24	25	26

October 2015						
Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
				1	2	3
4	5	6	7	8	9	10
11	12 Columbus Day	13	14	15	16	17
18	19	20 7PM U of Akron, Communicating the Invisible	21	22	23	24

November 2015						
Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
1	2	3	4	5	6	7
8	9	10	11 Veterans Day	12	13	14
15	16	17 7PM U of Akron; breakout groups	18	19	20	21
22	23	24	25	26 Thanksgiving Day	27	28

Below are acronyms and definitions Clean Water Lakewood Task Force may come across in our meetings or in the literature.

Acronyms and Abbreviations	
BAT	Best Available Technology
BID	Business Improvement District
BMP	Best Management Practice
CIP	Capital Improvement Plan
CWA	Clean Water Act
HRT	High-Rate Treatment
EMC	Event Mean Concentration
FEMA	Federal Emergency Management Agency
GIS	Geographic Information System
I/I	Inflow/Infiltration
IWWIP	Integrated Wet Weather Improvement Plan
LID	Low Impact Development
LTCP	Long Term Control Plan
MG	Million Gallons
MGD	Million Gallons per Day
MS4	Municipal Separate Storm Sewer System
NEDO	Northeast District Office of Ohio EPA
NLCD	National Land Cover Database
NPDES	National Pollutant Discharge Elimination System
O&M	Operation and Maintenance
OEPA	Ohio Environmental Protection Agency
POC	Pollutant of Concern
RDI/I	Rainfall-Derived Inflow and Infiltration
SWMM	Storm Water Management Model
TMDL	Total Maximum Daily Load
USACE	U.S. Army Corps Of Engineers
USEPA	U.S. Environmental Protection Agency
WWT	Wastewater Treatment
WWTP	Wastewater Treatment Plant

Definitions

Combined Sewer: a sewer designed to transport sanitary, industrial, and storm flows.

Dry Weather Flow (DWF): base flow rates not resulting from wet weather conditions.

Edgewater Interceptor: the main interceptor in the City of Lakewood, interceptor flow originates at 117th and Edgewater Drive, goes west to Webb Road, then south to Clifton, west to West Clifton, then south to the WWTP (waste water treatment plant).

Infiltration/Inflow (I/I): causes dilution in sanitary sewers. Dilution of sewage decreases the efficiency of treatment, and may cause sewage volumes to exceed design capacity. Although inflow is technically different from infiltration, it may be difficult to determine which is causing dilution problems in inaccessible sewers. The USEPA defines the term infiltration/inflow as combined contributions from both.

Infiltration: Groundwater entering sanitary sewers through defective pipe joints and broken pipes is called infiltration. Pipes may leak because of careless installation; or they may be damaged after installation by ground movement, heavy vehicle traffic on roadways above the sewer, careless construction practices in nearby trenches, or degradation of the sewer pipe materials. In general, volume of leakage will increase over time (The Environmental Dictionary, 1995).

Inflow: Water entering sanitary sewers from inappropriate connections is called inflow. Typical sources include sump pumps, roof drains, cellar drains, and yard drains where urban features prevent surface runoff, and storm drains are not conveniently accessible or identifiable. Inflow tends to peak during precipitation events, and causes greater flow variation than infiltration (The Environmental Dictionary, 1995).

Invert Plate: A removable cast iron plate that is installed at each manhole of an over/under sewer system to prevent mixing stormwater and sanitary sewage.

Inform / Influence Projects: Programmatic elements that engage and educate partners and the broader public in making sustainable decisions that provide water quantity and quality benefits. Examples include forming partnerships with educational institutions or community thought leaders to create highly visible projects within the community.

Integrated Wet Weather Improvement Plan (IWWIP)– Later branded “Clean Water Lakewood: Rebuilding the Pipeline for Our Future” that is focused on meeting the requirements in the City’s NPDES permit for controlling untreated sewage overflows.

NPDES Permit: (National Pollutant Discharge Elimination System) The permit issued by the Ohio EPA regulating point discharges into water bodies.

Urban: An area where the majority of land use is marked by a high density of created structures and developments. It is also marked by a high population density. A high population

density consists of core census block groups or blocks that have a population density of at least 1,000 people per square mile and surrounding census blocks that have an overall density of at least 500 people per square mile (<https://ask.census.gov>). Lakewood has approximately 9,400 people per square mile.

Sanitary Sewer: a sewer intended to transport sanitary and/or industrial wastes.

Storm Sewer: a sewer intended to transport surface runoff and drainage due to wet weather events (rain, sleet, snow melt).

Wet Weather Flow (WWF): flow generated by wet weather events such as rainfall or snowmelt.



Working Group Meeting #1
July 15, 2015 at 7PM

Introductory Meeting

Roster of members as of July 13, 2015

Ynes	Arocho
Connie	Bilowski
Glenn	Coyne
Byron	Crampton
Terrance	Dziak
John	Ehrnfelt
Bill	Fraunfelder
Jim	Gagan
Babette	Gowda
Jerry	Gubani
Jim	Hostacky
Ron	Hudak
John	Kilgore
Zuzanna	Kurowska
Cole	Mellino
Katelyn	Milius
Michelle	Nochta
Dana	Paul
Jim	Rambasek
Jeralyn	Saleet
Stuart	Sayler
Jeannie	Smith
Jan	Snow
Mike	Stewart
Allison	Urbanek

Patrick Wadden

Please email Julia (jlazar@ct.consultants.com) with a sentence about yourself. Eventually there will be a website for this project on onelakewood.com with all of this information listed on the website.

This is a diverse working group of residents, business owners, and home owners assembled to help identify the best paths forward for water infrastructure in Lakewood. This group is focusing on facilitating best-practice solutions for sewage overflows.

Please, talk to others about these meetings. You can be both a megaphone – spreading information out to your fellow citizens as well as a reporter– gathering input and relaying back to the group the comments and opinions you have heard.

Brief Statement of the Challenge

The city is currently faced with multiple regulatory requirements that will involve a variety of infrastructure, policy, and land management solutions.

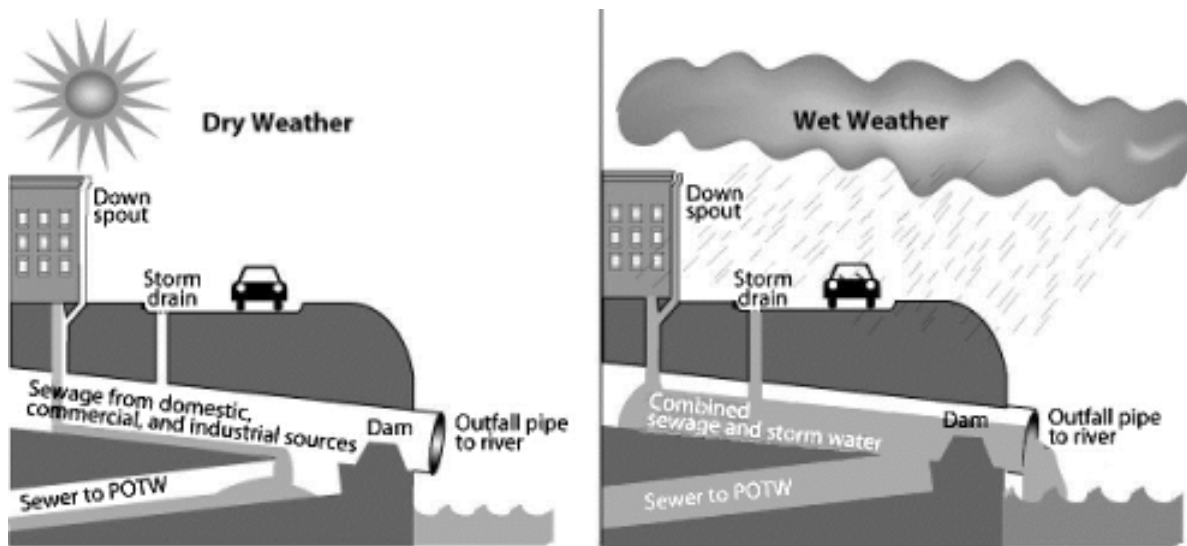
CT Consultants will work with the City and this working group to evaluate various water infrastructure improvement alternatives based on the working group’s suggestions, reflecting the community’s criteria and values.

Why do we have sewage overflows?

Lakewood has sewer systems that are designed to collect rainwater runoff, domestic sewage, and industrial wastewater in the same pipe. During dry weather, our sewer system transports all of the wastewater to a sewage treatment plant, where it is treated and then discharged to a water body. During periods of heavy rainfall or snowmelt, however, the wastewater volume can exceed the capacity of the sewer system or treatment plant. For this reason, our sewer system is designed to overflow and discharge excess wastewater directly to nearby waterways—Rocky River and Lake Erie.

These types of overflows are a major water pollution concern for the approximately 772 cities in the U.S. that have combined sewer systems (EPA, 2014). With the passage of the Clean Water Act in 1972, such overflows and other discharges must be controlled or eliminated in order to make water fishable and swimmable, among other uses.

To resolve this problem, US EPA and Ohio EPA have mandated that Lakewood capture, treat or remove the millions of gallons of overflow that happen every year. As with the original investments in the City, Lakewood must invest in its infrastructure so that it meets the demands of Lakewood’s second century, and for the benefit of human and environmental health.



Expectation of this Working Group

- 1) Help communicate and engage with the community to work on public awareness of this issue
- 2) Develop green and grey infrastructure alternative suggestions for CT to model, that reflect community values and priorities
- 3) Evaluate model results and to suggest top feasible alternatives for consideration

Resource People for this Working Group:

- 1) Robert H. Greytak, PE, bgreytak@ctconsultants.com, Engineer and Program Facilitator at CT Consultants, focus areas include water and waste water.
- 2) Kristin M. Hopkins, AICP, khopkins@ctconsultants.com, Planner and Lead Program Facilitator at CT Consultants, focusing on urban planning and community supported decision making.
- 3) Joyce M. Bond, RLA, jbond@ctconsultants.com, Landscape Architect and Program Facilitator at CT Consultants, focus area includes: green infrastructure.
- 4) Julia G. Lazar, PhD, jlazar@ctconsultants.com, Scientist and Program Facilitator at CT Consultants, applied researcher in industry, government, and academia; focus includes pollution transformations, hydrology, and scientific communication.
- 5) Louis L. McMahon, JD, lmcmahon@mdllp.net, Environmental Lawyer hired by City of Lakewood focusing on Clean Water Act compliance, partner at McMahon DeGulis LLP
- 6) Joseph J. Beno, PE, joe.beno@lakewoodoh.net, Director of Public Works, Lakewood
- 7) Mark K. Papke, PE, mark.papke@lakewoodoh.net, City Engineer, Lakewood
- 8) Shannon C. Strachan, JD, shannon.strachan@lakewoodoh.net, Assistant to the Mayor, Lakewood
- 9) Brian Shields, brian.shields@lakewoodoh.net, Project Manager, Lakewood
- 10) Bryce Sylvester, AICP, bryce.sylvester@lakewoodoh.net, City Planner, Lakewood
- 11) Ermelindo Gomes, Ohio EPA, erm.gomes@epa.ohio.gov, 330-963-1196, Environmental Engineer

Meeting Ground Rules

Group members are expected to respect the opinions of team members, have meaningful conversations, and provide constructive insight by:

- Everyone participating – all viewpoints are important
- Using active listening
- Avoiding side bar conversations – one person speaks at a time so everyone can hear
- Brainstorming without editing; all ideas are good ideas
- Respecting everyone's time by being concise, succinct with comments
- Turning off cell phones

Meetings are open to the public

- Opportunity for observers to comment will be provided at the end of the process, when feasible plans are developed
- Regular updates and meeting notes will be provided on the City's website

Meeting Structure:

- Meetings start promptly at 7PM
- Meetings will be a combination of learning, brainstorming and discussion
- When meeting materials are distributed ahead of time, participants are expected to review the materials and arrive prepared to participate in discussions
- Each meeting will begin with a summary of the concepts and discussion from the last meeting
- Meetings are open for public listening and at the end of each meeting there will be 5 minutes for public comment. Additionally index cards and a box will be provided at the meetings so if the public didn't get a chance to ask their question they can write it out, including their contact information, and one of the Resource Colleagues will get back to them. Comments can also be submitted directly to working group individuals, or to resource members, or to the City of Lakewood.

Facilitated Discussion means:

- Systemic approach to discussion, so that all voices are heard
- Can't always ask questions – might need to write down for later
- Won't necessarily debate issues to closure
- Discussion on some issues may need to be deferred, or may need more research between meetings

Meeting Date and Time

Meeting the 3rd Tuesday of every month, starting at 7PM.

Communication you can expect from us

Two email updates a month for the first 6-8 weeks sharing news and tweets from that week regarding stormwater, green infrastructure, sewage over flows in other municipalities, etc. We

consider this helpful in broadening everyone's awareness. Please feel free to pass this information on to others in the community.

What you can expect at our next meetings

We will spend the first few monthly meetings going over background information, providing educational resources for understanding the problem and discussing possible solutions.

Specifically, the next two meetings will be field trips: one to show you the sewage treatment plant and one which focuses on green infrastructure.

Tuesday, August 11th we meet at Lakewood Municipal Waste Water Treatment plant, 1699 Cleveland Metro Park Dr, at 7PM. We will gain an understanding of how a treatment plant works, and how it has evolved over time. We will also look at one overflow site right near the plant, which overflows into Rocky River.

Wednesday, August 26th we meet at the Watershed Stewardship Center to learn about green infrastructure options, 2277 W Ridgewood Dr, Parma, OH 44134. The tour starts at 7pm sharp, please arrive a few minutes early.

After that, we plan to have our September, October, and November meetings at the University of Akron, Lakewood campus, multi-use room.

December, January, and February meetings may be held at City Hall depending on auditorium availability.



Working Group Meeting #2
August 11, 2015

Tour of Lakewood's Waste Water Treatment Plant (WWTP) and an Overflow Site

Refresher Question: Why was this working group formed?

Goal of this meeting: To learn how a sewage treatment plant works, and to gain an understanding of where the overflows discharge when it rains.

Some might say the most important facility in Lakewood is our treatment plant. This plant treats an average of 7.85 million gallons of sewage water a day, and consistently meets all state water discharge permits. Bill Crute, the Division Manager, has been working at this plant for 45 years. He, along with a crew of about 22 people, makes sure the plant is running efficiently on an hourly basis.

In the USA there are 800,000 miles of sewage collection systems (networks of pipes) according to the EPA. This does not include private home laterals that connect to these systems, which would add an additional 500,000 miles of pipes.

In Lakewood, we have more than 875,000 feet (166 miles) of pipe, which includes 393,500 feet of sanitary sewer, 348,000 feet of storm sewer, and 133,500 feet of combined sewer. Lakewood has a sewered area of approximately 3,100 acres, 500 of those acres are serviced by combined sewers (Facility Plan for the City of Lakewood, 1978).

Large storms overwhelm sewers and dramatically increase the volume reaching the plant, often leading to overflows.

Part 1: Touring the Plant

Plant is located at 1699 Cleveland Metro Park Drive. See attached sewage treatment plant map to help guide you as you read the descriptions.

Preliminary Treatment

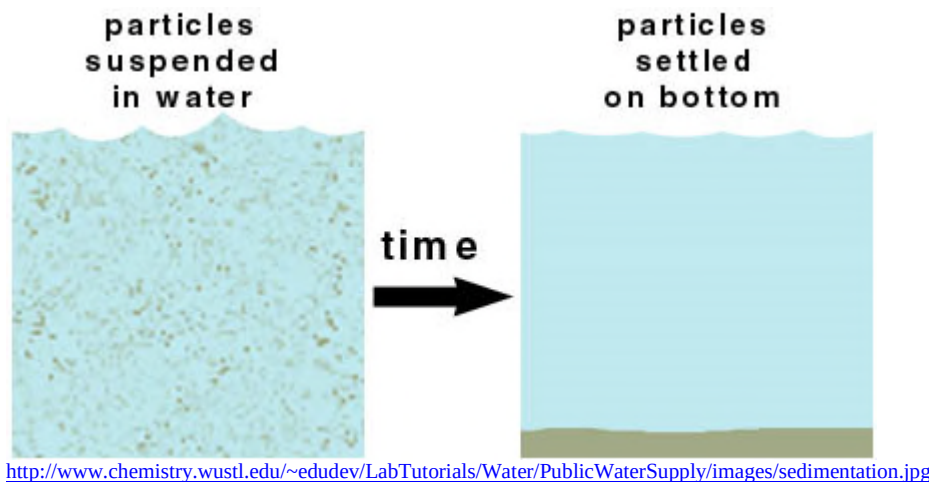
Goal of the headworks is to remove anything larger than ½ inch, things like: trash, rocks, rags and cans. Influent screens filter out large debris. This prevents pipes and pumps in the plant from getting clogged. The trash that is removed is landfilled.

Grit removal chamber

Water flows slowly, and heavier grit falls to bottom, lighter organics float. Rake runs across bottom of tank, sweeping grit away.

Primary Treatment/ Primary Clarifier

Goal: start to separate water from solids.



Primary treatment relies on physical separation methods—sedimentation is done via gravity. Other solids are screened out. Average detention time in these tanks is 2 hours.

Waste water comes up through center of the circular settling tank, water sits in this tank for a few hours, becoming very still. 60-70% of solids falls to bottom and is removed. Oil and grease form film on top and are skimmed off. Cleaner water flows over weirs as solids settle out.

There is a rotating arm that brings solids from the bottom of the clarifier into a hopper in the center, and the hopper is connected to a pipe that brings it to the sludge (biosolids) treatment process, located on site.

Secondary Treatment

This process removes solids and nutrients like nitrogen and phosphorous (N&P). N&P are important to remove for the health of Rocky River and Lake Erie as they promote algae growth, and can lead to low oxygen zones in the water.

Nutrients are also a valuable resource, particularly for agriculture, and these nutrients can be recovered through sludge processing.

Aeration tank is the first part of secondary treatment—it relies on biological science, not physical separation.

Blowers distribute oxygen via pipes into aeration basin. Oxygen is used by bacteria; they feed on the solids and reduce their volume as well as reduce nutrient concentrations.

Secondary clarification is similar to primary clarification, in the sense that the solids settle out and are sent to biosolids treatment. These solids are called “activated sludge”. Some of the activated sludge is sent back to aeration tank to keep bacteria counts high enough to continuously eat up the solids.

UV Disinfection

This removes bacteria that would cause illness. When bacteria are exposed to UV light, they are rendered incapable of reproducing and therefore they are short-lived.

Water is now free of solids, grit, and microorganisms and is considered clean enough for use in: cooling systems, irrigation, or firefighting.

Sludge Processing

Sludge is put into an anaerobic digester and different species of bacteria reduce pathogens and volatiles, as well as produce methane as a byproduct. This methane (natural gas) can be a great energy source and Lakewood uses this energy to run their boilers as well as heat their buildings in the winter. They are hoping to one day also use the methane produced by the digesters for electricity.

The sludge is squeezed between two belts so that all the water is squeezed out; the removed water is sent back to the headworks. Approximately 5000 wet tons of biosolids are produced annually.

Part 2: Where are the overflows?

Lakewood has sewer systems that are designed to collect rainwater runoff, domestic sewage, and industrial wastewater in the same pipe, as well as a unique system involving “over-under” sewers intermingled with combined sewers. Most of the time, our sewer system transports all of the wastewater to a sewage treatment plant, where it is treated and then discharged to Lake Erie.

During periods of heavy rainfall or snowmelt, however, the wastewater volume can exceed the capacity of the sewer system or treatment plant. For this reason as well as to guard against basement flooding, our sewer system was designed to overflow and discharge excess wastewater directly to nearby waterways—Rocky River and Lake Erie.

In a typical year Lakewood discharges over 15 million gallons of sewage mixed with stormwater to Lake Erie and Rocky River. This is equivalent to 4.4 million water bottles of waste released every day.

This June was an incredibly wet month and 51 million gallons overflowed just in that month.

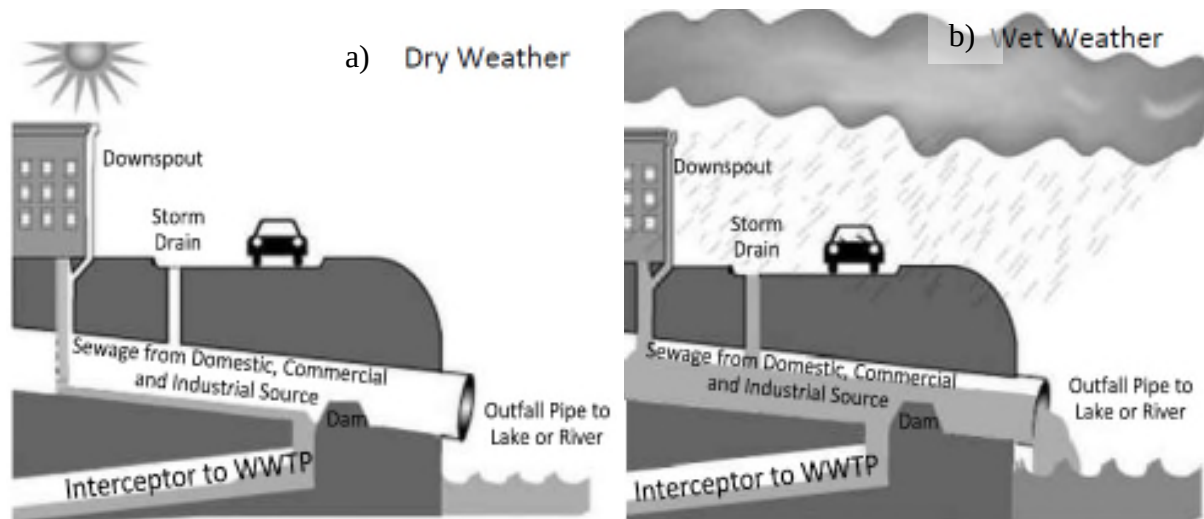


Figure 1. a) During dry weather, sewage and commercial wastes do not cause overflows. The waste flows into an interceptor pipe to the waste water treatment plant. b) During wet weather, sewage, commercial wastes and stormwater mix and overwhelm the system. Due to the surge in volume, not all waste gets to the interceptor and therefore it is released to the nearest water body.

Attached you will find two additional maps; 1) shows the 55 outflow pipes leading to the lake or the river from Lakewood, and 2) shows the CSO sewersheds of Lakewood.

Lakewood is making progress on reducing overflows and is in the process of removing two permitted CSOs that discharge into Rocky River.

One is overflow RRES 1140, which we can see from the bridge, the other is right near the sewage treatment plant, RRWS 1205, which acts as a release if too much water is going into the treatment plant influent pipe.

The pipe you can see from the bridge is going to remain, but it will only release stormwater, rather than combined sewage and stormwater.

By November of 2016, you will see a new pipe spanning across the river and leading into the sewage treatment plant (Figure 2), this is so that the combined sewage and stormwater from the



West End neighborhood, does not discharge to the river, but instead goes through the pipe for treatment. This is expected to cost about \$5 million, and half of this is covered by state grant and loan money.

Overall the cost to collect all of the waste water and manage the sewer system is estimated to cost \$6,748,370 in 2015. The cost to run the waste water treatment plant is estimated at \$4,480,745 for 2015. These numbers were taken from the 2015 Estimate of Expenses Report: <http://www.onelakewood.com/pdf/Finance%20Report.pdf>, page 152 and 156, respectively.

Figure 2. Rendering of new pipe spanning Rocky River leading to the WWTP.

Other types of grey infrastructure; which may be referenced in the future

What is grey infrastructure?

A general term referring to man-made, constructed assets, like tunnels and storm drains.

Examples are below:

Storage Tunnels: brings large volume of water into storage tunnel during rain event and then that water gets pumped to WWTP when they have capacity to treat it.



<http://www.waterworld.com/content/dam/etc/medialib/new-lib/waterworld/print-articles/volume-28/issue%208/parsons-tunnel-interior-1208ww.jpg>

Sewer Separation: separates the storm and sanitary sewers so that all overflows going into river and lake are just stormwater, not storm mixed with sewage



http://www.severinotrucking.com/images/gallery/12/lg_Lincoln%20Ave%202010%20-%201%20%2869%29.JPG

high rate treatment: increasing the capacity that the treatment plant can handle by using technology and chemicals that settle the solids and disinfect the water in minimal time



<http://vertassets.blob.core.windows.net/image/67a33121/67a33121-b234-4d63-9c86-b1ddda114e88/actiflomem.jpg>



Working Group Meeting #3
August 26, 2015

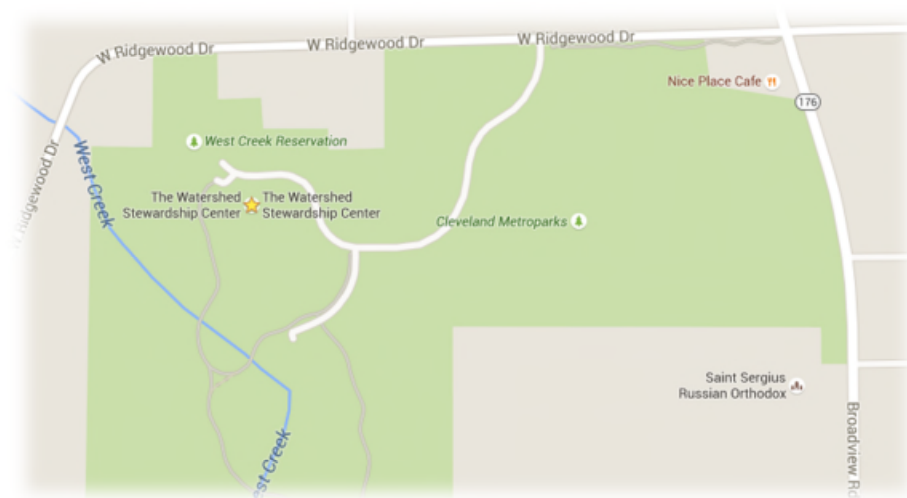
Tour of Watershed Stewardship Center at West Creek Reservation

Refresher Question: When does the waste water treatment plant have trouble treating all of the water flowing into the sewer system? Why?

Goal of today's meeting: Learning and interacting with the green infrastructure at the Watershed Stewardship Center. We also hope to learn about the effectiveness and maintenance of some of these options.

The Watershed Stewardship Center is located in Parma at **2277 West Ridgewood Drive**, just west of Broadview Road. This Center opened in 2013 and was made possible through a partnership between the West Creek Conservancy, Cleveland Metroparks and Northeast Ohio Regional Sewer District.

Jennifer Grieser, Senior Natural Resources Manager, focusing on Urban Watersheds for the Cleveland Metroparks, will be giving us a tour as well as an overview of results from a neighborhood green infrastructure study on Parkhaven Dr. and Klusner Ave in Parma. Please drive by those roads to get a glimpse of what the rain gardens, bio-retention, and rain barrels look like and if it is something you see working Lakewood.

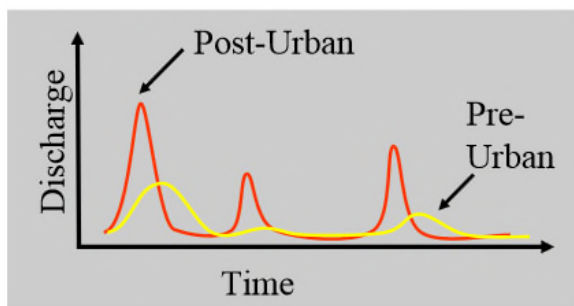


The Water Cycle

The water cycle, or hydrologic cycle, is a continuous exchange of water between land, water bodies, and the atmosphere. 97% of the earth's water is stored in the oceans, and only a fraction of the remaining water is usable freshwater, making Lake Erie an incredibly valuable natural resource.

When it rains, the water follows three major paths: 1) evaporation or returning the water to the atmosphere, 2) percolating into the ground and/or taken up by plant roots, and 3) traveling to surface waters like lakes, rivers, and eventually oceans.

Impervious surfaces associated with suburban and urban land uses alter the amount of water going into each of the above three pathways. The biggest change is a reduction in the volume of water seeping into the ground, resulting in an increased volume going to our surface water. This has implications for water quality in Lake Erie, affecting habitat for fish and wildlife as well as drinking water for humans.



This hydrograph to the left shows peak stormwater discharges in an urban watershed (red line) and in a less developed watershed (yellow line). In watersheds with large amounts of impervious cover, there is a larger volume of water and a faster rate of water discharge, leading to flooding and degraded water quality. <http://www.coastal.ca.gov/nps/watercyclefacts.pdf>

Lakewood's Water Cycle

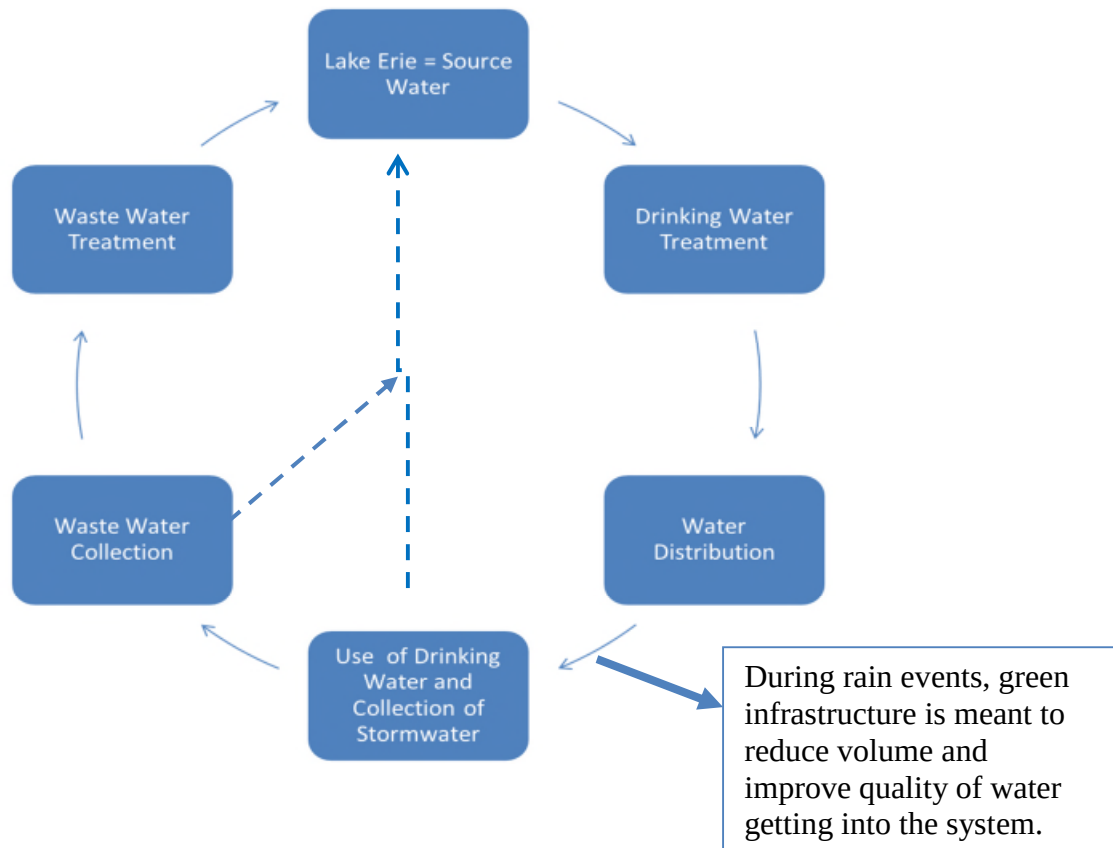
Development commonly eliminates natural green areas that once absorbed and filtered stormwater, the result is downstream flooding, erosion, and increases in various types of pollution; including: pet waste, fertilizers, salt, and sediment.

In Lakewood, about 65% of the land area is covered by impervious surfaces including areas devoted to houses, driveways, streets, sidewalks and parking lots, resulting in a significant amount of surface water runoff during storms.

Parts of Lakewood are serviced by a one-pipe system, carrying both storm water and sanitary waste. During rain events, the pipe capacity is overwhelmed, causing a combination of sewage and storm water to drain into Lake Erie, potentially violating the Clean Water Act and our Ohio EPA discharge permit (NPDES).

Some solutions to remediate these discharges include green infrastructure, which are on-site actions that can be taken by both public and private property owners to capture rainwater after it has hit the ground but before it flows to the sewer.

The figure below shows a simplified version of Lakewood's urban water cycle.



Adapted from <http://voices.nationalgeographic.com/files/2014/03/urban-water-cycle.png>

Green Infrastructure at the Watershed Stewardship Center in Parma

Definitions adapted from the *Minnesota Stormwater Manual*, 2015.

Permeable pavements

Permeable pavements allow stormwater runoff to filter through surface voids into an underlying stone reservoir for temporary storage and/or infiltration. Depending on the soil below the permeable pavement, pervious pavement can remove pollutants. The most commonly used permeable pavement surfaces are pervious concrete, porous asphalt, and permeable interlocking concrete pavers.

Permeable pavements have been used for areas with light traffic at commercial and residential sites to replace traditional impervious surfaces in low-speed roads, alleys, parking lots, driveways, sidewalks, plazas, and patios.

All permeable pavements have a similar structure, consisting of a surface pavement layer, an underlying stone aggregate reservoir layer, optional underdrains and geotextile over uncompacted soil subgrade.

From a hydrologic perspective, permeable pavement is designed to manage rainfall landing directly on the permeable pavement surface. Permeable pavement surfaces may accept runoff contributed by adjacent impervious areas such as driving lanes or rooftops. Runoff from vegetated areas often has sediment loads, and therefore must be directed elsewhere as sediment accelerates permeable pavement surface clogging.



Stormwater pond/retention basin

Stormwater ponds are constructed stormwater management practices, not natural ponds. They can contain a permanent pool and temporary storage for water quality control and runoff quantity control. When maintained properly, stormwater ponds can be an important aesthetic feature. If you have more land you can put in a stormwater wetland, which can be larger, have more vegetative growth and have greater water quality benefits. The Stewardship Center has a stormwater wetland, not a pond.



<http://www.drainagedoctor.com/Images/stormwater%20pond.jpg>

Green roof

A rooftop treatment practice where a thin planting media is established on roof surfaces and then planted with hardy, low-growing vegetation. Green roofs can reduce quantity of runoff as well as improve quality of runoff with proper management.



Bioretention

Bioretention is a water quality and quantity control process. Bioretention provides opportunity for runoff infiltration, filtration, storage, and water uptake by vegetation.

Bioretention areas are suitable stormwater treatment practices for all land uses, as long as the contributing drainage area is appropriate for the size of the facility. Common bioretention opportunities include landscaping islands, cul-de-sacs, parking lot margins, commercial setbacks, open space, rooftop drainage and street-scapes (i.e., between the curb and sidewalk). Bioretention, when designed with an underdrain and liner, is also a good design option for treating potential stormwater hotspots.

Bioretention is extremely versatile because of its ability to be incorporated into landscaped areas. The versatility of the practice also allows for bioretention areas to be frequently employed as stormwater retrofits.



<http://www.stormwaterpartners.com/lid/images/TitleBioretention.jpg>



<http://www.ence.umd.edu/~apdavis/Bioinstallations.htm>

Rain garden

Rain gardens are a form of bioretention and can have positive effects on both quantity and quality of runoff. Rain gardens are meant to be something that an individual can install themselves—digging it by hand, while other forms of bioretention require heavy machinery and more engineering, including drainage pipes underneath the soil. Rain gardens typically have no subsurface pipes for drainage.

Rain barrels

A container used to collect and store rainwater that is usually placed below the downspout of a roof gutter. The collected water is used to water the landscape.

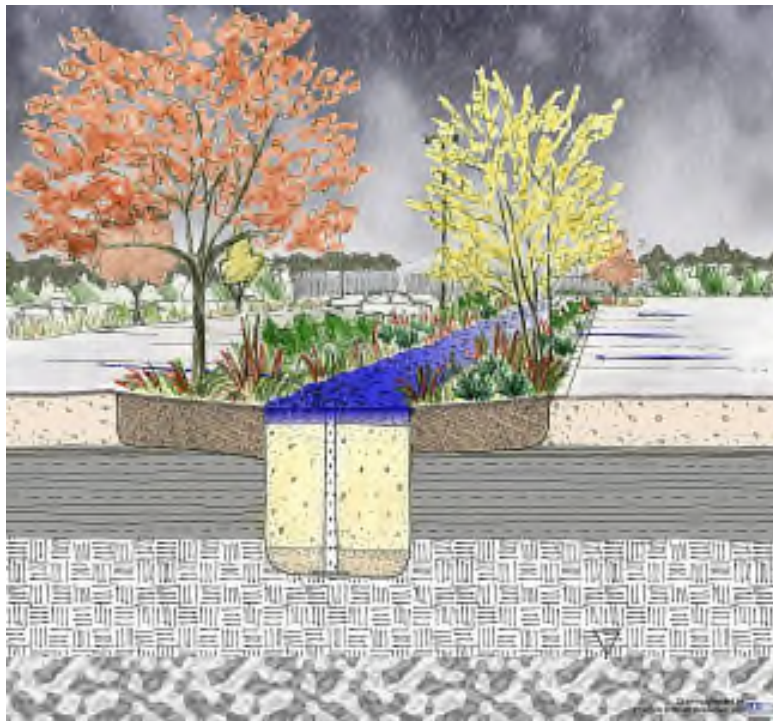


<https://stevenrhorn.files.wordpress.com/2014/06/rain-barrel.jpg>

Other examples of green infrastructure that aren't shown at the Watershed Stewardship Center:

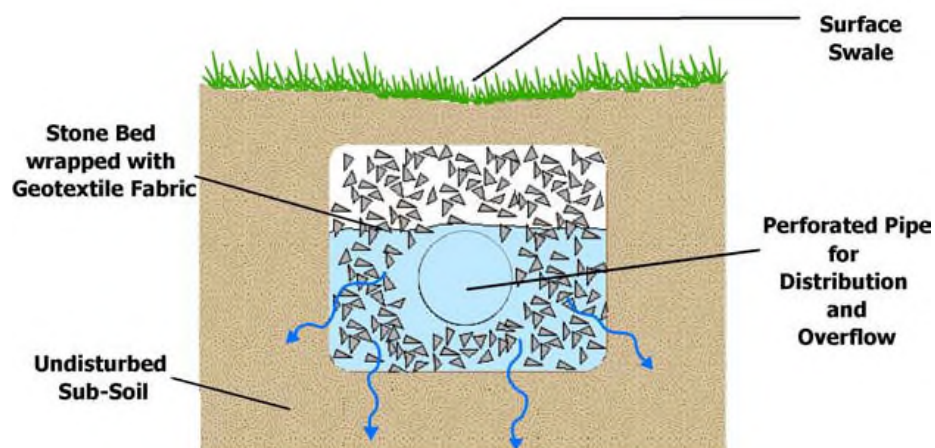
Infiltration trenches and basins

Infiltration practices treat urban stormwater runoff as it flows through a filtering medium and into underlying soil, where it may eventually percolate into groundwater. The filtering media is typically coarse-textured and may contain organic material. They are designed for reducing runoff volume and pollutants.



Source: Minnesota Stormwater Manual, 2013

INFILTRATION TRENCH



http://www.temple.edu/ambler/csc/t-vssi/images/survey_BMP/diagrams/infilt_trench_large.jpg

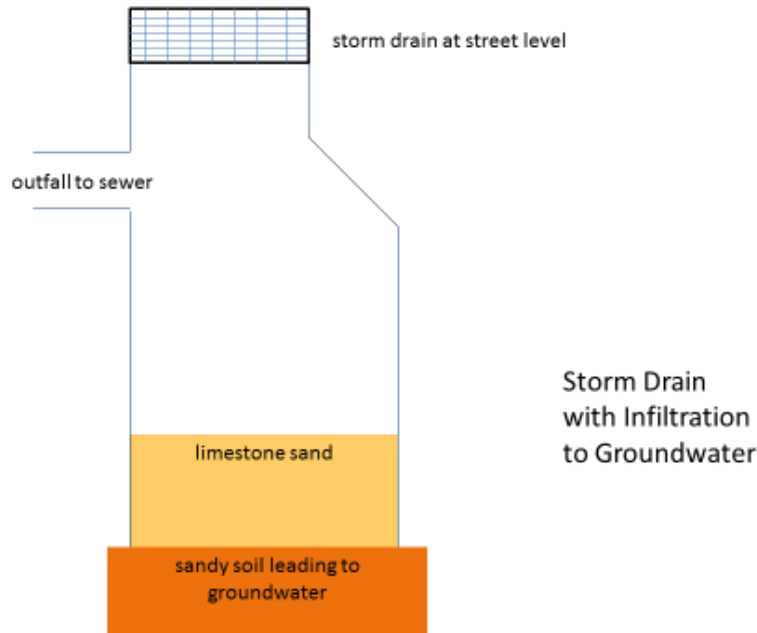
Filtration

Filtration practices treat urban stormwater runoff as it flows through a filtering medium, such as sand or an organic material. They are generally used on small drainage areas (5 acres or less) and are primarily designed for pollutant removal.

- Media (sand) filters

- Surface (vegetative) flow (grass channels, dry or wet swales, filter strips)
- Combination media/vegetative filters

The below example is an illustration of what is behind the Drug Mart and Quaker Steak and Lube Parking Lot in Lakewood:



Questions to consider asking while on this tour:

- 1) How successful was the stormwater pilot study in Parma?
- 2) What is the maintenance required for some of these practices?
- 3) Do you have any cost data available? Maintenance cost vs. construction/installation cost?
- 4) What do you think is your most effective green infrastructure practice? Why?
- 5) Is there any green infrastructure that has not been as successful as you imagined? Or has been most problematic?
- 6) What are the tools needed to make green infrastructure successful?
- 7) Do you think grey infrastructure is more reliable than green?
- 8) Do neighbors find green infrastructure unpleasant to look at since it sometimes has the overgrown and unmaintained look?
- 9) Does green infrastructure work in the winter?

Green Infrastructure Practices Common in Urban Areas

Green Infrastructure Practice	Description
 Disconnection	Disconnection refers to the practice of directing runoff from impervious areas such as roofs or parking lots onto pervious areas such as lawns or vegetative strips, rather than directly into storm drains.
 Rain Harvesting	Rain harvesting systems collect runoff from rooftops and convey it to a cistern tank where the water is available for uses that do not depend on potable water, like irrigation.
 Rain Gardens	Rain gardens are shallow depressions filled with an engineered soil mix that supports vegetative growth. They are designed to store and infiltrate captured runoff, and retain water for plant uptake. They are commonly used on individual home lots to capture roof runoff.
 Green Roofs	Green roofs (also known as vegetated roofs or ecoroofs) are vegetated detention systems placed on roof surfaces that capture and temporarily store rainwater in a soil medium. They typically have a waterproof membrane, a drainage layer, and a lightweight growing medium populated with plants that absorb and evaporate water.
 Infiltration Trench	Infiltration trenches are gravel-filled excavations that are used to collect runoff from impervious surfaces and infiltrate the runoff into the native soil. Some systems are designed to filter runoff and reduce clogging by routing water across grassed buffer strips.
 Street Planters	Street planters are typically placed along sidewalks or parking areas. They consist of concrete boxes filled with an engineered soil that supports vegetative growth. Beneath the soil is a gravel bed that provides additional storage as the captured runoff infiltrates into the existing soil below. Street planters also can be designed with underdrains to avoid ponding on sites with inadequate infiltration capacity.
 Porous Pavement	Permeable pavement and paver systems are excavated areas filled with gravel and paved over with a permeable concrete or asphalt mix. They may also be overset with a layer of pavers. Rainfall passes through the pavement or pavers into the gravel storage layer below where it can infiltrate at natural rates into the site's native soil.

Source:

http://water.epa.gov/infrastructure/greeninfrastructure/upload/Greening_CS0_Plans.PDF

Below is a summary table of volume reduction practices and BMPs associated with each process. Some BMPs occur in more than one process. Notice that many of the processes mimic natural processes in the hydrologic cycle, infiltration (percolating into ground), evaporation & plant uptake, conveyance (streams and rivers), storage (lakes and oceans).

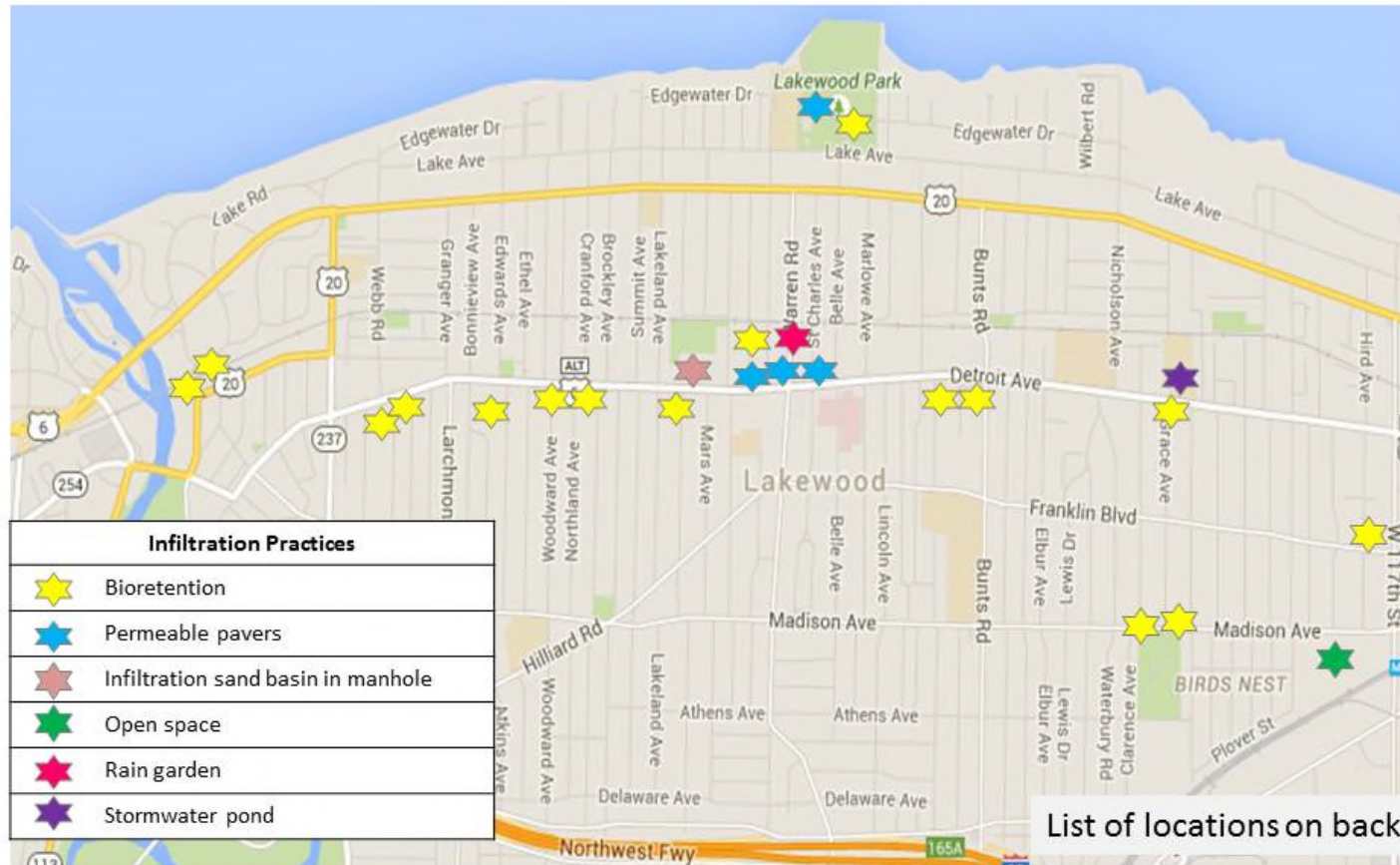
Process	Best Management Practice/Green Infrastructure	Comments
infiltration (percolating into the ground)	low impact development/better site design	includes: reduced street and sidewalk width, less curb and gutter drainage, shared pavement, scattered bioretention
	trench or basin	must be properly engineered, put in proper soils, and adequately maintained
	perforated sub-surface pipes, tanks, and storage systems	expensive, but effective and space-saving
	disconnected imperviousness	includes rooftop drains and road/parking surfaces
	pervious/porous pavement	includes a number of paving and block methods, or parking on reinforced grass surfaces
	bioretention (if it contains infiltration)	some bioretention are designed to infiltration
evapo- transpiration (evaporation+ plant uptake)	bioretention (rain gardens)	exposes runoff water to plant roots for uptake; can be under-drained and still effective
	vegetated swales	provides water a chance to soak into the ground and be filtered as it flows
	wetland/pond storage	combination of standing surface water and vegetative root exposure yields volume reductions
	vegetated drainage corridor	connecting numerous features increases opportunities for volume reduction
	recessed road/ parking garage	routing paved surface runoff to vegetated sump areas keeps it out of receiving water
storage	rain barrel/cistern	small-scale runoff collectors keep water around for later re-use or slow release
	rooftop (possibly including green roof)	storage on a roof prevents water from leaving the site; combining with vegetation (engineered green roof) has additional benefits
	wetland/pond storage	combination of standing surface water and vegetative root exposure yields volume reductions
conveyance	vegetated swales	provides water a chance to soak into the ground and be filtered as it flows
	filter strips/buffers	variation of vegetated swale with side-slope protection
diversion	landscaping/better site design	diverts stormwater runoff before it reaches storm drain

Adapted from: Minnesota Storm Water Manual, 2015: http://stormwater.pca.state.mn.us/index.php/Volume_reduction_practices

Map of Green Infrastructure in Lakewood, OH

Commercial and City Owned Land

Complete as of July 2015



Infiltration Practices in Lakewood		
Corresponding to Green Infrastructure Map of Lakewood		
<u>Bioretention</u>	<u>Permeable Pavers</u>	<u>Infiltration Basin</u>
Beck Center	Parking lots A,B,C downtown	Discount Drug Mart on Detroit & Cohasset
Bob Evans	Small path at Lakewood Park	
CVS on Detroit		
Discount Drug Mart near Lakeland		
Dunkin on both Detroit and 117th		
GetGo		
Madison Park		
New condos on Sloane		
Parking lots A,B,C		
Rite Aid		
YMCA		
Lakewood Park		
<u>Open Space</u>	<u>Rain Garden</u>	<u>Stormwater Pond</u>
Graphtech	Behind First Federal	Garfield Middle School



Working Group Meeting #4
September 15, 2015

Clean Water Act Policy Introduction & Grey vs Green Comparison Discussion

Refresher Question: What was the central goal of the green infrastructure we saw last month?

Goal of this meeting: What is an NPDES permit and why does Lakewood have one?

Note: Erm Gomes will be starting this meeting with an introduction of his work at OEPA, specifically as it relates to NPDES permits.

Part 1: History and Summary of the Clean Water Act

The Clean Water Act (CWA) establishes the basic structure for regulating discharges of pollutants into the waters of the United States and regulating quality standards for surface waters. The basis of the CWA was enacted in 1948 and was called the Federal Water Pollution Control Act, but the Act was significantly reorganized and expanded in 1972. "Clean Water Act" became the Act's common name with amendments in 1972.

EPA has set water quality standards for all contaminants in surface waters. Under the CWA, EPA has implemented pollution control programs such as setting wastewater discharge standards for industry and municipalities.

The CWA made it unlawful to discharge any pollutant from a point source into navigable waters, unless a permit was obtained.

EPA's [National Pollutant Discharge Elimination System \(NPDES\)](#) permit program controls discharges from point sources (pipes). Individual homes that are connected to a municipal system do not need an NPDES permit; however, industrial and municipal pipe discharges must obtain permits if their discharges go directly to surface waters.

Lakewood is in compliance with their effluent from the wastewater treatment plant (WWTP), but our combined sewage and stormwater overflows need to be reduced to no greater than 4 occurrences per year.

Adapted from: <http://www2.epa.gov/laws-regulations/summary-clean-water-act>

Summary of Lakewood's NPDES permit requirement in Part I.C.

- 1) Characterize the sewer and stormwater system
- 2) Monitor and record all overflows into Lake Erie and Rocky River
- 3) Create an integrated plan that addresses overflows from combined sewers and interconnected pipes
- 4) Install high rate treatment at the sewage treatment plant to deal with high volume, wet weather flows
- 5) Analyze alternatives that Lakewood expects to implement to bring overflows into compliance
- 6) Bring overflow discharges into compliance with the Clean Water Act to minimize human and environmental health impacts

Lakewood's NPDES Permit Deadlines

Deadline	Ohio EPA Requirement
September 2014	New NPDES Permit Issued
September 2016	Design specifications of High Rate Treatment (HRT) due to OEPA, as well as feasible alternatives plan created
March 2018	Submit a permit to install HRT plan, and any other measure decided on, and begin construction within 6 months of permit being approved
March 2019	Alternatives analysis and plan for dealing with overflows
September 2022	Construction of measures and HRT are complete, and there is a significant reduction in CSOs

Part 2: Grey and Green Comparison Discussion Questions

What are some advantages of green infrastructure? Advantages of grey infrastructure?

What are some disadvantages of each?

Where do you see risks and uncertainties?

(thoughts to be used if people don't participate: risks that green won't work, won't be maintained, grey is seen as more of a "sure thing," green can only be relied upon for smaller storms, although grey infrastructure is generally expected to be exceeded during large storms, both need lots of maintenance and can be expensive)

What benefits might come out of green infrastructure that won't show up in the modeling?

(thoughts to be used if people don't participate: air quality, real estate value, decreased heat island effect, carbon sequestration, habitat for native plants, birds, insects, reduction in pollutant runoff, public health-more people recreating outdoors)

How might investing in grey infrastructure meet the needs of Lakewood differently compared to investing in green infrastructure?

(thoughts to be used if people don't participate: would grey and green investments appreciate or depreciate similarly?)

CT will be writing notes on a whiteboard or large note pad for all to see and add to the discussion. The below chart might be useful for individual's own notes.

Advantages of Green Infrastructure	Disadvantages of Green Infrastructure

Advantages of Grey Infrastructure	Disadvantages of Grey Infrastructure



Working Group Meeting #5
October 20, 2015

Discussion: Comparing Green and Grey Infrastructure

Refresher Question: How do homeowners play a role in reducing the volume of water going into the sanitary sewer unnecessarily?

Goal of today's meeting: Understanding the advantages and disadvantages of various infrastructure options for addressing combined sewer overflows.

Definitions of common grey and green infrastructure investments.

Rain gardens/bioretention: shallow depressions filled with an engineered soil mix that supports vegetative growth. They are designed to store and infiltrate captured runoff and retain water for plant uptake.

Street Planters/tree boxes: these consist of curbed openings or concrete boxes filled with an engineered soil to support plantings. Beneath the soil is a gravel bed that provides storage as the captured runoff infiltrates into the soil below.

Pervious pavements: pavements with properties that allow stormwater runoff to filter through surface voids into an underlying stone reservoir for temporary storage and/or infiltration.

Sand/infiltration filter: water flows through sand and either into groundwater or into pipe. They are primarily designed for pollutant removal.

Tree planting: tree planting provides for canopy interception and evaporation of rainwater along with evapotranspiration and transpiration of groundwater which provide for improvements in the health of the watershed system.

Downspout disconnect: a practice of directing runoff from impervious roof areas onto pervious areas rather than directly into storm drains.

Green roofs: vegetated detention systems placed on roof surfaces that capture and temporarily store rainwater in a soil medium.

Blue roofs: non-vegetated detention systems placed on roof surfaces that capture and temporarily store rainwater

Rain harvesting: rain harvesting systems collect runoff from rooftops and convey it to a tank where water is available for use.

Sewer separation: separating the combined single pipe system into separate sanitary and stormwater flows. This includes manhole separation in over/under systems with invert plates.

Storage tunnel/interceptor: deep tunnel system to capture and store combined stormwater and sewage that later gets pumped to treatment plant when capacity is available.

Source Control: policies and measures to reduce the volume of “clean” water entering the sanitary sewer system from inflow and infiltration.

High rate treatment: technology that can clarify and treat water to certain standards at a rate much faster than a waste water treatment plant.

Upgrades to wastewater treatment plant: increasing capacity of plant to remove solids, nutrients, and bacteria before releasing to the lake.

Grey and Green Comparison Discussion Questions

What are some advantages of green infrastructure? Advantages of grey infrastructure?

What are some disadvantages of each?

Where do you see risks and uncertainties?

What benefits might come out of green infrastructure that won't show up in the modeling?

How might investing in grey infrastructure meet the needs of Lakewood differently compared to investing in green infrastructure?

What other information do you need to know to help make a decision?

Stakeholders will be writing notes on a whiteboard for all to see and add to the discussion. The chart below might be useful for individual's own notes.

Advantages of Green Infrastructure	Disadvantages of Green Infrastructure

Advantages of Grey Infrastructure	Disadvantages of Grey Infrastructure

Resources and Web Links

Chicago's Green Alley Program

http://www.cityofchicago.org/city/en/depts/cdot/provdrs/street/svcs/green_alleys.html

Milwaukee's Menomonee River Valley Industrial Site

<http://city.milwaukee.gov/AreaPlans/MenomoneeValley.htm#.Vgwt1E1FCJB>

Baltimore's National Aquarium

<http://www.aqua.org/care/conservation-initiatives/floating-wetland-island>

Seattle's Street Edge Alternatives (SEA Streets)

<http://www.seattle.gov/util/EnvironmentConservation/Projects/GreenStormwaterInfrastructure/CompletedGSIPProjects/StreetEdgeAlternatives/index.htm>

Portland's Grey to Green Program

<http://www.portlandoregon.gov/bes/47203>

New York's Green Infrastructure Program

http://www.nyc.gov/html/dep/html/stormwater/using_green_infra_to_manage_stormwater.shtml

http://water.epa.gov/infrastructure/greeninfrastructure/upload/Greening_CSO_Plans.PDF

http://www2.epa.gov/sites/production/files/2015-04/documents/green_infrastructure-om_report.pdf

http://www.cnt.org/sites/default/files/publications/CNT_Value-of-Green-Infrastructure.pdf

<http://www.cityofchicago.org/content/dam/city/progs/env/ChicagoGreenStormwaterInfrastructureStrategy.pdf>

CITY OF LAKEWOOD

GREEN AND GREY INFRASTRUCTURE CONTROL STRATEGIES

TOOL BOX

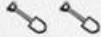
CLEAN WATER
LAKEWOOD



Rebuilding the Pipeline for Our Future

October 2015

Green Infrastructure Control Strategies

Stormwater Control Strategy	Relative Cost	Pros/Cons	Life Cycle/Maintenance
 Rain gardens/Bioretentation	\$ - \$\$\$	- Increased risk of groundwater pollution if there is not adequate separation between bioretention facilities and groundwater table; - High groundwater may impede proper functioning; + Good for areas less than 2 acres, various land areas; + Reduces temperature, suspended solids, metals; - Requires ongoing maintenance.	
 Street Planters	\$\$ - \$\$\$	+ Reduced runoff/volume, pollutants, water temperatures; - Need adequate separation from groundwater table; + Can be used in sidewalks, curbside, and within roads in urban areas; + Runoff conveyed by sheet flow or curb cuts; - Requires regular maintenance and trash removal; - Utility interferences could impact cost.	
 Pervious Pavement	\$\$\$	- Should not be used in areas of potential groundwater contamination; + Reduces suspended solids; + Reduces runoff volumes; + Filters solids and removes them in the sub-pavement layers; + Buffers water temperatures; + Reduces use of winter salt applications.	

\$ - Least expensive to \$\$\$\$ very expensive

 - Least maintenance to
 


 most maintenance

"+" - Considered to be a "pro" for this Control Strategy

"-" - Considered to be a "con" for this Control Strategy

Green Infrastructure Control Strategies

Stormwater Control Strategy	Relative Cost	Pros/Cons	Life Cycle/Maintenance
 Sand/Infiltration Filter	\$	+ Water flows through sand or gravel and either into groundwater or a pipe, or into storage; - Needs frequent maintenance depending on location; + Useful on smaller sites; - Prone to sediment clogging.	
 Tree Planting	\$	+ Intercepts rainfall, helps increase infiltration and ability of soil to store water; + Provides shade, reduces wind speed; + Releases water into atmosphere; + Absorbs air pollutants, reduces energy consumption; - Poorly chosen trees can affect powerlines, broken limbs incurs clean-up costs, requires maintenance; - Leaves need to be cleaned up to prevent storm sewer clogging.	
 Downspout Disconnect	\$	+ Reduces stormwater in the sewer system; + Minimal maintenance and cost; - Need positive drainage around the downspout discharge to ensure stormwater does not pool; - Policies and controls need to be in place and implemented to ensure compliance.	

\$ - Least expensive to \$\$\$\$ very expensive

 - Least maintenance to
 


 most maintenance

"+" - Considered to be a "pro" for this Control Strategy

"-" - Considered to be a "con" for this Control Strategy

Green Infrastructure Control Strategies

Stormwater Control Strategy	Relative Cost	Pros/Cons	Life Cycle/Maintenance
 Green Roofs	\$\$\$\$	+ Stores large amounts of water in growing media; + Reduces amount of solar radiation; + Reduces roof surface temperature; - Limited amount of plant choices; - Greater weight on roof; - Need for irrigation and drainage system requiring energy, water, materials; - Higher capital and maintenance cost;	
 Blue Roofs	\$\$\$\$	+ Non-vegetated detention systems placed on roofs that capture and temporarily store rainwater, slowly releasing to the sewer system; + Provides for evaporation; + Less costly than green roofs; - Greater weight on roof.	
 Rain Harvesting	\$\$	+ Reduces stormwater runoff by capturing rainfall where it lands—reduces flooding and erosion; + Reduce water treatment needs—reduces irrigation costs; + Used for non-drinking purposes; + Easy to maintain; - Unpredictable rainfall levels; - Initial moderate cost; - Roofs may seep chemicals into water;	

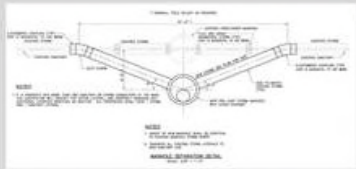
\$ - Least expensive to \$\$\$\$ very expensive

 - Least maintenance to
     most maintenance

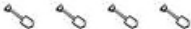
"+" - Considered to be a "pro" for this Control Strategy

"-" - Considered to be a "con" for this Control Strategy

Grey Infrastructure Control Strategies

Stormwater Control Strategy	Relative Cost	Pros/Cons	Life Cycle/Maintenance
 Sewer Separation	\$\$\$	+ Reduction in basement and street flooding; + Reduction in CSO and resulting biological impacts to receiving waters; + Possible cost savings related to incidental infrastructure upgrades performed under the same project; - Extensive construction impacts.	
 Storage Tunnels	\$\$\$\$	+ Existing sewer system can remain in place; + Effective CSO reduction without increases to stormwater discharges; - High initial cost for construction; - Moderate to high construction impacts depending on the location; - On-going cost of maintaining the pumping station, cleaning, maintaining volume; - Fixed volume can be regularly exceeded.	
 Source Control	\$\$	+ Relatively inexpensive, though costs can vary widely; + Can reduce the likelihood of sewer backup into structures; + Multiple solutions and technologies available from which to choose; - Can be intrusive on private property owners; - Can reduce the level of service of storm sewers.	

\$ - Least expensive to \$\$\$\$ very expensive

 - Least maintenance to
  most maintenance

"+" - Considered to be a "pro" for this Control Strategy

"-" - Considered to be a "con" for this Control Strategy

Grey Infrastructure Control Strategies

Stormwater Control Strategy	Relative Cost	Pros/Cons	Life Cycle/Maintenance
 High Rate Treatment	\$\$\$	+ Small footprint requires reduced space; + Competitively low cost when compared to WWTP upgrades; - Does not treat all nutrients; - Requires trained personnel to run and maintain with an increased cost to the City.	
 Waste Water Treatment Plant Up-grades	\$\$\$\$	- Costs vary, but are relatively high for any infrastructure improvement; - Space requirements may be substantial. + Nutrient treatment; + High pollutant removal.	

\$ - Least expensive to \$\$\$\$ very expensive

 - Least maintenance to
 


 most maintenance

"+" - Considered to be a "pro" for this Control Strategy

"-" - Considered to be a "con" for this Control Strategy



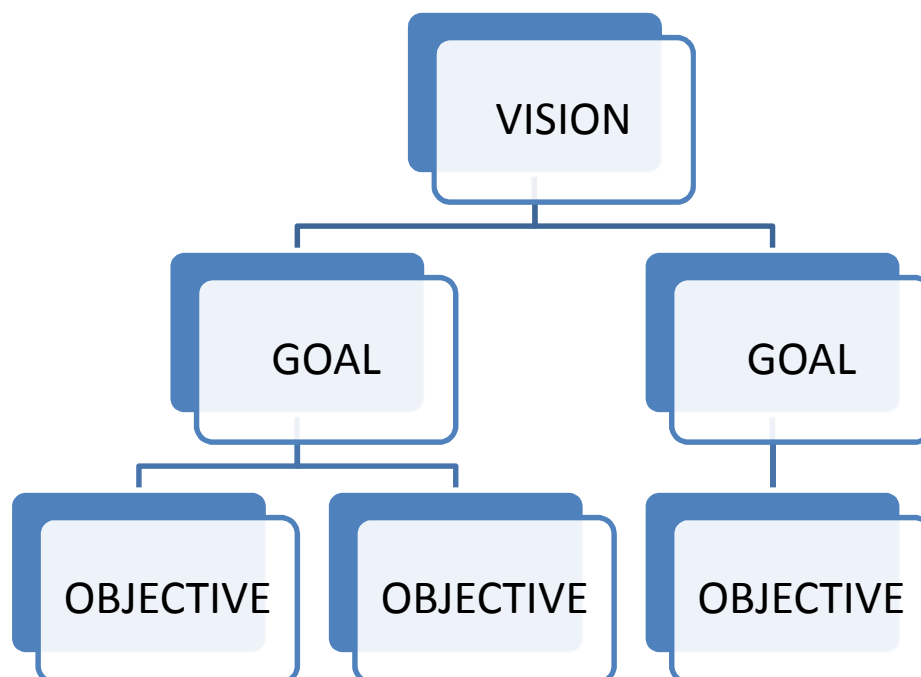
Working Group Meeting #6
November 17, 2015

Discussion: Integrated Planning Process and Lakewood's Vision for the Future

Refresher Question: What does Integrated Planning Framework mean?

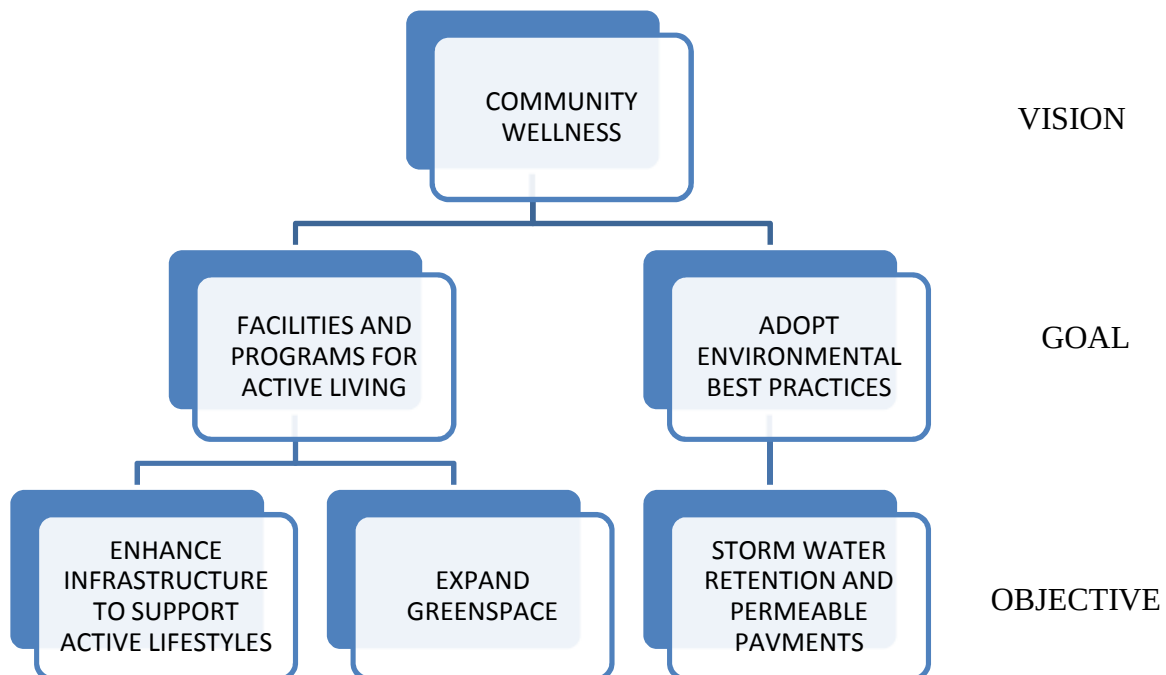
Goal of today's meeting: For small teams to look at a specific area of Lakewood and apply the Integrated Planning process to determine what they think might work best in terms of green and grey infrastructure.

The Planning Process



Lakewood Community Vision – a Picture of the Future

The City recently undertook a community planning process that resulted in the adoption of Lakewood Community Vision. This document is a picture of the desired future for the City of Lakewood in six areas: Commercial Development, Community Wellness, Education & Culture, Housing, Mobility and Safety. This Stakeholders Group will use the objectives for Community Wellness identified by the Lakewood community to help frame the strategies that will be tested as part of the IWWIP. Below is that portion of the Community Vision organized in a hierarchy chart representing Vision, Goal and Objective.



Please see the City website for a look at the entire visioning documents:
<http://www.onelakewood.com/search/?k=vision+for+the+future>

IWWIP – Planning for Sustainability

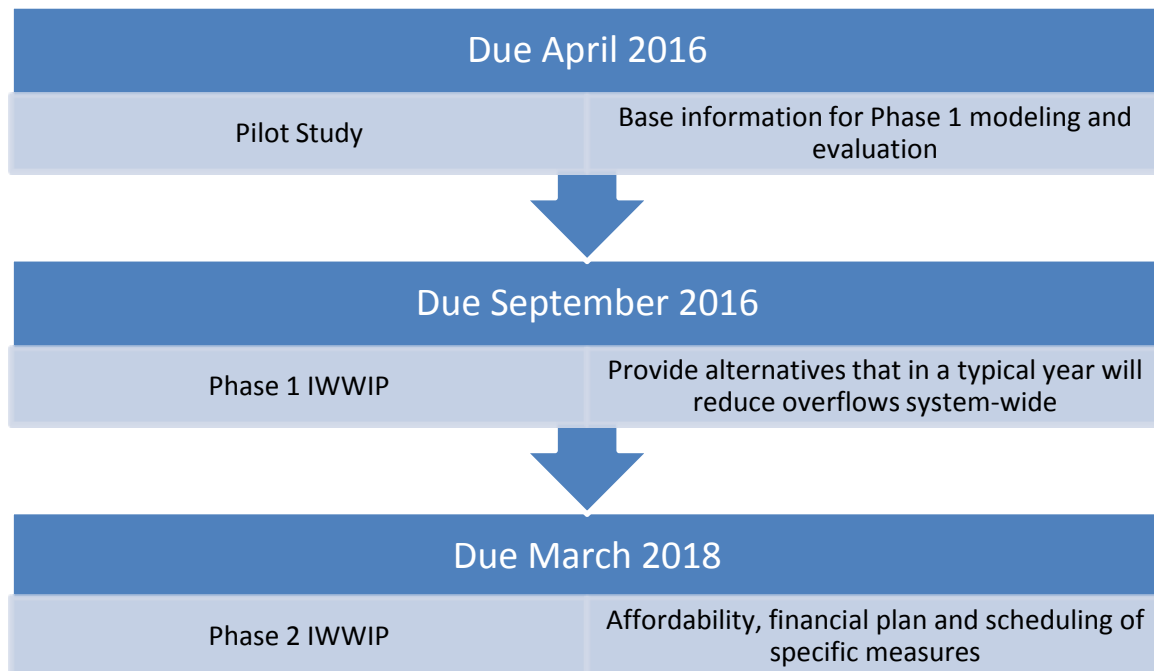
In October 2011, EPA’s Office of Water (OW) and Office of Enforcement and Compliance Assurance (OECA) issued a joint memo encouraging EPA Regions to assist their state and local partners in pursuing an integrated planning approach to Clean Water Act (CWA) waste and stormwater obligations. The memo identifies green infrastructure as one comprehensive solution that can improve water quality and provide other benefits that enhance the vitality of communities. Please take the time to visit the EPA website:.

<http://www2.epa.gov/green-infrastructure/integrating-green-infrastructure-federal-regulatory-programs>



Summary Timeline

Below is a summary timeline of the specific IWWIP requirements in Lakewood's permit.



EPA Supports Integrated Planning and Green Infrastructure

The overarching goal for the IWWIP is CSO reduction. But integrated planning allows us to look at options beyond just single purpose projects/solutions. Also, green infrastructure practices, in conjunction with grey infrastructure practices, have been evaluated as being more cost-effective than grey infrastructure practices alone. Green infrastructure also delivers other environmental, social and economic benefits.

Deciding How to Use GI in CSO Plans – Factors to Consider

Any proposal for the incorporation of green infrastructure into a Long Term Control Plan (LTCP) should include, at a minimum, robust analyses in the following two areas:

1. **Community and Institutional Support for Green Infrastructure** The municipality or sewer authority responsible for implementing the LTCP should solicit initial buy-in from the community and relevant governmental entities.
2. **Realistic Potential for Green Infrastructure Implementation** The municipality or sewer authority responsible for implementing the LTCP should adequately investigate local factors that may limit the implementation of green infrastructure, including physical factors (e.g. soils, topography and land availability), regulatory factors (e.g. codes and ordinances), and social and institutional factors.

Factors to consider when evaluating the degree of green infrastructure implementation potential within a catchment should minimally include:

Soil characteristics. Many green infrastructure practices rely on infiltration as a means of stormwater dissipation. Areas with very tight soils (e.g., clay soils not conducive to infiltration of

water) will reduce the infiltration potential of many green infrastructure measures. In some situations it may be appropriate to amend soils to enhance storage and infiltration, and to promote plant growth.

Land Use and Ownership. Since impervious cover tends to vary across land use type, parcel-level land use data can help estimate green infrastructure potential. Detailed land use data can also determine what types of green infrastructure approaches are most appropriate for a given catchment.

Local Buy-in. Will landowners be receptive or resistant to green infrastructure practices in the neighborhood or on their property? Drawing on the knowledge and experience of community leaders, as well as key groups such as home owner associations, land trusts, etc., will help inform outreach strategies.

Topography. Green infrastructure practices should ideally be located on slopes of less than 5%. GIS software can help identify and map steeper slopes, as well as areas with low infiltration potential (i.e., poorly drained soils).

Financing and Institutional Factors. What incentives would effectively encourage property owners to construct and maintain green infrastructure practices? Do codes and ordinances require green practices at existing sites or redevelopment sites?

Redevelopment Rate. Some localities require new and re-development to meet onsite retention standards. If this is the case, the CSO authority may use redevelopment rates to predict degree of new green infrastructure installation over time. If mandatory requirements do not exist, communities may consider incentives that encourage developers to install green infrastructure.

Green Infrastructure on Private Property. Privately-owned properties such as corporate campuses or shopping malls can be good locations for green infrastructure practices in terms of the availability of space and/or the location in a sewer shed. However, implementing green infrastructure on private property as part of a CSO control plan presents special challenges. Questions can arise as to who is responsible for maintenance, as well as whether the sewer authority has the right to come onto the property for inspections or maintenance.



April 19, 2016

Modeling Results and Discussion

Goal of meeting: to review public preferences and report on modeling results

Summary of previous meetings: Since December we have been meeting in small groups to solicit public preferences and to share the results. At this meeting each group will share their results and understanding with the larger Clean Water Lakewood group.

Study Areas and Preferences

<u>Larchmont, between Detroit and Madison</u> ● permeable pavement on sidewalks and driveway aprons ● bioretention in tree lawns ● south-end of Larchmont rerouted to Franklin sewers	<u>Lake, between Homewood and Estill</u> ● permeable pavement on sidewalk ● bioretention in tree lawns ● downspout disconnection ● detention basin (now replaced with a storm sewer bypassing a combined sewer)
<u>Birdtown: Madison to the north, Plover to the south, Halstead to the east and Magee to the west</u> ● bioretention on vacant lots, at the school, as bumpouts, in tree lawns, including area west of Birdtown ● green roof garages ● permeable pavement at Madison Park ● sewer separation ● routing flow to NEORSD or a detention basin ● 24" combined relief pipe at pinch point on Madison	<u>Parkwood, between Detroit and Madison</u> ● downspout disconnection ● public and private infiltration and inflow improvements such as relining or replacing laterals and public sewer, new manholes to bypass over/under access plates ● upsizing Detroit Ave sanitary sewer to 4 ft diameter (currently 1 ft) ● upsizing Detroit and Nicholson sanitary sewer to 4 ft (currently 1 ft)

Currently in a typical year of rainfall there is the following number of overflow events in each of the study areas:

Study Area	# of overflows
Larchmont	14
Lake	9
Birdtown	103
Parkwood	64

Remember, to meet EPA CSO Policy there can be no more than 4 overflow events in a typical year.

Larchmont Results

Model	*Estimated # of overflows	*Estimated total volume released in overflow (MG)	†Estimated # of overflows including Detroit sewer at full capacity	†Estimated total volume released in overflow (MG)
Existing conditions	2	0.101	14	0.96
With permeable pavement on sidewalk and driveway aprons	0	0	5	0.281
Bioretention in tree lawns or as bump-outs	2	0.007	4	0.309
Both permeable pavement <u>and</u> bioretention	0	0	4	0.052
Redirecting South end of Larchmont to Franklin	0	0	9	0.520

*The two columns highlighted in grey are only including water coming off of Larchmont Ave.

†The two columns highlighted in blue account for the sanitary sewer on Detroit Ave being at full capacity, as it currently is during rain events.

Interpreting results

- The overflows from Larchmont can be brought into compliance or eliminated based on the green infrastructure this group suggested, when the Detroit sewer is not taken into account.
- When Detroit sewer is taken into account the model suggests using both permeable pavement and bioretention should result in 4 overflows per year.
 - It is likely that the Detroit sewer would not be at full capacity if substantial areas of green infrastructure were installed upstream of where Larchmont intersects Detroit.

Lake Avenue Modeling Results

Model	Estimated # of overflows	Estimated total volume released in overflow (MG)
Existing conditions model	9	2.293 (mostly storm flow)
Existing conditions with storm bypass	2	0.092 (combined flow)
Permeable pavement on sidewalk with underground storage, with storm bypass	0	0
Bioretention in tree lawns, with storm bypass	0	0
Both permeable pavement <u>and</u> bioretention, with storm bypass	0	0

Interpreting results

- To meet the EPA standards you can have no more than 4 overflow events during a typical year.
- Under existing conditions without the stormwater bypass there are 9 overflows a year.
- The overflows from Lake Ave can be brought into compliance with the stormwater bypass. The green infrastructure reduces overflows beyond what is required by federal policy.
- If you did not have the stormwater bypass, and only green infrastructure, the model predicts 7-8 overflows per year, which is not in compliance with federal policy.
- The existing conditions model does not contain the detail necessary to confirm which downspouts are connected and/or plugged since comprehensive field studies have not been conducted in this area. On-going construction efforts in other locations in Lakewood have shown storm downspouts and/or laterals to be blocked by debris. Once a blockage is in place, the system typically will:
 - Release flow to the public sewers more slowly
 - Potentially back up/overflow on to pervious/impervious areas around the house as if the downspout were splash disconnected. If the downspouts were cleaned and remain connected to the sanitary sewer it is possible that an increase in the number of overflow events would occur.
 - If downspouts were cleaned and connected it is expected to result in an increase in the number of overflow events.

Birdtown Modeling Results

Model	Estimated # of overflows at Elbur and Madison	Estimated total volume released at Elbur and Madison (MG)	Estimated total volume released at Madison and W117 th
Existing conditions	103	54.3	312.9
Bioretention at school	103	54.3	312.3
Bioretention on vacant lots	103	54.3	312.2
Curbside bioretention	103	54.3	306.5
Fire hydrant bump-out bioretention	103	54.3	312.3
Green roof garages	103	54.3	300.0
Permeable pavement at Madison Park	103	54.3	312.1
Green Infrastructure composite run (not including GI west of Birdtown)	103	54.3	292.0
Sewer separation	103	54.3	260.7
Curbside bioretention west of Birdtown	99	46.1	302.9
Additional 24" combined pipe on Madison	70	26.8	339.8
Combination of above 2 runs	18	4.1	345.2

Model	Estimated # of overflows at 059	Total volume released at 059 during wet weather events (MG)
Existing conditions	61	57.9
Diverting to NEORSD	4	0.8
15 MG detention basin in Gold Coast	4	1.1

Interpreting results

- Green infrastructure in Birdtown does not reduce the number of overflows or the volume of water at the intersection of Elbur and Madison.
 - This is due to the layout of the system, including some bottle necks, and the fact that there is already a large volume of water in the system upstream of Birdtown.
 - Model shows green infrastructure can reduce volume of water entering 117th at Madison from 312.9 MG (existing conditions) to 292.0 MG (composite run), which is a 6.7% difference.
- The combination of implementing curbside bioretention upstream of Elbur and Lewis overflows, as well as adding a 24 inch pipe to reduce a bottleneck on Madison, significantly reduces overflows, although it still results in greater than 4 overflows per year.
- Overflow 059 is in compliance (≤ 4 overflows per year) in the following two scenarios:

- o Diverting 117th flows to NEORSD. This includes flows East of Lewis and south of Edgewater.
- o Creating a 15 MG detention basin, 2.5 acre footprint, and has a 25 MGD pump station. This would need to be placed in the Gold Coast area.

Parkwood Results

Model	Sanitary Sewer Peak Flow (MGD)	Sanitary Flow as % of Sanitary Sewer Capacity*	Storm Sewer Peak Flow (MGD)	Storm Flow as % of Storm Sewer Capacity*
Existing conditions	0.75	96%	6.6	97%
Disconnected downspouts	0.70	89%	7.3	107%
Public & private sewer improvements: downspout disconnection, lateral lining, manhole separation, public sewer repair	0.14	18%	8.2	120%

*percentage representative of largest storm event in a typical year

Model	Number of Overflow Events	Total Volume of Overflows (MG)
Existing Conditions	64	7.32
Detroit & Nicholson 4 ft. diameter sanitary sewer	0	0

Interpreting results

- When sanitary flow decreases, storm flow increases due to that water now being directed or indirectly connected to storm sewers.
 - o It would be recommended that homeowners have sump pumps installed to prevent basement flooding when storm sewer surcharges.
- Upsizing Detroit and Nicholson sanitary sewers has the greatest impact at reducing overflows at Detroit and Parkwood but:
 - o There are still many overflows occurring up and downstream of this site, even with the increased diameter pipe.
 - o The sewage conveyed by the 4 ft. will likely overflow at CSO 059A (Nicholson and Edgewater) resulting in a net overflow reduction of zero.
- If the public and private sewer improvements are applied to Blossom Park, Bunts, Elbur, Lewis, Chesterfield, and Waterbury and the green infrastructure initiatives from the Larchmont study group are applied to Robinwood, Wyandotte, Clarence and Grace, modeling should show the 7 overflows along Detroit Avenue in CSO Area 059A would be deactivated in a typical year.

- The existing conditions model does not contain the detail necessary to confirm which downspouts are connected and/or plugged since comprehensive field studies have not been conducted in this area. On-going construction efforts in other locations in Lakewood have shown storm downspouts and/or laterals to be blocked by debris. Once a blockage is in place, the system typically will:
 - Release flow to the public sewers more slowly
 - Potentially back up/overflow on to pervious/impervious areas around the house as if the downspout were splash disconnected. If the downspouts were cleaned and remain connected to the sanitary sewer it is possible that an increase in the number of overflow events would occur.

Background information on modeling

A master model of all sanitary and storm sewers in the City of Lakewood was created in 2014, and is currently used to help report expected overflows to the Ohio EPA. In order to evaluate the green infrastructure ideas brought up by this group, a series of models were developed for comparison purposes. These models needed to be calibrated against our larger city-wide model, to ensure that the results are reliable.

A “typical year” of rainfall is what was used in this modeling exercise. A typical year of rain was created by averaging rain intensity and frequency data from 1973-2006 collected at the Cleveland Hopkins International Airport.

It is important to remember that the results produced from this modeling study are not intended to be exact. The results should be used to identify if the suggested approaches are practical and the approximate levels of overflow improvements that might be expected.

CLEAN WATER LAKEWOOD



Rebuilding the Pipeline for Our Future

April 19th, 2016

Anonymous Survey

Thank you for your engagement on this important topic to Lakewood. We are interested in your feedback to guide us in the future.

1. What stormwater and overflow problems were you aware of prior to our meetings?

I was aware of CSO's and stormwater runoff quality and quantity issues.

2. With the knowledge provided by this group have your views changed on how to solve this problem, if so, how?

To some degree, I am more aware of the public resistance to certain remedies as well as more acceptance of others.

3. What needs to be communicated to the Lakewood community on this topic?

That there are critical issues that do matter to all of us. Issues that impact the pocketbook which is the point at which the majority of people become engaged.

4. What would like more information on?

5. Feedback on what you liked about the public input process, and what you think could be improved upon:

Stuart Bayler

CLEAN WATER LAKEWOOD



Rebuilding the Pipeline for Our Future

April 19th, 2016

Anonymous Survey

Thank you for your engagement on this important topic to Lakewood. We are interested in your feedback to guide us in the future.

1. What stormwater and overflow problems were you aware of prior to our meetings?

GENERAL KNOWLEDGE OF CSO ISSUES

2. With the knowledge provided by this group have your views changed on how to solve this problem, if so, how?

USE OF HRT. - FIRST TIME I HEARD OF THIS.

3. What needs to be communicated to the Lakewood community on this topic?

OVERVIEW OF MAGNITUDE OF THE PROBLEM
OF CSOs THAT THE CITY HAS
MAGNITUDE OF PROBLEM CAUSED BY
IMPROPER STORM/DOWNSPOT CONNECTION.

4. What would like more information on?

WHAT SERVICES THE CITY PROVIDES TO
TEST LATERALS

5. Feedback on what you liked about the public input process, and what you think could be improved upon:

GREATLY APPRECIATED OPPORTUNITY TO
PROVIDE INPUT.

CLEAN WATER LAKEWOOD



Rebuilding the Pipeline for Our Future

April 19th, 2016

Anonymous Survey

Thank you for your engagement on this important topic to Lakewood. We are interested in your feedback to guide us in the future.

1. What stormwater and overflow problems were you aware of prior to our meetings?
ALL OF THEM
 1. BASEMENT FLOODING
 2. CSO'S
 3. WWTP OPERATIONS
2. With the knowledge provided by this group have your views changed on how to solve this problem, if so, how?
 1. FOCUS ON GREEN INFRASTRUCTURE TO REDUCE STORM INFLOW
 2. DIVERSITY OF OPINION ON HOW PRIVATE OWNERS CAN BE INFLUENTIAL IN ~~THE SOLUTION~~ SELECTING PRACTICES
3. What needs to be communicated to the Lakewood community on this topic?
 1. THE SERIOUSNESS OF MAKING PROGRESS ON CSO REDUCTION AND ITS COSTS
 2. THE RELATIONSHIP TO BASEMENT FLOODING REDUCTION
4. What would like more information on?
BASEMENT FLOODING SOLUTIONS
5. Feedback on what you liked about the public input process, and what you think could be improved upon:
IT WAS GREAT TO HEAR THE OPINIONS OF FELLOW RESIDENTS FROM THEIR DIVERGE PERSPECTIVES

CLEAN WATER
LAKEWOOD



Rebuilding the Pipeline for Our Future

April 19th, 2016

Anonymous Survey

Thank you for your engagement on this important topic to Lakewood. We are interested in your feedback to guide us in the future.

1. What stormwater and overflow problems were you aware of prior to our meetings?

I was aware of issues in Cleveland and at the beaches (Edgewater & Euclid Beach)

2. With the knowledge provided by this group have your views changed on how to solve this problem, if so, how?

I better understand Lakewood specific issues.

3. What needs to be communicated to the Lakewood community on this topic?

Where the overflows are and what is contributing to them. Explain how every property contributes to this issue and explain how individuals can help

4. What would like more information on?

Issues on my street or neighborhood.

5. Feedback on what you liked about the public input process, and what you think could be improved upon:

I enjoyed the tours. More information on green infrastructure effectiveness with cost estimates, this helps to make it more realistic.

CLEAN WATER LAKEWOOD



Rebuilding the Pipeline for Our Future

April 19th, 2016

GLENN COYNE

Anonymous Survey

Thank you for your engagement on this important topic to Lakewood. We are interested in your feedback to guide us in the future.

1. What stormwater and overflow problems were you aware of prior to our meetings?

HAD GENERAL KNOWLEDGE, BUT NOT MUCH LAKEWOOD SPECIFICS. AWARE OF SOME BASEMENT FLOODING AND OVERFLOWS INTO LAKE ERIE DURING STORMS.

2. With the knowledge provided by this group have your views changed on how to solve this problem, if so, how?

INCREMENTAL, SMALL STEPS AT SOURCE COULD LEAD TO LARGE RESULTS DOWNSTREAM. ALSO, THIS IS A LONG TERM, MULTI-YEAR SOLUTION. THIS IS BEGINNING OF A LONG PROCESS...

3. What needs to be communicated to the Lakewood community on this topic?

WE ARE ALL IN THIS TOGETHER. WATER IS AN IMPORTANT RESOURCE BUT WE NEED TO BETTER MANAGE OUR STORMWATER. NOBODY "FESSED-UP" - THE TECHNOLOGY (I.E. COMBINED SEWERS) WAS STATE OF THE ART 80 YEARS AGO, BUT NOT NOW!

4. What would like more information on?

I THINK SOME AERIAL VIDEOS ^{AND} /OR VERY CLEAR PHOTOS IN LAKEWOOD WOULD HELP WITH EDUCATION OF GENERAL PUBLIC. WHAT IS REALLY UNDERGROUND?

5. Feedback on what you liked about the public input process, and what you think could be improved upon:

CLEAN WATER
LAKEWOOD



Rebuilding the Pipeline for Our Future

April 19th, 2016

Anonymous Survey

Thank you for your engagement on this important topic to Lakewood. We are interested in your feedback to guide us in the future.

1. What stormwater and overflow problems were you aware of prior to our meetings?

I was aware of the problems having addressed them at our house years ago.

2. With the knowledge provided by this group have your views changed on how to solve this problem, if so, how?

The permeable pavement idea was new + the extent of the CSO problem was a big surprise

3. What needs to be communicated to the Lakewood community on this topic?

The EPA's mandate about this problem + the extent of the co-mingling of storm/sanitary should be promulgated

4. What would like more information on?

Types of permeable pavers — none seem ideal.

5. Feedback on what you liked about the public input process, and what you think could be improved upon:

The information should be shared w all residents — it is a city-wide problem

CLEAN WATER LAKEWOOD



Rebuilding the Pipeline for Our Future

April 19th, 2016

Anonymous Survey

Thank you for your engagement on this important topic to Lakewood. We are interested in your feedback to guide us in the future.

1. What stormwater and overflow problems were you aware of prior to our meetings?
 - BASEMENT FLOODING
 - COMBINED SEWER ISSUE

2. With the knowledge provided by this group have your views changed on how to solve this problem, if so, how?
 - MANY SOLUTIONS OR POSSIBLE SOLUTIONS BUT NO CLEAR ANSWER -
 - STILL BELIEVE GREY SOLUTIONS BEST

3. What needs to be communicated to the Lakewood community on this topic?
 - EVERYONE SHOULD DO SOMETHING TO CONTRIBUTE TO SOLUTION

4. What would like more information on?
 - COST OF ALTERNATIVES

5. Feedback on what you liked about the public input process, and what you think could be improved upon:

CLEAN WATER LAKEWOOD



Rebuilding the Pipeline for Our Future

April 19th, 2016

Anonymous Survey

Thank you for your engagement on this important topic to Lakewood. We are interested in your feedback to guide us in the future.

1. What stormwater and overflow problems were you aware of prior to our meetings?

Combined sewer issues, CSO issues concerning outflow to the lake.

2. With the knowledge provided by this group have your views changed on how to solve this problem, if so, how?

Yes! Have acquired a full understanding of our clean/waste water infrastructure & how suggested/proposed changes can positively impact the entire system.

3. What needs to be communicated to the Lakewood community on this topic?

The uniqueness of each neighborhoods' water challenges & emphasis on incremental changes, when applied city-wide, having significant impact.

4. What would like more information on?

N/A

5. Feedback on what you liked about the public input process, and what you think could be improved upon:

Enjoyed the interaction, the challenge presented of the varied experience & expertise of my fellow panelists.

CLEAN WATER LAKEWOOD



Rebuilding the Pipeline for Our Future

April 19th, 2016

Anonymous Survey

Thank you for your engagement on this important topic to Lakewood. We are interested in your feedback to guide us in the future.

1. What stormwater and overflow problems were you aware of prior to our meetings?

AWARE OF BY PASSING WATER INTO LAKE

2. With the knowledge provided by this group have your views changed on how to solve this problem, if so, how?

VERY DEPRESSING, VERY DIFFICULT PROBLEM FOR CITY OF LAKEWOOD

3. What needs to be communicated to the Lakewood community on this topic?

MOST RESIDENTS ARE MOSTLY CONCERNED WITH THEIR COST. THE CHEAPEST, EASIEST SOLUTION WOULD BE THE MOST POPULAR EVEN IF IT DIDN'T SOLVE ALL 100% OF PROBLEM

4. What would like more information on?

NOT THE FINE DETAIL ON ECONOMICS OF IT, TOO DEPRESSING, AN UPDATE ON HOW SUCCESSFUL PILOT PROGRAM IS GOING

5. Feedback on what you liked about the public input process, and what you think could be improved upon:

VERY CREATIVE & INNOVATIVE, THE MORE INPUT BY THE MOST PEOPLE BY PUBLIC EDUCATION THE BETTER

John Robinson

CLEAN WATER LAKEWOOD



Rebuilding the Pipeline for Our Future

April 19th, 2016

Anonymous Survey

Thank you for your engagement on this important topic to Lakewood. We are interested in your feedback to guide us in the future.

1. What stormwater and overflow problems were you aware of prior to our meetings?

As a homeowner w/ flooding basement issues, I came into this committee w/ a pretty strong background in Lakewood's CSO problems.

2. With the knowledge provided by this group have your views changed on how to solve this problem, if so, how?

I am now able to see this issue ^{from} ~~as~~ a more public vantage. The problems are much more global than I realized.

3. What needs to be communicated to the Lakewood community on this topic?

Disconnecting downspouts needs to be shouted from the rooftops.

4. What would like more information on?

5. Feedback on what you liked about the public input process, and what you think could be improved upon:

I felt a bit ~~behind~~ behind the curve with the common use of acronyms. I didn't always comprehend what was being said without using a glossary.

CLEAN WATER LAKEWOOD



Rebuilding the Pipeline for Our Future

April 19th, 2016

Anonymous Survey

Thank you for your engagement on this important topic to Lakewood. We are interested in your feedback to guide us in the future.

1. What stormwater and overflow problems were you aware of prior to our meetings?

CSDs & Stormwater in general - Not Lakewood's System

2. With the knowledge provided by this group have your views changed on how to solve this problem, if so, how?

Lakewood is complex & whole system needs work!

3. What needs to be communicated to the Lakewood community on this topic?

The city is investing and Everyone is going to be accountable (including HRT area, Clifton Park)

4. What would like more information on?

How much capacity would be available if "brown" area also was held accountable for private I/I!
I don't think they should get off with HRT when it could benefit the whole upstream system.

5. Feedback on what you liked about the public input process, and what you think could be improved upon:

Process was very general, didn't get specific until very end & there was not time to digest & comment on overall recommendations.

CLEAN WATER LAKEWOOD



Rebuilding the Pipeline for Our Future

April 19th, 2016

Anonymous Survey

Thank you for your engagement on this important topic to Lakewood. We are interested in your feedback to guide us in the future.

1. What stormwater and overflow problems were you aware of prior to our meetings?

environmental issues from CSOs

2. With the knowledge provided by this group have your views changed on how to solve this problem, if so, how?

the complexity of Lakewood's sewer system.

3. What needs to be communicated to the Lakewood community on this topic?

can't help re that issue.

- ① Source control will definitely be a contentious issue.
- ② Provided color w/ suggestions regarding updating
- ③ Clean H₂O Lkwd webpage. Plan on writing articles in Lkwd Observer.
- ④ Signage for homes that use green infrastructure

4. What would like more information on? - would like to see what plan is submitted to EPA/OEPA.

- Response fm EPA/OEPA

- Are we part of Phase II? would like to be part of future groups Connie 216 402 6174.

5. Feedback on what you liked about the public input process, and what you think could be improved upon: excellent process.

CLEAN WATER LAKEWOOD



Rebuilding the Pipeline for Our Future

April 19th, 2016

Anonymous Survey

Thank you for your engagement on this important topic to Lakewood. We are interested in your feedback to guide us in the future.

1. What stormwater and overflow problems were you aware of prior to our meetings?

That Lakewood has sewer problems causing numerous basement floods during heavy rains

2. With the knowledge provided by this group have your views changed on how to solve this problem, if so, how?

The solutions to the problem in the 1st question are not only expensive, but also complex

3. What needs to be communicated to the Lakewood community on this topic?

Our sewer problem is multifaceted and the solution is not simple. It is costly, complicated and needs to be integrated vs. patched together

4. What would like more information on?

More history on what's been done in this area in the last 5 years & what is expected to be done in next 10,

5. Feedback on what you liked about the public input process, and what you think could be improved upon:

More education on terminology upfront. As a non-engineer, I felt less able to provide intelligent input to solutions.

CLEAN WATER LAKEWOOD



Rebuilding the Pipeline for Our Future

April 19th, 2016

Anonymous Survey

Thank you for your engagement on this important topic to Lakewood. We are interested in your feedback to guide us in the future.

1. What stormwater and overflow problems were you aware of prior to our meetings?

I was aware of the storm/sanitary combination and outflow to Lake Erie, first hand experience as I kayaked on the Lake during a very heavy rain for 15 minutes within 10 minutes the outflows opened up and spilled into the lake as enormous water falls. I continued to paddle along the brown/green water line, keeping out of the brown.

2. With the knowledge provided by this group have your views changed on how to solve this problem, if so, how?

Yes... at least in Birdtown it appears that green infrastructure does not have much of an impact. In this area large volume bio-retention is the only solution.

3. What needs to be communicated to the Lakewood community on this topic?

The complexity of the existing infrastructure. Perhaps a 3D model showing the impact of a rain event ... even if it was a small area of the City.

4. What would like more information on?

5. Feedback on what you liked about the public input process, and what you think could be improved upon:

Perhaps several opportunities to break out and discuss individual solutions with the modeling power/abilities of CI.

CLEAN WATER LAKEWOOD



Rebuilding the Pipeline for Our Future

April 19th, 2016

Anonymous Survey

Thank you for your engagement on this important topic to Lakewood. We are interested in your feedback to guide us in the future.

1. What stormwater and overflow problems were you aware of prior to our meetings?

Storm water infiltration.

2. With the knowledge provided by this group have your views changed on how to solve this problem, if so, how?

Yes, fixing cross connections will not solve problem with combined sewers.

3. What needs to be communicated to the Lakewood community on this topic?

The cost to come into compliance.

4. What would like more information on?

5. Feedback on what you liked about the public input process, and what you think could be improved upon:

Maybe a video of the work in test area could be made.

CLEAN WATER LAKEWOOD



Rebuilding the Pipeline for Our Future

April 19th, 2016

Anonymous Survey

Thank you for your engagement on this important topic to Lakewood. We are interested in your feedback to guide us in the future.

1. What stormwater and overflow problems were you aware of prior to our meetings?
I was aware Lakewood had some overflow problems. I've known several people that have had flooded basements in Lakewood.
2. With the knowledge provided by this group have your views changed on how to solve this problem, if so, how? *I learned there is no one solution. This problem will need to implement many innovative approaches.*
3. What needs to be communicated to the Lakewood community on this topic?
Explain the old sewers are not designed for the current high volume of people/water use. This problem is NOT going away. It will need to be addressed by us or our children, or our children's children.
4. What would like more information on?
Community outreach projects. Educational events, related to this topic.
5. Feedback on what you liked about the public input process, and what you think could be improved upon:
I enjoyed this process. Maybe a online chat group or group page we could use to communicate with the group.

CLEAN WATER LAKEWOOD



Rebuilding the Pipeline for Our Future

April 19th, 2016

Anonymous Survey

Thank you for your engagement on this important topic to Lakewood. We are interested in your feedback to guide us in the future.

1. What stormwater and overflow problems were you aware of prior to our meetings?

I was not aware of any.

2. With the knowledge provided by this group have your views changed on how to solve this problem, if so, how?

Yes, when I will become home owner I will know what solutions are available.

3. What needs to be communicated to the Lakewood community on this topic?

There is a collective problem of stormwater and overflow in Lakewood. There are ways that individual households can help deal with that.

4. What would like more information on?

I feel saturated with information.

5. Feedback on what you liked about the public input process, and what you think could be improved upon:

It was great! It is impressive how much talent, energy and effort was gathered here from the community members. Thank you - Organizers of this ^{discussion} group - to do such a thorough job!

Jim Gager

~~Jim Gager~~

~~(214) 573-4861~~

We have a complicated problem that we are attempting to resolve with integrated solutions, while complying with EPA mandates. At this critical time I would encourage homeowners to seek short-term solutions.

I would like to share w/ my neighbor that we are all in this together! We value Lake Erie and need to work together to create clean water solutions - Babette Granda

The storm/sanitary system is amazingly complex. Modifying one piece has a potential upside benefit or catastrophic result. Proceed with caution.

Jeralyn Sacket

The amount of overflow points
in Lakewood was sticking.

I would tell my neighbors this
is ~~a~~ necessary. It helps keep
Lakewood as it should be for
future generations. And keeps
the lake clean for them too!

Most useful info.
of CSO's

Mike Stewart

Connie Bralowski -

What I would tell my
neighbors: Clean water is
everyones responsibility. It is
through little things (ie rain
barrels, rain gardens) that
collectively we can do big
things.

Improving our great
lake is important
but its going to take
investment.

JERRY RUBINICH
JRUBANI@AOL.COM
STORMWATER@KENT-ONID.ORG

BOOTH 3 AT NOV 2, IMPROVED 20T SHOW

For me the most interesting
was to learn about mechanisms
of public engagement in city
matters. I am happy that I could
contribute to the decision process.
All this information about storm-
water and overflow problems

is useful for me when entering
the market of residential properties.
Overall I was very much impre-
ssed by the scale of this "workshop".
Every meeting was well thought-
through and therefore very pro-
ductive.

Zuzanna Kutowska

Study Area #1 – combined sewer on Larchmont Avenue

Overview of Study Area #1: This sewer was constructed circa 1911. There is a CSO located at the intersection of Larchmont Avenue and Detroit Avenue. The CSO discharges to the storm sewer on Detroit Avenue, flows westerly towards West Clifton, then southerly along West Clifton to the Rocky River. The outfall (RRES-1150) is adjacent to the aerial sewer into the WWTP. The CSO at the end of Larchmont is similar to 12 other CSO locations along Detroit Avenue and Madison Avenue, so the approach to reducing the overflows at this location is transferrable to other locations.

- The total area of lots and streets is 15.45 acres
- 71.75% impervious
- Average sewer slope 1.47%
- 19,470 gpd (0.020 mgd) water purchased (160 gpd per home)
- 7,310,000 gpd (7.31 mgd) maximum flow during typical year
- Number of overflow event in a typical year is 15
- Overflow data for a typical year:

Date	Duration (h)	Maximum Flow (mgd)	Volume of Exceedances (Mg)	Volume of Exceedances (Gal)
6/30/1977	1.50	7.004	0.2170	217,000
6/30/1977	2.25	4.298	0.1771	177,100
7/29/1977	1.50	5.734	0.1725	172,500
7/19/1977	1.50	4.095	0.1183	118,300
8/5/1977	1.25	2.096	0.0649	64,920
9/14/1977	1.25	1.204	0.0314	31,400
6/17/1977	1.00	1.054	0.0251	25,100
8/7/1977	1.00	0.955	0.0217	21,720
8/12/1977	1.00	0.560	0.0109	10,870
8/21/1977	1.00	0.368	0.0064	6,397
3/12/1977	0.75	0.311	0.0049	4,871
9/6/1977	0.50	0.194	0.0020	2,020
4/2/1977	0.50	0.117	0.0012	1,219
11/7/1977	0.50	0.027	0.0003	285
6/25/1977	0.50	0.005	0.0001	53
				853,755

Support Documents: Drawings from the city records are attached. The drawings consist of:

- Sewer Plan, Larchmont Avenue, Village of Lakewood, Drawing # B-37
- Paving Plan for Larchmont Avenue, Lakewood Ohio, Drawing #A-53, March 1911
- Manhole investigation sketch
- Aerial map from Cuyahoga County
- CSO manhole illustration
- Soils map
- CSO Activations
- Typical Year Precipitation
- Footing (Foundation) Drain studies
- Downspout Flow Rates

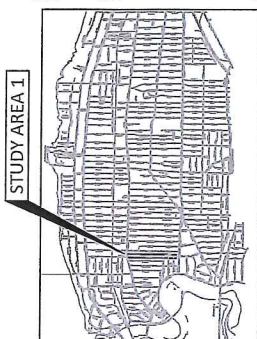
Comments: A 24-inch diameter pipe conveys sewage and storm water to an over/under sewer on Detroit Avenue (59-inch storm sewer over a 15-inch sanitary sewer). The Detroit Avenue sewer also conveys sewage from 11 streets to the east; it has a lot of flow from upstream areas. This is not a problem during dry weather. However, during wet weather, the sanitary sewer has more flow than it has capacity to convey, so it begins to surcharge (backup). When the Detroit Avenue sanitary sewer backs up, there is no room for the combined sewage from Larchmont and the combined sewage overflows into the Detroit Avenue storm sewer.

Goal: Reduce the number of overflows to four or less in a typical year.

I:\2015\150141\PHASE3 Public Involvement & Stakeholder Input\Community Education-Engagement\Documents To Be Given To All Stakeholders\STUDY AREAS\Study Area #1\Study Area #1 Support Information.Docx



LEGEND	CSO-COGS SERVICE AREA COMBINATION SERVER INTERCEPT SERVER SANITARY SERVER STORM MANHOLE NOT PART OF CSO COMBINATION/SANITARY MANHOLE OVER/UNDER MANHOLE STORM MANHOLE OUTFALL MANHOLE IDENTIFICATION 20" STORM SEWER OVER 6" SANITARY		[RE-CD] 20" 8'
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KEY PLAN

Subject Area #1
CSO Activations

Current Condition	CSO volume (gallons)
1st highest	217,000
2nd highest	177,100
3rd highest	172,500
4th highest	118,300
5th highest	64,920

Removed runoff from 1 subcatchment from Larchmont Ave.	CSO volume (gallons)
1st highest	187,700
2nd highest	150,600
3rd highest	141,600
4th highest	90,600
5th highest	51,180

Removed runoff from 1 subcatchment on each of the 4 combined sewers streets upstream of RRES 1150	CSO volume (gallons)
1st highest	184,500
2nd highest	149,600
3rd highest	133,000
4th highest	79,230
5th highest	49,580

Removed runoff from all subcatchments on the 4 combined sewers streets upstream of RRES 1150	CSO volume (gallons)	A volume of 200,000 gallons needs to be removed from the combined sewers <u>on each street</u> to reduce CSO to this level.
1st highest	14,220	
2nd highest	13,710	
3rd highest	3,041	
4th highest	1,085	
5th highest	1,069	

Removed I/I from O/U streets, runoff from all subcatchments connected on the combined sewers upstream of RRES 1150	CSO volume (gallons)
1st highest	125,400
2nd highest	90,690
3rd highest	78,670
4th highest	38,640
5th highest	12,390

Remove I/I from O/U streets and two subcatchments on each combined sewer street upstream of RRES 1150	CSO volume (gallons)	A volume of 86,150 gallons needs to be removed from the combined sewers <u>on each street</u> to reduce CSO to this level.
1st highest	68,880	
2nd highest	45,810	
3rd highest	33,490	
4th highest	12,200	
5th highest	0	

SEWER MANHOLE SURVEYS

Manhole No.: 002-32.1

Date: 12-15-10

Street Name: DETROIT + LARCHMONT
CROSSWALK

Crew: P. M. H.

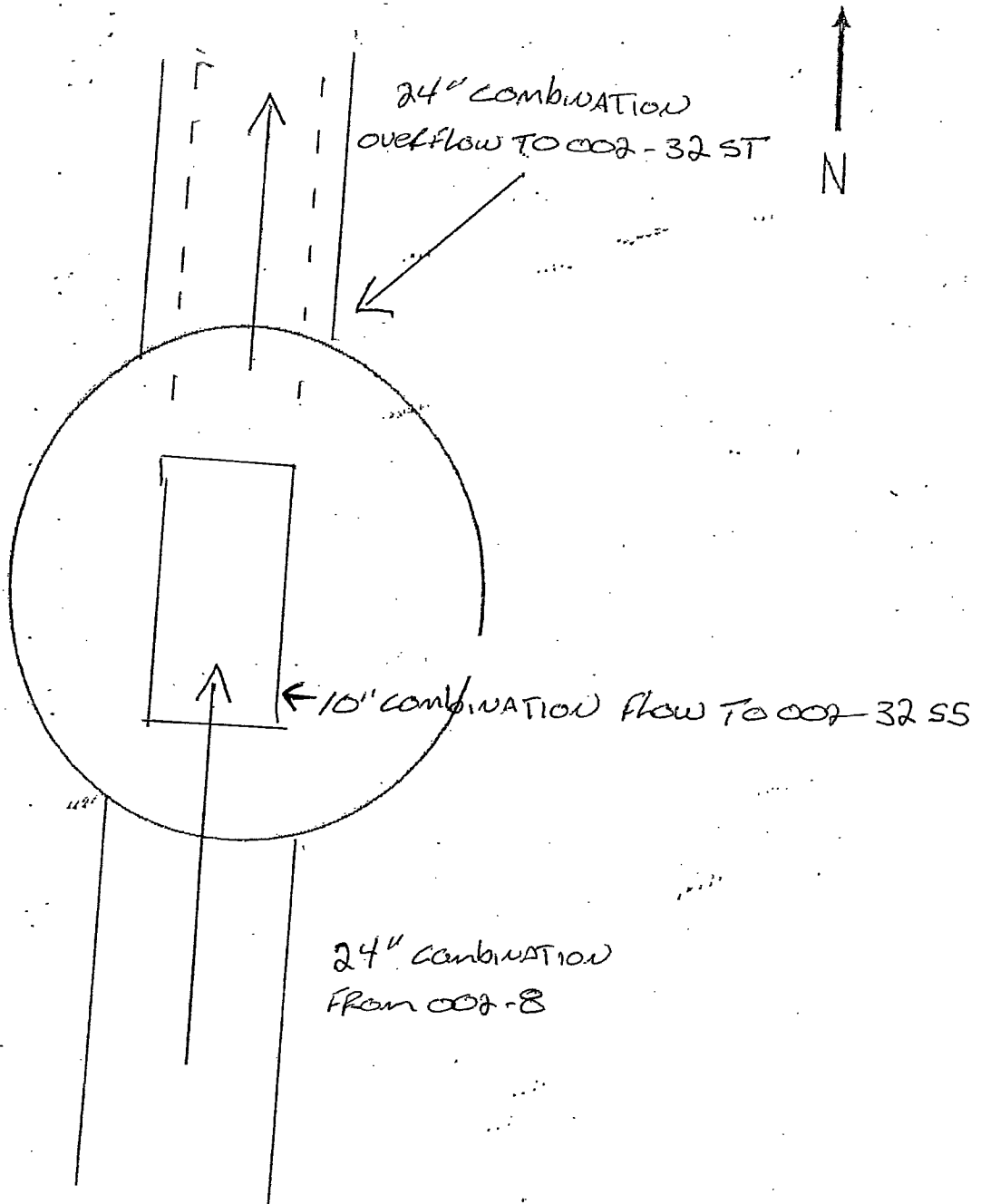
Structure Type: Over/Under 1 Combined 1 Side/Side

Only Sanitary Only Storm

Invert Plate: Yes Missing Not Required 1

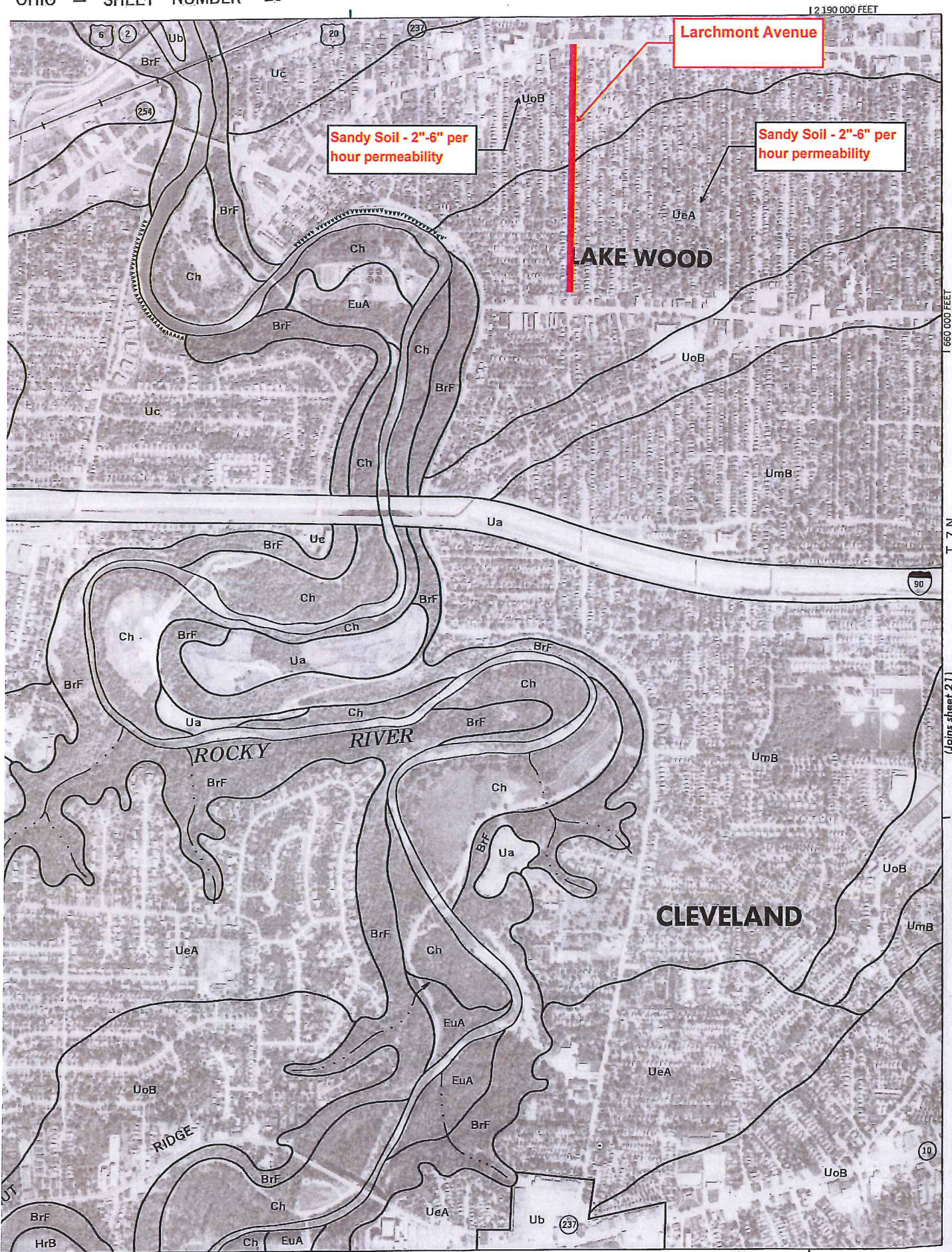
Manhole Depth 13.0

Draw all pipes entering M.H. with size & depth. Include flow of water/sewage.



P. M. H.

Notes:



4354

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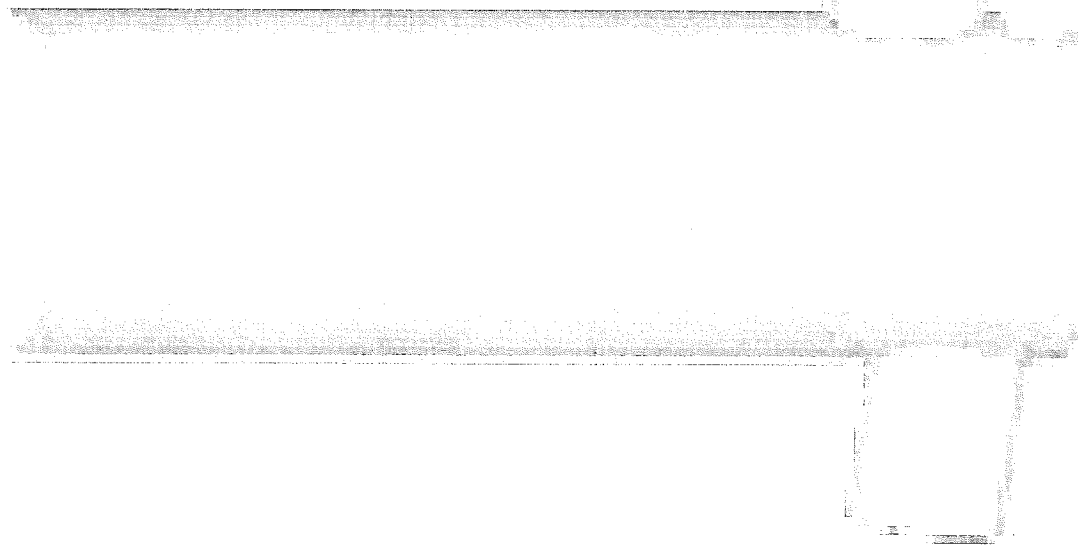
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→ TO STORM
SEWER

→ TO SANITARY
SEWER

COMBINED
SEWAGE IN →



TYPICAL YEAR PRECIPITATION

The City's comprehensive model was used to establish a baseline for overflow events during a typical precipitation year. It is the baseline predictions from the model that will be used to determine system improvements in accordance with the city's long-term control plan. Data from Cleveland Hopkins International Airport (CLE) were obtained for the 33-year period from 1973 to 2006. The following criteria were considered desirable for the typical year precipitation data:

- No storm events greater than a 1-year storm
- Include a 1-year 1-hour storm
- Include a 6-month 1-hour storm
- Include a 4-month 1-hour storm
- Include a 3-month 1-hour storm
- Have remaining storms less than a 3-month storm
- Close to average precipitation reported by United States Department of Agriculture (USDA)

The precipitation events from the 33-year record were classified and calendar year 1977 (35.48 inches, total) came closest to the previously stated criteria. This year of precipitation data was submitted to the USEPA for evaluation. The USEPA assessed the proposed precipitation record and requested that the total precipitation for the year be raised from 35.48 inches to 37.52 inches based on the CLE data (1973 to 2006) being more recent than the USDA data (1951 to 1976) previously used. To incorporate the additional precipitation requested, the 1977 monthly precipitation was compared to the monthly averages of the CLE data. January, February, May, September, and October were below the monthly average of the CLE data. The additional precipitation (2.04 inches) of precipitation was distributed to the below average months as shown in Table 8.1. The additional storms brought the respective monthly averages closer to the monthly averages of the CLE data.

Appendix B. Summary of District's Synthetic Design Storm and Typical Year Rainfall

Tables B-1 and B-3 were obtained from Appendix C of the District's CSO Facilities Planning Summary Report dated March 2005. The Consultant shall refer to this report for additional information regarding the District's selected design storms and synthetic typical year hyetographs is needed. Table B-2 summarizes the standard design storm hyetographs based on 15-minute rainfall increments have been adopted and are available for Consultant use if needed for particular project needs. District approval is required if finer rainfall time series is deemed necessary by the Consultant.

Table B-1. Official Design Storm Hyetographs Based on 1-Hour Rainfall Increments.

Return Period	Duration	Hourly Incremental Rainfall Depth (in)						Total Rainfall	Average Intensity
		Hour 1	Hour 2	Hour 3	Hour 4	Hour 5	Hour 6	(in)	(in/hr)
1-month	6-hour	0.06	0.15	0.09	0.09	0.08	0.09	0.56	0.09
4-month	6-hour	0.05	0.15	0.10	0.37	0.16	0.14	0.97	0.16
6-month	6-hour	0.01	0.06	0.02	0.73	0.26	0.02	1.10	0.18
1-year	6-hour	0.05	0.07	0.15	1.00	0.21	0.01	1.49	0.25
2-year	6-hour	0.12	0.04	0.14	1.17	0.18	0.10	1.75	0.29
5-year	6-hour	0.06	0.10	0.23	1.43	0.20	0.12	2.14	0.36
1-year	1-hour	1.00						1.00	1.00
5-year	1-hour	1.43						1.43	1.43
10-year	1-hour	1.69						1.69	1.69
25-year	1-hour	2.06						2.06	2.06
50-year	1-hour	2.40						2.40	2.40
100-year	1-hour	2.77						2.77	2.77

Table B-2. Design Storm Hyetographs Based on 15-Minute Rainfall Increments.

Return Period	6-Hour Duration ⁽¹⁾		24-Hour Duration ⁽²⁾	
	Total Rainfall (in)	Peak 1-Hour Intensity (in/hr)	Total Rainfall (in)	Peak 1-Hour Intensity (in/hr)
1-month	0.56	0.36	0.79	0.36
2-month	0.79	0.51	1.12	0.51
3-month	0.93	0.59	1.31	0.59
4-month	1.01	0.65	1.43	0.65
6-month	1.17	0.75	1.65	0.75
9-month	1.33	0.85	1.88	0.85
1-year	1.45	0.92	2.04	0.92
2-year	1.77	1.13	2.50	1.13
5-year	2.20	1.40	3.10	1.40

(1) Distribution based on peak 6-hr duration of the SCS Type 2 24-hr distribution at 15-minute increments.

(2) From District's 2006 RIDE Study and ISWS Bulletin 71 and SCS Type 2 24-hour distribution.

Table B-3. Storm Events for Typical Year Continuous Year Simulation.

Storm Event	Date	Hour	Duration (Hrs)	Depth (In)	Average Intensity (In/Hr)	Maximum Hourly Intensity (In/Hr)	Storm Event	Date	Hour	Duration (Hrs)	Depth (In)	Average Intensity (In/Hr)	Maximum Hourly Intensity (In/Hr)
1	01/03/91	12	1	0.01	0.01	0.01	62	07/03/93	2	1	0.01	0.01	0.01
2	01/05/91	13	10	0.18	0.02	0.03	63	07/04/93	16	1	0.44	0.44	0.44
3	01/09/91	13	2	0.03	0.01	0.02	64	07/06/93	16	1	0.47	0.47	0.47
4	01/11/91	4	19	0.39	0.02	0.09	65	07/11/93	20	3	0.35	0.12	0.24
5	01/12/91	12	21	0.04	0.00	0.01	66	07/19/93	14	2	0.14	0.07	0.13
6	01/15/91	24	8	0.33	0.04	0.08	67	07/26/93	6	2	0.04	0.02	0.02
7	01/16/91	19	10	0.17	0.02	0.03	68	07/28/93	17	9	1.08	0.12	0.72
8	01/20/91	13	30	0.53	0.02	0.05	69	07/29/93	20	3	0.67	0.22	0.31
9	01/26/91	7	10	0.03	0.00	0.01	70	08/02/93	5	2	0.42	0.21	0.41
10	01/27/91	19	4	0.08	0.02	0.03	71	08/03/93	21	10	0.42	0.04	0.20
11	01/29/91	20	11	0.37	0.03	0.10	72	08/06/93	19	4	0.10	0.03	0.06
12	01/30/91	18	1	0.01	0.01	0.01	73	08/07/93	13	1	0.13	0.13	0.13
13	01/31/91	14	1	0.01	0.01	0.01	74	08/10/93	16	2	0.02	0.01	0.01
14	02/05/91	7	1	0.01	0.01	0.01	75	08/11/93	4	4	0.24	0.06	0.23
15	02/06/91	15	9	0.10	0.01	0.02	76	08/12/93	17	1	0.02	0.02	0.02
16	02/10/91	15	20	0.73	0.04	0.09	77	08/16/93	4	1	0.07	0.07	0.07
17	02/13/91	14	59	1.53	0.03	0.16	78	08/20/93	9	1	0.01	0.01	0.01
18	02/16/91	24	14	0.18	0.01	0.04	79	08/28/93	2	1	0.06	0.06	0.06
19	02/18/91	15	13	0.08	0.01	0.04	80	08/31/93	13	6	0.03	0.00	0.02
20	02/19/91	17	7	0.29	0.04	0.10	81	09/02/93	8	21	1.02	0.05	0.67
21	02/26/91	4	40	0.08	0.00	0.01	82	09/06/93	13	1	0.35	0.35	0.35
22	02/28/91	9	4	0.04	0.01	0.02	83	09/07/93	9	1	0.01	0.01	0.01
23	03/02/91	1	14	0.06	0.00	0.02	84	09/10/93	1	1	0.01	0.01	0.01
24	03/03/91	13	24	0.70	0.03	0.10	85	09/10/93	13	1	0.01	0.01	0.01
25	03/06/91	6	14	0.83	0.06	0.13	86	09/15/93	20	16	2.38	0.15	0.40
26	03/09/91	18	2	0.07	0.04	0.05	87	09/22/93	24	16	0.12	0.01	0.05
27	03/10/91	12	4	0.08	0.02	0.03	88	09/25/93	16	20	1.63	0.08	0.29
28	03/17/91	21	31	0.50	0.02	0.07	89	09/27/93	13	9	0.15	0.02	0.06
29	03/22/91	6	4	0.32	0.08	0.18	90	09/28/93	10	3	0.23	0.08	0.12
30	03/22/91	24	3	0.14	0.05	0.08	91	09/29/93	10	17	0.97	0.06	0.24
31	03/23/91	24	10	0.23	0.02	0.06	92	10/01/93	10	1	0.01	0.01	0.01
32	03/26/91	13	1	0.02	0.02	0.02	93	10/01/93	23	6	0.58	0.10	0.22
33	03/27/91	24	1	0.62	0.62	0.62	94	10/09/93	6	13	0.43	0.03	0.13
34	03/31/91	19	6	0.07	0.01	0.03	95	10/16/93	22	16	0.60	0.04	0.18
35	04/01/93	23	5	0.16	0.03	0.07	96	10/19/93	15	1	0.04	0.04	0.04
36	04/02/93	17	12	0.06	0.00	0.02	97	10/20/93	15	6	0.04	0.01	0.02
37	04/09/93	14	16	0.77	0.05	0.09	98	10/27/93	22	4	0.15	0.04	0.10
38	04/11/93	16	1	0.09	0.09	0.09	99	10/30/93	10	39	1.67	0.04	0.12
39	04/14/93	19	2	0.03	0.01	0.02	100	11/01/91	17	1	0.01	0.01	0.01
40	04/15/93	23	3	0.34	0.11	0.16	101	11/07/91	9	12	0.12	0.01	0.02
41	04/19/93	17	13	0.27	0.02	0.11	102	11/11/91	2	7	0.69	0.10	0.14
42	04/20/93	16	18	0.61	0.03	0.13	103	11/12/91	11	12	0.21	0.02	0.06
43	04/24/93	12	2	0.03	0.01	0.02	104	11/15/91	1	31	0.62	0.02	0.10
44	04/25/93	8	15	0.46	0.03	0.16	105	11/18/91	17	21	0.30	0.01	0.10
45	04/30/93	1	6	0.10	0.02	0.03	106	11/20/91	17	19	0.46	0.02	0.14
46	05/04/93	13	25	0.63	0.03	0.22	107	11/23/91	20	3	0.24	0.08	0.12
47	05/19/93	4	6	0.15	0.02	0.07	108	11/24/91	17	8	0.03	0.00	0.01
48	05/23/93	16	1	0.01	0.01	0.01	109	11/25/91	14	1	0.01	0.01	0.01
49	05/24/93	6	6	0.08	0.01	0.04	110	11/28/91	6	8	0.19	0.02	0.05
50	05/28/93	24	2	0.03	0.01	0.02	111	11/30/91	6	1	0.04	0.04	0.04
51	05/31/93	23	2	0.16	0.08	0.08	112	12/02/91	16	17	1.19	0.07	0.29
52	06/03/93	23	2	0.07	0.03	0.04	113	12/03/91	21	11	0.06	0.01	0.02
53	06/05/93	5	6	0.37	0.06	0.25	114	12/12/91	15	17	0.16	0.01	0.06
54	06/07/93	16	9	1.56	0.17	0.67	115	12/14/91	7	6	0.15	0.02	0.12
55	06/09/93	10	1	0.21	0.21	0.21	116	12/15/91	16	16	0.07	0.00	0.01
56	06/09/93	24	1	0.24	0.24	0.24	117	12/18/91	3	2	0.02	0.01	0.01
57	06/19/93	6	2	0.31	0.16	0.22	118	12/18/91	16	16	0.03	0.00	0.01
58	06/20/93	13	26	0.54	0.02	0.15	119	12/20/91	22	8	0.22	0.03	0.07
59	06/25/93	20	1	0.08	0.08	0.08	120	12/23/91	7	6	0.10	0.02	0.03
60	06/27/93	18	1	0.94	0.94	0.94	121	12/28/91	22	35	0.26	0.01	0.03
61	07/01/93	21	4	0.05	0.01	0.02	Total						37.51

Study Design

operation of the basin is seen as it starts to fill just before midnight and is surcharged between 1:00 and 4:30 AM. During surcharged conditions, the levels rise and fall quickly as storage in the collection system is limited.

E.1.3.5 Footing Drain Monitoring

One potentially significant source of inflow into the sanitary sewer system during storms is from house foundation footing drains that are directly connected to the sanitary sewers. Previous studies conducted in Ann Arbor have reported that the footing drain connection from a single home could contribute as much as 10 gpm during a storm. Since most of the houses in the study areas have directly connected footing drains, footing drains can introduce a significant proportion of the observed

To estimate the amount of footing drain flow in each of the study areas, 20 locations were identified throughout the 5 study areas (about 4 per area) where house connections enter the sanitary sewer in manholes above the manhole benching. This configuration allowed the installation of temporary house lead extensions of about 1' into each manhole. Of the 20 locations identified, 16 installations were made as shown in Table E-9.

To estimate flows produced from individual homes, these house leads were visited during rainfall events to measure the flows being generated. Flows were measured using bucket and stopwatch methods. During each storm being monitored, flows were measured a number of times as field crews visited multiple manholes during the monitoring events. The storms of 8/17/00 and 9/11/00 were monitored by field crews. Two to three tests were performed at each location during each event.

Table E-9. Footing Drain Study Locations

<u>Region</u>	<u>Manhole ID</u>	<u>Approximate Address</u>
Orchard Hills	2	3000 Bluett
Orchard Hills	4	3022 Bluett
Orchard Hills	7	3130 Bluett
Orchard Hills	29	2488 Antietam
Orchard Hills	60	2537 Georgetown
Bromley	49 (E&W)	2814 Renfrew
Bromley	55	2500 Prairie
Bromley	5 (E)	2235 Prairie
Bromley	5 (W)	2235 Prairie
Glen Leven	94	1707 Tudor
Glen Leven	95	1706 Tudor
Glen Leven	22	1315 Glen Leven
Glen Leven	101 (E)	1530 Dicken Drive
Glen Leven	101 (W)	1530 Dicken Drive
Morehead Street	75	2189 Seventh
Morehead	35	2095 Chaucer

As noted earlier, footing drain flows were monitored during selected storms. This information was collected on August 17, 2000 and on September 11, 2000. The August 17, 2000 storm was short and of low volume and produced a limited wet weather flow response. During this period, footing drain flows ranged from 0.1 to 0.5 gpm.

The September 11, 2000 storm produced between 1.57" to 1.8" of rain over a 5-hour period. During this storm, footing drain flows were collected during a period of steady rainfall. Figure E-5 shows the

Table E-10 Average Footing Drain Flows

<u>Study Area</u>	<u>Flow (gpm)</u>
Orchard Hills	1.1
Bromley	1.9
Dartmoor	No Test Locations
Glen Leven	1.8
Morehead	1.4

footing drain flows measured during this storm. The measured flows ranged from 0 to 3 gpm, with an average of 1.4 gpm for all locations measured. The average footing drain flows for the tests performed



Study Design

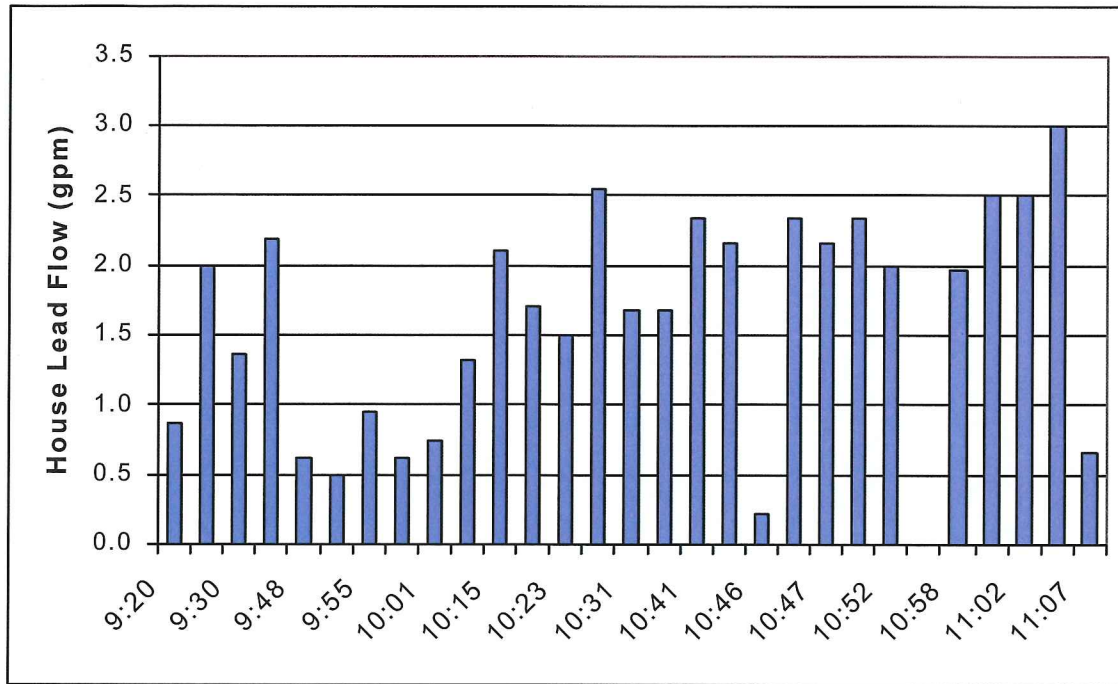


Figure E-5 Footing Drain Flow Measurements

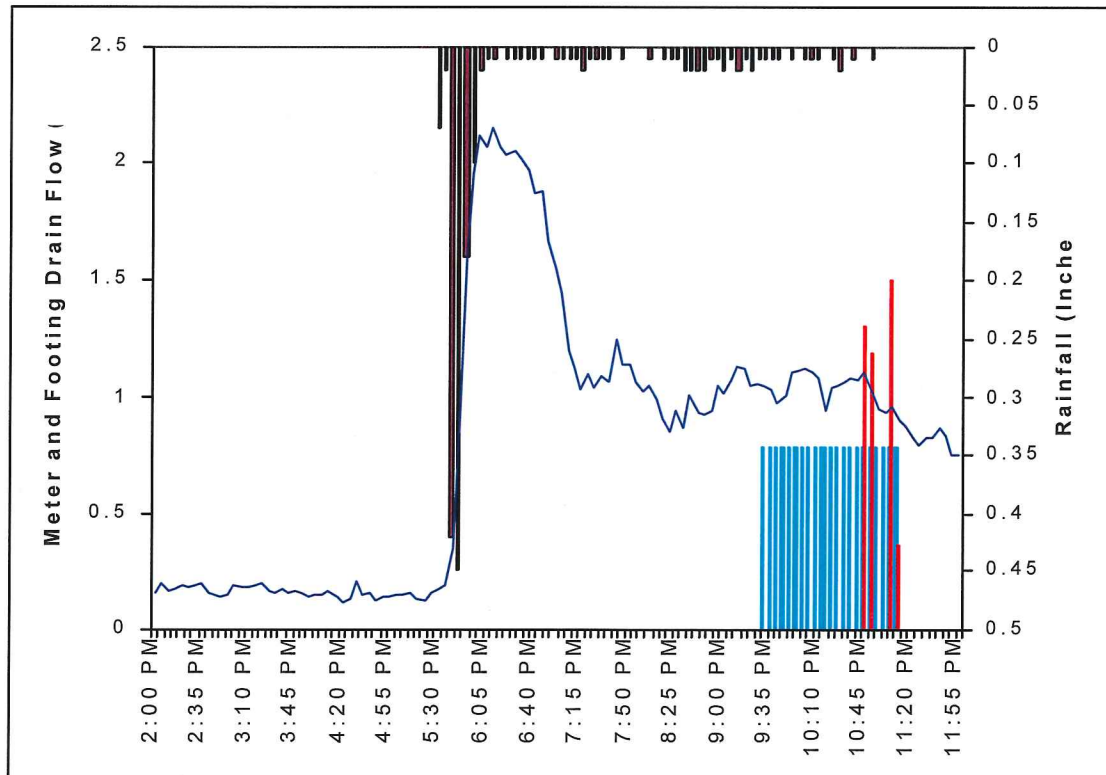


Figure E-6 Rainfall, Metered Flow, and Footing Drain Flows for Bromley Study Area

in each study area are summarized in Table E-10.

The rainfall, metered flow, and calculated footing drain flows were then compared for each study area. An example of this is shown in Figure E-6 for the Bromley study area. The rainfall data is graphed on the top of this figure. The peak of the storm took place at about 5:45 PM and then produced lower, but consistent, rainfall over the next five hours. The flow meter data is plotted as the continuous line with its ordinate of flow in cfs shown on the left axis. This figure shows a response that is similar in shape to the rainfall, peaking at about 6:00 PM and leveling off for a few hours before dropping back to a dry weather flow pattern.

An estimate of the total flow generated by all footing drains in each area was made using the assumption that the average footing drain flow of all areas, 1.4 gpm, is multiplied by the number of homes with footing drains in each study area. This estimate is graphed over the time the data was collected in all areas, and shown as the vertical blue bars in Figure E-6. The total footing drain flow estimates based on the individual measurements taken directly within the Bromley area are also shown as the variable height bars.

Figure E-6 suggests that as much as 90% of the wet weather flow in the Bromley area was caused by flows generated from footing drains. Similar results were found for three of the other study areas, with the Dartmoor study area being an exception. In this area, there appear to be other sources of RDI/I that are contributing to the flows recorded at the flow meter or the flow contribution from footing drain flows are higher than the average measured in the other areas.

E.1.4 Collection System Inspection Programs

E.1.4.1 Manhole Inspections

As part of the project scope, inspection of each accessible manhole in the study areas was performed. This work was performed to assess the

current condition of the manholes and better understand the sewer connections between the manholes. The inspection work was documented on forms completed by field crews and through digital photographs to document manhole condition, sewer connections, and specific defects. Over 800 manholes were inspected as part of this effort. The overall condition of the manholes and the sewer connections was found to be excellent. The inspection did identify 24 minor maintenance issues, which the Water Utilities Department addressed shortly after identification.

In addition to providing information regarding infrastructure condition, the inspection notes and photos provided useful information when assembling the collection system computer models. These photos allowed rapid verification of the collection system connectivity and other attributes such as approximate invert elevation.

Field notes and digital photographs were provided to the Water Utilities Department separately. The field notes and photos are accessible using the project GIS. The available GIS coverage includes the manhole identifier used to locate manholes as part of this project and this identifier is also cross-referenced to the City's identifier system where possible. The identifier used is also listed on the field forms and is contained in the filename of the digital images. The digital images referred to on each field sheet were, with a few exceptions, taken in the following order:

1. The downstream pipe was photographed looking down the pipe from the manhole.
2. Each upstream pipe was photographed (clockwise, looking down manhole, from the downstream pipe).
3. Each house lead was photographed (clockwise, looking down manhole, from the downstream pipe).
4. Specific defects, blockages, or sources of I/I



Table 1. Summary of Footing Drain Flow Studies

Downstream System Metering	Wet Weather Sanitary Flow		Peak Footing Drain Flows			Projected Peak Footing Drain Flows (gpm/house)		
	Peak Flow with FD (cfs/1000)	Peak Flow Without FD (cfs/1000)	Flow (gpm/house)	Rainfall (inches)	RDII from FD (percent)	4" Linear	4" Log	
Beverly Hills	1.56	0.38 ⁵	2.5	2.23"	76%	2.1	1.7	
Oakland County 1967	1.76	0.53	1.8	1.86"	70%	3.8	3.0	
1968 Study	---	---	2.1	---	---	---	---	
Canton Township FD Removal	2.7	---	3.0 ⁴	2.50" ³	---	3.0 ⁴	1.8 ⁴	
GDRSS Data	2	0.63	1.5	2.0	69%	---	---	
Clinton Township Data	3.3	---	3.3	---	---	---	---	
Auburn Hills Data	1.8	---	1.1 ³	1.8 in/hr	70%	3.7	1.7	
Center Line Data	1.7	---	1.7	---	---	---	---	
West Lafayette, In	---	---	5 ¹	---	---	---	---	
Midland, MI	---	---	5 ¹	---	---	---	---	
Direct Measurement Metering	Wet Weather Sanitary Flow		Observed Footing Drain Flows			Projected Footing Drain Flows		
	Peak Flow with FD (cfs/1000)	Peak Flow Without FD (cfs/1000)	Average Flow (gpm/house)	Peak Flow (gpm/house)	Rainfall ²	RDII from FD (percent)	4" Linear	4" Log
Ann Arbor 2000 FD Study	2.5	---	1.3	8.7	4.01"	60-90%	4.5	3.1
Dearborn Heights Study	3.0	---	0.55	1.0	0.87"	85-90%	2.2	1.1
WWMP Monitors	---	---	1.7	25.0	1.86"	---	3.0	1.7
Ann Arbor FD Monitoring 2002	---	---	1.0	8.5	1.81"	---	---	---
Toledo	---	---	0.3	3.3	1.72"	---	1.6	0.9
South Macomb Sanitary District:	---	---	---	3.2	1.73"	---	6.5	3.8
Simulated Rainfall Events	---	---	6.4	10.1	2.7 in/hr	---	--	---
Other Oakland County Studies	---	---	2.5 to 10	---	---	---	---	---

1 - Based on model calibration, not direct metering.

2 - Rainfall is displayed in total volume (") or intensity (in/hr)

3 - Based on interpolation of data.

4 - Actual flows are higher. These systems allowed up to 1 gpm to pass to the sanitary system

5 - After removal of footing drain connections to sanitary sewer

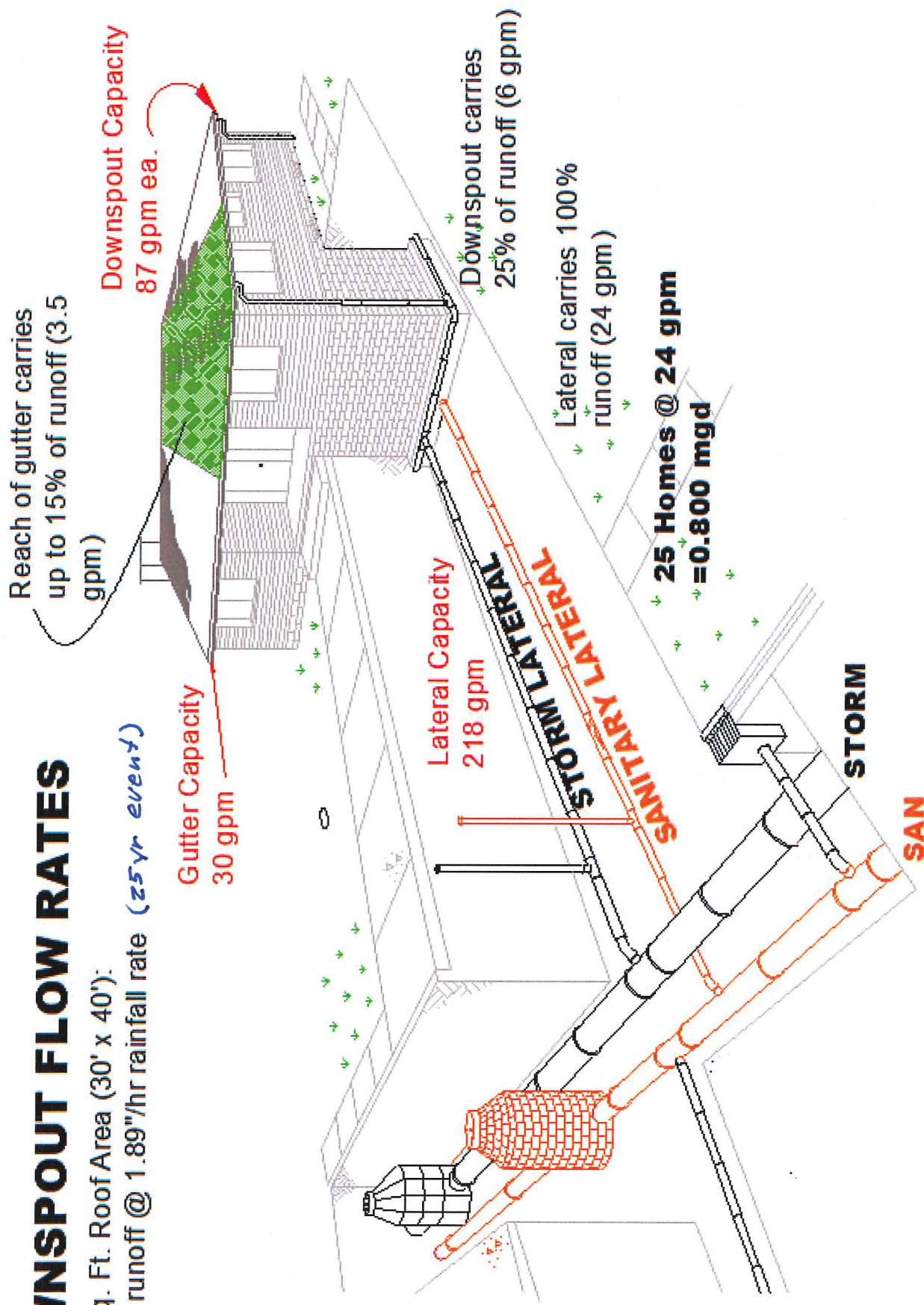
FD: Footing Drain

RDII: Rainfall Dependent I/I

DOWNSPOUT FLOW RATES

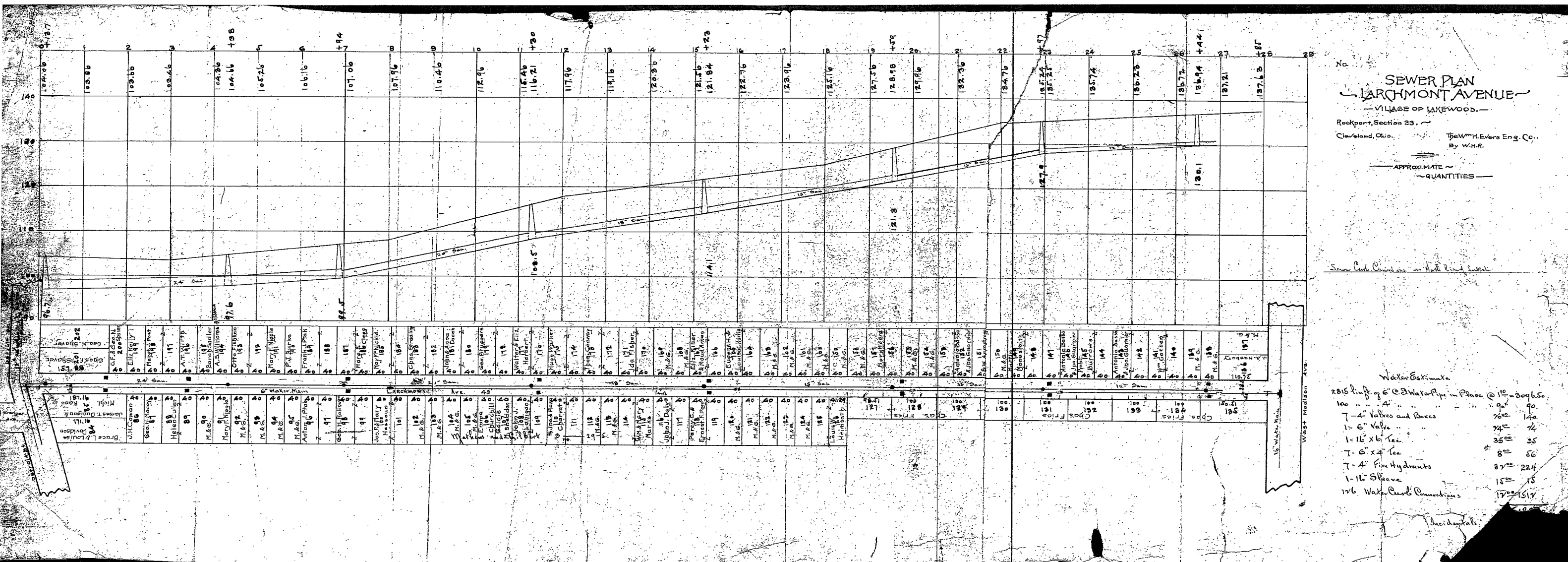
1200 Sq. Ft. Roof Area (30' x 40'):

24 gpm runoff @ 1.89"/hr rainfall rate (25-yr event)









PAVING PLAN

LARCHMONT AVENUE

LAKEWOOD OHIO

SCALE 1"=100'

THE W. H. EVERS ENG CO.

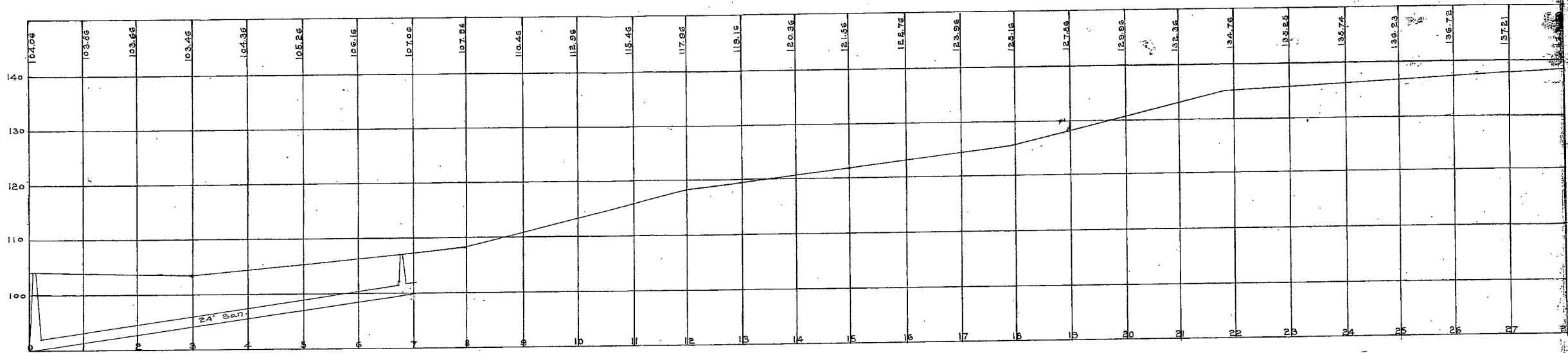
MARCH 1911

ESTIMATE COST.

68000 sq. ft. 4" Brick Paving Complete @ .18¢	12240.00
5600 lin. ft. curb redressed & reset in 6" curbs @ .10¢	560.00
200 lin. ft. 4" x 18" curb furnished & set in 6" @ .30¢	60.00
3100 cu. yds. Excavation @ .35¢	1085.00
1 Manhole @ 45.00	45.00
7 M.H. Covers adjusted to grade @ 2.00	14.00
700 lin. ft. 24" Sewer lowered @ 2.00	1400.00
300 sq. ft. Walks relaid @ .03	9.00
200 sq. ft. new Walks at intersections @ .12	24.00
28 Reconnections @ 2.00	56.00
Total	15493.00
Incidentals, Engineering, Inspection	1507.00
Grand Total	17000.00

TAXABLE AS FOLLOWS

City Portion 2%	340.00
Intersection	406.00
Frontage 5160 ft. @ 3¢	16230.00
Total	17000.00



201 Eligible Shaver	157.88	85 Elizabeth Shaver	187.76
199 E. N. & Eliza Shaver	157.88	86 Jes. A. Parsons	187.76
198 Josephine Tiffany	157.88	87 William & E. Harding	187.76
197 Max & J. East	157.88	88 Maud Alice Cullen	187.76
196 Arthur E. & Lydia Kellogg	157.88	89 Chas. F. & Anna E. Evers	187.76
195 Sarah J. Sadler	157.88	90 Mary F. Niggle	187.76
194 Lawrence & Laura Leick	157.88	91 P. & Anna West	187.76
193 J. Brock	157.88	92 James M. Leach	187.76
192 Mary F. Niggle	157.88	93 Aug. Zillmer	187.76
191 Mary F. Niggle	157.88	94 Anker J. Tola	187.76
190 F. J. Burke	157.88	95 Anna C.	187.76
189 Frank Prick	157.88	96 Geo. H. Reinhard	187.76
188 Philip C. Legg	157.88	97 Joseph P. & Mary Haggard	187.76
187 Roy McNickle	157.88	98 Agnes Bremer	187.76
186 Charles Stradling	157.88	99 John J. Langston	187.76
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85 Stephen & Anna Decek	157.88	200 John J. Langston	187.76

WEST MADISON AVE.

Study Area #2 – over/under sewer on Parkwood Road

Overview of Study Area #2: The over/under sewer on Parkwood Road discharges to a sanitary sewer on Detroit Avenue. The Parkwood Road sewer was constructed circa 1920 while the sanitary sewer on Detroit was constructed in 2007. The sanitary sewer on Detroit was constructed to replace the old over/under sanitary sewer on Detroit Avenue. After construction of the new sanitary sewer on Detroit Avenue, the sewer began to regularly surcharge to such an extent that overflows were constructed between the sanitary sewer and storm sewer on Detroit Avenue. This overflow is representative of 7 overflow locations along Detroit Avenue that ultimately discharge to Lake Erie at LEWS 1035/1040 through the Nicholson Avenue the storm sewer.

- The total area of lots and streets is 20.01 acres
- 70.68 % impervious
- Average sewer slope 1.88%
- 19,730 gpd (0.020 mgd) water purchased (177 gpd per home)
- 3,146,000 gpd (3.146 mgd) maximum flow during typical year
- Number of overflow event in a typical year is 80

- Overflow data for a typical year:

Date	Duration (h)	Maximum Flow (mgd)	Total Flow (Mg)	Total Flow (Gal)
3/18/1977	11.75	2.435	0.564	564,000
12/13/1977	13.00	1.575	0.473	473,200
3/12/1977	10.50	2.236	0.358	358,300
9/13/1977	8.00	2.863	0.310	310,300
6/30/1977	5.00	2.932	0.284	284,300
4/25/1977	8.00	1.584	0.282	281,900
11/7/1977	6.75	2.507	0.255	255,300
4/2/1977	4.25	2.007	0.200	200,300
3/22/1977	4.00	1.786	0.177	176,500
6/30/1977	2.50	3.146	0.174	173,500
10/19/1977	5.25	1.561	0.172	172,000
7/19/1977	2.75	2.549	0.161	161,200
12/5/1977	5.75	1.456	0.160	160,000
11/10/1977	5.75	0.995	0.152	152,100
7/29/1977	2.50	2.827	0.146	145,700
6/9/1977	4.25	1.520	0.135	135,300
4/20/1977	3.25	1.930	0.128	128,100
3/28/1977	4.00	1.188	0.107	107,300
8/5/1977	2.00	2.549	0.103	102,900
8/7/1977	2.25	2.171	0.103	102,500
12/24/1977	3.00	1.569	0.100	100,100
11/16/1977	4.75	0.760	0.100	100,000
9/6/1977	2.50	2.420	0.100	99,840
8/21/1977	3.00	1.766	0.090	89,710
1/16/1977	2.25	2.120	0.089	89,230
3/22/1977	4.50	0.729	0.088	88,200
10/1/1977	3.00	1.139	0.088	87,810
6/17/1977	1.50	2.615	0.084	84,100
4/22/1977	3.00	1.133	0.083	83,200
10/29/1977	2.25	2.061	0.082	81,910
6/18/1977	2.75	1.436	0.081	81,170
6/29/1977	2.25	1.251	0.080	80,060
8/12/1977	2.25	1.525	0.077	77,180
5/8/1977	2.25	1.893	0.076	75,590
5/2/1977	3.25	0.939	0.075	74,740
9/16/1977	2.75	1.189	0.073	73,490
5/12/1977	2.25	1.874	0.072	71,870
4/2/1977	2.00	1.719	0.069	68,500
5/16/1977	2.00	1.812	0.068	68,310
12/5/1977	3.75	0.734	0.068	67,650
9/16/1977	2.25	1.103	0.063	63,360
8/11/1977	2.25	1.418	0.061	61,160
5/4/1977	2.50	0.954	0.060	60,240
3/20/1977	2.25	1.084	0.054	54,420
4/22/1977	3.00	1.074	0.054	54,270
6/25/1977	1.50	1.585	0.051	51,470
7/4/1977	2.00	0.916	0.050	50,250
2/24/1977	2.00	1.280	0.048	48,180
2/8/1977	2.00	1.464	0.046	46,270
11/11/1977	2.75	0.978	0.043	42,770
11/30/1977	4.00	0.499	0.042	42,470
5/31/1977	1.75	1.449	0.042	42,020
9/15/1977	2.25	0.702	0.040	40,350
7/25/1977	1.50	1.350	0.037	36,970
9/13/1977	1.75	0.951	0.035	34,510
12/3/1977	2.00	0.660	0.034	34,250
12/14/1977	2.25	0.530	0.032	31,920
10/9/1977	1.50	0.921	0.027	27,220
9/12/1977	1.75	0.496	0.027	26,690
3/28/1977	1.50	0.694	0.026	26,030
8/8/1977	1.25	0.911	0.025	25,060
8/13/1977	2.00	0.763	0.025	24,840
10/8/1977	2.00	0.461	0.023	22,770
11/25/1977	2.00	0.715	0.022	21,940
4/2/1977	1.50	0.658	0.020	19,940
7/31/1977	1.00	0.798	0.019	19,490
8/6/1977	1.00	0.803	0.019	19,250
8/17/1977	1.00	0.763	0.018	18,340
9/13/1977	2.75	0.422	0.018	18,030
7/18/1977	1.00	0.764	0.017	16,760
9/10/1977	0.75	0.656	0.010	9,736
3/29/1977	0.75	0.628	0.009	9,477
7/16/1977	1.25	0.317	0.009	8,986
4/23/1977	1.00	0.403	0.008	8,097
10/16/1977	1.00	0.308	0.007	6,764
8/10/1977	0.75	0.426	0.005	5,173
12/14/1977	1.00	0.190	0.004	4,343
3/18/1977	0.50	0.084	0.001	880
3/28/1977	0.50	0.079	0.001	821
4/5/1977	0.50	0.032	0.000	334
Total Volume ==			7.223,210	

Support Documents: Drawings from the city records are attached. The drawings consist of:

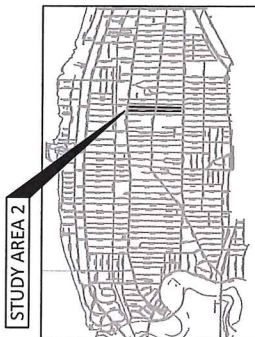
- Improvement Plan, Parkwood Road, City of Lakewood, Drawing # D-156, March 1920
- Detroit Avenue Sewer Rehabilitation Project, New South Sanitary Sewer, Drawing File A-1035, Sheet C-3, Record Drawing-September 2007
- Detroit Avenue Sewer Rehabilitation Project, Connection Detail Parkwood Rd. & Wyandotte Rd., Drawing File A-1035, Sheet C-15, Record Drawing-September 2007
- Manhole investigation sketches and photographs
- Aerial map from Cuyahoga County
- Soils map
- Typical Year Precipitation
- Footing (Foundation) Drain studies
- Downspout Flow Rates

Comments: Modeling indicates that there are significant impacts from I/I on Parkwood as well as other streets in the area. Elimination of surface drainage will help reduce the volume of overflows, but will not eliminate the occurrences of overflows at the end of Parkwood and overflow locations along this portion of Detroit Avenue.

Goal: Eliminate all discharges from the overflow



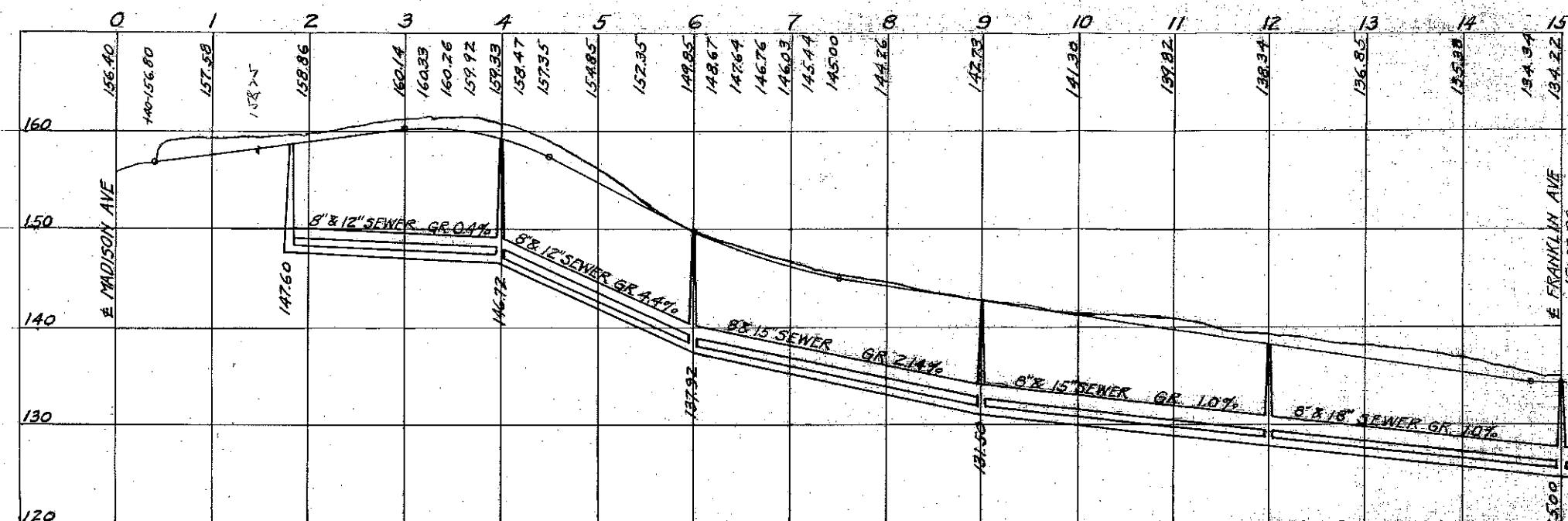
LEGEND	
CSO-0022 SERVICE AREA	
COMBINATION SEWER	
SEWER/STORM SEWER	
STORM SEWER	
NOT PART OF CSO	
COMBINATION/SANITARY MANHOLE	
ONLY/UNDER MANHOLE	
STORM MANHOLE	
OUTFALL	
20" STORM SEWER	
OVER	
6" SANITARY	



KEY PLAN



IWWIP AREA 2

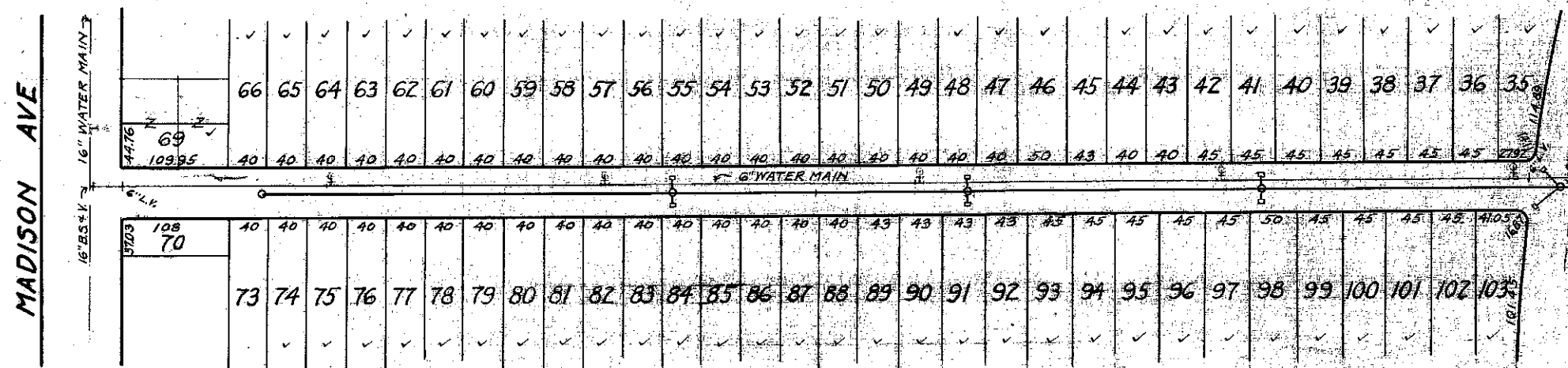
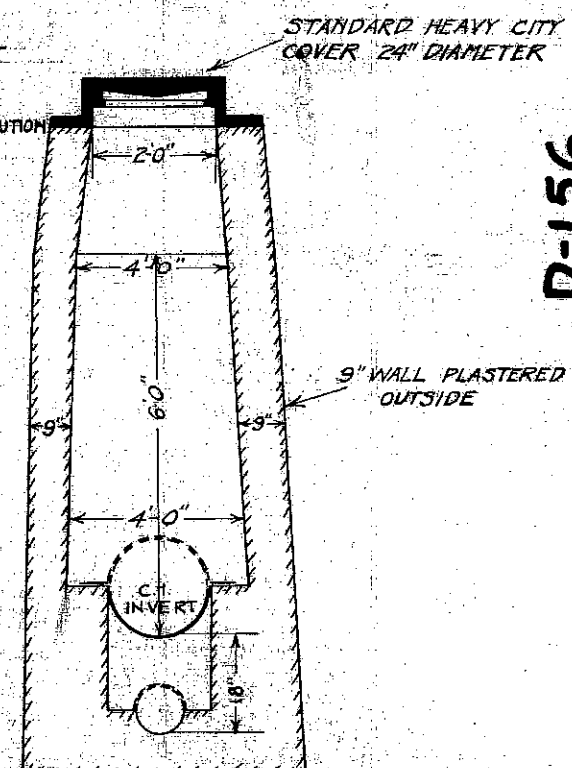


APPROVED
CITY WATER DEPT
5-1-20
Chas Schmitt
ENGINEER OF DISTRIBUTION
J.E. Martin
COMMISSIONER

ENTERED
5-8-20
BY W.J.S.

Sewer and water plan approved by the Engineer
of the City of Lakewood this 26th day of April 1920

E. A. Fisher
CITY ENGINEER



MANHOLE DETAIL
RETRACED FROM BLUEPRINT

CITY OF LAKEWOOD
IMPROVEMENT PLAN
PARKWOOD RD.
FROM MADISON AVE TO FRANKLIN AVE
SCALE 1"=10' VER.
1"=100' HOR. MARCH 1920
C.W. COURTNEY CIVIL ENGINEER

BENCHMARK #3:
M IN "MUELLER" ON FIRE HYDRANT AT THE
NORTH SIDE OF DETROIT AVE. OPPOSITE
PARKWOOD ROAD IN FRONT OF ARISTOCRAT
LAKEWOOD RETIREMENT COMMUNITY.
ELEV 682.66

NOTES:

1. SEE SHEET C-24 FOR DETAIL OF DEFORMATION
MONITORING POINTS.

DMP-1
DMP-2

1. STORM AND SANITARY LATERALS FOR 14000, MOON
GROUP, DISCHARGE FROM SAME CONNECTION IN EXISTING
CENTER SANITARY SEWER. RECONNECT STORM LATERAL TO
EXISTING CENTER STORM SEWER. SEE SHEET C-9.

2. 12" STORM LATERAL FOR 14013, GIANT EAGLE,
DISCHARGES INTO EXISTING BUNTS' SANITARY MANHOLE
(TO BE REPLACED BY DROP MH 9). RECONNECT STORM
LATERAL TO EXISTING STORM MANHOLE IN BUNTS. SEE
SHEET C-14.

2. THE CONTRACTOR SHALL VERIFY THAT THESE STORM LATERALS
DISCHARGE FROM SANITARY LATERALS INTO THE EXISTING CENTER SANITARY
SEWER.

3. CEI DETERMINED THIS POLE WILL NEED TO BE
SUPPORTED DURING CONSTRUCTION. CONTRACTOR
SHALL COORDINATE WITH CEI TO PROPERLY SUPPORT
UTILITY POLE.

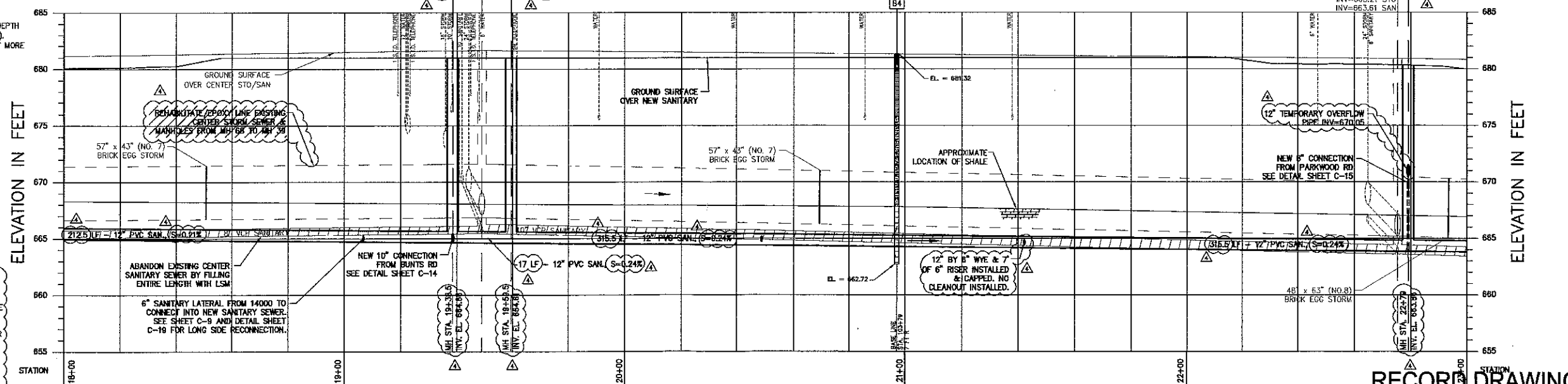
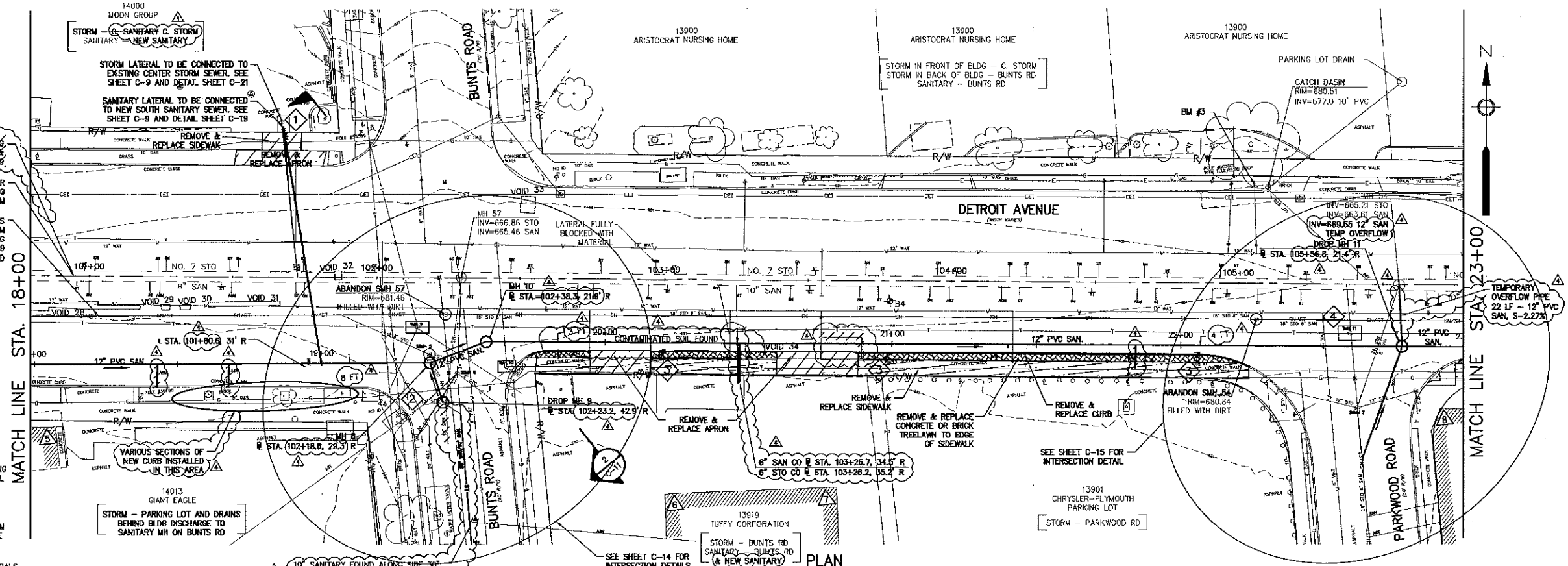
4. CONTRACTOR SHALL VERIFY TELEPHONE MH DEPTH
AND BASE MATERIAL (SAND, CONCRETE, ETC.).
DEPTHS OF TELEPHONE MHS ARE GENERALLY MORE
SHALLOW THAN THE NEW SANITARY SEWER.

1. ALL DESIGN ELEVATIONS HAVE BEEN CHANGED TO
ACTUAL ELEVATIONS.

2. ALL DESIGN PIPE LENGTHS AND PIPE SLOPES HAVE
BEEN CHANGED TO ACTUAL NUMBERS.

3. ALL DESIGN BASELINE STATIONS AND OFFSETS FOR
MANHOLES HAVE BEEN CHANGED TO ACTUAL
LOCATIONS.

4. REHABILITATION OF THE EXISTING CENTER STORM
SEWER BY EPOXY LINING WAS NOT PERFORMED.



RECORD DRAWING

NOTE: This Record Drawing has been prepared based
on information provided by others. Metcalf & Eddy
has not verified the accuracy and/or completeness of
this information and shall not be responsible for
errors or omissions which may be incorporated as a
result.

REVISIONS	NUMBER	DATE	MADE BY	CHECKED	DESCRIPTION
	1	9/13/07	CMF	GF	RECORD DRAWINGS

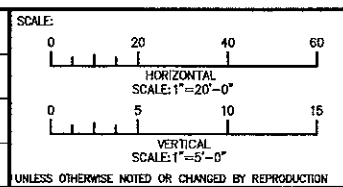
LAKEWOOD
OHIO

METCALF & EDDY | AECOM

RANDOLPH ROSTAS, P.E.

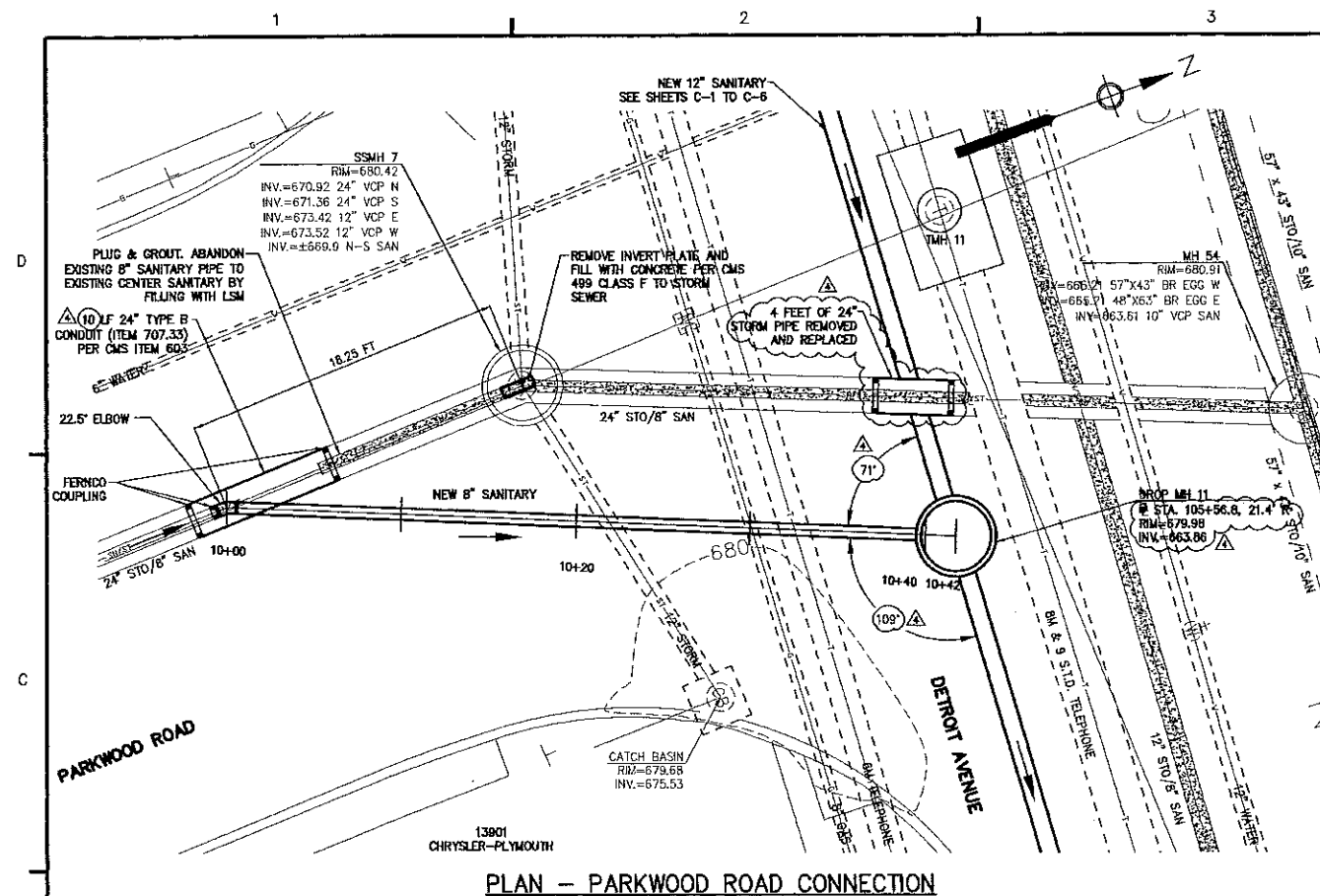
DESIGNED BY: TGV
DRAWN BY: CMF
DEPT. CHECK: RR
PROJ. CHECK: RR

DATE

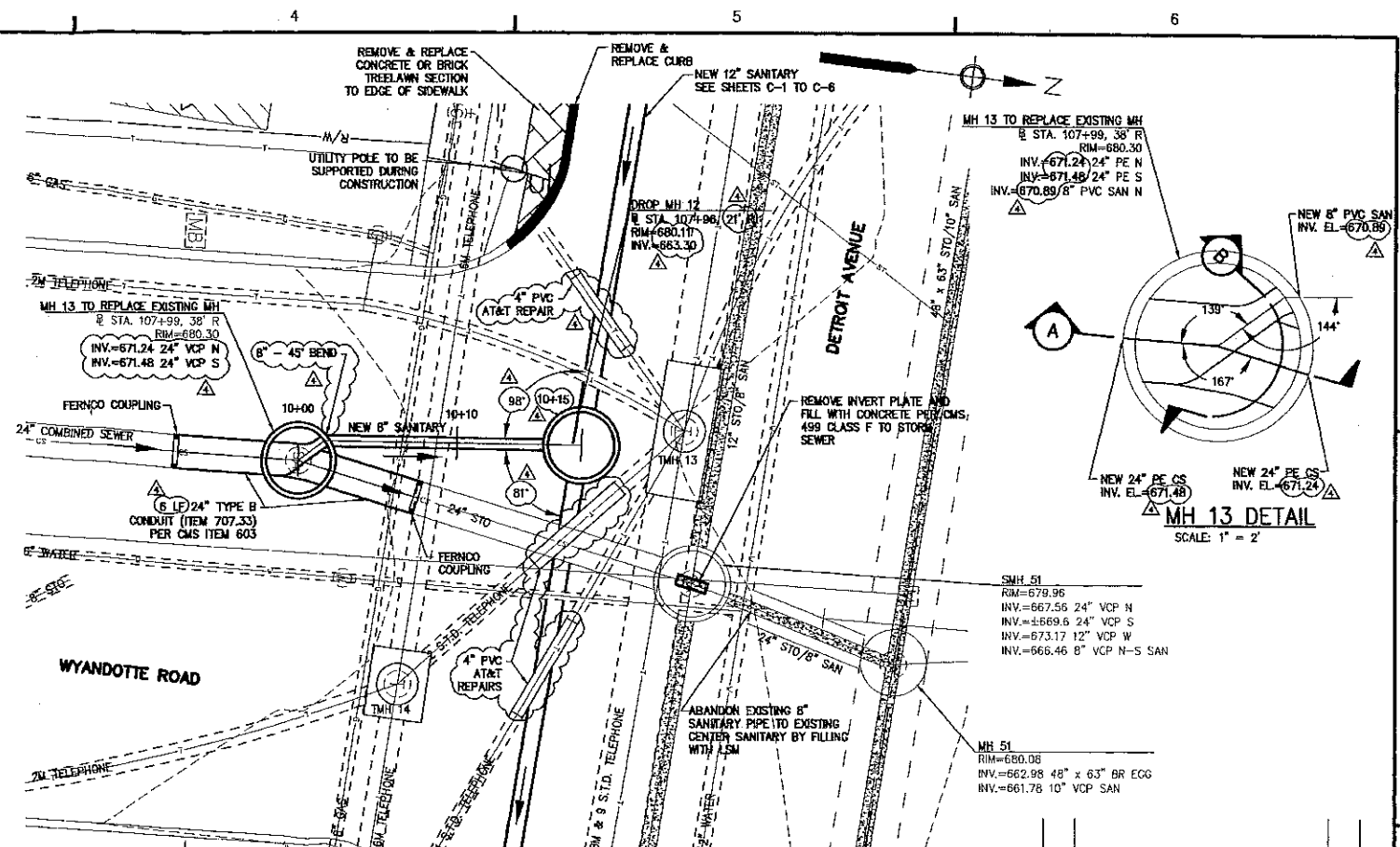


CITY OF LAKEWOOD, OHIO
DETROIT AVENUE
SEWER REHABILITATION PROJECT
NEW SOUTH SANITARY SEWER
PLAN & PROFILE
STA. 18+00 TO STA. 23+00

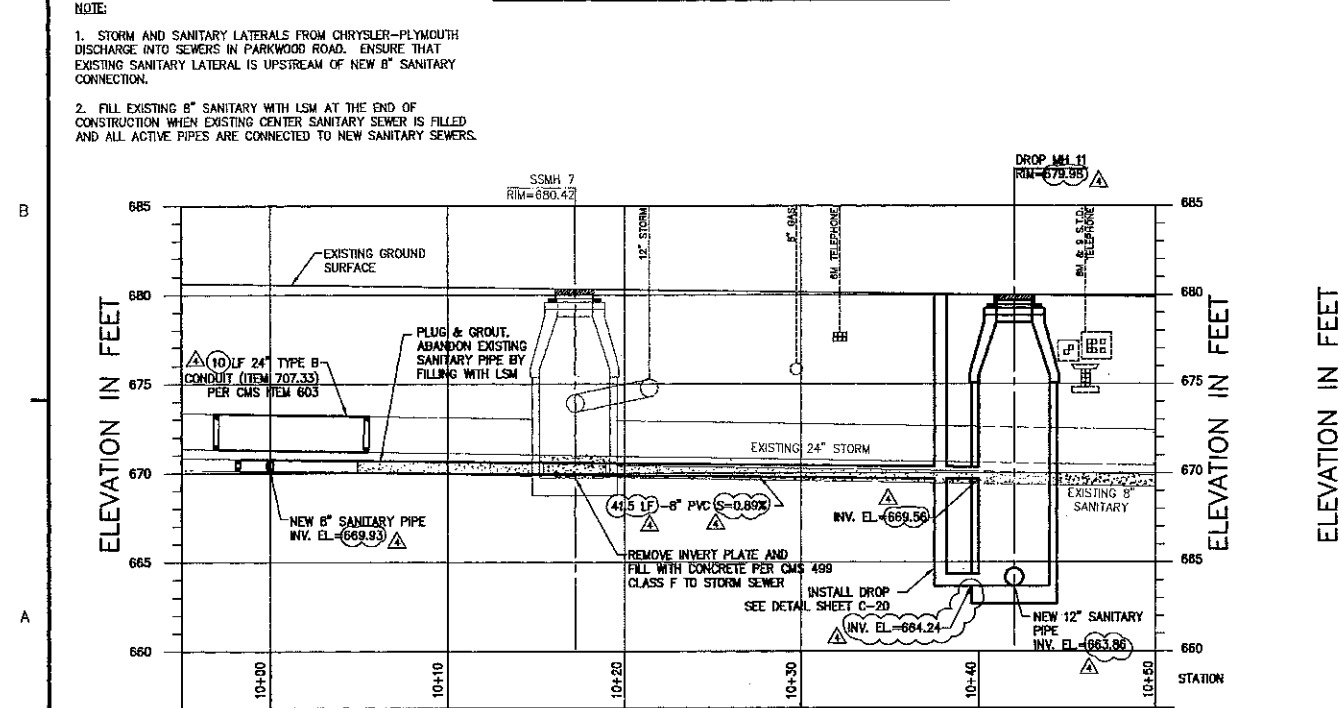
JOB: 60004368
FILE NO.:
CAD FILE: CZDET003
SHEET: C-3
JULY 2008



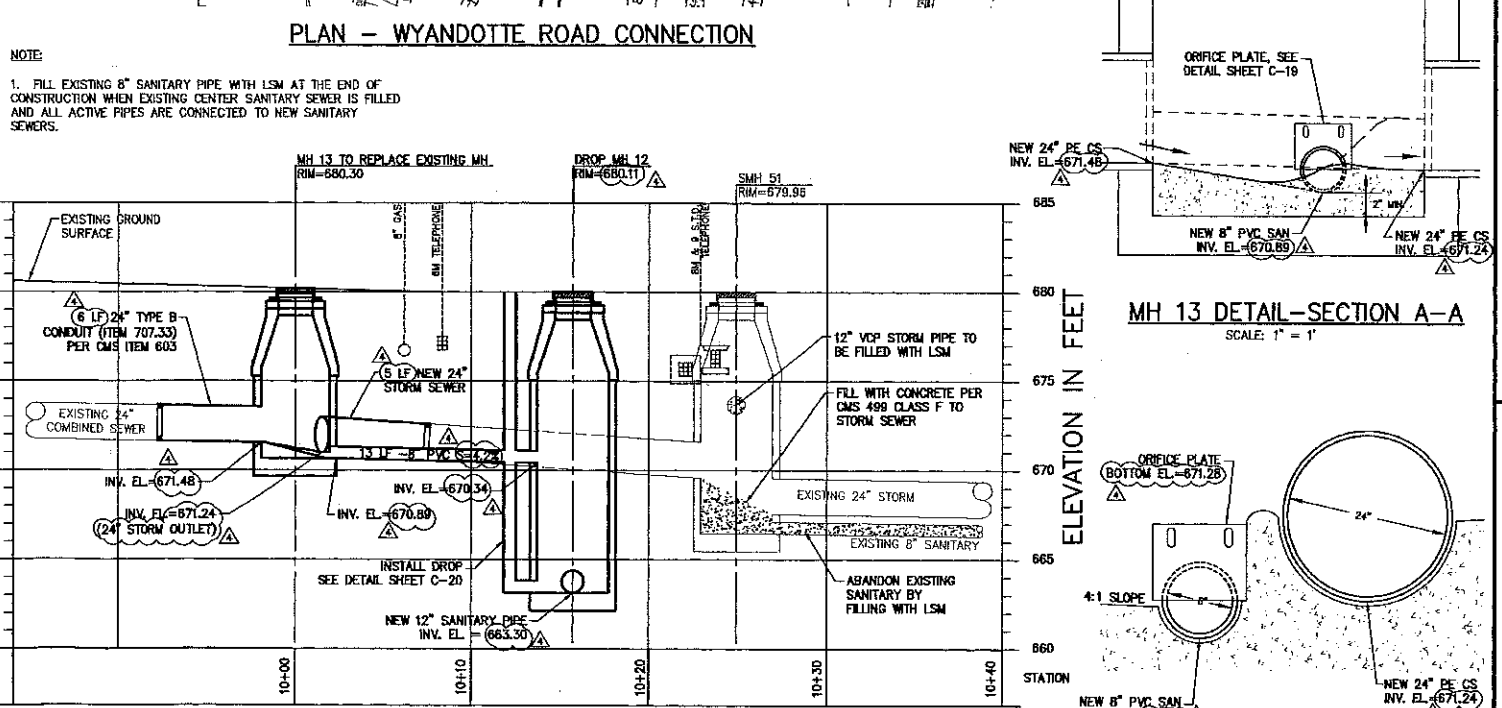
PLAN - PARKWOOD ROAD CONNECTION



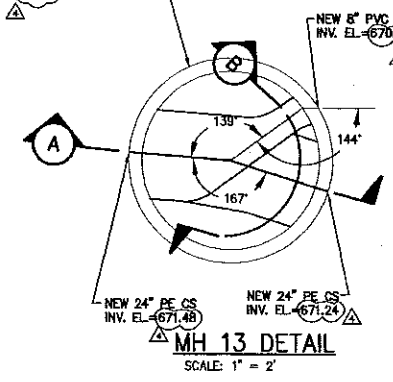
PLAN - WYANDOTTE ROAD CONNECTION



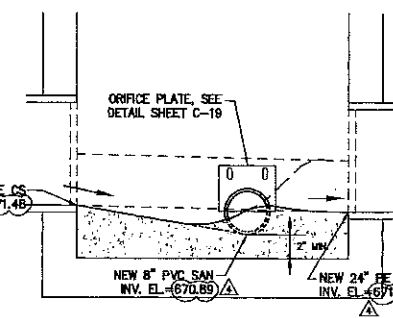
PROFILE - PARKWOOD ROAD CONNECTION



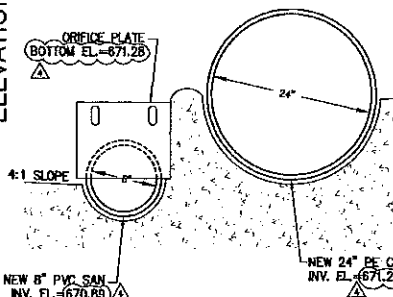
PROFILE - WYANDOTTE ROAD CONNECTION



MH 13 DETAIL



MH 13 DETAIL-SECTION A-A



MH 13 DETAIL-SECTION B-B

RECORD DRAWING

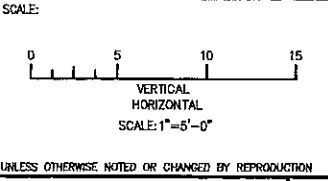
NOTE: This Record Drawing has been prepared based on information provided by others. Metcalf & Eddy has not verified the accuracy and/or completeness of this information and shall not be responsible for errors or omissions which may be incorporated as a result.

NUMBER	DATE	MADE BY	CHECKED	REVISIONS	DESCRIPTION
1	9/28/07	CMF	GF		RECORD DRAWINGS



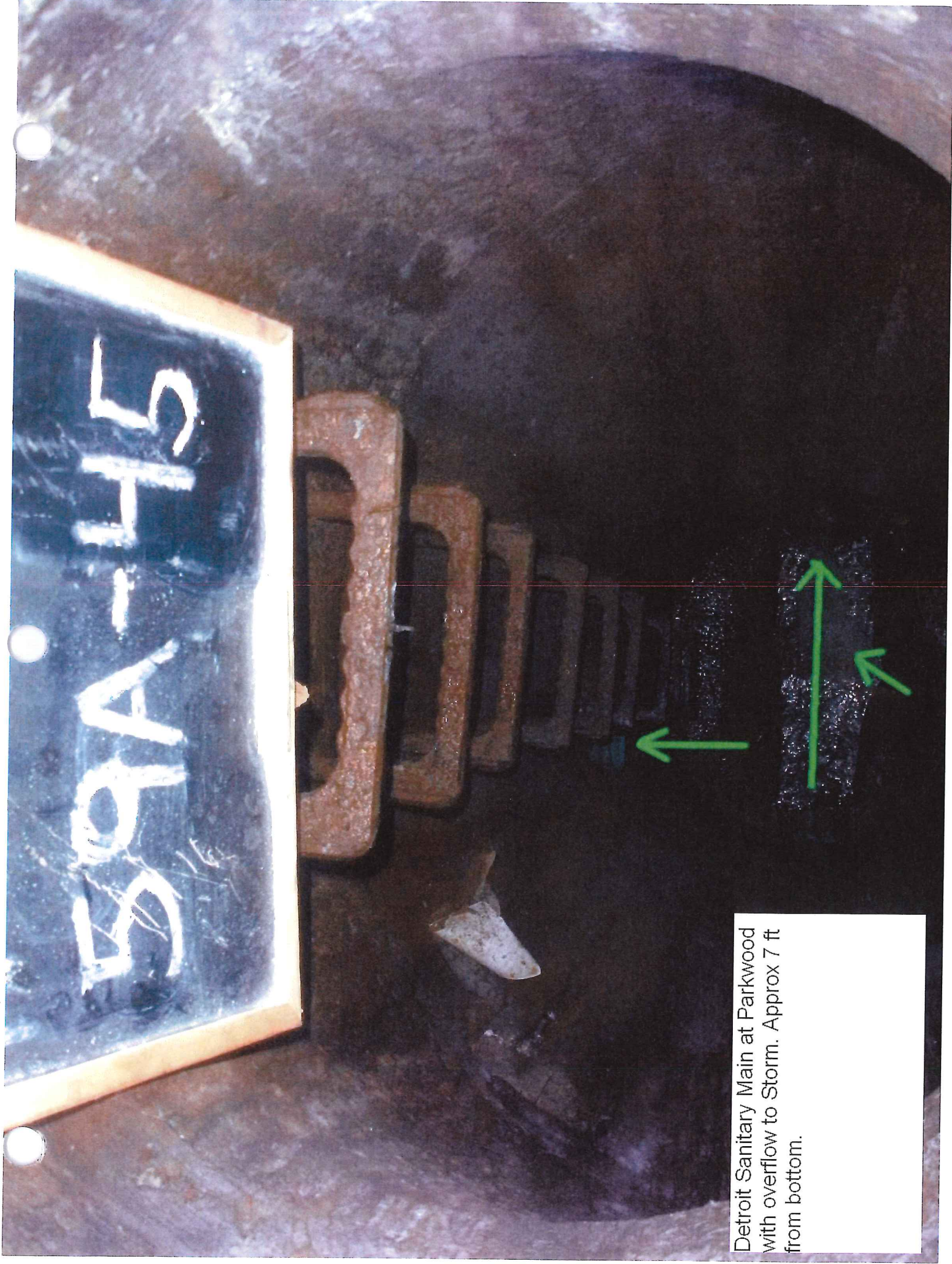
METCALF & EDDY | AECOM

DESIGNED BY:	TGW
DRAWN BY:	CMF
DEPT. CHECK:	RR
PROJ. CHECK:	RR



CITY OF LAKEWOOD, OHIO
DETROIT AVENUE
SEWER REHABILITATION PROJECT
CONNECTION DETAIL
PARKWOOD RD. & WYANDOTTE RD.

JOB	60004368
FILE NO.	
CAD FILE	CZDET015 - BOUND
SHEET	C-15



Detroit Sanitary Main at Parkwood
with overflow to Storm. Approx 7 ft
from bottom.

SEWER MANHOLE SURVEYS

Manhole No.: 059A-22

Date: 2-25-10

Street Name: DETROIT - PARKWOOD

Crew: Jim, DH

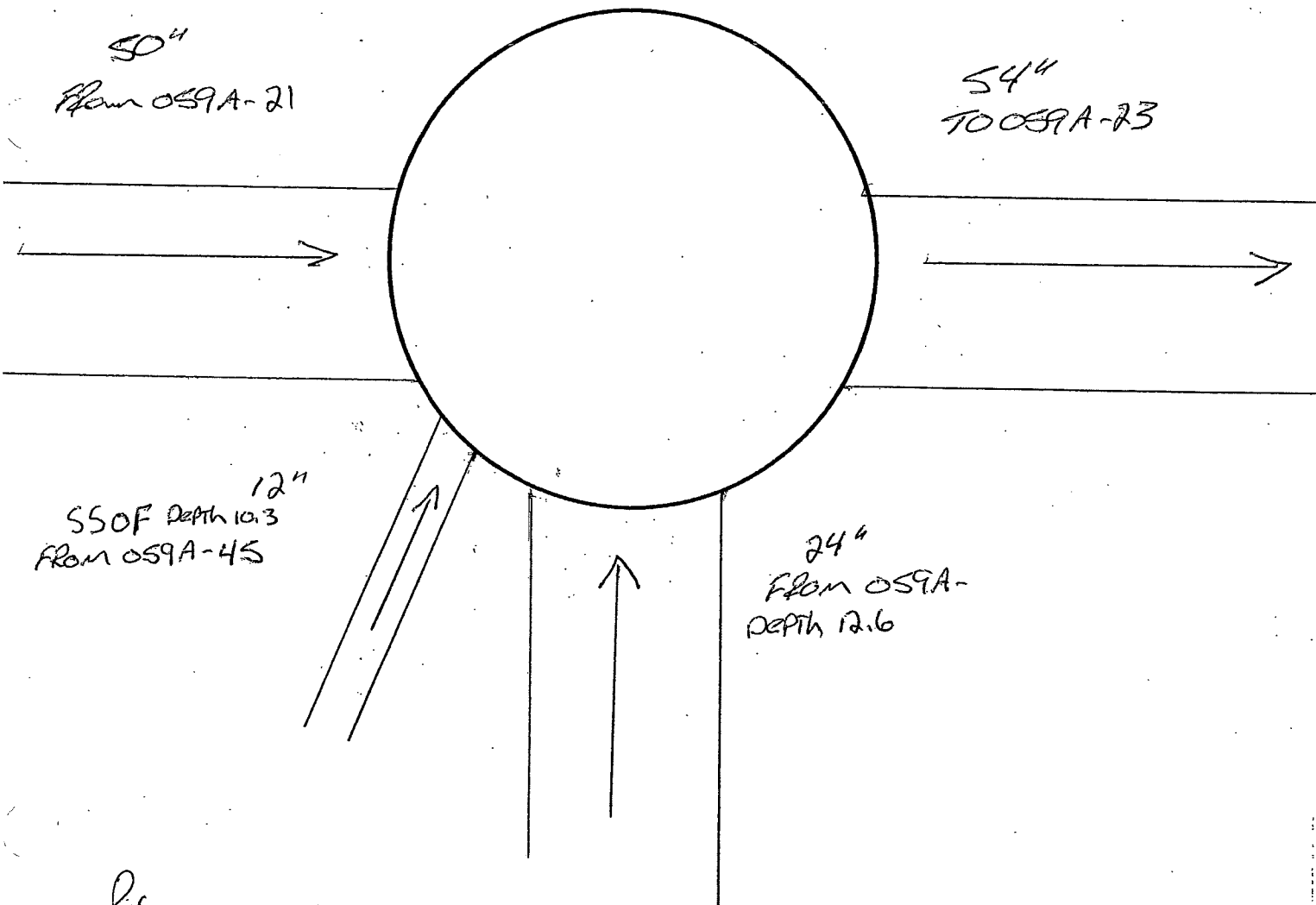
Structure Type: Over/Under ☐ Combined ☐ Side/Side ☐

Only Sanitary ☐ Only Storm ☒

Invert Plate: Yes ☐ Missing ☐ Not Required ☒

Manhole Depth 15.6

Draw all pipes entering M.H. with size & depth. Include flow of water/sewage.



Pic

Notes:



SEWER MANHOLE SURVEYS

Manhole No.: 059A-45

Date: 3-19-10

Street Name: DETROIT + PARKWOOD

Crew: En, DH

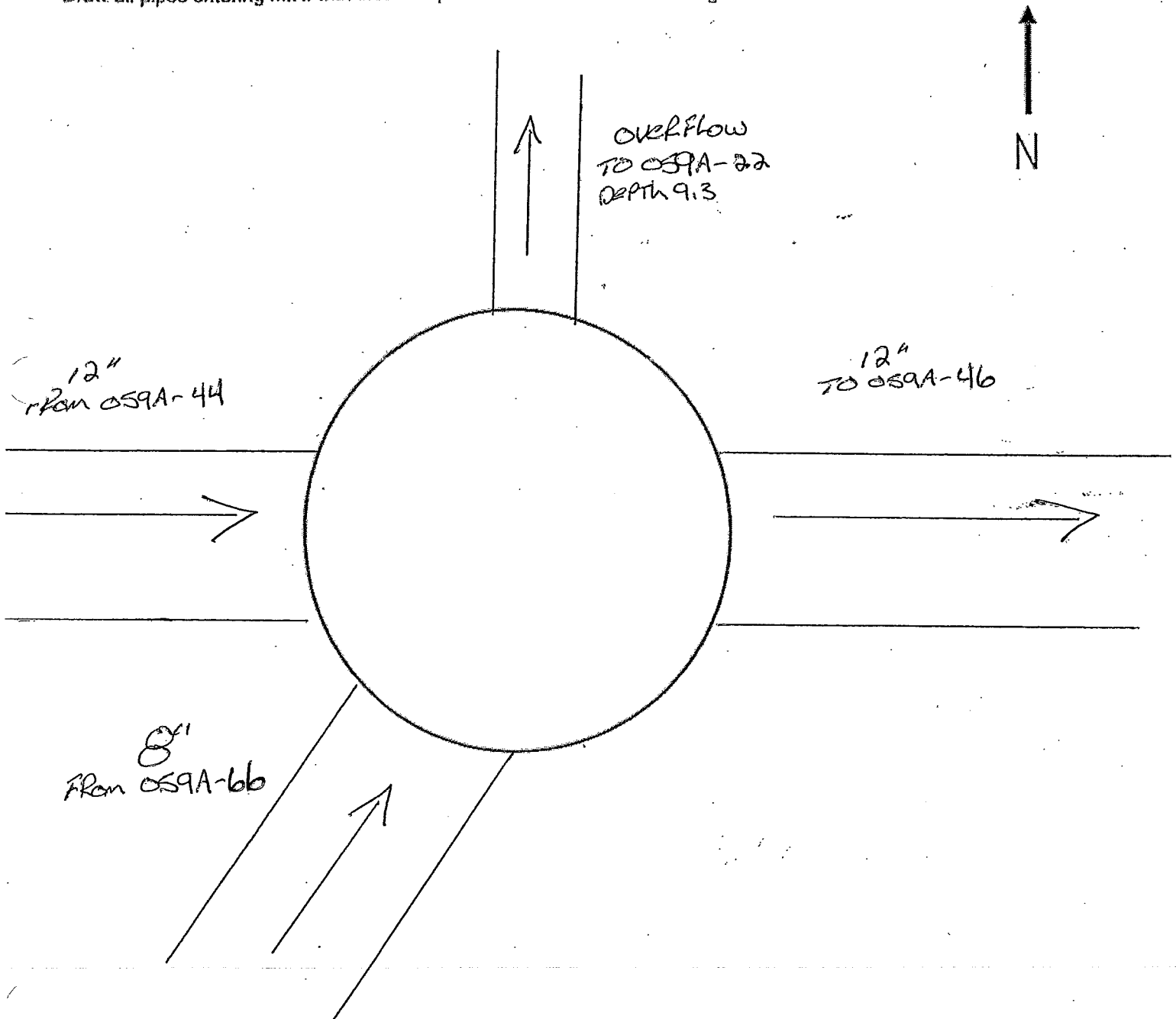
Structure Type: Over/Under Combined Side/Side

Only Sanitary / Only Storm

Invert Plate: Yes Missing Not Required /

Manhole Depth 16.5

Draw all pipes entering M.H. with size & depth. Include flow of water/sewage.



Pic

Notes:





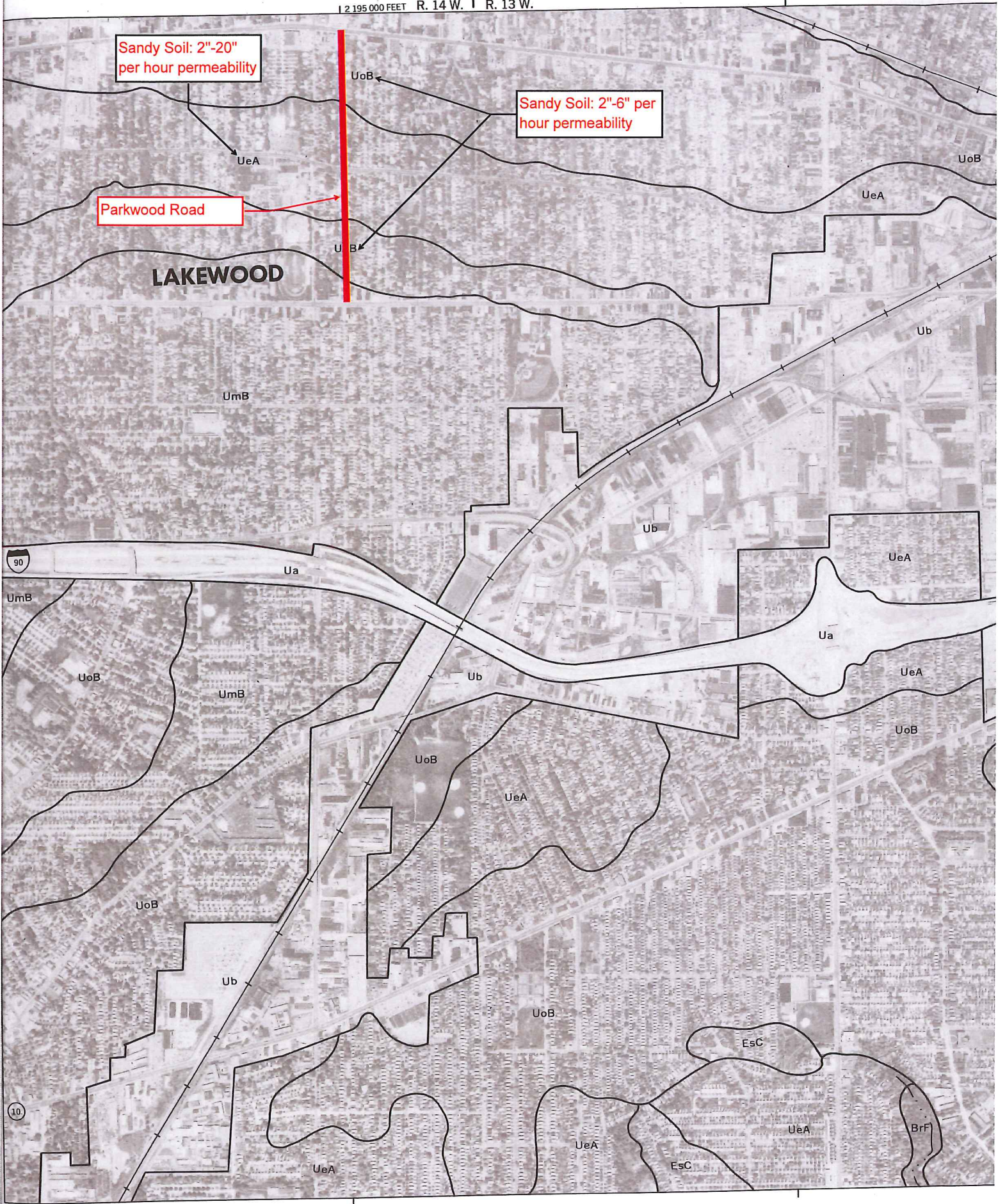
12 195 000 FEET R. 14 W. | R. 13 W.

Sandy Soil: 2"-20"
per hour permeability

Sandy Soil: 2"-6" per
hour permeability

Parkwood Road

LAKEWOOD



TYPICAL YEAR PRECIPITATION

The City's comprehensive model was used to establish a baseline for overflow events during a typical precipitation year. It is the baseline predictions from the model that will be used to determine system improvements in accordance with the city's long-term control plan. Data from Cleveland Hopkins International Airport (CLE) were obtained for the 33-year period from 1973 to 2006. The following criteria were considered desirable for the typical year precipitation data:

- No storm events greater than a 1-year storm
- Include a 1-year 1-hour storm
- Include a 6-month 1-hour storm
- Include a 4-month 1-hour storm
- Include a 3-month 1-hour storm
- Have remaining storms less than a 3-month storm
- Close to average precipitation reported by United States Department of Agriculture (USDA)

The precipitation events from the 33-year record were classified and calendar year 1977 (35.48 inches, total) came closest to the previously stated criteria. This year of precipitation data was submitted to the USEPA for evaluation. The USEPA assessed the proposed precipitation record and requested that the total precipitation for the year be raised from 35.48 inches to 37.52 inches based on the CLE data (1973 to 2006) being more recent than the USDA data (1951 to 1976) previously used. To incorporate the additional precipitation requested, the 1977 monthly precipitation was compared to the monthly averages of the CLE data. January, February, May, September, and October were below the monthly average of the CLE data. The additional precipitation (2.04 inches) of precipitation was distributed to the below average months as shown in Table 8.1. The additional storms brought the respective monthly averages closer to the monthly averages of the CLE data.

Appendix B. Summary of District's Synthetic Design Storm and Typical Year Rainfall

Tables B-1 and **B-3** were obtained from Appendix C of the District's CSO Facilities Planning Summary Report dated March 2005. The Consultant shall refer to this report for additional information regarding the District's selected design storms and synthetic typical year hyetographs is needed. **Table B-2** summarizes the standard design storm hyetographs based on 15-minute rainfall increments have been adopted and are available for Consultant use if needed for particular project needs. District approval is required if finer rainfall time series is deemed necessary by the Consultant.

Table B-1. Official Design Storm Hyetographs Based on 1-Hour Rainfall Increments.

Return Period	Duration	Hourly Incremental Rainfall Depth (in)						Total Rainfall	Average Intensity
		Hour 1	Hour 2	Hour 3	Hour 4	Hour 5	Hour 6	(in)	(in/hr)
1-month	6-hour	0.06	0.15	0.09	0.09	0.08	0.09	0.56	0.09
4-month	6-hour	0.05	0.15	0.10	0.37	0.16	0.14	0.97	0.16
6-month	6-hour	0.01	0.06	0.02	0.73	0.26	0.02	1.10	0.18
1-year	6-hour	0.05	0.07	0.15	1.00	0.21	0.01	1.49	0.25
2-year	6-hour	0.12	0.04	0.14	1.17	0.18	0.10	1.75	0.29
5-year	6-hour	0.06	0.10	0.23	1.43	0.20	0.12	2.14	0.36
1-year	1-hour	1.00						1.00	1.00
5-year	1-hour	1.43						1.43	1.43
10-year	1-hour	1.69						1.69	1.69
25-year	1-hour	2.06						2.06	2.06
50-year	1-hour	2.40						2.40	2.40
100-year	1-hour	2.77						2.77	2.77

Table B-2. Design Storm Hyetographs Based on 15-Minute Rainfall Increments.

Return Period	6-Hour Duration ⁽¹⁾		24-Hour Duration ⁽²⁾	
	Total Rainfall (in)	Peak 1-Hour Intensity (in/hr)	Total Rainfall (in)	Peak 1-Hour Intensity (in/hr)
1-month	0.56	0.36	0.79	0.36
2-month	0.79	0.51	1.12	0.51
3-month	0.93	0.59	1.31	0.59
4-month	1.01	0.65	1.43	0.65
6-month	1.17	0.75	1.65	0.75
9-month	1.33	0.85	1.88	0.85
1-year	1.45	0.92	2.04	0.92
2-year	1.77	1.13	2.50	1.13
5-year	2.20	1.40	3.10	1.40

(1) Distribution based on peak 6-hr duration of the SCS Type 2 24-hr distribution at 15-minute increments.

(2) From District's 2006 RIDE Study and ISWS Bulletin 71 and SCS Type 2 24-hour distribution.

Table B-3. Storm Events for Typical Year Continuous Year Simulation.

Storm Event	Date	Hour	Duration (Hrs)	Depth (In)	Average Intensity (In/Hr)	Maximum Hourly Intensity (In/Hr)	Storm Event	Date	Hour	Duration (Hrs)	Depth (In)	Average Intensity (In/Hr)	Maximum Hourly Intensity (In/Hr)
1	01/03/91	12	1	0.01	0.01	0.01	62	07/03/93	2	1	0.01	0.01	0.01
2	01/05/91	13	10	0.18	0.02	0.03	63	07/04/93	16	1	0.44	0.44	0.44
3	01/09/91	13	2	0.03	0.01	0.02	64	07/06/93	16	1	0.47	0.47	0.47
4	01/11/91	4	19	0.39	0.02	0.09	65	07/11/93	20	3	0.35	0.12	0.24
5	01/12/91	12	21	0.04	0.00	0.01	66	07/19/93	14	2	0.14	0.07	0.13
6	01/15/91	24	8	0.33	0.04	0.08	67	07/26/93	6	2	0.04	0.02	0.02
7	01/16/91	19	10	0.17	0.02	0.03	68	07/28/93	17	9	1.08	0.12	0.72
8	01/20/91	13	30	0.53	0.02	0.05	69	07/29/93	20	3	0.67	0.22	0.31
9	01/26/91	7	10	0.03	0.00	0.01	70	08/02/93	5	2	0.42	0.21	0.41
10	01/27/91	19	4	0.08	0.02	0.03	71	08/03/93	21	10	0.42	0.04	0.20
11	01/29/91	20	11	0.37	0.03	0.10	72	08/06/93	19	4	0.10	0.03	0.06
12	01/30/91	18	1	0.01	0.01	0.01	73	08/07/93	13	1	0.13	0.13	0.13
13	01/31/91	14	1	0.01	0.01	0.01	74	08/10/93	16	2	0.02	0.01	0.01
14	02/05/91	7	1	0.01	0.01	0.01	75	08/11/93	4	4	0.24	0.06	0.23
15	02/06/91	15	9	0.10	0.01	0.02	76	08/12/93	17	1	0.02	0.02	0.02
16	02/10/91	15	20	0.73	0.04	0.09	77	08/16/93	4	1	0.07	0.07	0.07
17	02/13/91	14	59	1.53	0.03	0.16	78	08/20/93	9	1	0.01	0.01	0.01
18	02/16/91	24	14	0.18	0.01	0.04	79	08/28/93	2	1	0.06	0.06	0.06
19	02/18/91	15	13	0.08	0.01	0.04	80	08/31/93	13	6	0.03	0.00	0.02
20	02/19/91	17	7	0.29	0.04	0.10	81	09/02/93	8	21	1.02	0.05	0.67
21	02/26/91	4	40	0.08	0.00	0.01	82	09/06/93	13	1	0.35	0.35	0.35
22	02/28/91	9	4	0.04	0.01	0.02	83	09/07/93	9	1	0.01	0.01	0.01
23	03/02/91	1	14	0.06	0.00	0.02	84	09/10/93	1	1	0.01	0.01	0.01
24	03/03/91	13	24	0.70	0.03	0.10	85	09/10/93	13	1	0.01	0.01	0.01
25	03/06/91	6	14	0.83	0.06	0.13	86	09/15/93	20	16	2.38	0.15	0.40
26	03/09/91	18	2	0.07	0.04	0.05	87	09/22/93	24	16	0.12	0.01	0.05
27	03/10/91	12	4	0.08	0.02	0.03	88	09/25/93	16	20	1.63	0.08	0.29
28	03/17/91	21	31	0.50	0.02	0.07	89	09/27/93	13	9	0.15	0.02	0.06
29	03/22/91	6	4	0.32	0.08	0.18	90	09/28/93	10	3	0.23	0.08	0.12
30	03/22/91	24	3	0.14	0.05	0.08	91	09/29/93	10	17	0.97	0.06	0.24
31	03/23/91	24	10	0.23	0.02	0.06	92	10/01/93	10	1	0.01	0.01	0.01
32	03/26/91	13	1	0.02	0.02	0.02	93	10/01/93	23	6	0.58	0.10	0.22
33	03/27/91	24	1	0.62	0.62	0.62	94	10/09/93	6	13	0.43	0.03	0.13
34	03/31/91	19	6	0.07	0.01	0.03	95	10/16/93	22	16	0.60	0.04	0.18
35	04/01/93	23	5	0.16	0.03	0.07	96	10/19/93	15	1	0.04	0.04	0.04
36	04/02/93	17	12	0.06	0.00	0.02	97	10/20/93	15	6	0.04	0.01	0.02
37	04/09/93	14	16	0.77	0.05	0.09	98	10/27/93	22	4	0.15	0.04	0.10
38	04/11/93	16	1	0.09	0.09	0.09	99	10/30/93	10	39	1.67	0.04	0.12
39	04/14/93	19	2	0.03	0.01	0.02	100	11/01/91	17	1	0.01	0.01	0.01
40	04/15/93	23	3	0.34	0.11	0.16	101	11/07/91	9	12	0.12	0.01	0.02
41	04/19/93	17	13	0.27	0.02	0.11	102	11/11/91	2	7	0.69	0.10	0.14
42	04/20/93	16	18	0.61	0.03	0.13	103	11/12/91	11	12	0.21	0.02	0.06
43	04/24/93	12	2	0.03	0.01	0.02	104	11/15/91	1	31	0.62	0.02	0.10
44	04/25/93	8	15	0.46	0.03	0.16	105	11/18/91	17	21	0.30	0.01	0.10
45	04/30/93	1	6	0.10	0.02	0.03	106	11/20/91	17	19	0.46	0.02	0.14
46	05/04/93	13	25	0.63	0.03	0.22	107	11/23/91	20	3	0.24	0.08	0.12
47	05/19/93	4	6	0.15	0.02	0.07	108	11/24/91	17	8	0.03	0.00	0.01
48	05/23/93	16	1	0.01	0.01	0.01	109	11/25/91	14	1	0.01	0.01	0.01
49	05/24/93	6	6	0.08	0.01	0.04	110	11/28/91	6	8	0.19	0.02	0.05
50	05/28/93	24	2	0.03	0.01	0.02	111	11/30/91	6	1	0.04	0.04	0.04
51	05/31/93	23	2	0.16	0.08	0.08	112	12/02/91	16	17	1.19	0.07	0.29
52	06/03/93	23	2	0.07	0.03	0.04	113	12/03/91	21	11	0.06	0.01	0.02
53	06/05/93	5	6	0.37	0.06	0.25	114	12/12/91	15	17	0.16	0.01	0.06
54	06/07/93	16	9	1.56	0.17	0.67	115	12/14/91	7	6	0.15	0.02	0.12
55	06/09/93	10	1	0.21	0.21	0.21	116	12/15/91	16	16	0.07	0.00	0.01
56	06/09/93	24	1	0.24	0.24	0.24	117	12/18/91	3	2	0.02	0.01	0.01
57	06/19/93	6	2	0.31	0.16	0.22	118	12/18/91	16	16	0.03	0.00	0.01
58	06/20/93	13	26	0.54	0.02	0.15	119	12/20/91	22	8	0.22	0.03	0.07
59	06/25/93	20	1	0.08	0.08	0.08	120	12/23/91	7	6	0.10	0.02	0.03
60	06/27/93	18	1	0.94	0.94	0.94	121	12/28/91	22	35	0.26	0.01	0.03
61	07/01/93	21	4	0.05	0.01	0.02	Total						37.51

operation of the basin is seen as it starts to fill just before midnight and is surcharged between 1:00 and 4:30 AM. During surcharged conditions, the levels rise and fall quickly as storage in the collection system is limited.

E.1.3.5 Footing Drain Monitoring

One potentially significant source of inflow into the sanitary sewer system during storms is from house foundation footing drains that are directly connected to the sanitary sewers. Previous studies conducted in Ann Arbor have reported that the footing drain connection from a single home could contribute as much as 10 gpm during a storm. Since most of the houses in the study areas have directly connected footing drains, footing drains can introduce a significant proportion of the observed

To estimate the amount of footing drain flow in each of the study areas, 20 locations were identified throughout the 5 study areas (about 4 per area) where house connections enter the sanitary sewer in manholes above the manhole benching. This configuration allowed the installation of temporary house lead extensions of about 1' into each manhole. Of the 20 locations identified, 16 installations were made as shown in Table E-9.

To estimate flows produced from individual homes, these house leads were visited during rainfall events to measure the flows being generated. Flows were measured using bucket and stopwatch methods. During each storm being monitored, flows were measured a number of times as field crews visited multiple manholes during the monitoring events. The storms of 8/17/00 and 9/11/00 were monitored by field crews. Two to three tests were performed at each location during each event.

Table E-9. Footing Drain Study Locations

<u>Region</u>	<u>Manhole ID</u>	<u>Approximate Address</u>
Orchard Hills	2	3000 Bluett
Orchard Hills	4	3022 Bluett
Orchard Hills	7	3130 Bluett
Orchard Hills	29	2488 Antietam
Orchard Hills	60	2537 Georgetown
Bromley	49 (E&W)	2814 Renfrew
Bromley	55	2500 Prairie
Bromley	5 (E)	2235 Prairie
Bromley	5 (W)	2235 Prairie
Glen Leven	94	1707 Tudor
Glen Leven	95	1706 Tudor
Glen Leven	22	1315 Glen Leven
Glen Leven	101 (E)	1530 Dicken Drive
Glen Leven	101 (W)	1530 Dicken Drive
Morehead Street	75	2189 Seventh
Morehead	35	2095 Chaucer

As noted earlier, footing drain flows were monitored during selected storms. This information was collected on August 17, 2000 and on September 11, 2000. The August 17, 2000 storm was short and of low volume and produced a limited wet weather flow response. During this period, footing drain flows ranged from 0.1 to 0.5 gpm.

The September 11, 2000 storm produced between 1.57" to 1.8" of rain over a 5-hour period. During this storm, footing drain flows were collected during a period of steady rainfall. Figure E-5 shows the

Table E-10 Average Footing Drain Flows

<u>Study Area</u>	<u>Flow (gpm)</u>
Orchard Hills	1.1
Bromley	1.9
Dartmoor	No Test Locations
Glen Leven	1.8
Morehead	1.4

footing drain flows measured during this storm. The measured flows ranged from 0 to 3 gpm, with an average of 1.4 gpm for all locations measured. The average footing drain flows for the tests performed

Study Design

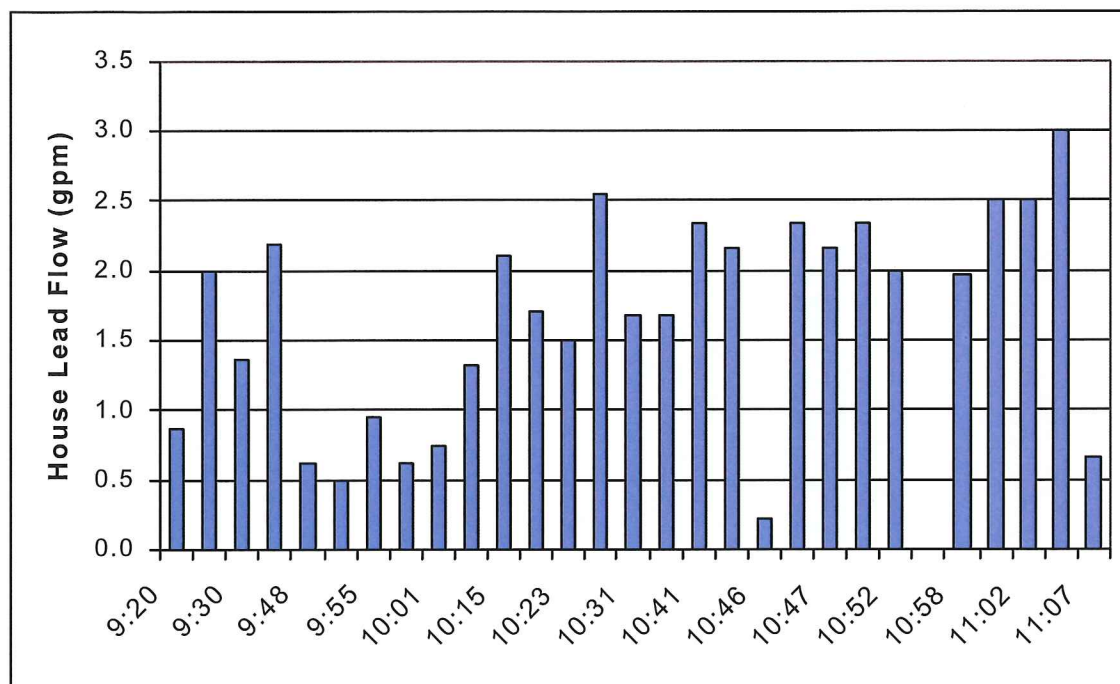


Figure E-5 Footing Drain Flow Measurements

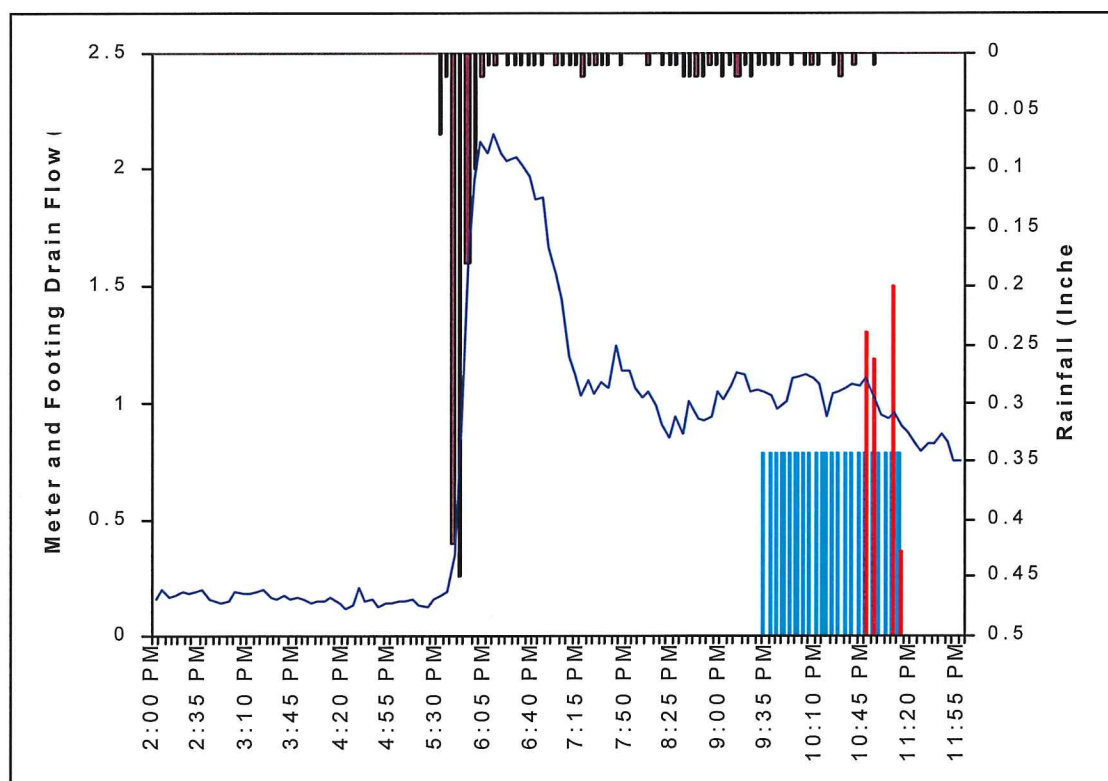


Figure E-6 Rainfall, Metered Flow, and Footing Drain Flows for Bromley Study Area

in each study area are summarized in Table E-10.

The rainfall, metered flow, and calculated footing drain flows were then compared for each study area. An example of this is shown in Figure E-6 for the Bromley study area. The rainfall data is graphed on the top of this figure. The peak of the storm took place at about 5:45 PM and then produced lower, but consistent, rainfall over the next five hours. The flow meter data is plotted as the continuous line with its ordinate of flow in cfs shown on the left axis. This figure shows a response that is similar in shape to the rainfall, peaking at about 6:00 PM and leveling off for a few hours before dropping back to a dry weather flow pattern.

An estimate of the total flow generated by all footing drains in each area was made using the assumption that the average footing drain flow of all areas, 1.4 gpm, is multiplied by the number of homes with footing drains in each study area. This estimate is graphed over the time the data was collected in all areas, and shown as the vertical blue bars in Figure E-6. The total footing drain flow estimates based on the individual measurements taken directly within the Bromley area are also shown as the variable height bars.

Figure E-6 suggests that as much as 90% of the wet weather flow in the Bromley area was caused by flows generated from footing drains. Similar results were found for three of the other study areas, with the Dartmoor study area being an exception. In this area, there appear to be other sources of RDI/I that are contributing to the flows recorded at the flow meter or the flow contribution from footing drain flows are higher than the average measured in the other areas.

E.1.4 Collection System Inspection Programs

E.1.4.1 Manhole Inspections

As part of the project scope, inspection of each accessible manhole in the study areas was performed. This work was performed to assess the

current condition of the manholes and better understand the sewer connections between the manholes. The inspection work was documented on forms completed by field crews and through digital photographs to document manhole condition, sewer connections, and specific defects. Over 800 manholes were inspected as part of this effort. The overall condition of the manholes and the sewer connections was found to be excellent. The inspection did identify 24 minor maintenance issues, which the Water Utilities Department addressed shortly after identification.

In addition to providing information regarding infrastructure condition, the inspection notes and photos provided useful information when assembling the collection system computer models. These photos allowed rapid verification of the collection system connectivity and other attributes such as approximate invert elevation.

Field notes and digital photographs were provided to the Water Utilities Department separately. The field notes and photos are accessible using the project GIS. The available GIS coverage includes the manhole identifier used to locate manholes as part of this project and this identifier is also cross-referenced to the City's identifier system where possible. The identifier used is also listed on the field forms and is contained in the filename of the digital images. The digital images referred to on each field sheet were, with a few exceptions, taken in the following order:

1. The downstream pipe was photographed looking down the pipe from the manhole.
2. Each upstream pipe was photographed (clockwise, looking down manhole, from the downstream pipe).
3. Each house lead was photographed (clockwise, looking down manhole, from the downstream pipe).
4. Specific defects, blockages, or sources of I/I



Table 1. Summary of Footing Drain Flow Studies

Downstream System Metering	Wet Weather Sanitary Flow		Peak Footing Drain Flows			Projected Peak Footing Drain Flows (gpm/house)		
	Peak Flow with FD (cfs/1000)	Peak Flow Without FD (cfs/1000)	Flow (gpm/house)	Rainfall (inches)	RDII from FD (percent)	4" Linear	4" Log	
Beverly Hills	1.56	0.38 ⁵	2.5	2.23"	76%	2.1	1.7	
Oakland County 1967	1.76	0.53	1.8	1.86"	70%	3.8	3.0	
1968 Study		---	2.1	---	---	---	---	
Canton Township FD Removal	2.7	---	3.0 ⁴	2.50" ³	---	3.0 ⁴	1.8 ⁴	
GDRSS Data	2	0.63	1.5	2.0	69%	---	---	
Clinton Township Data	3.3	---	3.3	---	---	---	---	
Auburn Hills Data	1.8	---	1.1 ³	1.8 in/hr	70%	3.7	1.7	
Center Line Data	1.7	---	1.7	---	---	---	---	
West Lafayette, In	---	---	5 ¹	---	---	---	---	
Midland, MI	---	---	5 ¹	---	---	---	---	
Direct Measurement Metering	Wet Weather Sanitary Flow		Observed Footing Drain Flows			Projected Footing Drain Flows		
	Peak Flow with FD (cfs/1000)	Peak Flow Without FD (cfs/1000)	Average Flow (gpm/house)	Peak Flow (gpm/house)	Rainfall ²	RDII from FD (percent)	4" Linear	4" Log
Ann Arbor 2000 FD Study	2.5	---	1.3	8.7	4.01"	60-90%	4.5	3.1
Dearborn Heights Study	3.0	---	0.55	1.0	0.87"	85-90%	2.2	1.1
WWMP Monitors	---	---	1.7	25.0	1.86"	---	3.0	1.7
Ann Arbor FD Monitoring 2002	----	---	1.0	8.5	1.81"	---	---	---
Toledo	---	---	0.3	3.3	1.72"	---	1.6	0.9
South Macomb Sanitary District	---	---	---	3.2	1.73"	---	6.5	3.8
Simulated Rainfall Events	---	---	6.4	10.1	2.7 in/hr	---	--	---
Other Oakland County Studies	---	---	2.5 to 10	---	---	---	---	---

1 - Based on model calibration, not direct metering.

2 - Rainfall is displayed in total volume (") or intensity (in/hr)

3 - Based on interpolation of data.

4 - Actual flows are higher. These systems allowed up to 1 gpm to pass to the sanitary system

5 - After removal of footing drain connections to sanitary sewer

FD: Footing Drain
RDII: Rainfall Dependent I/I

DOWNSPOUT FLOW RATES

1200 Sq. Ft. Roof Area (30' x 40'):

24 gpm runoff @ 1.89"/hr rainfall rate (25-yr event)

Reach of gutter carries
up to 15% of runoff (3.5
gpm)

Gutter Capacity
30 gpm

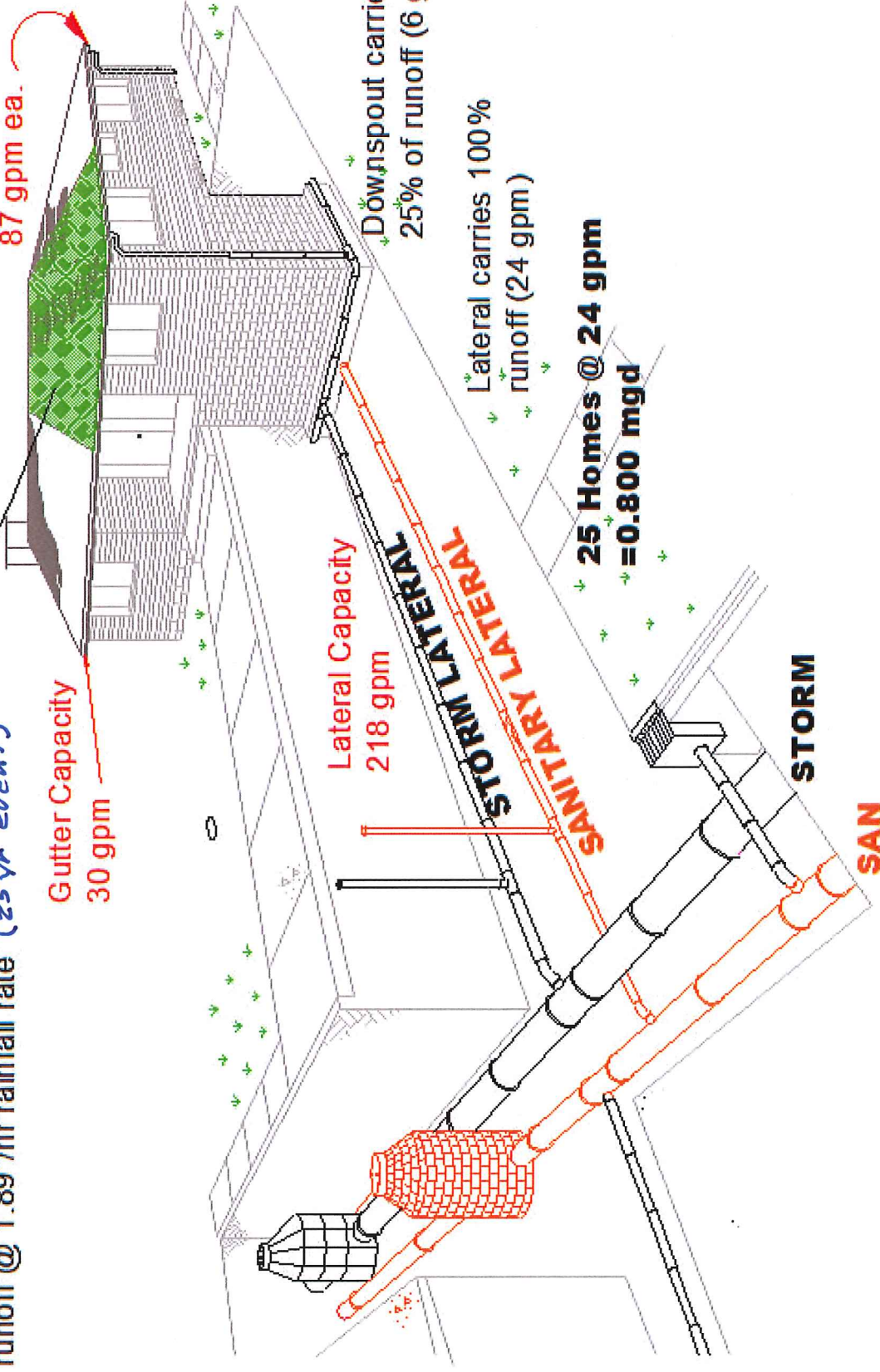
Downspout Capacity
87 gpm ea.

Lateral Capacity
218 gpm

Downspout carries
25% of runoff (6 gpm)

Lateral carries 100%
runoff (24 gpm)

25 Homes @ 24 gpm
= 0.800 mgd



Study Area #3 – combined sewer on Lake Avenue

Overview of Study Area #3: The combined sewer on Lake Avenue directly connects to an outfall sewer that conveys primarily storm water to Lake Erie at CSO 058 (located between Roy Drive and Kirtland Lane). There may be some illicit connections on the outfall sewer upstream of Lake Road that contaminates the storm water with sewage. A regulator on the outfall sewer at Edgewater Drive directs low flow to the Interceptor for treatment at the WWTP. Higher flows are discharged to Lake Erie. This area is representative of many areas along Lake Avenue and Clifton Boulevard.

- The total area of lots and streets is 20.3 acres
- 56.8% impervious
- Average sewer slope 0.36% from the west. The average slope for the first two eastern sections has a slope of 0.16%. The last section near the outfall sewer has a reverse slope of 0.07%.
- 13,180 gpd (0.013 mgd) water purchased (49 homes, 1 gas station, 1 school)
- 17,590,000 gpd (17.59 mgd) maximum flow during typical year
- Number of overflow event in a typical year is 11
- Overflow data for a typical year:

Date	Duration (h)	Maximum Flow (mgd)	Total Flow (Mg)	Total Flow (Gal)
6/30/1977	2.00	17.580	0.613	612,500
7/29/1977	1.75	17.590	0.605	605,100
7/19/1977	1.75	8.599	0.300	300,000
6/30/1977	2.00	7.613	0.265	264,700
8/5/1977	1.50	8.380	0.246	245,600
3/18/1977	1.75	2.294	0.087	86,610
6/17/1977	1.25	3.341	0.073	73,050
11/7/1977	1.25	2.339	0.053	53,390
8/21/1977	1.00	1.279	0.018	17,570
9/6/1977	0.75	1.448	0.017	17,270
9/14/1977	0.75	0.751	0.008	8,371
				2,284,161

Support Documents: Drawings from the city records are attached. The drawings consist of:

- Homewood Clifton Relief Storm Sewer – October 1935, Lakewood Drawing A-490
- Edgewater Intercepting Sanitary Sewer – Abbieshire to Nicholson – September 1927, Lakewood Drawing A-427
- Manhole investigation sketches
- Aerial map from Cuyahoga County
- Soils map
- CSO-058 Tributary Flows, May 2014
- Typical Year Precipitation
- Footing (Foundation) Drain studies
- Downspout Flow Rates

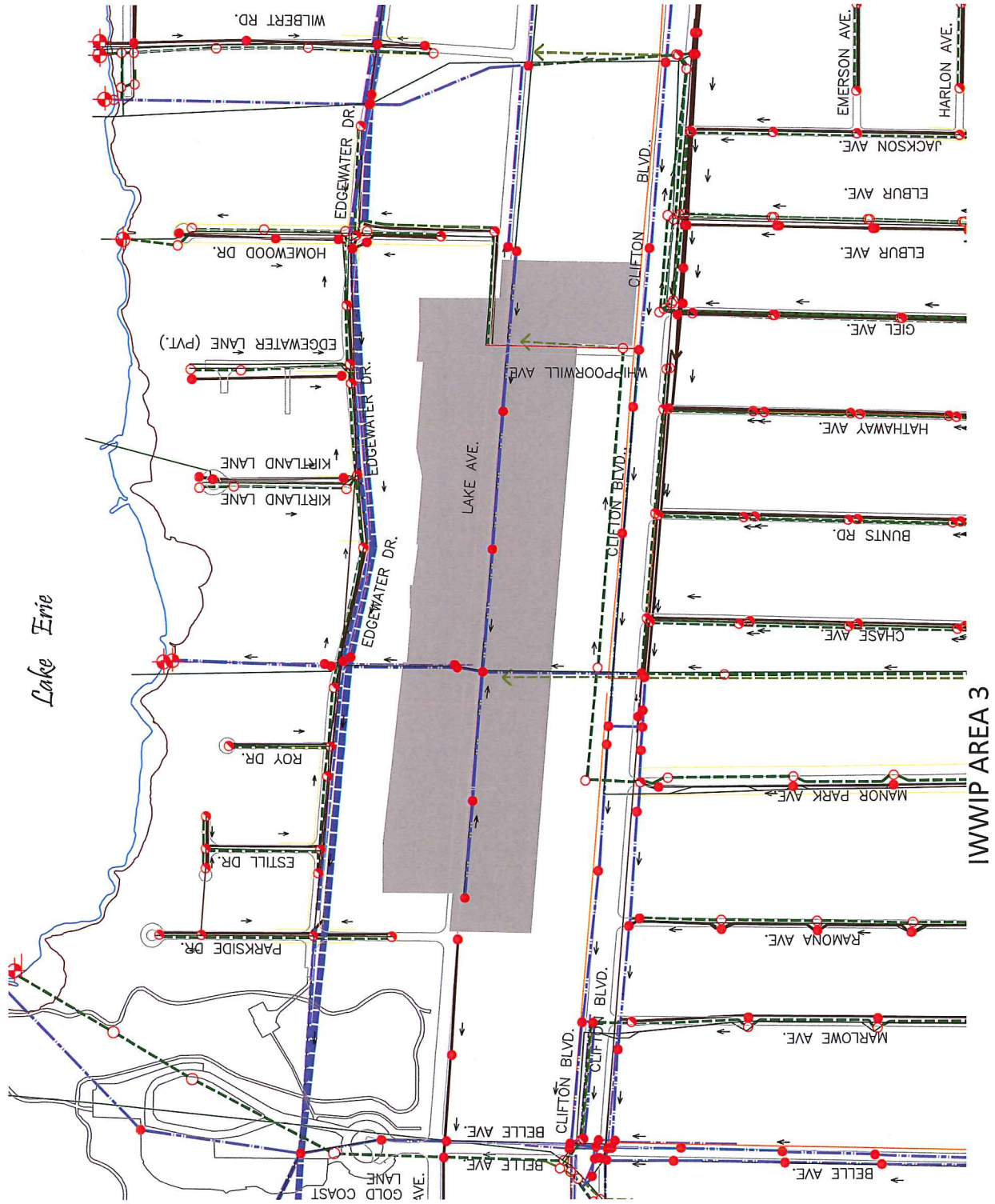
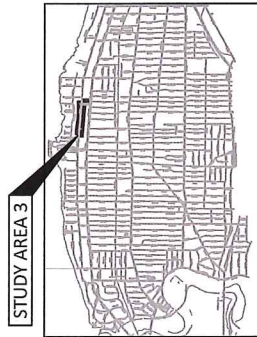
Comments: Many of the sewers along Lake Road appear to be old storm sewers that were converted to combined sewers. Some of the combined sewers had some form of basic sewage treatment at the lake shore before discharging to Lake Erie. No record has been found for this sewer. The 1927 interceptor drawings do indicate a connection (Separation Manhole) was to be constructed at Edgewater Drive. Sketches of this manhole show how the combined sewer was diverted to the interceptor. The 1927 interceptor drawing has a detail for a typical separation manhole.

Goal: Reduce the discharges from the overflow to less than 4 in a typical year

I:\2015\150141\PHASE3 Public Involvement & Stakeholder Input\Community Education-Engagement\Documents To Be Given To All Stakeholders\STUDY AREAS\Study Area #3\Study Area #3 Support Information.Docx



LEGEND	---	CSO-SEWER SERVICE AREA	 Map to Scale
	---	COMBINATION SEWER	
	---	INTERCEPTOR SEWER	
	---	SANITARY SEWER	
	---	STORM SEWER	
	---	NOT PART OF CSO	
	●	COMBINATION/SANITARY MANHOLE	
	●	OVER/UNDER MANHOLE	
	●	STORM MANHOLE	
	◆	OUTFALL	
	■	MANHOLE IDENTIFICATION	
	■	20" STORM SEWER OVER 8" SANITARY	



IWWIP AREA 3

SEWER INVESTIGATION - CSO 056 AREA

Manhole No.: Interceptor

Date: 9-15-09

Street Name: 13909 Edgewater

Crew: FM, DH

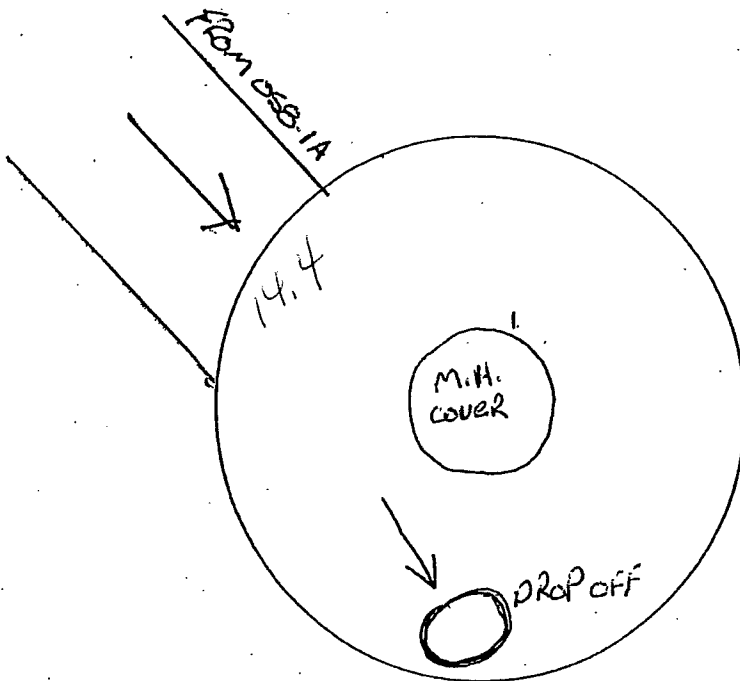
Structure Type: Over/Under: _____ Combined: 1 Side/Side: _____

Only Sanitary: _____ Only Storm: _____

Invert Plate: Yes _____ Not required 1 Missing _____

Depth 14.9

Draw the all pipes entering M.H. with size & depth, include flow of water/sewage.



PK

Notes: _____

SEWER INVESTIGATION - CSO 056 AREA

Manhole No.: 058-1A

Date: 9-15-09

Street Name: 13909 Edgewater

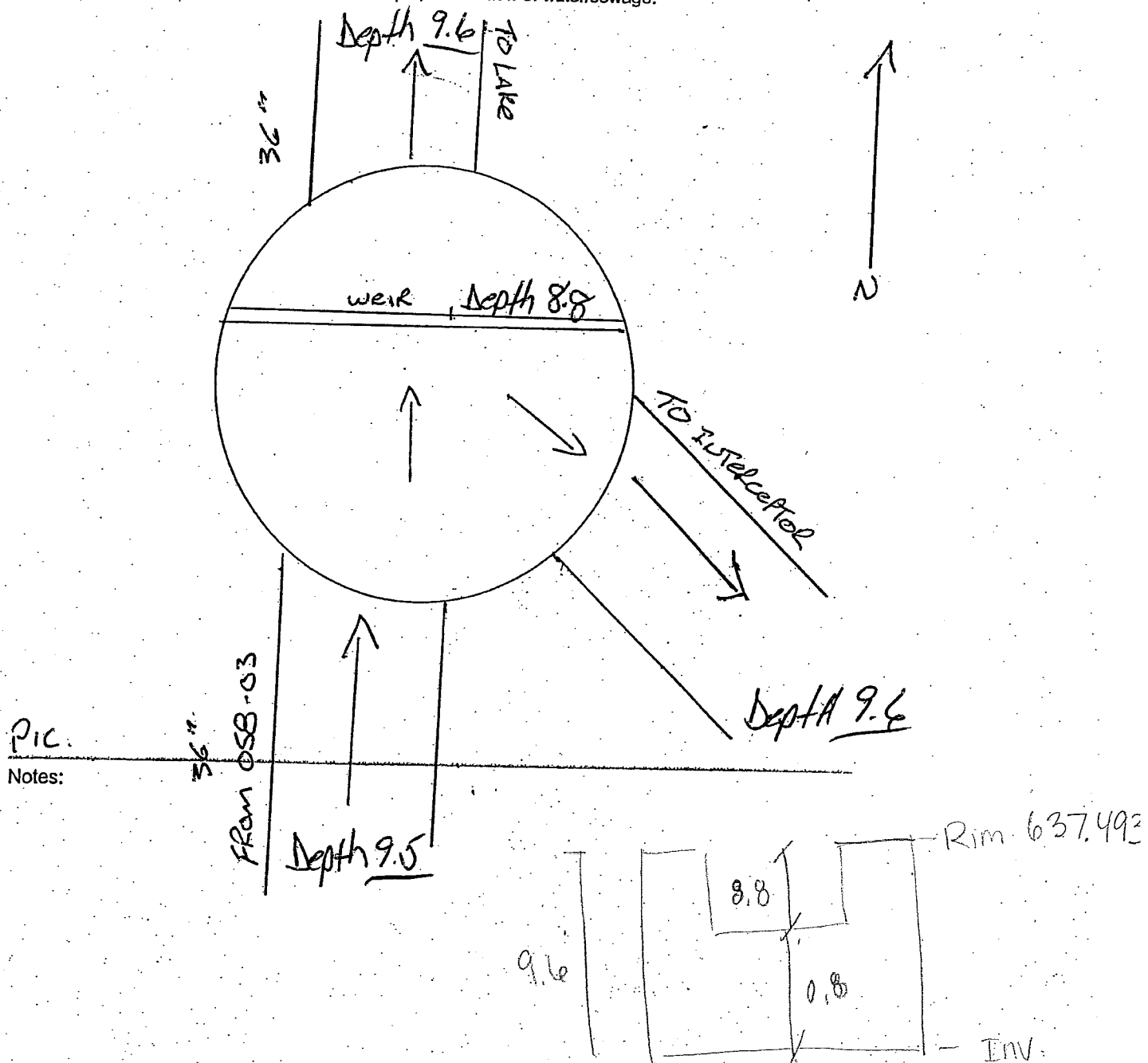
Crew: Sam, DH

Structure Type: Over/Under: Combined: 1 Side/Side:

Only Sanitary: Only Storm:

Invert Plate: Yes Not required 1 Missing Depth 9.4

Draw the all pipes entering M.H. with size & depth, include flow of water/sewage.



1675 000 FEET

T. 7 N.

(Joins sheet 12)

LAKE ERIE

T. 7 N. | 1680 000 FEET

3000 AND !

HsC

Uc

Lake Avenue

HsC

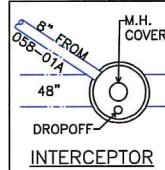
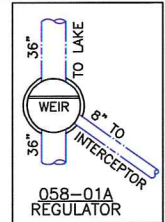
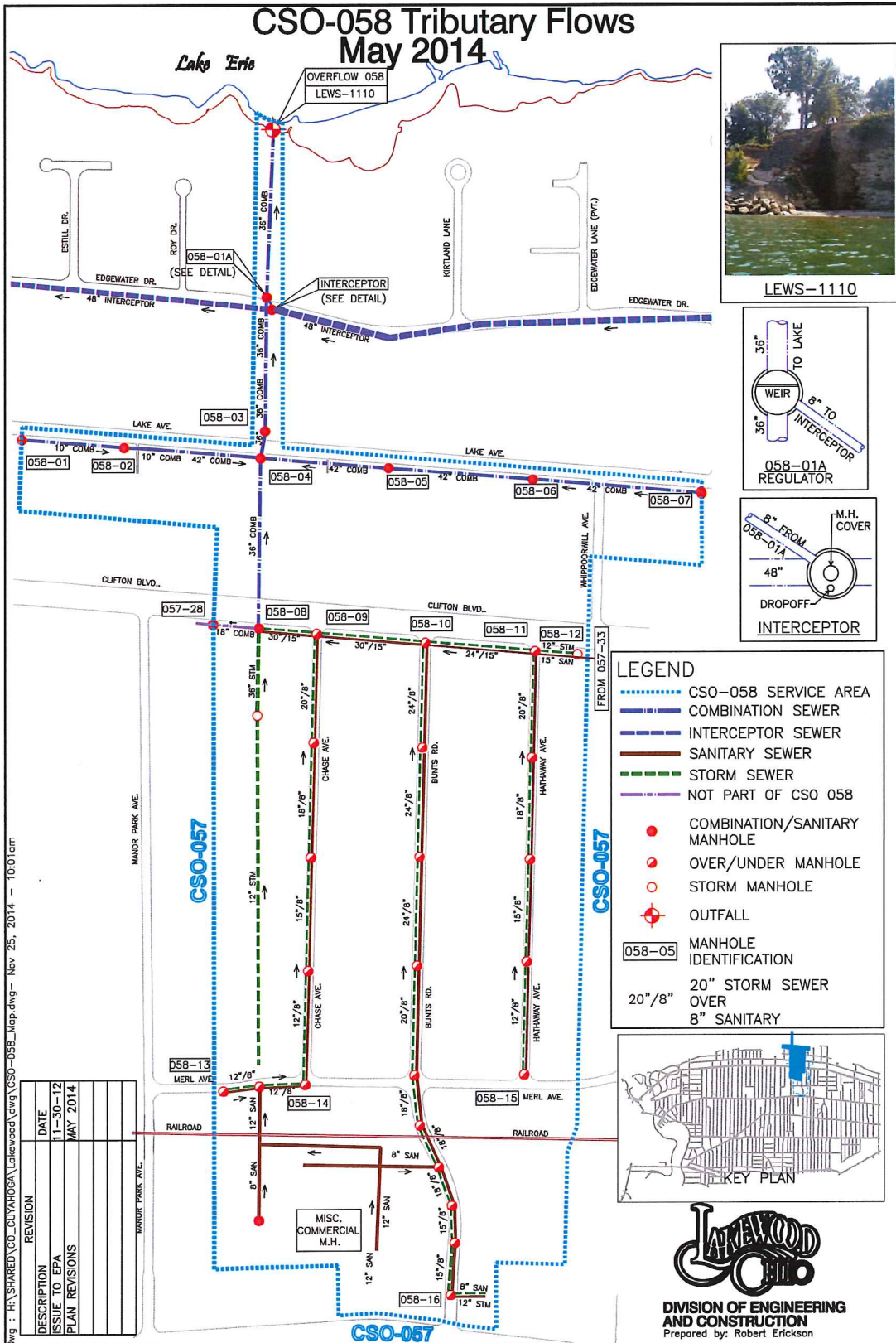
LAKE WOOD

UoB

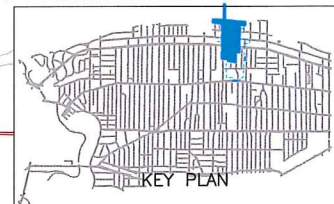
Silty Clay Soil over
weathered bedrock -
permeability <0.2"
per hour



CSO-058 Tributary Flows May 2014



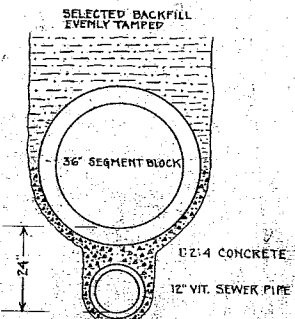
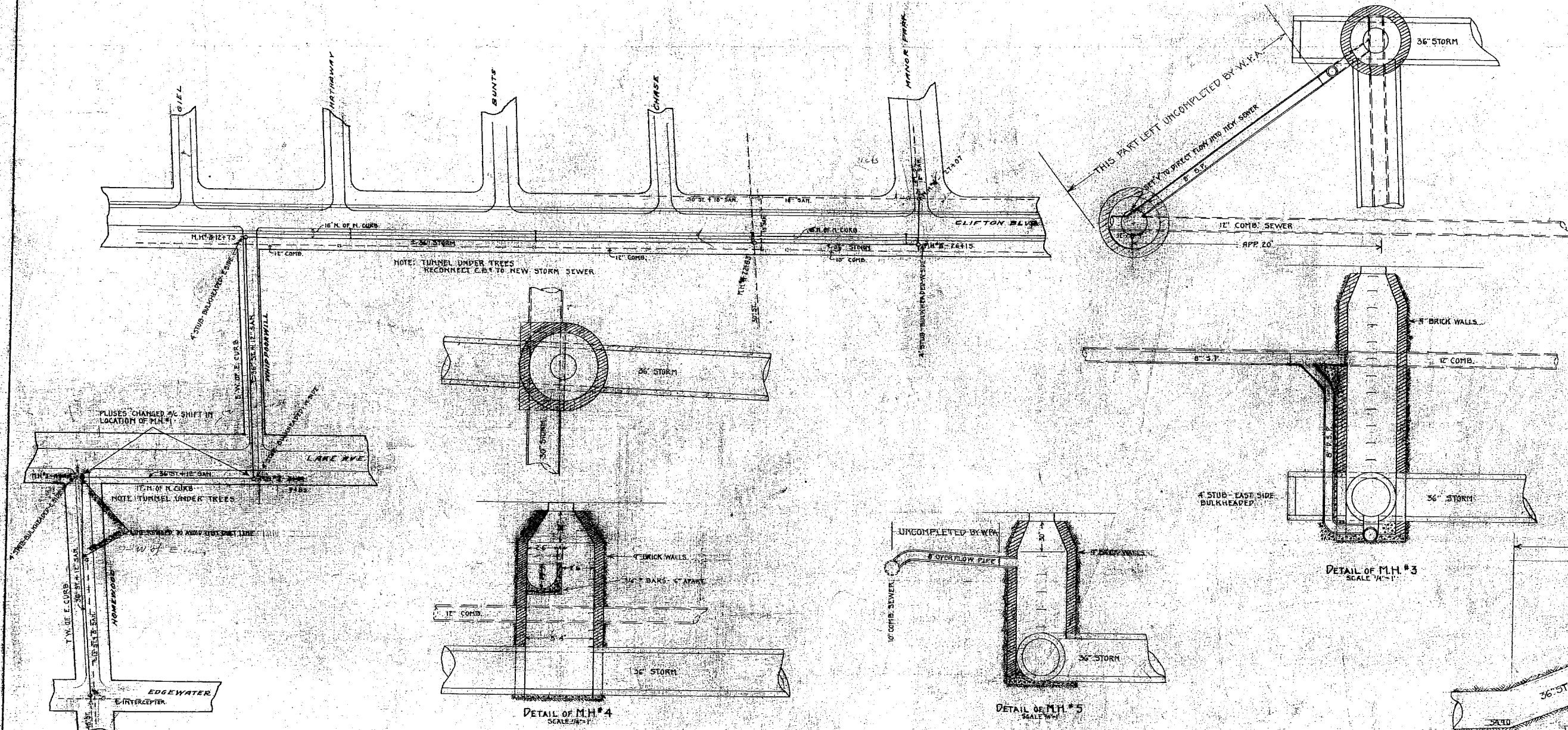
- LEGEND**
- CSO-058 SERVICE AREA
 - COMBINATION SEWER
 - INTERCEPTOR SEWER
 - SANITARY SEWER
 - STORM SEWER
 - NOT PART OF CSO 058
 - COMBINATION/SANITARY MANHOLE
 - OVER/UNDER MANHOLE
 - STORM MANHOLE
 - OUTFALL
 - MANHOLE IDENTIFICATION
 - 20" STORM SEWER OVER 8" SANITARY



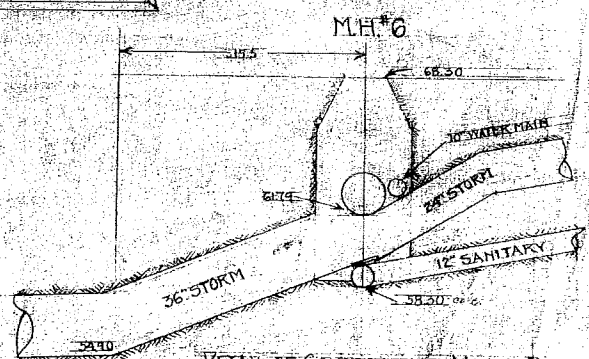
LakeWood
DIVISION OF ENGINEERING
AND CONSTRUCTION
Prepared by: Robert Erickson

Dwg : H:\SHARED\CO_CUYAHOGA\LakeWood.dwg CSO-058_Map.dwg - Nov 25, 2014 - 10:01am

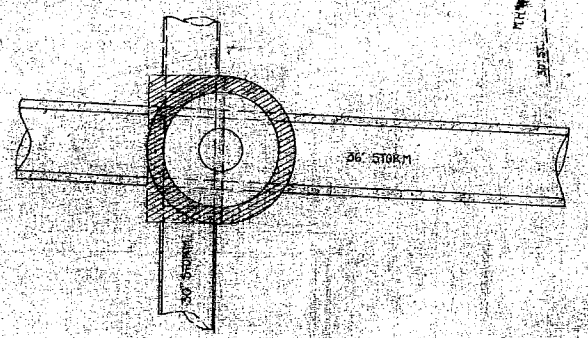
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DESCRIPTION	11-30-12
ISSUE TO EPA	MAY 2014
PLAN REVISIONS	



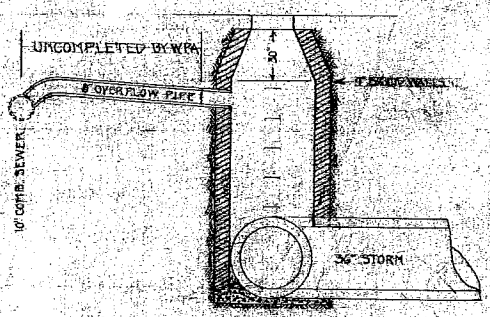
SEWER TRENCH SECTION
SCALE 1/2"=1'



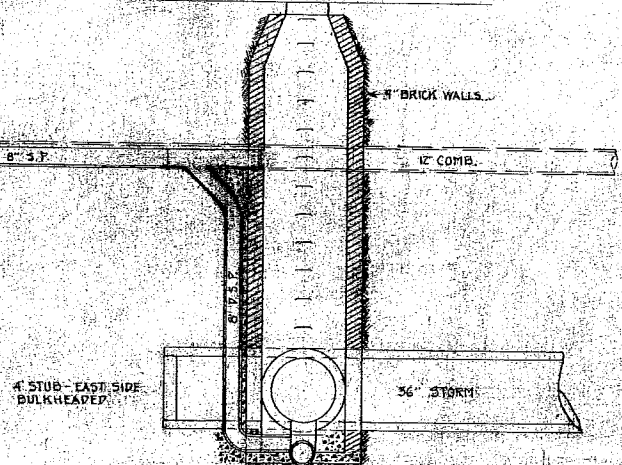
DETAIL OF CONNECTION AT MANOR PK.
MADE BY THE STREET DEPT.
SCALE 1/4"=1'



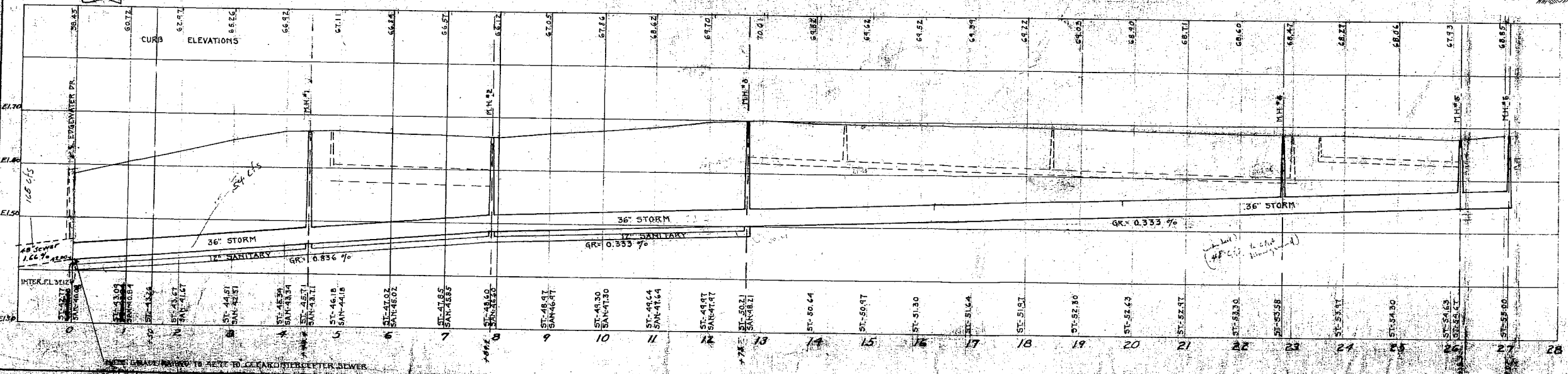
DETAIL OF MH#4
SCALE 1/4"=1'



DETAIL OF MH#5
SCALE 1/4"=1'



DETAIL OF MH#3
SCALE 1/4"=1'



CITY OF LAKEWOOD, OHIO
DIVISION OF ENGINEERING
HOMWOOD CLIFTON RELIEF
STORM SEWER

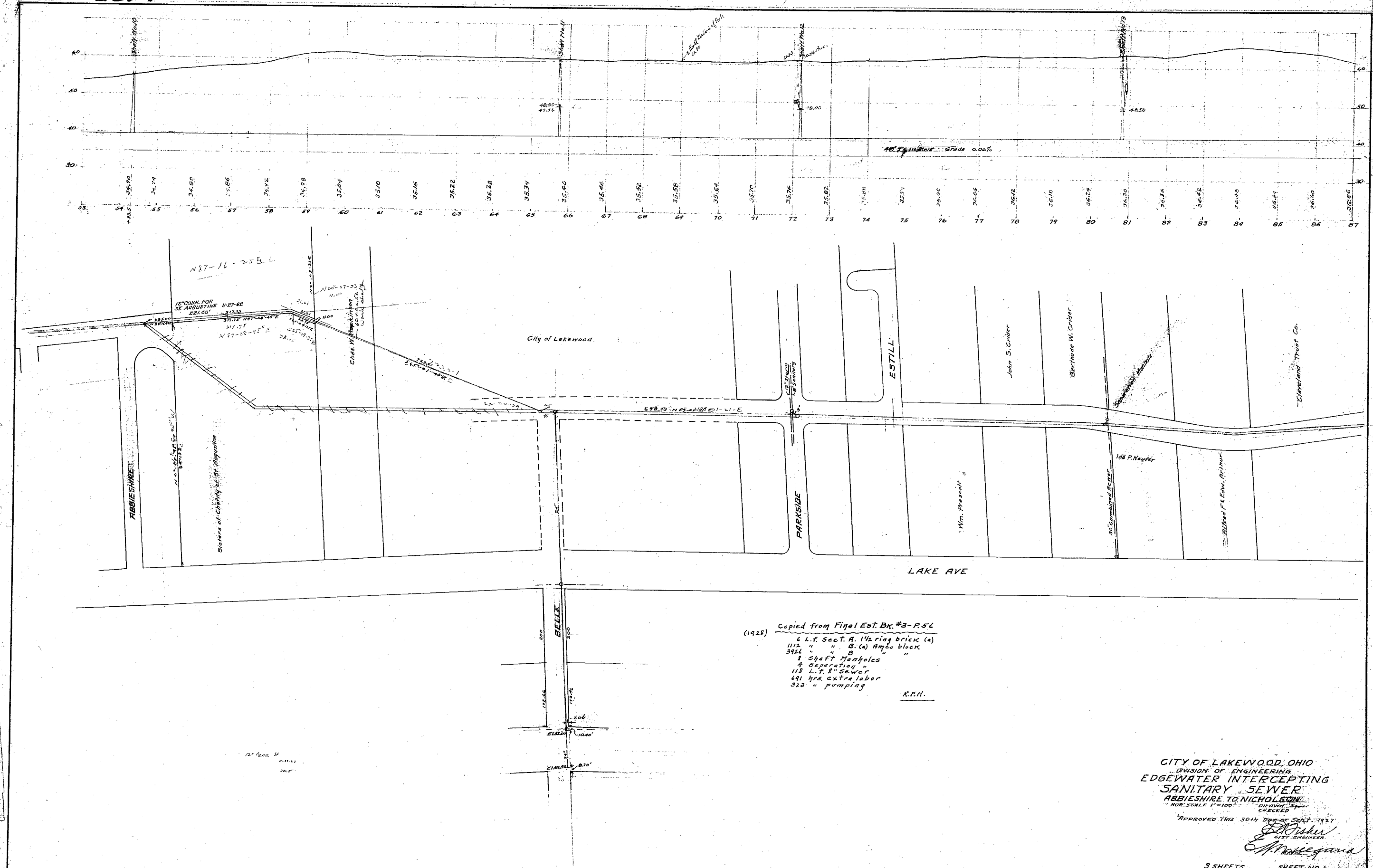
Oct, 1935
Horz Scale 1"=100'
Vert Scale 1"=10'

Drawn Squier
Checked R.F.H.

Approved this 12 day of November, 1935

[Signature]
City Engineer

A 927



CITY OF LAKEWOOD, OHIO
DIVISION OF ENGINEERING
EDGEWATER INTERCEPTING
SANITARY SEWER
ABBIESHIRE TO NICHOLSON
HOR. SCALE 1"=100' DRAWN BY *Spahr*
CHECKED

APPROVED THIS 30TH DAY OF SEPT. 1927

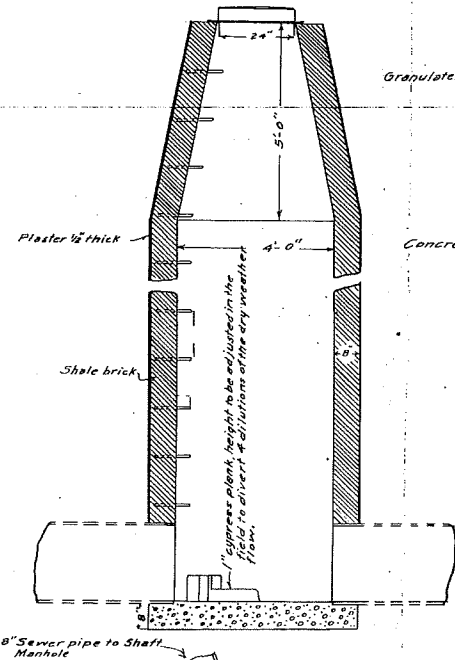
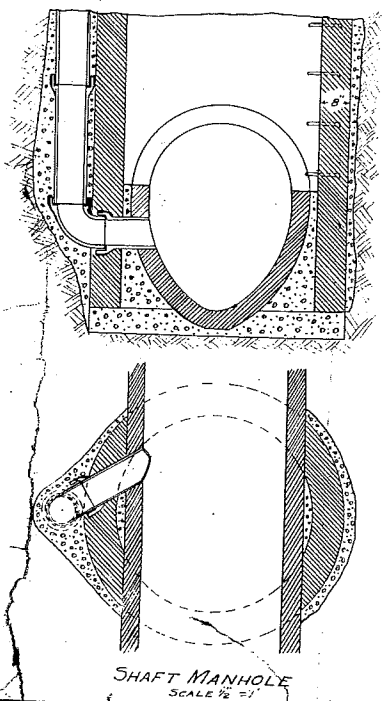
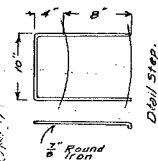
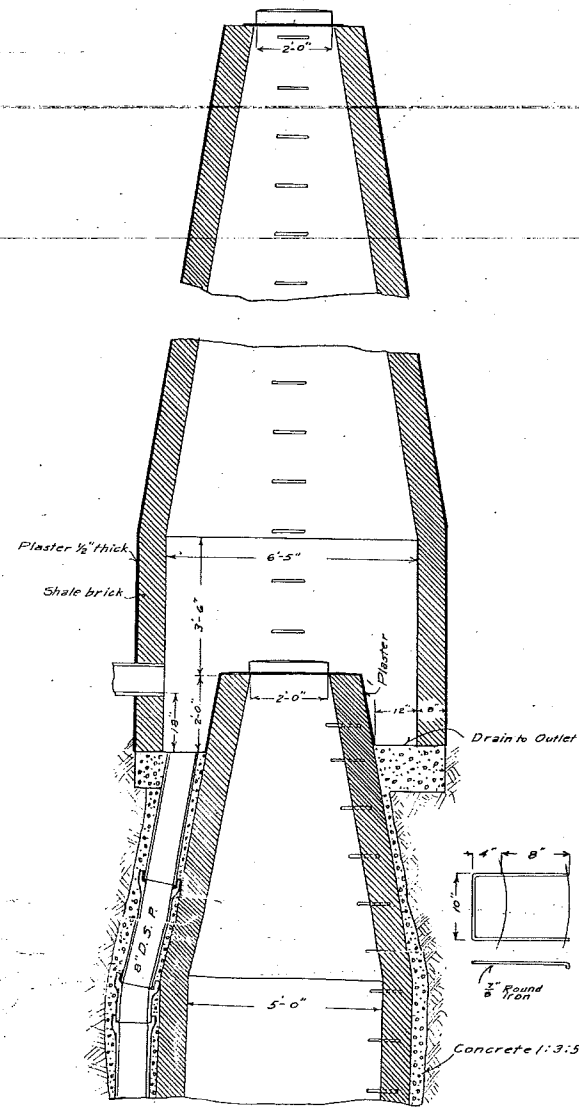
E. Fisher
CITY ENGINEER

M. M. Heger
Mayor

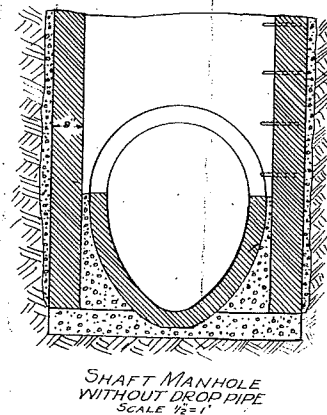
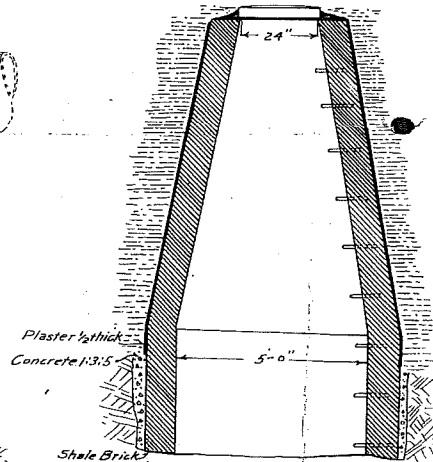
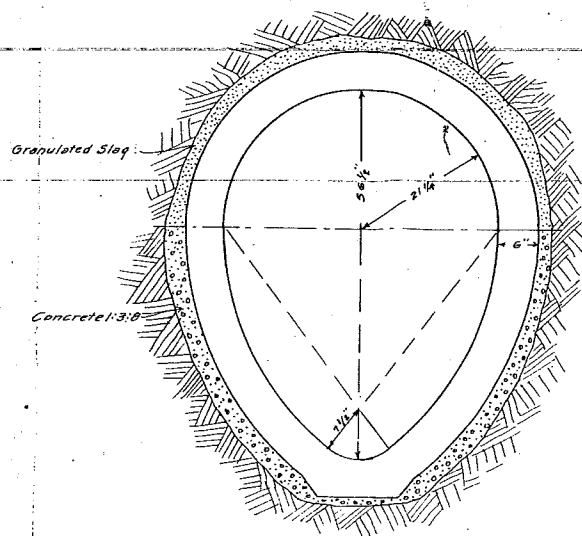
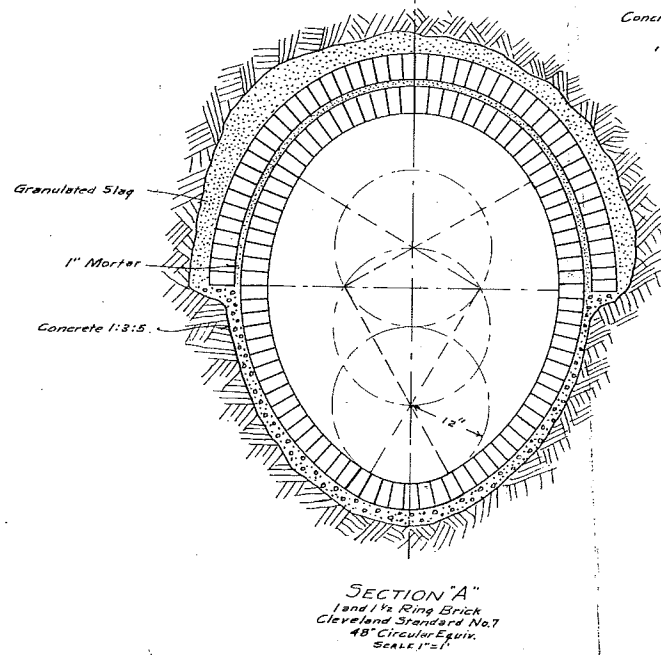
3 SHEETS SHEET NO. 1

A427

SHEET #3 IS ALSO



SEPARATION MANHOLE
SCALE $\frac{1}{2}$ " = 1'



CITY OF LAKEWOOD, OHIO
DIVISION OF ENGINEERING
EDGEWATER INTERCEPTING
SANITARY SEWER
WEBB TO ABBIESHIRE
Scales as indicated
DRAWN: Saurer
CHECKED:
APPROVED THIS DAY OF 192
CITY ENGINEER
MAYOR
5 SHEETS SHEET No. 5



TYPICAL YEAR PRECIPITATION

The City's comprehensive model was used to establish a baseline for overflow events during a typical precipitation year. It is the baseline predictions from the model that will be used to determine system improvements in accordance with the city's long-term control plan. Data from Cleveland Hopkins International Airport (CLE) were obtained for the 33-year period from 1973 to 2006. The following criteria were considered desirable for the typical year precipitation data:

- No storm events greater than a 1-year storm
- Include a 1-year 1-hour storm
- Include a 6-month 1-hour storm
- Include a 4-month 1-hour storm
- Include a 3-month 1-hour storm
- Have remaining storms less than a 3-month storm
- Close to average precipitation reported by United States Department of Agriculture (USDA)

The precipitation events from the 33-year record were classified and calendar year 1977 (35.48 inches, total) came closest to the previously stated criteria. This year of precipitation data was submitted to the USEPA for evaluation. The USEPA assessed the proposed precipitation record and requested that the total precipitation for the year be raised from 35.48 inches to 37.52 inches based on the CLE data (1973 to 2006) being more recent than the USDA data (1951 to 1976) previously used. To incorporate the additional precipitation requested, the 1977 monthly precipitation was compared to the monthly averages of the CLE data. January, February, May, September, and October were below the monthly average of the CLE data. The additional precipitation (2.04 inches) of precipitation was distributed to the below average months as shown in Table 8.1. The additional storms brought the respective monthly averages closer to the monthly averages of the CLE data.

Appendix B. Summary of District's Synthetic Design Storm and Typical Year Rainfall

Tables B-1 and B-3 were obtained from Appendix C of the District's CSO Facilities Planning Summary Report dated March 2005. The Consultant shall refer to this report for additional information regarding the District's selected design storms and synthetic typical year hyetographs is needed. Table B-2 summarizes the standard design storm hyetographs based on 15-minute rainfall increments have been adopted and are available for Consultant use if needed for particular project needs. District approval is required if finer rainfall time series is deemed necessary by the Consultant.

Table B-1. Official Design Storm Hyetographs Based on 1-Hour Rainfall Increments.

Return Period	Duration	Hourly Incremental Rainfall Depth (in)						Total Rainfall	Average Intensity
		Hour 1	Hour 2	Hour 3	Hour 4	Hour 5	Hour 6	(in)	(in/hr)
1-month	6-hour	0.06	0.15	0.09	0.09	0.08	0.09	0.56	0.09
4-month	6-hour	0.05	0.15	0.10	0.37	0.16	0.14	0.97	0.16
6-month	6-hour	0.01	0.06	0.02	0.73	0.26	0.02	1.10	0.18
1-year	6-hour	0.05	0.07	0.15	1.00	0.21	0.01	1.49	0.25
2-year	6-hour	0.12	0.04	0.14	1.17	0.18	0.10	1.75	0.29
5-year	6-hour	0.06	0.10	0.23	1.43	0.20	0.12	2.14	0.36
1-year	1-hour	1.00						1.00	1.00
5-year	1-hour	1.43						1.43	1.43
10-year	1-hour	1.69						1.69	1.69
25-year	1-hour	2.06						2.06	2.06
50-year	1-hour	2.40						2.40	2.40
100-year	1-hour	2.77						2.77	2.77

Table B-2. Design Storm Hyetographs Based on 15-Minute Rainfall Increments.

Return Period	6-Hour Duration ⁽¹⁾		24-Hour Duration ⁽²⁾	
	Total Rainfall (in)	Peak 1-Hour Intensity (in/hr)	Total Rainfall (in)	Peak 1-Hour Intensity (in/hr)
1-month	0.56	0.36	0.79	0.36
2-month	0.79	0.51	1.12	0.51
3-month	0.93	0.59	1.31	0.59
4-month	1.01	0.65	1.43	0.65
6-month	1.17	0.75	1.65	0.75
9-month	1.33	0.85	1.88	0.85
1-year	1.45	0.92	2.04	0.92
2-year	1.77	1.13	2.50	1.13
5-year	2.20	1.40	3.10	1.40

(1) Distribution based on peak 6-hr duration of the SCS Type 2 24-hr distribution at 15-minute increments.

(2) From District's 2006 RIDE Study and ISWS Bulletin 71 and SCS Type 2 24-hour distribution.

Table B-3. Storm Events for Typical Year Continuous Year Simulation.

Storm Event	Date	Hour	Duration (Hrs)	Depth (In)	Average Intensity (In/Hr)	Maximum Hourly Intensity (In/Hr)	Storm Event	Date	Hour	Duration (Hrs)	Depth (In)	Average Intensity (In/Hr)	Maximum Hourly Intensity (In/Hr)
1	01/03/91	12	1	0.01	0.01	0.01	62	07/03/93	2	1	0.01	0.01	0.01
2	01/05/91	13	10	0.18	0.02	0.03	63	07/04/93	16	1	0.44	0.44	0.44
3	01/09/91	13	2	0.03	0.01	0.02	64	07/06/93	16	1	0.47	0.47	0.47
4	01/11/91	4	19	0.39	0.02	0.09	65	07/11/93	20	3	0.35	0.12	0.24
5	01/12/91	12	21	0.04	0.00	0.01	66	07/19/93	14	2	0.14	0.07	0.13
6	01/15/91	24	8	0.33	0.04	0.08	67	07/26/93	6	2	0.04	0.02	0.02
7	01/16/91	19	10	0.17	0.02	0.03	68	07/28/93	17	9	1.08	0.12	0.72
8	01/20/91	13	30	0.53	0.02	0.05	69	07/29/93	20	3	0.67	0.22	0.31
9	01/26/91	7	10	0.03	0.00	0.01	70	08/02/93	5	2	0.42	0.21	0.41
10	01/27/91	19	4	0.08	0.02	0.03	71	08/03/93	21	10	0.42	0.04	0.20
11	01/29/91	20	11	0.37	0.03	0.10	72	08/06/93	19	4	0.10	0.03	0.06
12	01/30/91	18	1	0.01	0.01	0.01	73	08/07/93	13	1	0.13	0.13	0.13
13	01/31/91	14	1	0.01	0.01	0.01	74	08/10/93	16	2	0.02	0.01	0.01
14	02/05/91	7	1	0.01	0.01	0.01	75	08/11/93	4	4	0.24	0.06	0.23
15	02/06/91	15	9	0.10	0.01	0.02	76	08/12/93	17	1	0.02	0.02	0.02
16	02/10/91	15	20	0.73	0.04	0.09	77	08/16/93	4	1	0.07	0.07	0.07
17	02/13/91	14	59	1.53	0.03	0.16	78	08/20/93	9	1	0.01	0.01	0.01
18	02/16/91	24	14	0.18	0.01	0.04	79	08/28/93	2	1	0.06	0.06	0.06
19	02/18/91	15	13	0.08	0.01	0.04	80	08/31/93	13	6	0.03	0.00	0.02
20	02/19/91	17	7	0.29	0.04	0.10	81	09/02/93	8	21	1.02	0.05	0.67
21	02/26/91	4	40	0.08	0.00	0.01	82	09/06/93	13	1	0.35	0.35	0.35
22	02/28/91	9	4	0.04	0.01	0.02	83	09/07/93	9	1	0.01	0.01	0.01
23	03/02/91	1	14	0.06	0.00	0.02	84	09/10/93	1	1	0.01	0.01	0.01
24	03/03/91	13	24	0.70	0.03	0.10	85	09/10/93	13	1	0.01	0.01	0.01
25	03/06/91	6	14	0.83	0.06	0.13	86	09/15/93	20	16	2.38	0.15	0.40
26	03/09/91	18	2	0.07	0.04	0.05	87	09/22/93	24	16	0.12	0.01	0.05
27	03/10/91	12	4	0.08	0.02	0.03	88	09/25/93	16	20	1.63	0.08	0.29
28	03/17/91	21	31	0.50	0.02	0.07	89	09/27/93	13	9	0.15	0.02	0.06
29	03/22/91	6	4	0.32	0.08	0.18	90	09/28/93	10	3	0.23	0.08	0.12
30	03/22/91	24	3	0.14	0.05	0.08	91	09/29/93	10	17	0.97	0.06	0.24
31	03/23/91	24	10	0.23	0.02	0.06	92	10/01/93	10	1	0.01	0.01	0.01
32	03/26/91	13	1	0.02	0.02	0.02	93	10/01/93	23	6	0.58	0.10	0.22
33	03/27/91	24	1	0.62	0.62	0.62	94	10/09/93	6	13	0.43	0.03	0.13
34	03/31/91	19	6	0.07	0.01	0.03	95	10/16/93	22	16	0.60	0.04	0.18
35	04/01/93	23	5	0.16	0.03	0.07	96	10/19/93	15	1	0.04	0.04	0.04
36	04/02/93	17	12	0.06	0.00	0.02	97	10/20/93	15	6	0.04	0.01	0.02
37	04/09/93	14	16	0.77	0.05	0.09	98	10/27/93	22	4	0.15	0.04	0.10
38	04/11/93	16	1	0.09	0.09	0.09	99	10/30/93	10	39	1.67	0.04	0.12
39	04/14/93	19	2	0.03	0.01	0.02	100	11/01/91	17	1	0.01	0.01	0.01
40	04/15/93	23	3	0.34	0.11	0.16	101	11/07/91	9	12	0.12	0.01	0.02
41	04/19/93	17	13	0.27	0.02	0.11	102	11/11/91	2	7	0.69	0.10	0.14
42	04/20/93	16	18	0.61	0.03	0.13	103	11/12/91	11	12	0.21	0.02	0.06
43	04/24/93	12	2	0.03	0.01	0.02	104	11/15/91	1	31	0.62	0.02	0.10
44	04/25/93	8	15	0.46	0.03	0.16	105	11/18/91	17	21	0.30	0.01	0.10
45	04/30/93	1	6	0.10	0.02	0.03	106	11/20/91	17	19	0.46	0.02	0.14
46	05/04/93	13	25	0.63	0.03	0.22	107	11/23/91	20	3	0.24	0.08	0.12
47	05/19/93	4	6	0.15	0.02	0.07	108	11/24/91	17	8	0.03	0.00	0.01
48	05/23/93	16	1	0.01	0.01	0.01	109	11/25/91	14	1	0.01	0.01	0.01
49	05/24/93	6	6	0.08	0.01	0.04	110	11/28/91	6	8	0.19	0.02	0.05
50	05/28/93	24	2	0.03	0.01	0.02	111	11/30/91	6	1	0.04	0.04	0.04
51	05/31/93	23	2	0.16	0.08	0.08	112	12/02/91	16	17	1.19	0.07	0.29
52	06/03/93	23	2	0.07	0.03	0.04	113	12/03/91	21	11	0.06	0.01	0.02
53	06/05/93	5	6	0.37	0.06	0.25	114	12/12/91	15	17	0.16	0.01	0.06
54	06/07/93	16	9	1.56	0.17	0.67	115	12/14/91	7	6	0.15	0.02	0.12
55	06/09/93	10	1	0.21	0.21	0.21	116	12/15/91	16	16	0.07	0.00	0.01
56	06/09/93	24	1	0.24	0.24	0.24	117	12/18/91	3	2	0.02	0.01	0.01
57	06/19/93	6	2	0.31	0.16	0.22	118	12/18/91	16	16	0.03	0.00	0.01
58	06/20/93	13	26	0.54	0.02	0.15	119	12/20/91	22	8	0.22	0.03	0.07
59	06/25/93	20	1	0.08	0.08	0.08	120	12/23/91	7	6	0.10	0.02	0.03
60	06/27/93	18	1	0.94	0.94	0.94	121	12/28/91	22	35	0.26	0.01	0.03
61	07/01/93	21	4	0.05	0.01	0.02	Total						37.51

operation of the basin is seen as it starts to fill just before midnight and is surcharged between 1:00 and 4:30 AM. During surcharged conditions, the levels rise and fall quickly as storage in the collection system is limited.

E.1.3.5 Footing Drain Monitoring

One potentially significant source of inflow into the sanitary sewer system during storms is from house foundation footing drains that are directly connected to the sanitary sewers. Previous studies conducted in Ann Arbor have reported that the footing drain connection from a single home could contribute as much as 10 gpm during a storm. Since most of the houses in the study areas have directly connected footing drains, footing drains can introduce a significant proportion of the observed

To estimate the amount of footing drain flow in each of the study areas, 20 locations were identified throughout the 5 study areas (about 4 per area) where house connections enter the sanitary sewer in manholes above the manhole benching. This configuration allowed the installation of temporary house lead extensions of about 1' into each manhole. Of the 20 locations identified, 16 installations were made as shown in Table E-9.

To estimate flows produced from individual homes, these house leads were visited during rainfall events to measure the flows being generated. Flows were measured using bucket and stopwatch methods. During each storm being monitored, flows were measured a number of times as field crews visited multiple manholes during the monitoring events. The storms of 8/17/00 and 9/11/00 were monitored by field crews. Two to three tests were performed at each location during each event.

Table E-9. Footing Drain Study Locations

<u>Region</u>	<u>Manhole ID</u>	<u>Approximate Address</u>
Orchard Hills	2	3000 Bluett
Orchard Hills	4	3022 Bluett
Orchard Hills	7	3130 Bluett
Orchard Hills	29	2488 Antietam
Orchard Hills	60	2537 Georgetown
Bromley	49 (E&W)	2814 Renfrew
Bromley	55	2500 Prairie
Bromley	5 (E)	2235 Prairie
Bromley	5 (W)	2235 Prairie
Glen Leven	94	1707 Tudor
Glen Leven	95	1706 Tudor
Glen Leven	22	1315 Glen Leven
Glen Leven	101 (E)	1530 Dicken Drive
Glen Leven	101 (W)	1530 Dicken Drive
Morehead Street	75	2189 Seventh
Morehead	35	2095 Chaucer

As noted earlier, footing drain flows were monitored during selected storms. This information was collected on August 17, 2000 and on September 11, 2000. The August 17, 2000 storm was short and of low volume and produced a limited wet weather flow response. During this period, footing drain flows ranged from 0.1 to 0.5 gpm.

The September 11, 2000 storm produced between 1.57" to 1.8" of rain over a 5-hour period. During this storm, footing drain flows were collected during a period of steady rainfall. Figure E-5 shows the

Table E-10 Average Footing Drain Flows

<u>Study Area</u>	<u>Flow (gpm)</u>
Orchard Hills	1.1
Bromley	1.9
Dartmoor	No Test Locations
Glen Leven	1.8
Morehead	1.4

footing drain flows measured during this storm. The measured flows ranged from 0 to 3 gpm, with an average of 1.4 gpm for all locations measured. The average footing drain flows for the tests performed

Study Design

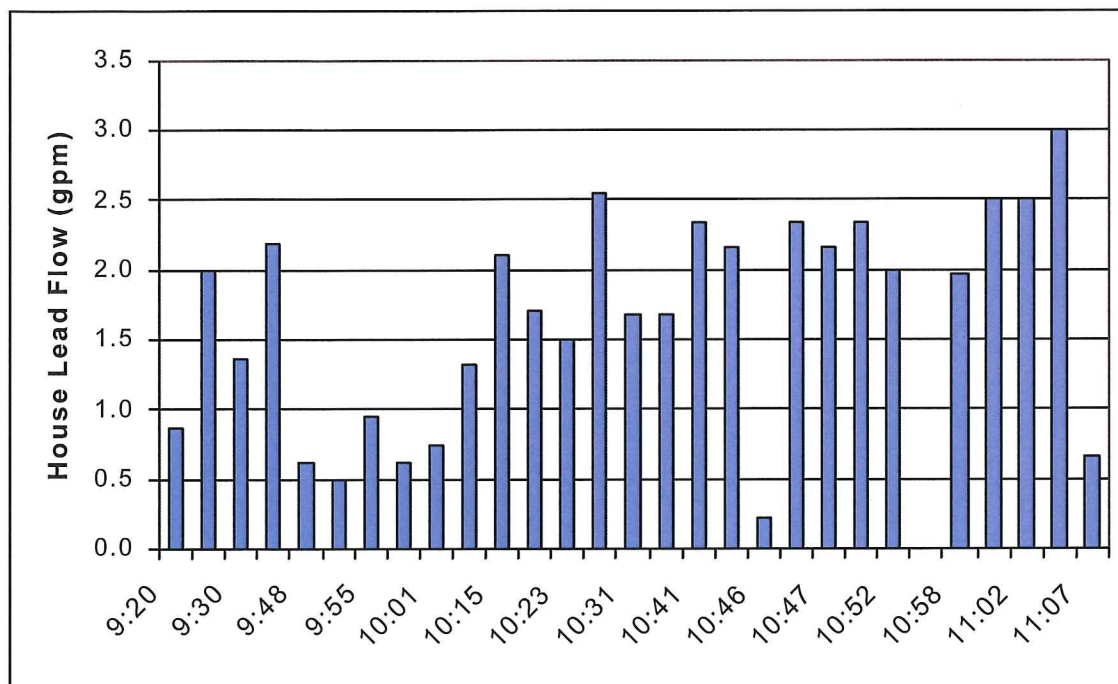


Figure E-5 Footing Drain Flow Measurements

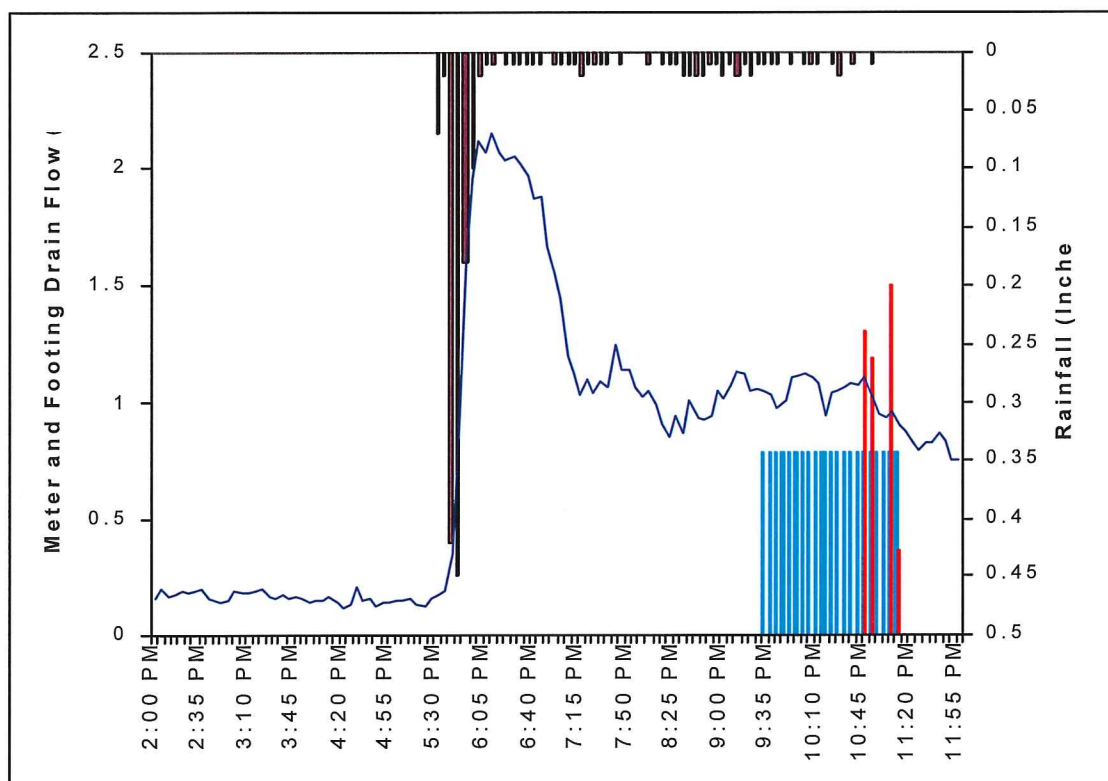


Figure E-6 Rainfall, Metered Flow, and Footing Drain Flows for Bromley Study Area

in each study area are summarized in Table E-10.

The rainfall, metered flow, and calculated footing drain flows were then compared for each study area. An example of this is shown in Figure E-6 for the Bromley study area. The rainfall data is graphed on the top of this figure. The peak of the storm took place at about 5:45 PM and then produced lower, but consistent, rainfall over the next five hours. The flow meter data is plotted as the continuous line with its ordinate of flow in cfs shown on the left axis. This figure shows a response that is similar in shape to the rainfall, peaking at about 6:00 PM and leveling off for a few hours before dropping back to a dry weather flow pattern.

An estimate of the total flow generated by all footing drains in each area was made using the assumption that the average footing drain flow of all areas, 1.4 gpm, is multiplied by the number of homes with footing drains in each study area. This estimate is graphed over the time the data was collected in all areas, and shown as the vertical blue bars in Figure E-6. The total footing drain flow estimates based on the individual measurements taken directly within the Bromley area are also shown as the variable height bars.

Figure E-6 suggests that as much as 90% of the wet weather flow in the Bromley area was caused by flows generated from footing drains. Similar results were found for three of the other study areas, with the Dartmoor study area being an exception. In this area, there appear to be other sources of RDI/I that are contributing to the flows recorded at the flow meter or the flow contribution from footing drain flows are higher than the average measured in the other areas.

E.1.4 Collection System Inspection Programs

E.1.4.1 Manhole Inspections

As part of the project scope, inspection of each accessible manhole in the study areas was performed. This work was performed to assess the

current condition of the manholes and better understand the sewer connections between the manholes. The inspection work was documented on forms completed by field crews and through digital photographs to document manhole condition, sewer connections, and specific defects. Over 800 manholes were inspected as part of this effort. The overall condition of the manholes and the sewer connections was found to be excellent. The inspection did identify 24 minor maintenance issues, which the Water Utilities Department addressed shortly after identification.

In addition to providing information regarding infrastructure condition, the inspection notes and photos provided useful information when assembling the collection system computer models. These photos allowed rapid verification of the collection system connectivity and other attributes such as approximate invert elevation.

Field notes and digital photographs were provided to the Water Utilities Department separately. The field notes and photos are accessible using the project GIS. The available GIS coverage includes the manhole identifier used to locate manholes as part of this project and this identifier is also cross-referenced to the City's identifier system where possible. The identifier used is also listed on the field forms and is contained in the filename of the digital images. The digital images referred to on each field sheet were, with a few exceptions, taken in the following order:

1. The downstream pipe was photographed looking down the pipe from the manhole.
2. Each upstream pipe was photographed (clockwise, looking down manhole, from the downstream pipe).
3. Each house lead was photographed (clockwise, looking down manhole, from the downstream pipe).
4. Specific defects, blockages, or sources of I/I



Table 1. Summary of Footing Drain Flow Studies

Downstream System Metering	Wet Weather Sanitary Flow		Peak Footing Drain Flows			Projected Peak Footing Drain Flows (gpm/house)		
	Peak Flow with FD (cfs/1000)	Peak Flow Without FD (cfs/1000)	Flow (gpm/house)	Rainfall (inches)	RDII from FD (percent)	4" Linear	4" Log	
Beverly Hills	1.56	0.38 ⁵	2.5	2.23"	76%	2.1	1.7	
Oakland County 1967 1968 Study	1.76	0.53	1.8	1.86"	70%	3.8	3.0	
Canton Township FD Removal	2.7	---	2.1	---	---	---	---	
GDRSS Data	2	0.63	3.0 ⁴	2.50" ³	---	3.0 ⁴	1.8 ⁴	
Clinton Township Data	3.3	---	1.5	2.0	69%	---	---	
Auburn Hills Data	1.8	---	3.3	---	---	---	---	
Center Line Data	1.7	---	1.1 ³	1.8 in/hr	70%	3.7	1.7	
West Lafayette, In	---	---	1.7	---	---	---	---	
Midland, MI	---	---	5 ¹	---	---	---	---	
Direct Measurement Metering	Wet Weather Sanitary Flow		Observed Footing Drain Flows			Projected Footing Drain Flows		
	Peak Flow with FD (cfs/1000)	Peak Flow Without FD (cfs/1000)	Average Flow (gpm/house)	Peak Flow (gpm/house)	Rainfall ²	RDII from FD (percent)	4" Linear	4" Log
Ann Arbor 2000 FD Study	2.5	---	1.3	8.7	4.01"	60-90%	4.5	3.1
Dearborn Heights Study	3.0	---	0.55	1.0	0.87"	85-90%	2.2	1.1
WWMP Monitors	---	---	1.7	25.0	1.86"	---	3.0	1.7
Ann Arbor FD Monitoring 2002	---	---	1.0	8.5	1.81"	---	---	---
Toledo	---	---	0.3	3.3	1.72"	---	1.6	0.9
South Macomb Sanitary District: Simulated Rainfall Events	---	---	---	3.2	1.73"	---	6.5	3.8
Other Oakland County Studies	---	---	6.4	10.1	2.7 in/hr	---	--	---
	---	---	2.5 to 10	---	---	---	---	---

1 - Based on model calibration, not direct metering.

2 - Rainfall is displayed in total volume (") or intensity (in/hr)

3 - Based on interpolation of data.

4 - Actual flows are higher. These systems allowed up to 1 gpm to pass to the sanitary system

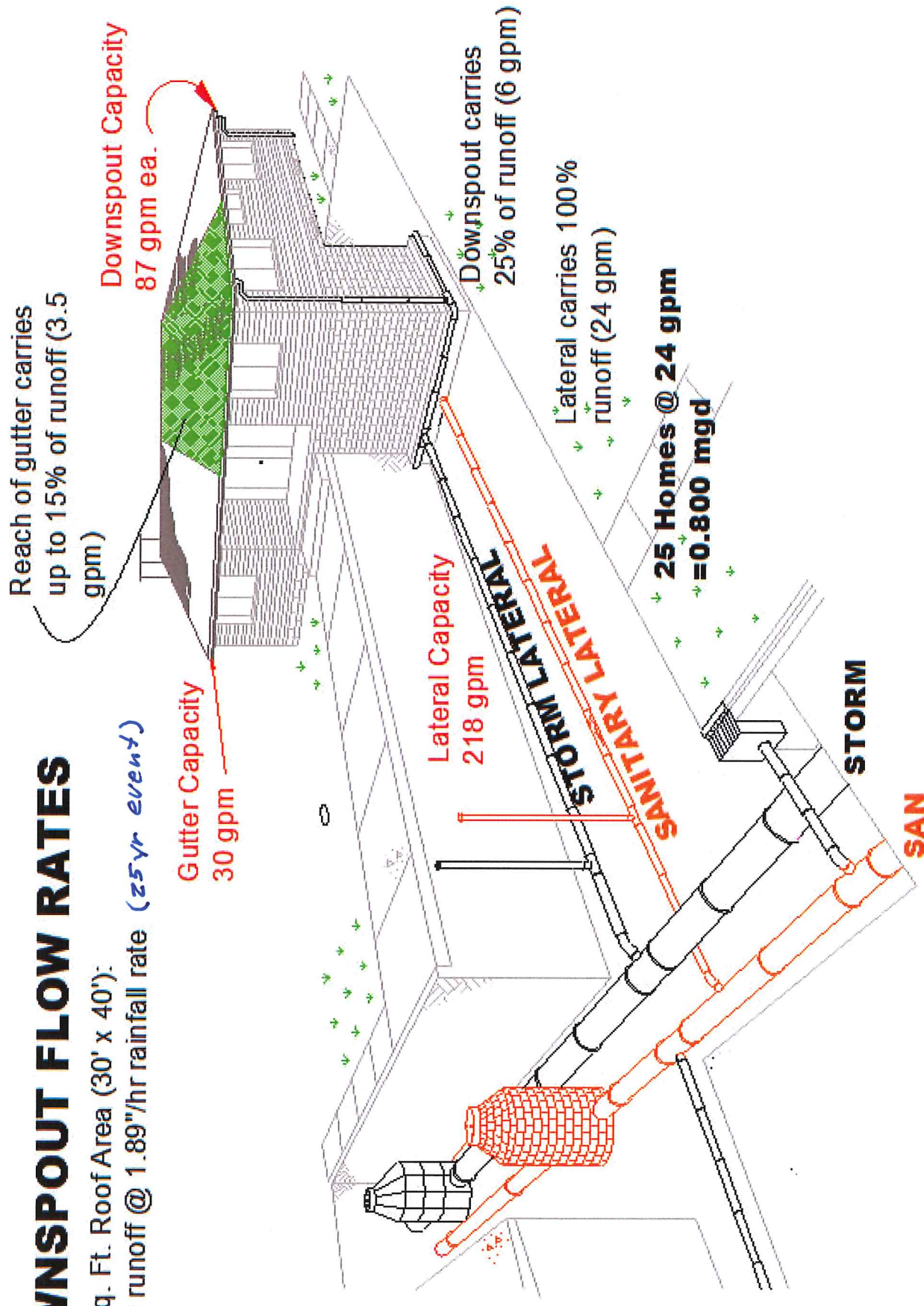
5 - After removal of footing drain connections to sanitary sewer

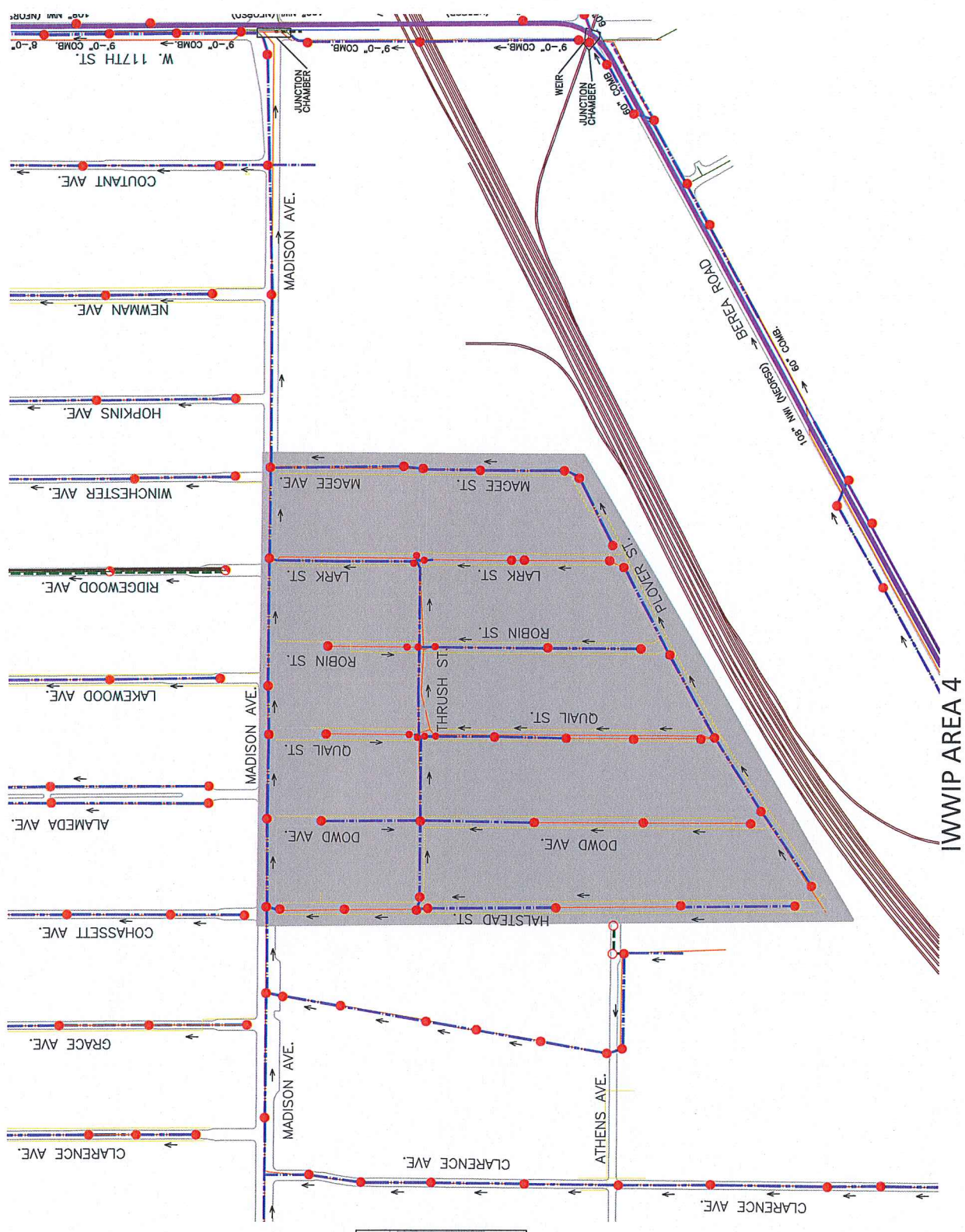
FD: Footing Drain
RDII: Rainfall Dependent I/I

DOWNSPOUT FLOW RATES

1200 Sq. Ft. Roof Area (30' x 40'):

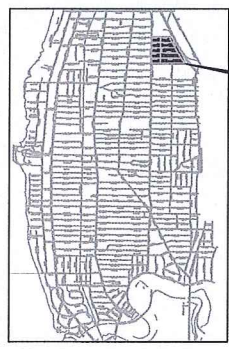
24 gpm runoff @ 1.89"/hr rainfall rate (25-yr event)





LEGEND

CSO-ODD SERVICE AREA	Not to Scale
INTERCEPTOR SEWER	
STORM SEWER	
COMBINATION/SANITARY	
MANHOLE	
OVER/UNDER MANHOLE	
STORM MANHOLE	
OUTFALL	
MANHOLE	
20" STORM SEWER	
8" SANITARY	



CITY OF LAKEWOOD

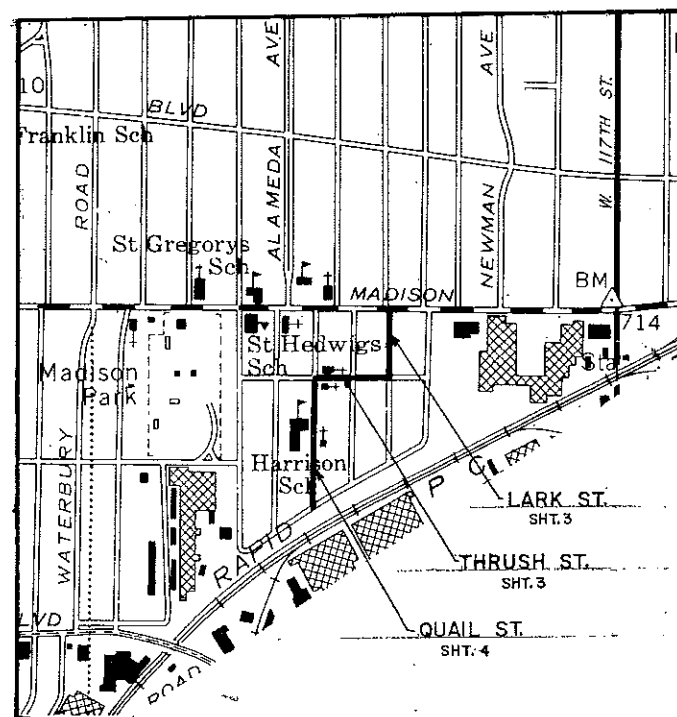
DEPARTMENT OF PUBLIC WORKS

PLANS FOR THE CONSTRUCTION OF

BASEMENT FLOODING RELIEF FACILITIES

CITY DRAWING NUMBER **A-652**

QUAIL - THRUSH - LARK PROJECT
ANTHONY C. SINAGRA - MAYOR



GENERAL LOCATION MAP
(NO SCALE)

- | | |
|--------------------------|--------------------------|
| 1. HARRY F. BROCKMAN JR. | - COUNCIL PRESIDENT |
| 2. JOHN G. SALMON | - COUNCIL VICE PRESIDENT |
| 3. THOMAS C. BROWN | - COUNCILMAN |
| 4. WILLIAM F. CHINNOCK | - COUNCILMAN |
| 5. THOMAS O. MCBRIDE | - COUNCILMAN |
| 6. DANIEL MCNALLY | - COUNCILMAN |
| 7. TRUDY WENDLING | - COUNCILWOMAN |

INDEX OF PLAN SHEETS

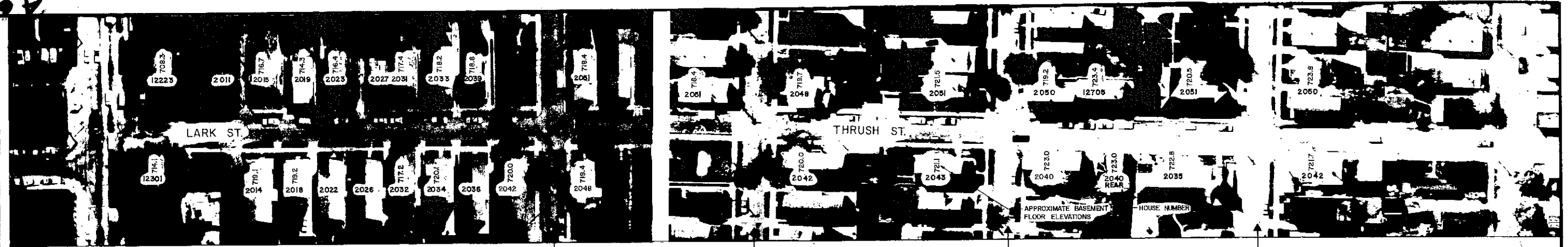
SHT.	
1.	TITLE SHEET
2.	LEGEND, REFERENCE BENCH MARKS, SYMBOLS; ABBREVIATIONS, AND GENERAL NOTES
3.	RELIEF SEWER STA. 0+00 TO STA. 4+56 LARK ST, MADISON AVE. TO THRUSH ST.
4.	RELIEF SEWER STA. 0+00 TO STA. 5+68 THRUSH ST, LARK ST. TO QUAIL ST.
5.	RELIEF SEWER STA. 0+00 TO STA. 9+47 QUAIL ST, THRUSH ST. TO PLOVER ST.
6.	CONNECTION DETAIL TO EXISTING MANHOLE & DROP MANHOLE DETAIL.
7.	STANDARD PRECAST MANHOLES & CONNECTION DETAILS TO EXISTING MANHOLES.
8.	JUNCTION MANHOLES, MANHOLE SCHEDULE, & MISC. DETAILS.

FINAL MEASUREMENTS SEWER BOOK 36 PGS. 37 - 42

J. HOWARD CHILDS P.E. - CITY ENGINEER



752



MADISON AVE.

THRUSH ST.

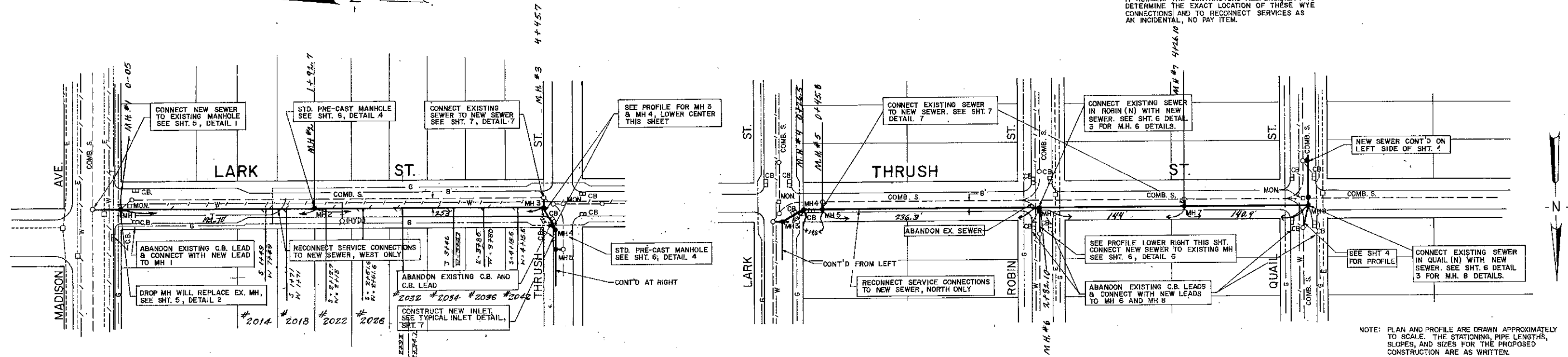
LARK ST.

ROBIN ST.

QUAIL ST.

NOTE: AERIAL PHOTO STRIP PROVIDED TO SHOW AREA OF CONSTRUCTION.
ALL NOTES, DIMENSIONS, ETC., SHOWN BELOW.

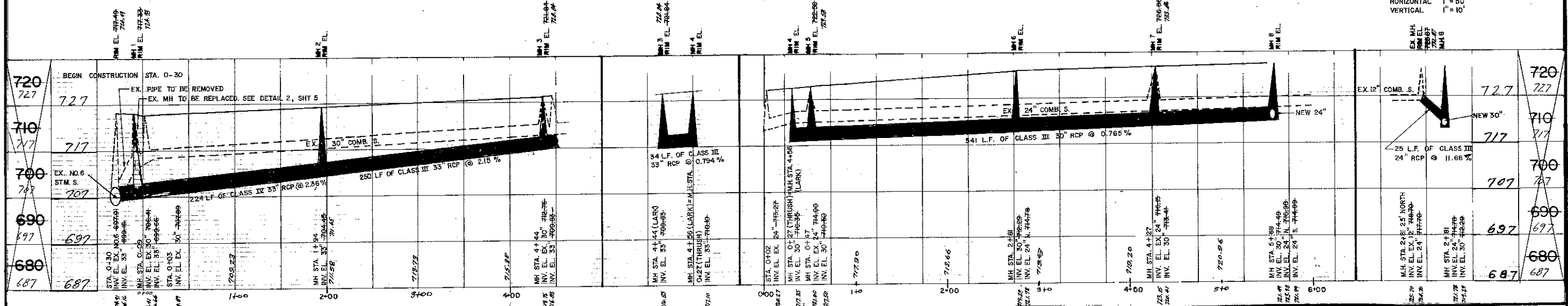
NOTE: THE WYE CONNECTIONS SHOWN ON THE DRAWINGS
ARE PROVIDED AS AN AID TO THE CONTRACTOR.
IT REMAINS THE CONTRACTOR'S RESPONSIBILITY TO
DETERMINE THE EXACT LOCATION OF THESE WYE
CONNECTIONS AND TO RECONNECT SERVICES AS
AN INCIDENTAL, NO PAY ITEM.



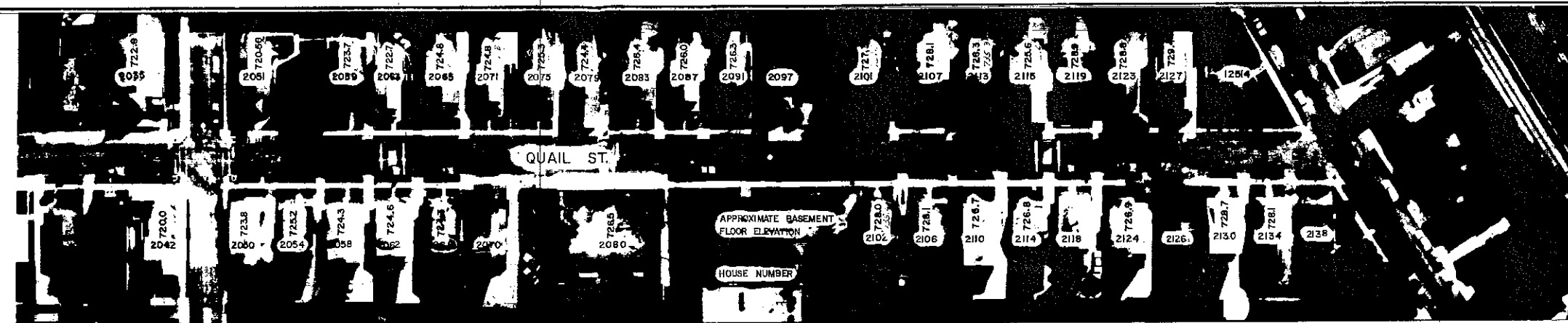
FINAL MEASUREMENTS SEWER BOOK 36- P65, 37-42

NOTE: RIM ELEVATIONS FOR EXISTING MANHOLES

SCALE
HORIZONTAL 1" = 50'
VERTICAL 1" = 10'



REVISIONS		CITY OF LAKEWOOD, OHIO		WATERMATION, INC.		RELIEF SEWER STA. 0+00 TO STA. 4+56	
		BASEMENT FLOODING RELIEF FACILITIES		CONSULTING ENGINEERS		LARK ST., MADISON AVE. TO THRUSH ST.	
APPROVED:		CITY ENGINEER		2304 UNIVERSITY AVENUE		RELIEF SEWER STA. 0+00 TO STA. 5+68	
				ST. PAUL, MINNESOTA 55114		THRUSH ST., LARK ST. TO QUAIL ST.	
						A652	
				DRAWN SAC		CITY DRAWING NUMBER A-652	
				DATE OCTOBER 22, 1979		SHEET 3 OF 7	
				CHECKED DLL EPG			
				DATE 12-14-79			



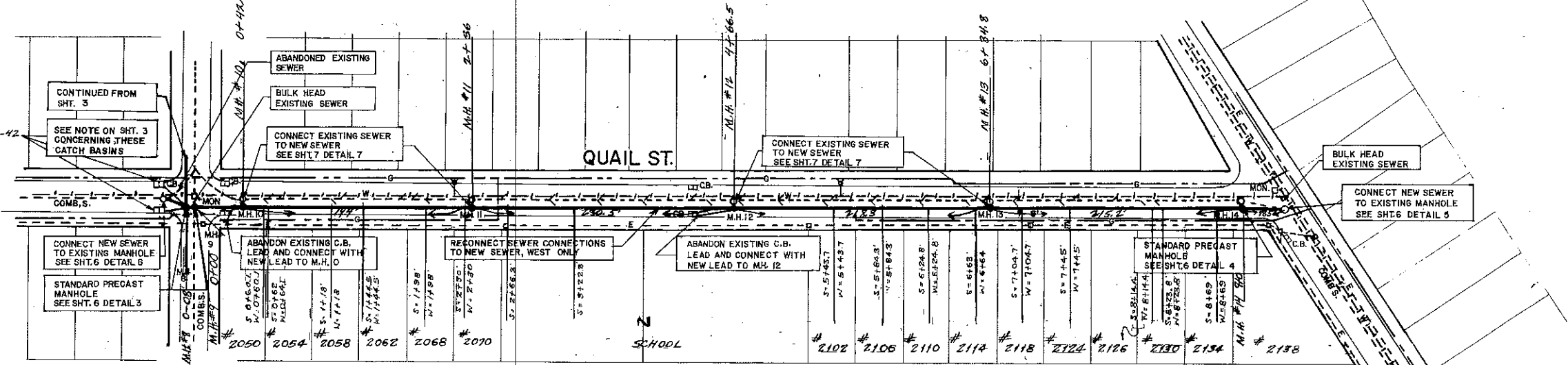
THRUSH ST.

PLOVER ST.

NOTE: THE WYE CONNECTIONS SHOWN ON THESE DRAWINGS ARE PROVIDED AS AN AID TO THE CONTRACTOR. IT REMAINS THE CONTRACTOR'S RESPONSIBILITY TO DETERMINE THE EXACT LOCATION OF THESE WYE CONNECTIONS AND TO RECONNECT SERVICES AS AN INCIDENTAL, NO PAY ITEM.

NOTE: AERIAL PHOTO STRIP PROVIDED TO SHOW AREA OF CONSTRUCTION, ALL NOTES, DIMENSIONS, ETC., SHOWN BELOW.

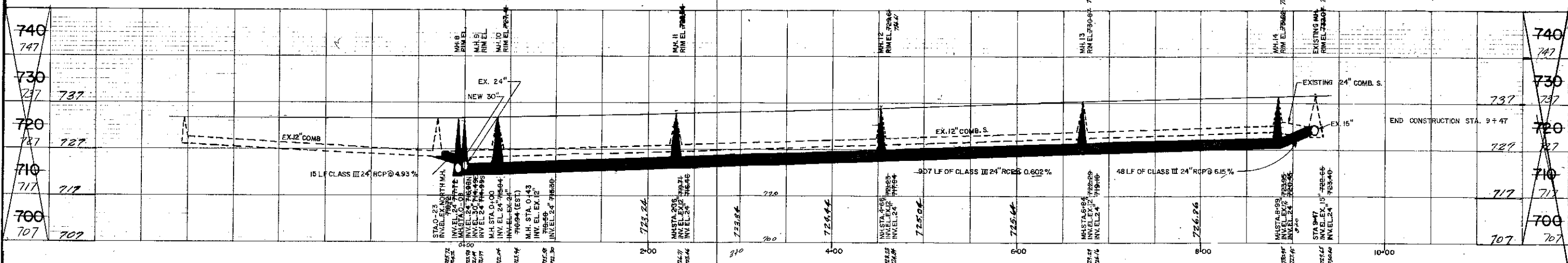
FINAL MEASUREMENTS-SEWER BOOK 36 P63, 37-42



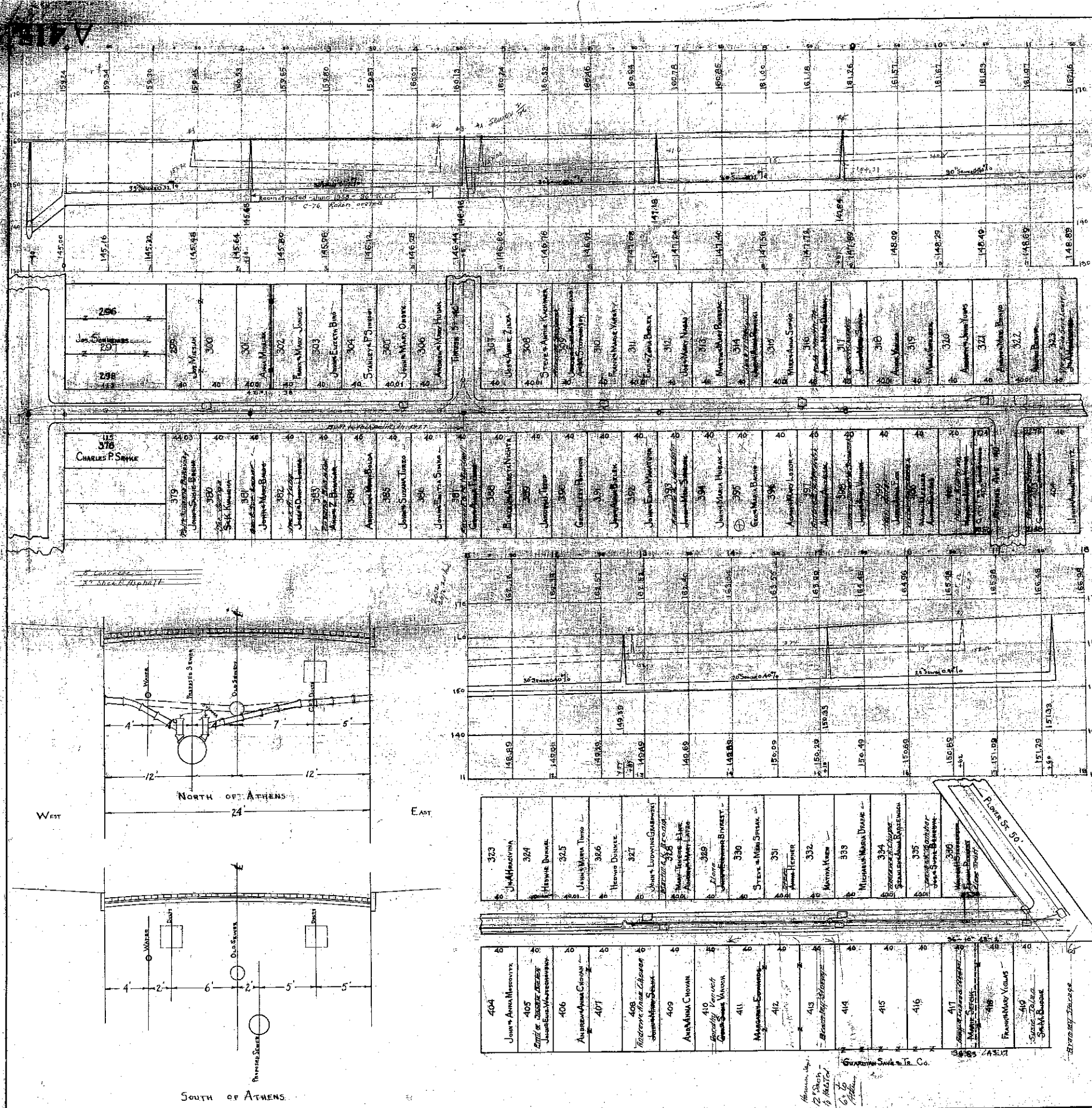
NOTE: PLAN AND PROFILE ARE DRAWN APPROXIMATELY TO SCALE. THE STATIONING, PIPE LENGTHS, SLOPES, AND SIZES FOR THE PROPOSED CONSTRUCTION ARE AS WRITTEN.

SCALE
HORIZONTAL 1"=50'
VERTICAL 1"=10'

NOTE: RIM ELEVATIONS FOR EXISTING MANHOLE



REVISIONS	CITY OF LAKEWOOD, OHIO BASEMENT FLOODING RELIEF FACILITIES			WATERMATION, INC. CONSULTING ENGINEERS 2304 UNIVERSITY AVENUE ST. PAUL, MINNESOTA 55114	DRAWN <u>DRP</u>	RELIEF SEWER STA. 0+00 TO STA. 9+47 QUAIL ST, THRUSH ST, TO PLOVER ST.	CITY DRAWING NUMBER <u>A-652</u>	SHEET <u>4</u> OF <u>7</u>
					DATE <u>OCTOBER 22, 1979</u>			
					CHECKED <u>DL</u> <u>EPC</u>			
					DATE <u>12-14-79</u>			
APPROVED: _____ CITY ENGINEER								



APPROXIMATE QUANTITIES
 405 LIN. FT. 30" SEWER
 822 LIN. FT. 30" SEWER
 453 LIN. FT. 20" SEWER
 60 SEWER RECONNECTIONS
 9 NEW MANHOLES

LEGEND

- PROPOSED SEWER.
- C.E.I. DUCTS.
- OLD SEWER.
- WATER LINE.

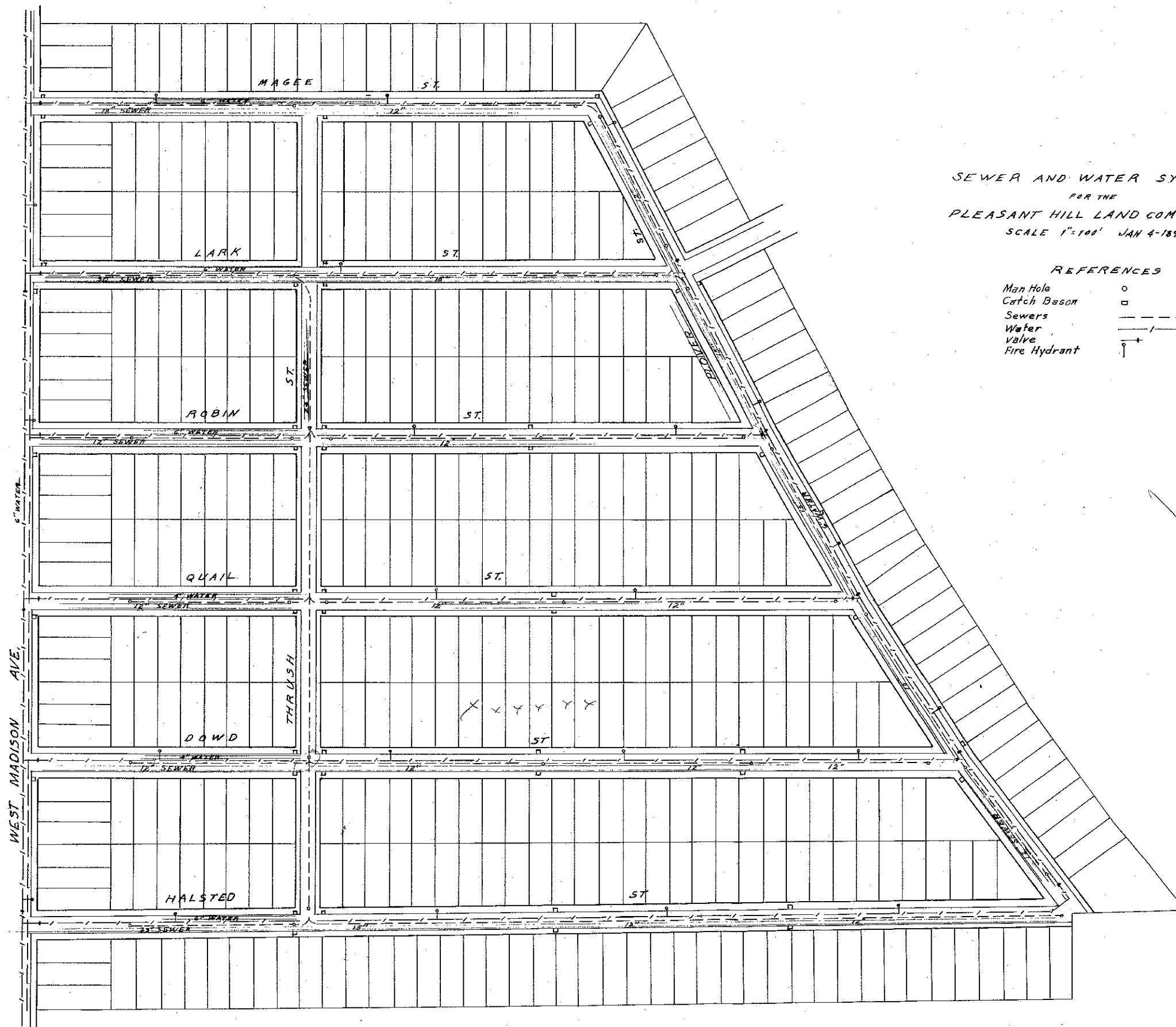
CITY OF LAKEWOOD, OHIO.
 DIVISION OF ENGINEERING
SEWER PLAN
HALSTEAD ST.
 FROM WEST MADISON SOUTH TO PLOVER 1770'
 HORIZ. SCALE 1"=60'
 VERT. SCALE 1"=10'
 DRAWN BY COTTON
 CHECKED BY
 CITY ENGINEER
 APPROVED THIS DAY 192

1927 T.M. 2500'
 Front 30' 1/2"

DIV 14 1908

A 415

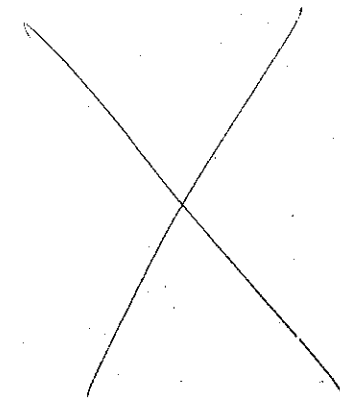
A 49 B



SEWER AND WATER SYSTEM
FOR THE
PLEASANT HILL LAND COMPANY
SCALE 1"=100' JAN 4-1895

REFERENCES

Man Hole	○
Catch Basin	□
Sewers	— — — — —
Water	— — — — —
Valve	— — — — —
Fire Hydrant	— — — — —

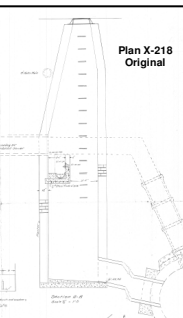


A 49 B

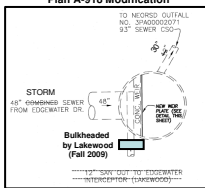
CSO-071 Tributary Flows – November 2009

West 117th Street From Lake Erie to Berea Road – Cities of Cleveland & Lakewood, Ohio

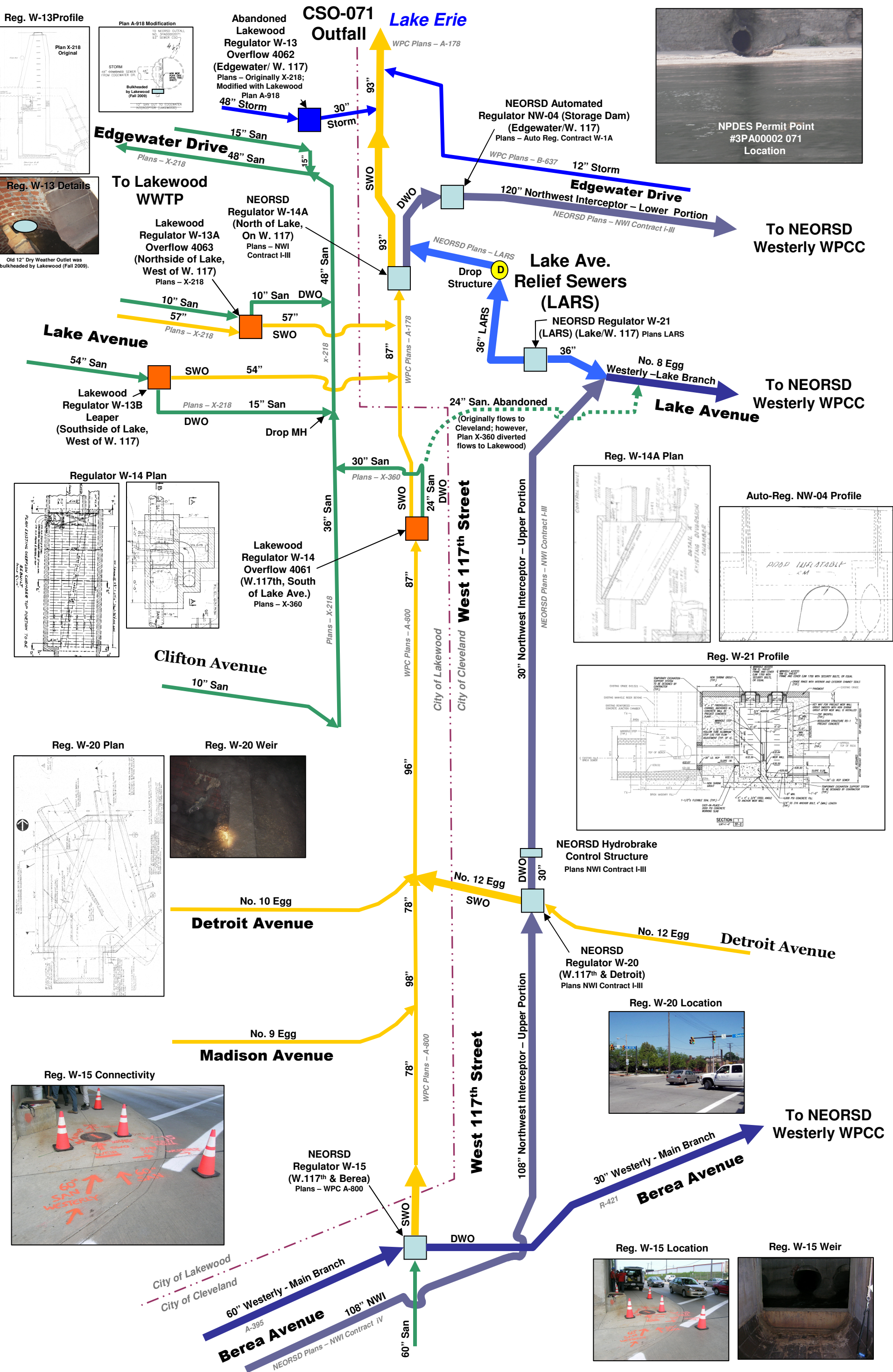
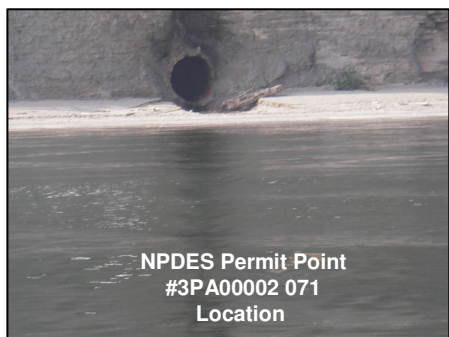
Reg. W-13 Profile



Plan A-918 Modification



Reg. W-13 Details





AGREEMENT
By and Between
NORTHEAST OHIO REGIONAL SEWER DISTRICT
and
CITY OF LAKEWOOD

THIS AGREEMENT made and entered into this 16th day of November, 1995, by and between the Northeast Ohio Regional Sewer District (hereinafter "DISTRICT"), a regional sewer district organized and existing as a political subdivision under Chapter 6119 of the Ohio Revised Code, by authority of Resolution No. 45-92, adopted by the Board of Trustees on February 6, 1992, and the City of Lakewood (hereinafter "LAKEWOOD"), by authority of Ordinance No. 88-92, adopted on October 5, 1992.

WHEREAS, pursuant to an agreement dated July 29, 1965 between the City of Cleveland and LAKEWOOD the Westerly Interceptor was jointly owned and maintained by the parties; and

WHEREAS, pursuant to Resolution No. 169-73, adopted by the Board of Trustees on December 19, 1973, the DISTRICT assumed the duties and obligations of the City of Cleveland under the aforementioned agreement; and

WHEREAS, the DISTRICT subsequently constructed the Northwest Interceptor which runs parallel to the Westerly Interceptor along West 117th Street thereby separating the flow between the communities; and

WHEREAS, over the course of time the invert of the West 117th Street sewer eroded away thereby necessitating reconstruction and rehabilitation of the sewer; and

WHEREAS, the parties have agreed that LAKEWOOD shall be responsible for the West

117th Street Sewer Rehabilitation Project (hereinafter "Project") with the DISTRICT contributing a portion of the costs associated with said Project; and

WHEREAS, LAKEWOOD has constructed the Project; and

WHEREAS, the parties have agreed to revise the ownership of certain portions of the West 117th Street sewer to reflect current sewer usage, and;

WHEREAS, the parties have agreed that the 24-inch wet weather overflow from the West 117th Street sewer to the Westerly Interceptor at West 117th Street and Lake Avenue shall be bulkheaded; and

WHEREAS, the 5.5' x 6.5' sewer along West 117th Street from Berea Road to Madison Avenue has had five vent grates repaired by the District; and

WHEREAS, prior to April 4, 1994, certain sewer charges for residential and industrial customers were assessed by the parties and paid by customers without respect to actual connections, based on prior agreements, custom, and tradition, and;

WHEREAS, the passage of time between completion of the Project and resolution of outstanding issues between the parties has caused a dispute to arise relating to possible arrearages in sewer charges which might have been assessed to customers being transferred from one parties billing to the other; and

WHEREAS, the parties intend by this agreement to settle and resolve all outstanding differences between them including possible claims or debts without further delay, expense or legal costs.

NOW, THEREFORE, in consideration of the mutual covenants hereinafter stipulated to be performed, it is agreed between the parties as follows:

Section 1 The 24-inch wet weather overflow sewer from the West 117th Street sewer to the Westerly Interceptor at West 117th Street and Lake Avenue shall be bulkheaded within thirty (30) days after execution of this Agreement. Upon completion of the bulkhead, LAKEWOOD shall notify the District's Supervisor of Technical Support (216) 641-6000 for the purpose of arranging an inspection of the bulkhead by DISTRICT personnel. Should any hydraulic problems appear in the future that are caused by the bulkhead, the bulkhead may be removed by LAKEWOOD after consultation with the District.

Section 2 Upon execution of this Agreement, all rights, title and interest in the sanitary sewers depicted in the attached sewer plans (Attachment "A") shall pass to and vest in LAKEWOOD absolutely, free and clear of all liens, encumbrances, claims and restrictions whatsoever, without other or further consideration, or conveyance by the DISTRICT. Upon and after title to the sewers is vested in LAKEWOOD, LAKEWOOD shall have the sole responsibility and bear the full cost of the operation, maintenance, replacement, repair and servicing of the sewers.

Section 2.1 In accordance with Attachment "A," Sewer #2, more fully described as the 5.5' X 6.5' Increasing to a 8.5' x 9.2' combined sewer located on the west side of West 117th Street from the overflow chamber at Berea Road and West 117th Street up to and including the overflow chamber 170' south of Lake Avenue, shall be transferred to LAKEWOOD pursuant to Section 2, above.

Section 2.2 In accordance with Attachment "A," Sewer #3, more fully described as the 24" increasing to 30" sanitary sewer, including the diversion chamber, located east and west of the centerline of West 117th Street from the overflow chamber 170' south of Lake Avenue to the

existing 36" sanitary sewer approximately 65' south of Lake Avenue, shall be transferred to LAKEWOOD pursuant to Section 2, above.

Section 2.3 In accordance with Attachment "A," Sewer #5, more fully described as the 7'3" increasing to 7'9" wet weather overflow sewer located east and west of the centerline of West 117th Street from the overflow chamber on West 117th Street 170' south of Lake Avenue to the diversion chamber 140' north of the centerline of Lake Avenue, shall be transferred to LAKEWOOD pursuant to Section 2, above.

Section 3. From and after the execution of this Agreement, LAKEWOOD agrees to inform the DISTRICT monthly of all residential sewer connection permits issued in the areas of LAKEWOOD which are tributary to the DISTRICT's wastewater collection, treatment and disposal system. From and after the execution of this agreement all applications for sewer connection permits by industrial users (as defined in the Standard Industrial Classification Manual of the Office of Management and Budget) within LAKEWOOD shall be subject to approval by the DISTRICT as to conformance with the DISTRICT's Code of Regulations prior to the issuance of a permit.

Section 3.1 LAKEWOOD shall report metered water consumption to the DISTRICT for industrial, commercial, and/or residential accounts that are located in LAKEWOOD but have flow tributary to the District.

Section 3.2 Neither party shall modify the present service area without the mutual consent of the other party.

Section 4 The parties agree to a reconciliation of costs and charges as more fully described below.

Section 4.1 The DISTRICT agrees to assume and bear one-fourth (1/4) of the actual costs to LAKEWOOD in the amount of Thirty-Nine Thousand One Hundred Sixty-Two Dollars (\$39,162.00) for the labor and materials utilized in connection with construction of the Project.

Section 4.2 LAKEWOOD agrees to assume and bear one-half (1/2) of the actual costs to the DISTRICT in the amount of Three Thousand Nine Hundred Fifty-Four Dollars (\$3,954.00) for the repair of five (5) vent grates along West 117th Street.

Section 4.3 The DISTRICT agrees that it owes LAKEWOOD Fifteen Thousand Two Hundred Dollars (\$15,200.00) for sewer charges it improperly billed accounts tributary to LAKEWOOD's treatment system from January 1, 1992 until April 4, 1994.

Section 4.4 LAKEWOOD agrees that it owes the DISTRICT Seventy-Three Thousand Five Hundred Dollars (\$73,500.00) for sewer charges it improperly billed accounts tributary to the DISTRICT's treatment system from January 1, 1992 until April 4, 1994.

Section 5 Pursuant to the costs and charges reconciliation listed in Section 4 above, Lakewood agrees to pay to the District Twenty-Two Thousand Nine Hundred Ninety-Two Dollars (\$22,992.00) by February 1, 1996.

Section 6 The payments provided for herein shall constitute payment in full of all outstanding debts and claims between the parties; and this agreement shall constitute full and final settlement of all heretofore unresolved issues arising out of the joint undertakings and transfer of customers set forth in the preamble herefor including any claims that the parties may have against the customer accounts in question for the period prior to April 4, 1994.

Section 7 A determination that any part of this Agreement is invalid shall not invalidate or impair the force or effect of any other part thereof, except to the extent that such other part is

wholly dependent for its operation upon the part so declared invalid.

IN WITNESS WHEREOF, LAKEWOOD and the DISTRICT have caused this Agreement to be executed by their respective officers, duly authorized to act on behalf of their respective principals as of the day and year first above written.

WITNESSETH:

CITY OF LAKEWOOD, OHIO

David R. Harbarger
Elizabeth L. McLaughlin

BY: *David R. Harbarger*
 David R. Harbarger, Mayor

WITNESSETH

NORTHEAST OHIO REGIONAL SEWER DISTRICT

Erwin J. Odeal
Terry A. Nelson

BY: *Erwin J. Odeal*
 Erwin J. Odeal, Executive Director
Michael L. Nelson Sr.
 Michael L. Nelson Sr., Board President

The legal form and correctness of the within instrument is hereby approved.

Michael E. Murman
 Michael E. Murman, Law Director
 City of Lakewood

DATE: *11/3/95*

William B. Schatz
 William B. Schatz, General Counsel
 Northeast Ohio Regional Sewer District

DATE: *11/16/95*

legal(LAKEWOOD)

Transportation

• Biking Continued

- Bike racks should be installed for safe storage along the Madison Avenue corridor and at key spots within the neighborhood. Currently, the only existing bike racks in the neighborhood are located at Harrison School.



• Traffic Calming

- Traffic calming involves changes in street alignment, installation of barriers, and other physical measures to reduce traffic speeds and/or cut-through volumes, in the interest of street safety, livability, and other public purposes. Raised crosswalks should be constructed near Harrison School, slowing traffic without creating an impediment for snow plows. These could be constructed of an attractive building material such as brick and could incorporate public art. The extension of portions of concrete into the street, "bulbs," would slow traffic on Madison Avenue and improve pedestrian safety. Currently, two-way stop signs at four-way intersections help slow motorists. Speeding is still a concern for some neighborhood residents, especially parents.



• Public Art

- Works of art in various media will be planned and executed with the specific intention of being sited or staged in the physical public domain, usually outside and accessible to all.
- Employ local artists to develop decorative bus shelters.
- Use brick patterning in sidewalks and crosswalks to add interest to landscape.
- Incorporate the community's ethnic history into artworks, perhaps employing Eastern European folk art styles.



A specially designed bus shelter adds interest to the street in Sioux Falls, South Dakota



Birdtown/Madison East Neighborhood Plan
December, 2009

12 195 000 FEET R. 14 W. | R. 13 W.

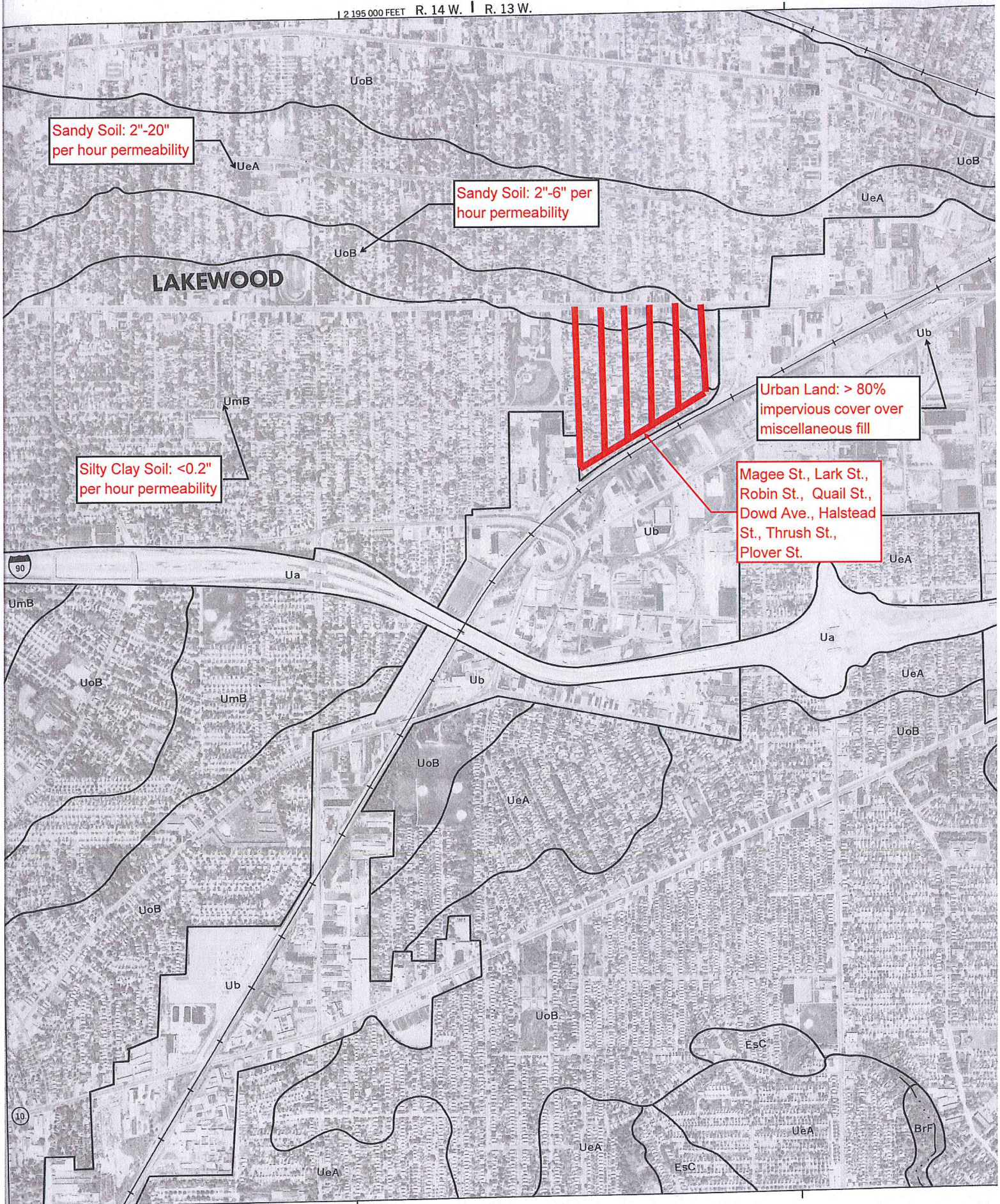
Sandy Soil: 2"-20"
per hour permeability

Sandy Soil: 2"-6"
per hour permeability

Silty Clay Soil: <0.2"
per hour permeability

Urban Land: > 80%
impervious cover over
miscellaneous fill

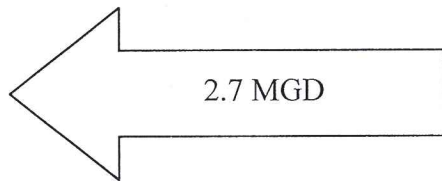
Magee St., Lark St.,
Robin St., Quail St.,
Dowd Ave., Halstead
St., Thrush St.,
Plover St.



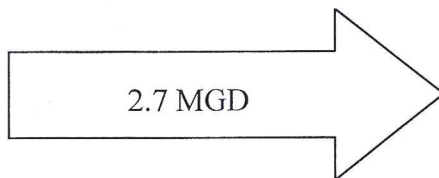
W. 117th Street Mass Balance
Dry Weather Flow

Lakewood System

To Lakewood Interceptor

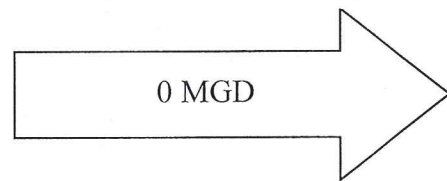


From W. 117th (Lakewood side),
Madison Avenue, Detroit Avenue,
Lake Avenue

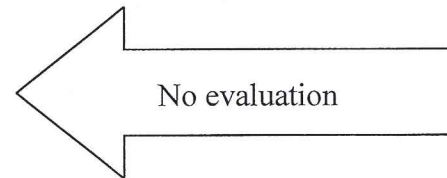


NEORSD System

To Westerly Interceptor – Lake
Branch, Northwest Interceptor

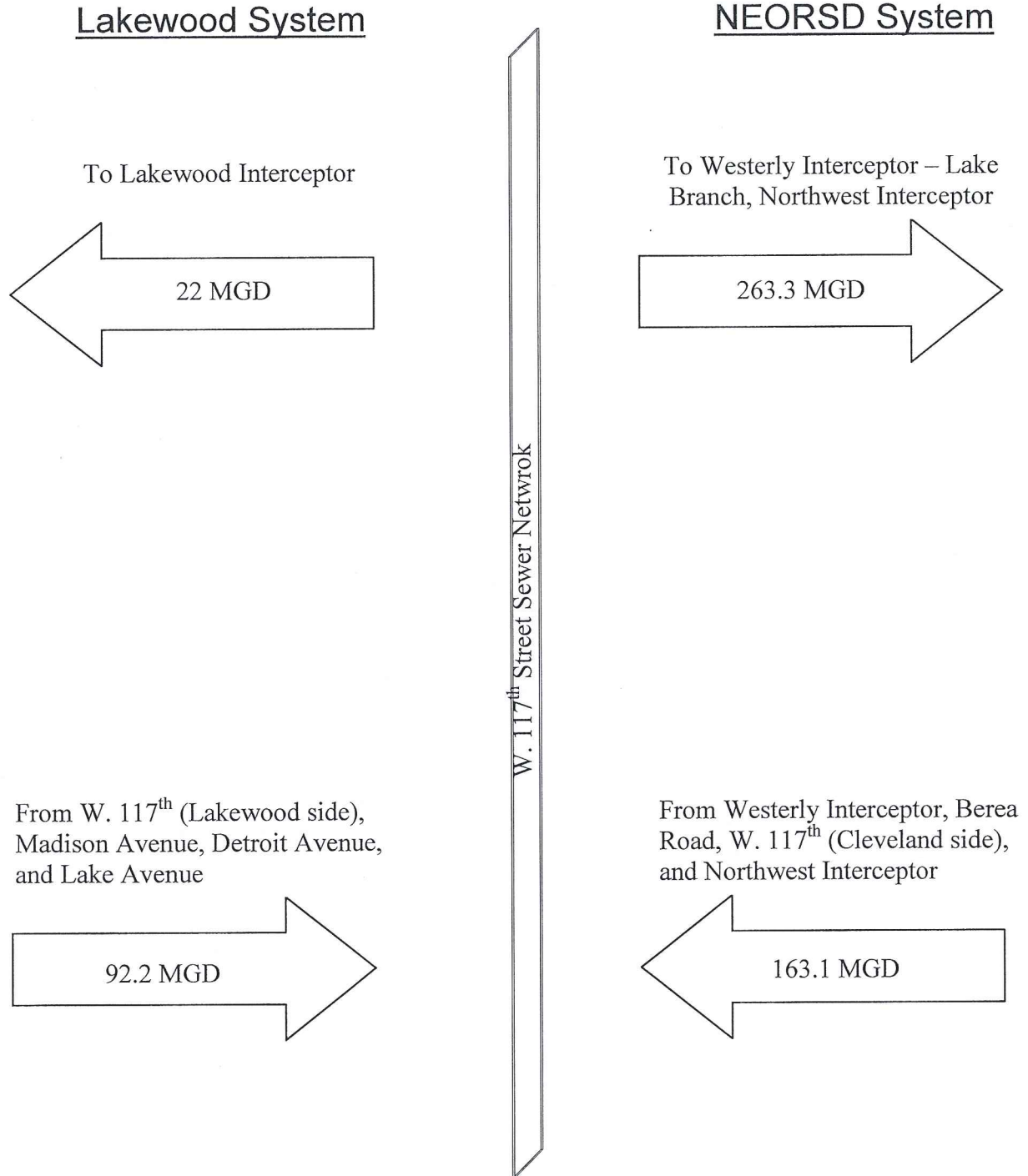


From Westerly Interceptor, Berea
Road, W. 117th (Cleveland side),
and Northwest Interceptor



W. 117th Street Sewer Network

W. 117th Street Mass Balance
Peak Wet Weather Flow Rate – Typical Year



Site ID Madison Park - 2014

Meter Location: Madison Park
Design Storm: 2 year 1-hr
 Design Rainfall: 1.15 in./1-hr

Dry Day ADF - 0.000 MGD
 Sewer Size - 12 in.

Peak Flow Summary - Madison Park, 2 Year - 1 Hour Event

Storm Date	Storm Day	Rainfall 1-hr (in.)	Peak Hour Measured I/I Rate (MGD)	Peaking Factor	Design Storm I/I Rate (MGD)
06/29/14	Sunday	0.38	0.076	3.00	0.228
06/18/14	Wednesday	0.50	0.234	2.30	0.538
06/24/14	Tuesday	0.86	0.401	1.30	0.521
DESIGN STORM I/I RATE (Average)					0.429

I/I Volume Summary - Madison Park, 2 Year - 1 Hour Event

Storm Date	Storm Day	Rainfall Total (in.)	Measured I/I Volume (gal)	Design Storm Volume Factor	Design Storm Volume (gal)
06/29/14	Sunday	0.38	3,174	3.03	9,617
06/18/14	Wednesday	0.59	11,021	1.95	21,491
06/24/14	Tuesday	1.94	37,667	0.59	22,224
DESIGN STORM I/I VOLUME (Average)					17,777

Site ID Madison Park - 2015

Meter Location: Madison Park - 2015

Dry Day ADF - 0.000 MGD

Design Storm: 2 year 1-hr

Sewer Size - 12 in.

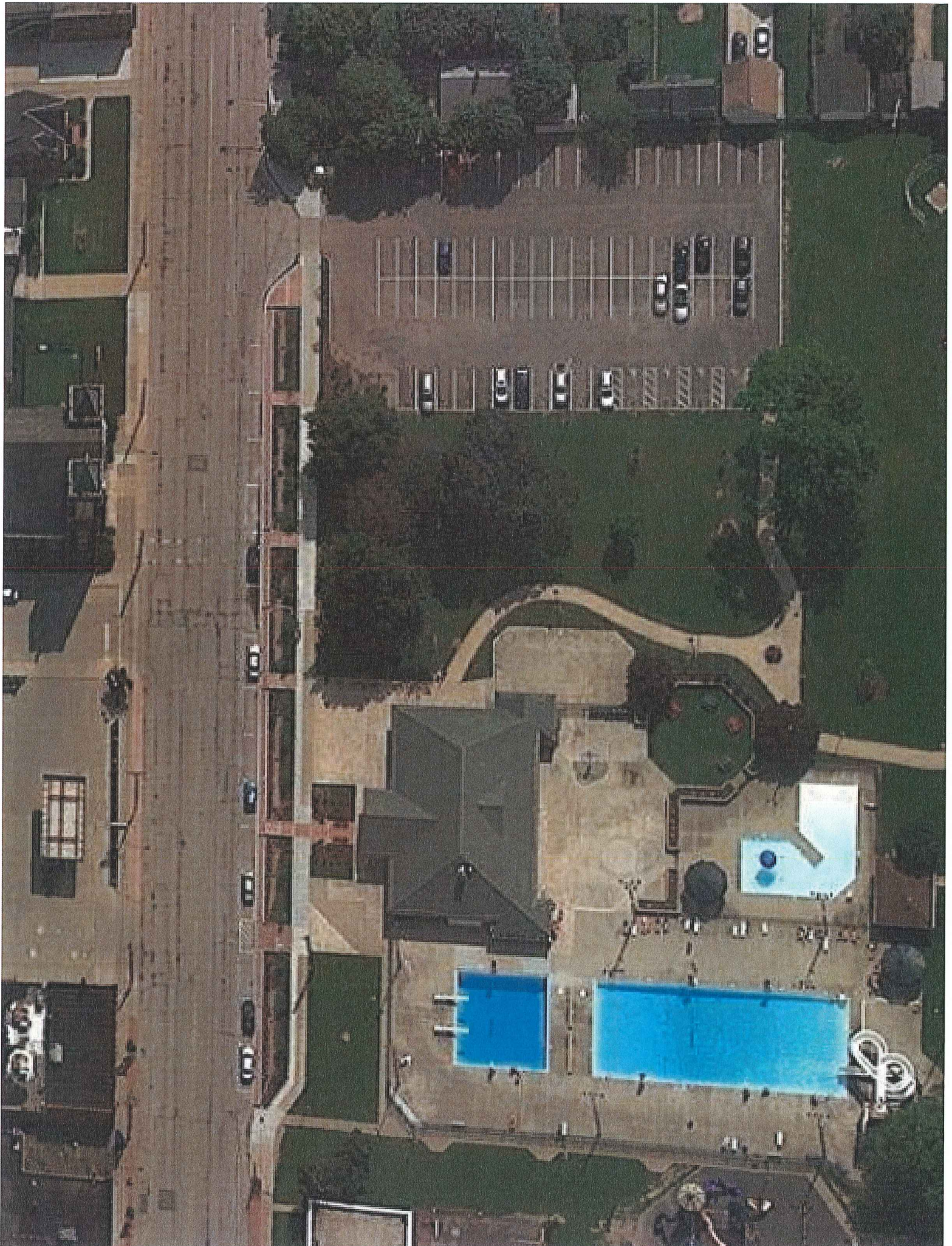
Design Rainfall: 1.15 in./1-hr

Peak Flow Summary - Madison Park, 2 Year - 1 Hour Event

Storm Date	Storm Day	Rainfall 1-hr (in.)	Peak Hour Measured I/I Rate (MGD)	Peaking Factor	Design Storm I/I Rate (MGD)
08/10/15	Monday	0.47	0.006	2.40	0.014
08/18/15	Tuesday	0.48	0.003	2.40	0.007
09/12/15	Saturday	0.22	0.043	5.20	0.224
DESIGN STORM I/I RATE (Average)					0.082

I/I Volume Summary - Madison Park, 2 Year - 1 Hour Event

Storm Date	Storm Day	Rainfall Total (in.)	Measured I/I Volume (gal)	Design Storm Volume Factor	Design Storm Volume (gal)
08/10/15	Monday	0.64	840	1.80	1,512
08/18/15	Tuesday	0.56	417	2.05	855
09/12/15	Saturday	1.03	8,583	1.12	9,613
DESIGN STORM I/I VOLUME (Average)					3,993



TYPICAL YEAR PRECIPITATION

The City's comprehensive model was used to establish a baseline for overflow events during a typical precipitation year. It is the baseline predictions from the model that will be used to determine system improvements in accordance with the city's long-term control plan. Data from Cleveland Hopkins International Airport (CLE) were obtained for the 33-year period from 1973 to 2006. The following criteria were considered desirable for the typical year precipitation data:

- No storm events greater than a 1-year storm
- Include a 1-year 1-hour storm
- Include a 6-month 1-hour storm
- Include a 4-month 1-hour storm
- Include a 3-month 1-hour storm
- Have remaining storms less than a 3-month storm
- Close to average precipitation reported by United States Department of Agriculture (USDA)

The precipitation events from the 33-year record were classified and calendar year 1977 (35.48 inches, total) came closest to the previously stated criteria. This year of precipitation data was submitted to the USEPA for evaluation. The USEPA assessed the proposed precipitation record and requested that the total precipitation for the year be raised from 35.48 inches to 37.52 inches based on the CLE data (1973 to 2006) being more recent than the USDA data (1951 to 1976) previously used. To incorporate the additional precipitation requested, the 1977 monthly precipitation was compared to the monthly averages of the CLE data. January, February, May, September, and October were below the monthly average of the CLE data. The additional precipitation (2.04 inches) of precipitation was distributed to the below average months as shown in Table 8.1. The additional storms brought the respective monthly averages closer to the monthly averages of the CLE data.

Appendix B. Summary of District's Synthetic Design Storm and Typical Year Rainfall

Tables B-1 and **B-3** were obtained from Appendix C of the District's CSO Facilities Planning Summary Report dated March 2005. The Consultant shall refer to this report for additional information regarding the District's selected design storms and synthetic typical year hyetographs is needed. **Table B-2** summarizes the standard design storm hyetographs based on 15-minute rainfall increments have been adopted and are available for Consultant use if needed for particular project needs. District approval is required if finer rainfall time series is deemed necessary by the Consultant.

Table B-1. Official Design Storm Hyetographs Based on 1-Hour Rainfall Increments.

Return Period	Duration	Hourly Incremental Rainfall Depth (in)						Total Rainfall	Average Intensity
		Hour 1	Hour 2	Hour 3	Hour 4	Hour 5	Hour 6	(in)	(in/hr)
1-month	6-hour	0.06	0.15	0.09	0.09	0.08	0.09	0.56	0.09
4-month	6-hour	0.05	0.15	0.10	0.37	0.16	0.14	0.97	0.16
6-month	6-hour	0.01	0.06	0.02	0.73	0.26	0.02	1.10	0.18
1-year	6-hour	0.05	0.07	0.15	1.00	0.21	0.01	1.49	0.25
2-year	6-hour	0.12	0.04	0.14	1.17	0.18	0.10	1.75	0.29
5-year	6-hour	0.06	0.10	0.23	1.43	0.20	0.12	2.14	0.36
1-year	1-hour	1.00						1.00	1.00
5-year	1-hour	1.43						1.43	1.43
10-year	1-hour	1.69						1.69	1.69
25-year	1-hour	2.06						2.06	2.06
50-year	1-hour	2.40						2.40	2.40
100-year	1-hour	2.77						2.77	2.77

Table B-2. Design Storm Hyetographs Based on 15-Minute Rainfall Increments.

Return Period	6-Hour Duration ⁽¹⁾		24-Hour Duration ⁽²⁾	
	Total Rainfall (in)	Peak 1-Hour Intensity (in/hr)	Total Rainfall (in)	Peak 1-Hour Intensity (in/hr)
1-month	0.56	0.36	0.79	0.36
2-month	0.79	0.51	1.12	0.51
3-month	0.93	0.59	1.31	0.59
4-month	1.01	0.65	1.43	0.65
6-month	1.17	0.75	1.65	0.75
9-month	1.33	0.85	1.88	0.85
1-year	1.45	0.92	2.04	0.92
2-year	1.77	1.13	2.50	1.13
5-year	2.20	1.40	3.10	1.40

(1) Distribution based on peak 6-hr duration of the SCS Type 2 24-hr distribution at 15-minute increments.

(2) From District's 2006 RIDE Study and ISWS Bulletin 71 and SCS Type 2 24-hour distribution.

Table B-3. Storm Events for Typical Year Continuous Year Simulation.

Storm Event	Date	Hour	Duration (Hrs)	Depth (In)	Average Intensity (In/Hr)	Maximum Hourly Intensity (In/Hr)	Storm Event	Date	Hour	Duration (Hrs)	Depth (In)	Average Intensity (In/Hr)	Maximum Hourly Intensity (In/Hr)
1	01/03/91	12	1	0.01	0.01	0.01	62	07/03/93	2	1	0.01	0.01	0.01
2	01/05/91	13	10	0.18	0.02	0.03	63	07/04/93	16	1	0.44	0.44	0.44
3	01/09/91	13	2	0.03	0.01	0.02	64	07/06/93	16	1	0.47	0.47	0.47
4	01/11/91	4	19	0.39	0.02	0.09	65	07/11/93	20	3	0.35	0.12	0.24
5	01/12/91	12	21	0.04	0.00	0.01	66	07/19/93	14	2	0.14	0.07	0.13
6	01/15/91	24	8	0.33	0.04	0.08	67	07/26/93	6	2	0.04	0.02	0.02
7	01/16/91	19	10	0.17	0.02	0.03	68	07/28/93	17	9	1.08	0.12	0.72
8	01/20/91	13	30	0.53	0.02	0.05	69	07/29/93	20	3	0.67	0.22	0.31
9	01/26/91	7	10	0.03	0.00	0.01	70	08/02/93	5	2	0.42	0.21	0.41
10	01/27/91	19	4	0.08	0.02	0.03	71	08/03/93	21	10	0.42	0.04	0.20
11	01/29/91	20	11	0.37	0.03	0.10	72	08/06/93	19	4	0.10	0.03	0.06
12	01/30/91	18	1	0.01	0.01	0.01	73	08/07/93	13	1	0.13	0.13	0.13
13	01/31/91	14	1	0.01	0.01	0.01	74	08/10/93	16	2	0.02	0.01	0.01
14	02/05/91	7	1	0.01	0.01	0.01	75	08/11/93	4	4	0.24	0.06	0.23
15	02/06/91	15	9	0.10	0.01	0.02	76	08/12/93	17	1	0.02	0.02	0.02
16	02/10/91	15	20	0.73	0.04	0.09	77	08/16/93	4	1	0.07	0.07	0.07
17	02/13/91	14	59	1.53	0.03	0.16	78	08/20/93	9	1	0.01	0.01	0.01
18	02/16/91	24	14	0.18	0.01	0.04	79	08/28/93	2	1	0.06	0.06	0.06
19	02/18/91	15	13	0.08	0.01	0.04	80	08/31/93	13	6	0.03	0.00	0.02
20	02/19/91	17	7	0.29	0.04	0.10	81	09/02/93	8	21	1.02	0.05	0.67
21	02/26/91	4	40	0.08	0.00	0.01	82	09/06/93	13	1	0.35	0.35	0.35
22	02/28/91	9	4	0.04	0.01	0.02	83	09/07/93	9	1	0.01	0.01	0.01
23	03/02/91	1	14	0.06	0.00	0.02	84	09/10/93	1	1	0.01	0.01	0.01
24	03/03/91	13	24	0.70	0.03	0.10	85	09/10/93	13	1	0.01	0.01	0.01
25	03/06/91	6	14	0.83	0.06	0.13	86	09/15/93	20	16	2.38	0.15	0.40
26	03/09/91	18	2	0.07	0.04	0.05	87	09/22/93	24	16	0.12	0.01	0.05
27	03/10/91	12	4	0.08	0.02	0.03	88	09/25/93	16	20	1.63	0.08	0.29
28	03/17/91	21	31	0.50	0.02	0.07	89	09/27/93	13	9	0.15	0.02	0.06
29	03/22/91	6	4	0.32	0.08	0.18	90	09/28/93	10	3	0.23	0.08	0.12
30	03/22/91	24	3	0.14	0.05	0.08	91	09/29/93	10	17	0.97	0.06	0.24
31	03/23/91	24	10	0.23	0.02	0.06	92	10/01/93	10	1	0.01	0.01	0.01
32	03/26/91	13	1	0.02	0.02	0.02	93	10/01/93	23	6	0.58	0.10	0.22
33	03/27/91	24	1	0.62	0.62	0.62	94	10/09/93	6	13	0.43	0.03	0.13
34	03/31/91	19	6	0.07	0.01	0.03	95	10/16/93	22	16	0.60	0.04	0.18
35	04/01/93	23	5	0.16	0.03	0.07	96	10/19/93	15	1	0.04	0.04	0.04
36	04/02/93	17	12	0.06	0.00	0.02	97	10/20/93	15	6	0.04	0.01	0.02
37	04/09/93	14	16	0.77	0.05	0.09	98	10/27/93	22	4	0.15	0.04	0.10
38	04/11/93	16	1	0.09	0.09	0.09	99	10/30/93	10	39	1.67	0.04	0.12
39	04/14/93	19	2	0.03	0.01	0.02	100	11/01/91	17	1	0.01	0.01	0.01
40	04/15/93	23	3	0.34	0.11	0.16	101	11/07/91	9	12	0.12	0.01	0.02
41	04/19/93	17	13	0.27	0.02	0.11	102	11/11/91	2	7	0.69	0.10	0.14
42	04/20/93	16	18	0.61	0.03	0.13	103	11/12/91	11	12	0.21	0.02	0.06
43	04/24/93	12	2	0.03	0.01	0.02	104	11/15/91	1	31	0.62	0.02	0.10
44	04/25/93	8	15	0.46	0.03	0.16	105	11/18/91	17	21	0.30	0.01	0.10
45	04/30/93	1	6	0.10	0.02	0.03	106	11/20/91	17	19	0.46	0.02	0.14
46	05/04/93	13	25	0.63	0.03	0.22	107	11/23/91	20	3	0.24	0.08	0.12
47	05/19/93	4	6	0.15	0.02	0.07	108	11/24/91	17	8	0.03	0.00	0.01
48	05/23/93	16	1	0.01	0.01	0.01	109	11/25/91	14	1	0.01	0.01	0.01
49	05/24/93	6	6	0.08	0.01	0.04	110	11/28/91	6	8	0.19	0.02	0.05
50	05/28/93	24	2	0.03	0.01	0.02	111	11/30/91	6	1	0.04	0.04	0.04
51	05/31/93	23	2	0.16	0.08	0.08	112	12/02/91	16	17	1.19	0.07	0.29
52	06/03/93	23	2	0.07	0.03	0.04	113	12/03/91	21	11	0.06	0.01	0.02
53	06/05/93	5	6	0.37	0.06	0.25	114	12/12/91	15	17	0.16	0.01	0.06
54	06/07/93	16	9	1.56	0.17	0.67	115	12/14/91	7	6	0.15	0.02	0.12
55	06/09/93	10	1	0.21	0.21	0.21	116	12/15/91	16	16	0.07	0.00	0.01
56	06/09/93	24	1	0.24	0.24	0.24	117	12/18/91	3	2	0.02	0.01	0.01
57	06/19/93	6	2	0.31	0.16	0.22	118	12/18/91	16	16	0.03	0.00	0.01
58	06/20/93	13	26	0.54	0.02	0.15	119	12/20/91	22	8	0.22	0.03	0.07
59	06/25/93	20	1	0.08	0.08	0.08	120	12/23/91	7	6	0.10	0.02	0.03
60	06/27/93	18	1	0.94	0.94	0.94	121	12/28/91	22	35	0.26	0.01	0.03
61	07/01/93	21	4	0.05	0.01	0.02	Total						37.51

1 yr gtu

operation of the basin is seen as it starts to fill just before midnight and is surcharged between 1:00 and 4:30 AM. During surcharged conditions, the levels rise and fall quickly as storage in the collection system is limited.

E.1.3.5 Footing Drain Monitoring

One potentially significant source of inflow into the sanitary sewer system during storms is from house foundation footing drains that are directly connected to the sanitary sewers. Previous studies conducted in Ann Arbor have reported that the footing drain connection from a single home could contribute as much as 10 gpm during a storm. Since most of the houses in the study areas have directly connected footing drains, footing drains can introduce a significant proportion of the observed

To estimate the amount of footing drain flow in each of the study areas, 20 locations were identified throughout the 5 study areas (about 4 per area) where house connections enter the sanitary sewer in manholes above the manhole benching. This configuration allowed the installation of temporary house lead extensions of about 1' into each manhole. Of the 20 locations identified, 16 installations were made as shown in Table E-9.

To estimate flows produced from individual homes, these house leads were visited during rainfall events to measure the flows being generated. Flows were measured using bucket and stopwatch methods. During each storm being monitored, flows were measured a number of times as field crews visited multiple manholes during the monitoring events. The storms of 8/17/00 and 9/11/00 were monitored by field crews. Two to three tests were performed at each location during each event.

Table E-9. Footing Drain Study Locations

<u>Region</u>	<u>Manhole ID</u>	<u>Approximate Address</u>
Orchard Hills	2	3000 Bluett
Orchard Hills	4	3022 Bluett
Orchard Hills	7	3130 Bluett
Orchard Hills	29	2488 Antietam
Orchard Hills	60	2537 Georgetown
Bromley	49 (E&W)	2814 Renfrew
Bromley	55	2500 Prairie
Bromley	5 (E)	2235 Prairie
Bromley	5 (W)	2235 Prairie
Glen Leven	94	1707 Tudor
Glen Leven	95	1706 Tudor
Glen Leven	22	1315 Glen Leven
Glen Leven	101 (E)	1530 Dicken Drive
Glen Leven	101 (W)	1530 Dicken Drive
Morehead Street	75	2189 Seventh
Morehead	35	2095 Chaucer

As noted earlier, footing drain flows were monitored during selected storms. This information was collected on August 17, 2000 and on September 11, 2000. The August 17, 2000 storm was short and of low volume and produced a limited wet weather flow response. During this period, footing drain flows ranged from 0.1 to 0.5 gpm.

The September 11, 2000 storm produced between 1.57" to 1.8" of rain over a 5-hour period. During this storm, footing drain flows were collected during a period of steady rainfall. Figure E-5 shows the

Table E-10 Average Footing Drain Flows

<u>Study Area</u>	<u>Flow (gpm)</u>
Orchard Hills	1.1
Bromley	1.9
Dartmoor	No Test Locations
Glen Leven	1.8
Morehead	1.4

footing drain flows measured during this storm. The measured flows ranged from 0 to 3 gpm, with an average of 1.4 gpm for all locations measured. The average footing drain flows for the tests performed

Study Design

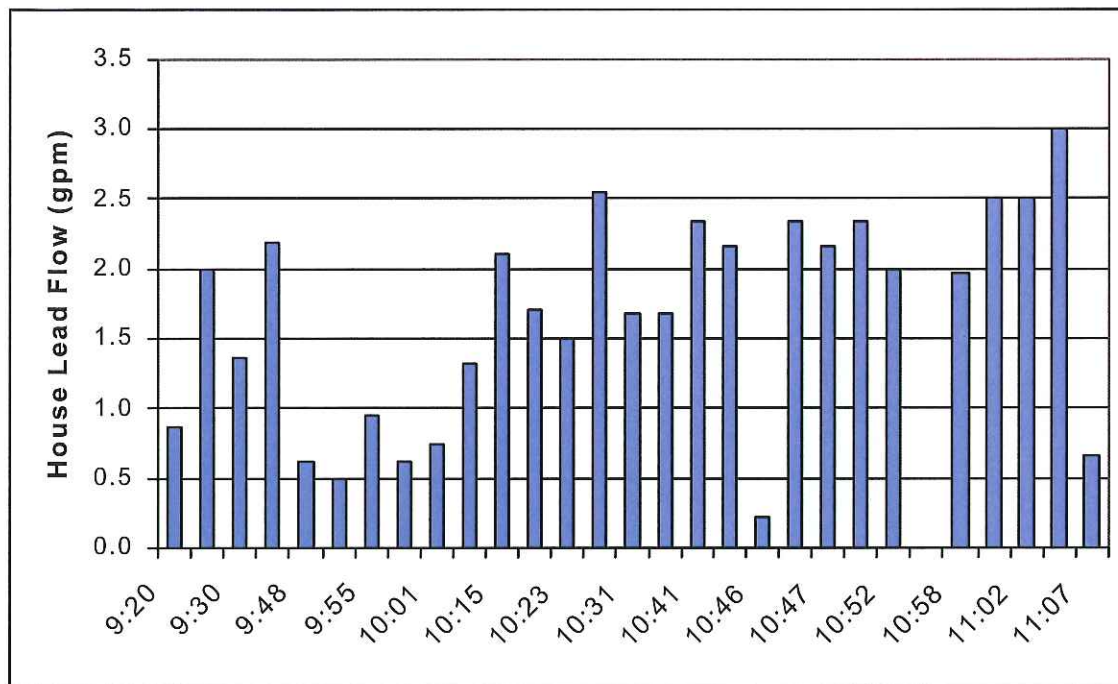


Figure E-5 Footing Drain Flow Measurements

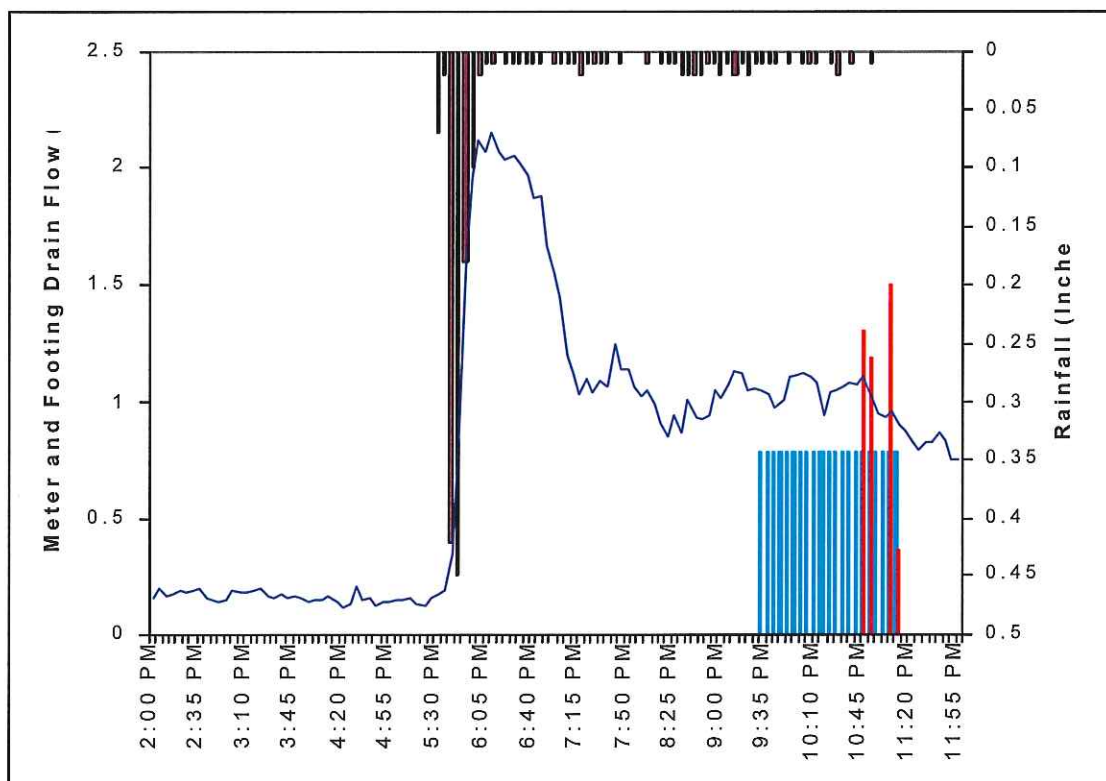


Figure E-6 Rainfall, Metered Flow, and Footing Drain Flows for Bromley Study Area

in each study area are summarized in Table E-10.

The rainfall, metered flow, and calculated footing drain flows were then compared for each study area. An example of this is shown in Figure E-6 for the Bromley study area. The rainfall data is graphed on the top of this figure. The peak of the storm took place at about 5:45 PM and then produced lower, but consistent, rainfall over the next five hours. The flow meter data is plotted as the continuous line with its ordinate of flow in cfs shown on the left axis. This figure shows a response that is similar in shape to the rainfall, peaking at about 6:00 PM and leveling off for a few hours before dropping back to a dry weather flow pattern.

An estimate of the total flow generated by all footing drains in each area was made using the assumption that the average footing drain flow of all areas, 1.4 gpm, is multiplied by the number of homes with footing drains in each study area. This estimate is graphed over the time the data was collected in all areas, and shown as the vertical blue bars in Figure E-6. The total footing drain flow estimates based on the individual measurements taken directly within the Bromley area are also shown as the variable height bars.

Figure E-6 suggests that as much as 90% of the wet weather flow in the Bromley area was caused by flows generated from footing drains. Similar results were found for three of the other study areas, with the Dartmoor study area being an exception. In this area, there appear to be other sources of RDI/I that are contributing to the flows recorded at the flow meter or the flow contribution from footing drain flows are higher than the average measured in the other areas.

E.1.4 Collection System Inspection Programs

E.1.4.1 Manhole Inspections

As part of the project scope, inspection of each accessible manhole in the study areas was performed. This work was performed to assess the

current condition of the manholes and better understand the sewer connections between the manholes. The inspection work was documented on forms completed by field crews and through digital photographs to document manhole condition, sewer connections, and specific defects. Over 800 manholes were inspected as part of this effort. The overall condition of the manholes and the sewer connections was found to be excellent. The inspection did identify 24 minor maintenance issues, which the Water Utilities Department addressed shortly after identification.

In addition to providing information regarding infrastructure condition, the inspection notes and photos provided useful information when assembling the collection system computer models. These photos allowed rapid verification of the collection system connectivity and other attributes such as approximate invert elevation.

Field notes and digital photographs were provided to the Water Utilities Department separately. The field notes and photos are accessible using the project GIS. The available GIS coverage includes the manhole identifier used to locate manholes as part of this project and this identifier is also cross-referenced to the City's identifier system where possible. The identifier used is also listed on the field forms and is contained in the filename of the digital images. The digital images referred to on each field sheet were, with a few exceptions, taken in the following order:

1. The downstream pipe was photographed looking down the pipe from the manhole.
2. Each upstream pipe was photographed (clockwise, looking down manhole, from the downstream pipe).
3. Each house lead was photographed (clockwise, looking down manhole, from the downstream pipe).
4. Specific defects, blockages, or sources of I/I



Table 1. Summary of Footing Drain Flow Studies

Downstream System Metering	Wet Weather Sanitary Flow		Peak Footing Drain Flows			Projected Peak Footing Drain Flows (gpm/house)		
	Peak Flow with FD (cfs/1000)	Peak Flow Without FD (cfs/1000)	Flow (gpm/house)	Rainfall (inches)	RDII from FD (percent)	4" Linear	4" Log	
Beverly Hills	1.56	0.38 ⁵	2.5	2.23"	76%	2.1	1.7	
Oakland County 1967 1968 Study	1.76	0.53	1.8	1.86"	70%	3.8	3.0	
Canton Township FD Removal	2.7	---	2.1	---	---	---	---	
GDRSS Data	2	0.63	3.0 ⁴	2.50" ³	---	3.0 ⁴	1.8 ⁴	
Clinton Township Data	3.3	---	1.5	2.0	69%	---	---	
Auburn Hills Data	1.8	---	3.3	---	---	---	---	
Center Line Data	1.7	---	1.1 ³	1.8 in/hr	70%	3.7	1.7	
West Lafayette, In	---	---	1.7	---	---	---	---	
Midland, MI	---	---	5 ¹	---	---	---	---	
	---	---	5 ¹	---	---	---	---	
Direct Measurement Metering	Wet Weather Sanitary Flow		Observed Footing Drain Flows			Projected Footing Drain Flows		
	Peak Flow with FD (cfs/1000)	Peak Flow Without FD (cfs/1000)	Average Flow (gpm/house)	Peak Flow (gpm/house)	Rainfall ²	RDII from FD (percent)	4" Linear	4" Log
Ann Arbor 2000 FD Study	2.5	---	1.3	8.7	4.01"	60-90%	4.5	3.1
Dearborn Heights Study	3.0	---	0.55	1.0	0.87"	85-90%	2.2	1.1
WWMP Monitors	---	---	1.7	25.0	1.86"	---	3.0	1.7
Ann Arbor FD Monitoring 2002	---	---	1.0	8.5	1.81"	---	---	---
Toledo	---	---	0.3	3.3	1.72"	---	1.6	0.9
South Macomb Sanitary District	---	---	---	3.2	1.73"	---	6.5	3.8
Simulated Rainfall Events	---	---	6.4	10.1	2.7 in/hr	---	--	---
Other Oakland County Studies	---	---	2.5 to 10	---	---	---	---	---

1 - Based on model calibration, not direct metering.

2 - Rainfall is displayed in total volume ("") or intensity (in/hr)

3 - Based on interpolation of data.

4 - Actual flows are higher. These systems allowed up to 1 gpm to pass to the sanitary system

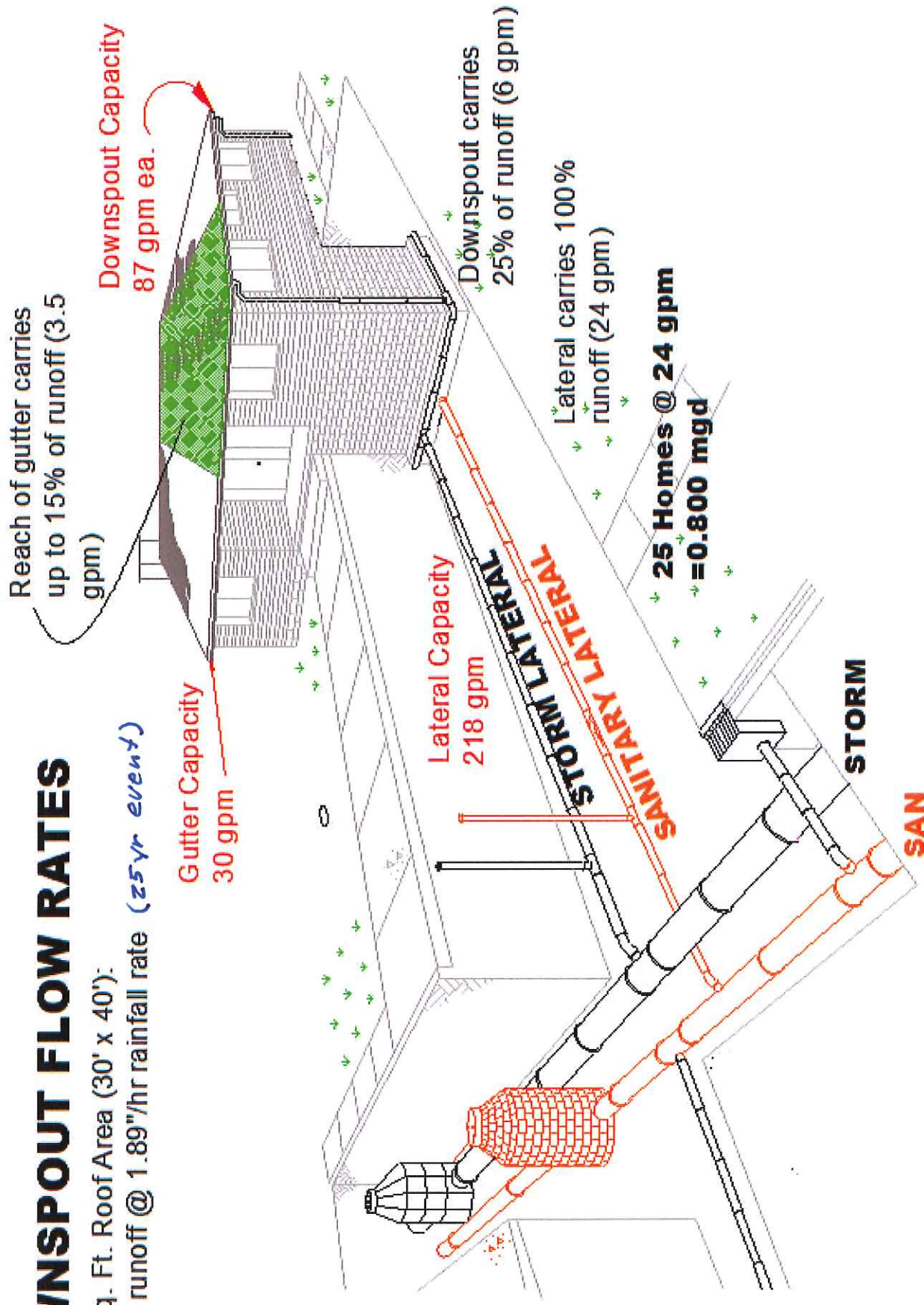
5 - After removal of footing drain connections to sanitary sewer

FD: Footing Drain
RDII: Rainfall Dependent I/I

DOWNSPOUT FLOW RATES

1200 Sq. Ft. Roof Area (30' x 40'):

24 gpm runoff @ 1.89"/hr rainfall rate (25-yr event)



Attachment I
Modeling Public Preferences at Catchment-scale
Technical Memorandum

ATTACHMENT I—MODEL DEVELOPMENT USING PUBLIC INPUT IN FOUR STUDY AREAS

1.0 INTRODUCTION

Four working groups, each with approximately five people, were formed within the larger Clean Water Lakewood task force. The objective of each group was to develop alternatives for reducing sewer overflows in their study area.

Each of the alternatives suggested by the Clean Water Lakewood task force was modeled to determine their impacts on the system. Each model was simulated for the “typical year”, or 365 days of typical rainfall data. Descriptions of model development and model results are contained within this report.

It is important to remember that the results produced from this modeling study are not intended to be exact. The results should be used to identify a) if the suggested approaches are practical and b) the approximate levels of overflow improvements that might be expected. Four specific areas were identified by the City which represent other similar areas throughout the sewer system. The intent was to examine techniques at the four selected areas which would be applicable across the City; however, the benefits from applying concepts at the study-area level, as done for the purposes of this memo, will garner much less impact on overflows than applying concepts city-wide.

The concepts employed from a modeling perspective differ slightly from both the Atkins Pilot Study modeling efforts and the final IWWIP Model. This is because the working group models explained below were completed in parallel with the modeling (Chapter 6 and 7). Lessons learned from both the Source Control Pilot Study modeling and these working group models were applied when developing the final IWWIP Model.

2.0 LARCHMONT STUDY AREA

The Larchmont study area was selected with the intent of being able to apply concepts found to be viable to other similar streets in the City. The alternatives suggested by the Larchmont Avenue working group included: permeable pavement, bioretention, and sewer separation.

The combined sewer (single pipe) system being studied on Larchmont comes to an end at the intersection of Larchmont and Detroit Avenues. Detroit Avenue has an over/under sewer system where both storm and sanitary sewer lines are in a single trench. The “under” pipe is for sanitary flow and the “over” pipe is for conveying stormwater. There is a regulator manhole along the combined sewer at the end of Larchmont’s near Detroit which provides a primary flow path to “under” pipe running east to west under Detroit Avenue. The secondary flow path, at a raised invert elevation, connects a second line to the storm pipe in Detroit. For the purposes of this document, an overflow occurs when the flows build up and exit the combined regulator manhole through the second pipe which flows into the storm sewer running east to west on Detroit Avenue, eventually discharging into the Rocky River.

2.2 VERIFYING CONSISTENCY BETWEEN MODELS

Models were created to test the effectiveness of the preferences identified by the working group. The first two models (Model #1a and Model #1b) were used to verify that the approximate same volume was produced when the subcatchments were broken into smaller areas (called: children subcatchments). A subcatchment is a drainage area that directs runoff to a single point in the model.

Larchmont Model #1a (Master Model) – This model is the calibrated existing conditions model which preceded this project. This model has been used historically to predict overflows for the City. The surfaces represented by a single subcatchment flow to the outlet node of that particular subcatchment. The typical subcatchment contains several houses rooftops, garages, driveways, sidewalks, tree-lawns, and streets.

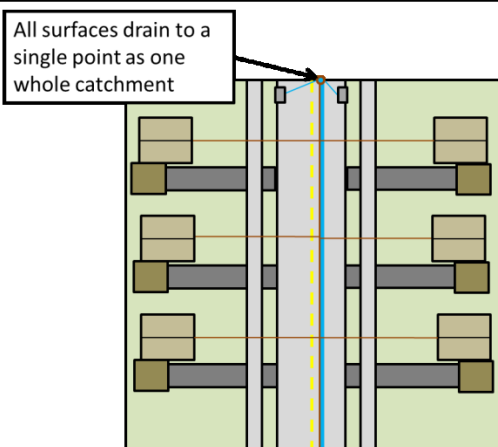


Figure 2-1: Typical Existing Conditions Catchment

Larchmont Model #1b (Master Model Existing Revised) – This model replicates the existing conditions “Master Model”, except each subcatchment was split into 5 children subcatchments where there was only one catchment originally. The 5 catchments represent: 2 sets of private property (1 per each side of the street), 2 sets of sidewalks/driveway aprons (1 per each side of the street), and 1 street.

This model provides more catchments and thereby more refined opportunity to load Runoff Characteristics in the model. Runoff Characteristics (RCs) are represented in the model via PCSWMM’s LID tools. No RCs are loaded in this model. The additional subcatchments were adjusted in composition to produce results equal to the flows from the original catchment in Larchmont Model #1a.

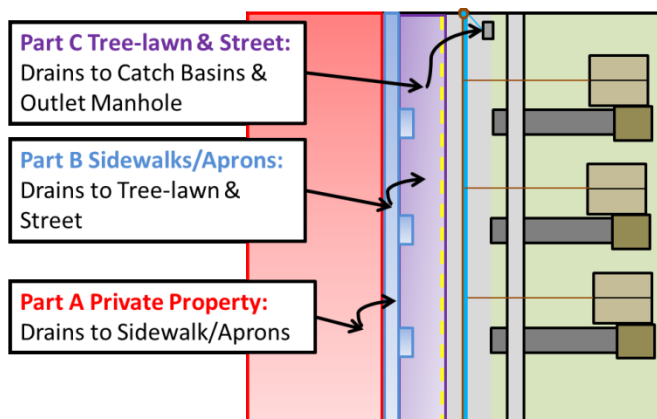


Figure 2-2: Modified Existing Conditions Catchment

2.3 MODEL DEVELOPMENT: DOWNSTREAM AND STUDY AREA IMPACTS

Models #2a and #2b were created to check the impacts of the Detroit Avenue sewers on Larchmont Avenue sewers before any alternatives were analyzed.

Larchmont Model #2a (Master Model Existing Revised – No Local Flows) – This model was established for the purpose of quantifying downstream and upstream influences on the study area and to identify whether the interceptor flows would back up and cause overflows at the Larchmont combined sewer system.

The flows generated within the study area were removed, and the model was used to simulate what would happen if all Larchmont flows no longer contributed to the downstream system. Our findings indicate that the downstream sewer flows rise up in the Larchmont combined system and cause overflow. Therefore, no matter how much source control reduction is undertaken in the study area, it is likely that the Larchmont combined overflow pipe will remain active if nothing else is changed. In order to eliminate this overflow, work will need to be done elsewhere in the City’s system to prevent backwater into Larchmont sewers.

Larchmont Model #2b (Master Model Existing Revised – Local Flow Only) – This model contains flows generated solely in the study area. It was created with the intent of determining the frequency and volume of overflows caused by surface flows generated only within the study area. No downstream sewer backwater impacts were loaded in this model.

2.4 MODELING SUGGESTED ALTERNATIVES

The models explained within section 2.4 represent the ideas presented by the Larchmont task force working group.

Larchmont Model #3a (Alt 1 – Local Flow Only) – This model includes permeable pavement RCs with a storage component underneath both the sidewalks and driveway aprons throughout the study area. The Permeable Pavement RC reduces runoff to the street by allowing additional infiltration and storage. All runoff from the private property must flow to the sidewalk catchment on its way to the curb line. Street runoff, however, are not treated by this RC as it would not be hydraulically feasible to route flows from the streets to the sidewalks. No backwater impacts are loaded in the model, to isolate the effect of the permeable pavement in the study area.

Larchmont Model #3b (Alt 1) – This model includes the same permeable pavement and storage LID mentioned in 3a, but includes total system impacts.

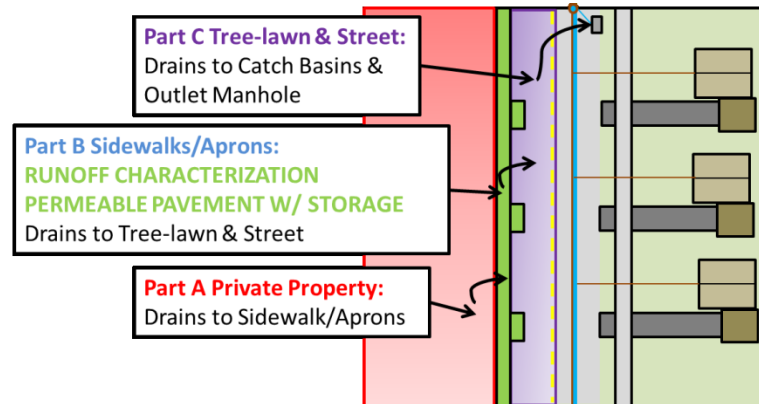


Figure 2-3: Proposed Alt 1 Catchment

Larchmont Model #4a (Alt 2 – Local Flow Only) – This model includes Runoff Characterizations for street side bioretention incorporated into the tree lawn on both sides of the street. For planning purposes 60 linear feet (LF) x 4 LF of bioretention was included for every 150 LF of road for each side. Storage is incorporated in the surface layer and subsurface for each bioretention RC. The RCs were applied as part of the street subcatchment. Runoff from the private property and the sidewalk flows to the street. The bioretention RCs accept flows from the street until the RC storage is full and then begins discharging to the storm system (catch basins and sewers). No backwater impacts are loaded in this model, which isolates the Larchmont drainage area.

Larchmont Model #4b (Alt 2) – This model includes the same bioretention and storage RCs mentioned in 4a, but includes total system impacts.

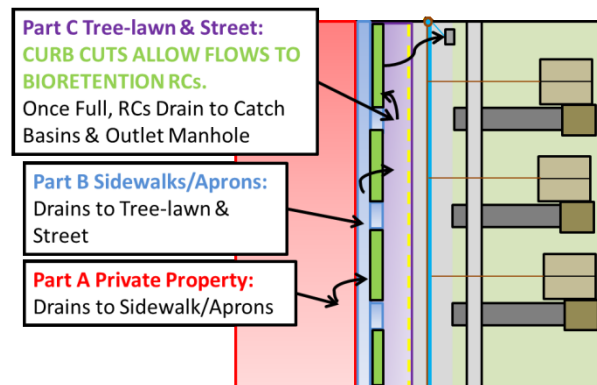


Figure 2-4: Proposed Alt 2 Catchment

Larchmont Model #5a (Alt 3 – Local Flow Only) – This model includes the two cumulative RC approaches mentioned in models 3a and 4a. No backwater impacts are loaded in the model, isolating the effect of the permeable pavement and bioretention on the flows generated only within the Larchmont study area. The RCs are two separate RCs from two separate subcatchments. The private property drains first to the sidewalk/apron RC. Once full, the sidewalk/apron RC drains to the street, and then the

street drains to the bioretention RC. Once the bioretention RC is full, it then drains to the public storm sewer system.

Larchmont Model #5b (Alt 3) – This model includes the same two RC approaches mentioned in 5a, but includes total system impacts.

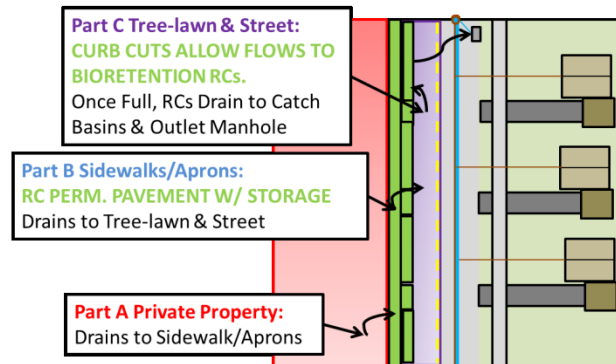


Figure 2-5: Proposed Alt 3 Catchment

Larchmont Model #6a (Alt 4 - Local Flow Only) – This model contains no RCs, but exhibits sewer separation to the south of Manhole 002C3692. Flows are re-routed from MH 002C3692 to the west along Franklin Avenue to MH 052S4441. It is assumed in this model that the Franklin Avenue sewer has capacity for this increase in flow from Larchmont. No backwater impacts are loaded in the model.

Larchmont Model #6b (Alt 4) – This model includes the same assumptions and re-routing of flows to Franklin mentioned in 6a, and also includes total system impacts.

2.5 RESULTS

Table 2-1 includes results from each of the Larchmont Study Area model runs.

Table 2-1: Results for Larchmont Study Area

Description	Combined Regulator Node	Combined Regulator Node	Overflow Pipe	Overflow Pipe	Overflow Pipe
Larchmont Models	Peak Flow (mgd)	Total Flow (mg)	Peak Flow (mgd)	Total Flow (mg)	# OFs
#1a Existing Conditions – Total System Flows	7.33	17.98	7.292	0.8127	12
#1b Existing Conditions with children subcatchments – Total System Flows	7.183	18.17	7.142	0.9625	14
#2a Downstream Verification - No Local Flows	0.9034	0.08795	0.8187	0.04862	4
#2b Downstream Verification – Local Flows Only	7.278	17.81	2.48	0.1008	2
#3a Permeable sidewalk and aprons – Local Flows Only	3.223	13.82	0	0	0 ✓
#3b Permeable sidewalk and aprons –Total System Flows	3.703	13.84	3.257	0.2813	5 ✖
#4a Bioretention in tree lawns – Local Flows Only	5.004	11.97	0.6351	0.006821	2 ✓
#4b Bioretention in tree lawns – Total System Flows	5.128	12.02	5.033	0.3094	4 ✓
#5a Permeable Pavement & Bioretention – Local Flows Only	0.1531	11.57	0	0	0 ✓
#5b Permeable Pavement & Bioretention – Total System Flows	0.8995	11.64	0.8451	0.05201	4 ✓
#6a Redirect south end of Larchmont to Franklin – Local Flows Only	4.582	11.68	0	0	0 ✓
#6b Redirect south end of Larchmont to Franklin – Total System Flows	5.043	11.69	4.483	0.5198	9 ✖

3.0 PARKWOOD STUDY AREA

The Parkwood study area was selected with the intent of being able to apply concepts found to be viable to other similar streets in the City. The alternatives suggested by the Parkwood working group included: downspout disconnection, improvements to reduce infiltration and inflow (I/I) in the public sewer system, and upsizing the Detroit Avenue conveyance sewer.

Parkwood Road has over-under sewers, with the storm sewer on top of the sanitary sewer in a shared trench with shared manholes separated by invert plates. During wet weather events it is noticeable that these sewers interact with each other due to factors such as: pipe cracks, ineffective or missing invert plates, and leakiness of the system due to age.

The Parkwood study area sewers begin near Madison Avenue flowing north along Parkwood until they reach Detroit Avenue and turn east. Once the Parkwood sanitary flows reach Detroit Avenue they may contribute to numerous overflows locations within the Lakewood collection system due to system interconnectivity. A storm sewer cross connection provides relief from the Bunts Road storm sewer to the storm sewer on Parkwood, however; no direct sanitary connections exist between the two streets. During wet weather events, the Bunts Road storm sewer flows towards Detroit, but it also may spill over into the Parkwood storm line.

3.1 MODEL DEVELOPMENT: DOWNSTREAM AND STUDY AREA IMPACTS

The #1a & #1b models are the existing conditions models which serve as a basis for comparison for the alternative models developed.

Parkwood Model #1a (Master Model) – This model is the calibrated existing conditions model which preceded this project. This model has been used historically to predict overflows for the City.

Parkwood Model #1b (Master Model Local Flows Only) – Contains flows generated solely in the Parkwood study area. It was created to determine the volume of flows generated within the study area when no upstream or backwater impacts are present. In this model, the Bunts Road and Detroit Avenue sewers have been disconnected and therefore do not influence flow volumes or overflow events.

3.2 MODELING SUGGESTED ALTERNATIVES

3.2.1 ALTERNATIVE 1: DOWNSPOUT DISCONNECTION

Typically roof gutter downspouts are connected to a storm or sanitary pipe leading from private property into the public sewer under the street. Communities which were built with downspouts connecting to the sanitary sewer sometimes consider disconnecting

(splashing) the downspouts to remove excess water from the sanitary system. This reduces the burden on the sanitary or combined sewer system, and could potentially help reduce overflows.

The existing conditions model was calibrated at a level of refinement that does not include detailed information on:

- Flows at the property level (i.e. which amounts of flows come from downspouts, garages, driveways, yard drains, etc.)
- Which downspouts are connected versus splashed
- Which connected downspouts connect to the sanitary line versus the storm line
- Which storm laterals have plugged P-traps near the right of way creating overland flow
- Whether the directly connected impervious area for each calibrated catchment represents connected rooftops or driveways

Additionally, unit hydrographs (RTKs) were used in the existing conditions model to help generate the sanitary system's response during wet weather. RTKs are model parameters that allow a certain percentage of the rainfall which falls on the surface, to be routed to the sanitary sewer system. The RTKs are loaded to the sanitary node, representing infiltration and inflow.

For the Parkwood model, existing conditions subcatchments are configured such that as much as 22.4% of the rainfall that falls on the system is making its way into the sanitary system from RTKs. The RTK contributions to the model are thought to represent a range of unknown conditions including connected sanitary laterals which have rooftops directly connected, driveways and others surfaces which have quick access to the interconnected public storm/sanitary systems and rainfall seeping into the sanitary system as a result of rising groundwater during and after rain events.

An example RTK set which is loaded in the Parkwood study area is provided below. R1, R2, and R3 explanations are provided.

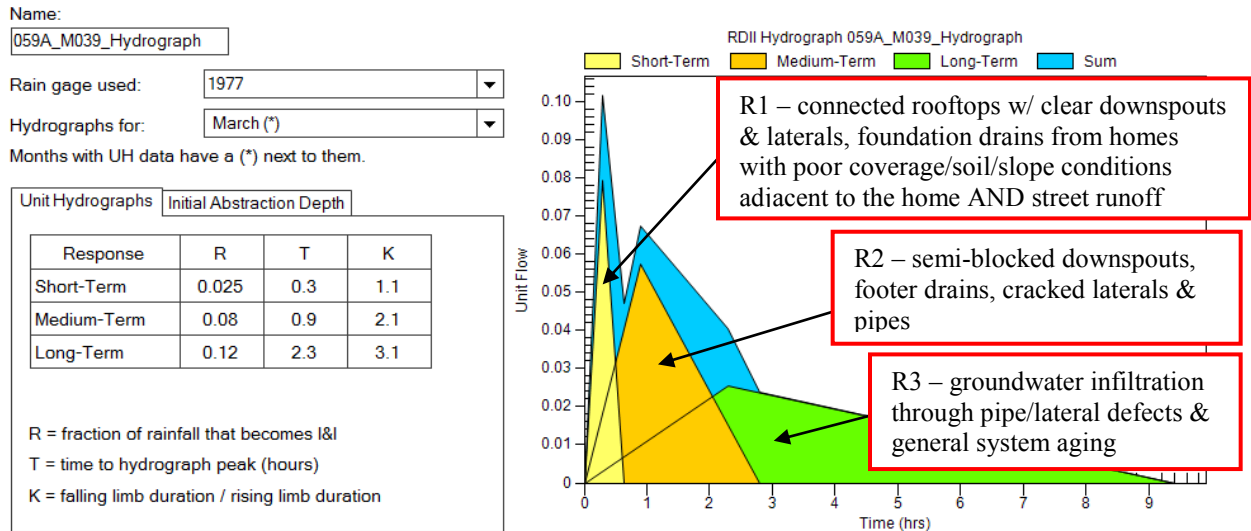


Figure 3-1: RTK Breakdown Explanation

Source Control Pilot Study work has confirmed that at least 70% of the storm lateral P-traps are blocked by debris and acting as if the downspouts are already splashed to the surface. In reality, there is some level of storage provided by the blocked storm lateral systems, and once that storage becomes filled, the storm laterals will start spilling to the surface at the crocks. This water is thought to make its way back into the system as represented by RTKs.

A series of model runs were completed to understand the potential benefits of having downspouts splashed (not directly connected to the sewer system) as requested by the group. Knowing that the storm and sanitary sewers in an over/under system generally share wet weather flows, it should be recognized that corrective action on both public and private property would be necessary to correct the infiltration witnessed in the flow data.

Parkwood Model #2a (Disconnected Downspouts by RCs) – This model includes RCs representing house rooftops throughout the Parkwood study area. The average rooftop area per parcel along Parkwood is approximately 1400 square feet. The model simulates all rooftops being splashed (routed to the pervious portion of the catchment), and allowed to infiltrate based upon hydrologic conditions. R values are unchanged in this model since no public sewer or private lateral rehab is included.

Parkwood Model #2b (Disconnected Downspouts by RCs – Local Flows Only) – Same as Model #2a except; Bunts Road and Detroit Avenue sewers were disconnected, such that only local flows were generated from the model.

Parkwood Model #3a (Disconnected Downspouts by Increased % Routed to Pervious) – No RCs are used in this model. This model assumes storm downspout disconnection occurs by decreasing the directly connected impervious area. Percent

routed to pervious is increased proportionally with estimated rooftop area. R values are again unchanged in this model since no public sewer or private lateral rehab is included.

Existing conditions model calibration suggests that 30%-35% of directly connected impervious area exists on private property (versus being in the right of way). This private property impervious area consists of the connected rooftops and portions of the driveway which enter the system almost immediately through catch basins. We do not know what percentage of the 30%-35% is rooftops versus what percentage is quick routed driveways. The #3a model run assumes that the entire percentage of directly connected impervious area is represented by rooftops which are directly connected to the storm system, and that the storm downspouts and laterals are currently clear.

Parkwood Model #3b (Disconnected Downspouts by Increased % Routed to Pervious – Local Flows Only) – Same as 3a except; Bunts Road and Detroit Avenue sewers were disconnected, such that only local flows were generated from the model.

3.2.2 ALTERNATIVE 2: PUBLIC SEWER I/I REDUCTION

Alternative 2 combines the concepts explored in Alternative 1 with public sewer I/I improvements, illicit connection removal, and sanitary lateral lining.

Parkwood Model #4a (Public & Private Improvements) – This model assumes downspout disconnection as provided in model #3a. Additionally, all R1, R2, & R3 were decreased to a maximum of 1%, totaling a maximum of 3 percent (R1+R2+R3) for each month at the sanitary loading nodes. This reduction in R values is intended to represent a placeholder for “like new” system rehabilitation. Post construction monitoring results from the Atkins Pilot Area will reveal more refined remaining R values. No additional values were added to the storm system as this analysis was focused particularly on the flows in the sanitary system. In accordance with the modeled approach, the following rehab/repair would have to occur:

- Downspout disconnection
- Rerouting of any sanitary clear water connections to the storm system
- Relining or replacement of sanitary laterals
- Relining or replacement of the public sanitary sewer
- New manholes to bypass storm water around the existing “over-under” access plates.

Parkwood Model #4b (Public & Private Improvements – Local Flows Only) – Same as model 4a except; Bunts Road and Detroit Avenue sewers were disconnected, such that only local flows were generated from the model.

3.2.3 ALTERNATIVE 3: UPSIZE LOCAL CONVEYANCE SEWERS

Alternative 3 explores the concept of providing additional conveyance and/or storage opportunity in the downstream conveyance sewers to which the Parkwood Road sanitary sewer contributes. For the purposes of quantifying results, models were computed with the Detroit Sewer upsized to both 3' and 4' in diameter. CT also examined the effect of upsizing both the Detroit Avenue and Nicholson Avenue sewers to 3' and 4'. The typical current size of these sewers ranged from 1' to 2'.

A concern of upsizing local sewers is the affect to be had on the downstream system. Increased flooding, basement backups, capacity issues, and system overflows are possible outcomes when allowing more flow to more quickly pass through the system. The following alternatives were considered primarily for the benefit on the local sewers, although the downstream effects would need to be validated should the City pursue this type of alternative.

Parkwood Model #5a (Master Model_Detroit_3ft) – This model includes upsizing of the Detroit Avenue sewers to 3' in diameter from manhole 059AS033 to 059S3012. Existing slopes were preserved and no control points were provided along the upsized system. Upon entering the Nicholson Avenue system, flows are naturally restricted by the decrease in diameter, since the existing Nicholson sewer starts as 15" at the intersection with Detroit Avenue.

Parkwood Model #5b (Master Model_Detroit_4ft) – Same as model 5a except ; upsized Detroit Avenue sewers are sized at 4' in diameter.

Parkwood Model #5c (Master Model_Detroit_Nicholson_3ft) – Same as model 5a except ; additional sewers along Nicholson Avenue are upsized from manhole 059AS056 to 059AC004. The upsized diameters are consistent in both runs of sewer at 3' in diameter.

Parkwood Model #5d (Master Model_Detroit_Nicholson_4ft) – Same as model 5c except; upsized diameters are consistent in both runs of sewer at 4' in diameter.

3.3 RESULTS

The tables included in the results section of this report were included for the sake of comparing the alternatives suggested by the public. Additional analysis was required since these technologies alone did not completely bring the study area into compliance. The additional efforts have been incorporated into the submitted IWWIP. Included in Table 3-1 Parkwood Model Total System Flows are all of the immediately effected overflow locations related to the Parkwood model efforts. Table 3-2 only lists the reporting locations along Parkwood since Local Flows Only models do not consider the effects downstream.

Table 3-1: Parkwood Model Total System Flows

Model	Location	# of Events	Total Volume(MG)
1a Master Model			
	Wyandotte & Detroit	6	0.32
	Robinwood & Detroit	99	10.37
	Clarence & Detroit	28	1.08
	Parkwood & Detroit	64	7.32
	Elbur & Detroit	0	0
	In Detroit, just East of Elbur	63	3.44
	Grace & Detroit	17	0.38
2a Disconnected Downspouts by RCs			
	Wyandotte & Detroit	6	0.31
	Robinwood & Detroit	99	10.3
	Clarence & Detroit	28	1.08
	Parkwood & Detroit	63	6.83
	Elbur & Detroit	0	0
	In Detroit, just East of Elbur	62	3.36
	Grace & Detroit	17	0.38
3a Disconnected Downspouts by Increased % Routed to Pervious			
	Wyandotte & Detroit	6	0.32
	Robinwood & Detroit	99	10.29
	Clarence & Detroit	28	1.08
	Parkwood & Detroit	63	7.05
	Elbur & Detroit	0	0
	In Detroit, just East of Elbur	63	3.4
	Grace & Detroit	17	0.38
4a Public & Private Improvements			
	Wyandotte & Detroit	6	0.3
	Robinwood & Detroit	99	10.09
	Clarence & Detroit	28	1.08
	Parkwood & Detroit	60	4.72
	Elbur & Detroit	0	0
	In Detroit, just East of Elbur	60	3.23
	Grace & Detroit	17	0.38
5a Master Model Detroit 3ft			
	Wyandotte & Detroit	6	0.18

Model	Location	# of Events	Total Volume(MG)
	Robinwood & Detroit	99	5.63
	Clarence & Detroit	31	1.22
	Parkwood & Detroit	0	0
	Elbur & Detroit	0	0
	In Detroit, just East of Elbur	24	4.03
	Grace & Detroit	17	0.38
5b Master Model Detroit 4ft			
	Wyandotte & Detroit	6	0.19
	Robinwood & Detroit	99	5.63
	Clarence & Detroit	29	1.09
	Parkwood & Detroit	0	0
	Elbur & Detroit	0	0
	In Detroit, just East of Elbur	12	2.12
	Grace & Detroit	17	0.38
5c Master Model Detroit Nicholson 3ft			
	Wyandotte & Detroit	6	0.18
	Robinwood & Detroit	99	5.63
	Clarence & Detroit	23	0.81
	Parkwood & Detroit	0	0
	Elbur & Detroit	0	0
	In Detroit, just East of Elbur	0	0
	Grace & Detroit	17	0.37
5d Master Model Detroit Nicholson 4ft			
	Wyandotte & Detroit	6	0.18
	Robinwood & Detroit	99	5.63
	Clarence & Detroit	23	0.8
	Parkwood & Detroit	0	0
	Elbur & Detroit	0	0
	In Detroit, just East of Elbur	0	0
	Grace & Detroit	16	0.37

Table 3-2: Parkwood Model Local Flows Only

Reporting Pipe (Model ID)	Parkwood Sanitary line just before Detroit	Parkwood Sanitary line just before Detroit	Parkwood Storm line just before Detroit	Parkwood Storm line just before Detroit	Combined Total Volume
Model	Peak Flow (mgd)	Total Flow (mg)	Peak Flow (mgd)	Total Flow (mg)	Total Flow (mg)
<i>Existing Conditions</i>					
1b Master Model Local Flows Only	0.7511	17.1	6.593	2.408	19.508
<i>Downspout Disconnection</i>					
2b Disconnected Downspouts RCs Local Flows Only	0.7525	14.66	7.3	1.594	16.254
3b Disconnected Downspouts Increased % Routed Local Flows Only	0.764	15.69	7.484	1.695	17.385
<i>Public (and Private) I/I Improvements</i>					
4b Public & Private Separation Local Flows Only	0.1457	10.93	7.968	4.128	15.058

4.0 LAKE STUDY AREA

The Lake study area was selected with the intent of being able to apply concepts to other similar streets in the City. The alternatives suggested by the Lake Avenue working group included permeable pavement with storage, curb cuts to bioretention in the tree lawn, downspout disconnection on private property, and storage at the Marathon gas station parcel. Each of the alternatives was modeled to determine their impacts on the system.

The combined sewer system being studied on Lake Avenue comes to an end behind the Marathon Gas Station, where the combined pipe connects to the interceptor system. Primarily, flows enter the interceptor at the invert of regulator manhole 058C001A until enough flow causes the Hydraulic Grade Line (HGL) to rise up and spill into the combined sewer overflow pipe. For the purposes of this document, an overflow occurs when the flows build up in this system and spill out of overflow pipe 058 into Lake Erie.

4.1 VERIFYING CONSISTENCY BETWEEN MODELS

The same approach that was taken in the Larchmont Study Area was applied. This is the same approach taken for the Larchmont Study Area.

Lake Model #1a (Master Model) – Same configuration as Larchmont Model #1a

Lake Model #1b (Master Model Existing Revised) – Same configuration as Larchmont Model #1b

4.2 MODEL DEVELOPMENT: DOWNSTREAM AND STUDY AREA IMPACTS

Models #2a and #2b were created to check the upstream and downstream impacts on the study area. Downstream of the study area are the Edgewater Drive sewers, while upstream of the study area are Bunts Road, Chase Avenue, and Hathaway Avenue sewers.

Lake Model #2a (Master Model Existing Revised – No Local Flows) – Flows generated within the study area were removed, and the model was used to simulate what would happen if the Lake Avenue pilot area flows no longer contributed to the downstream system.

Our findings indicate that the combination of downstream flows and upstream flows attempting to enter the Edgewater Drive sewer system cause the levels to rise enough that the 058 overflow is active during the typical year. Therefore, no matter how much source control reduction is undertaken in the study area, it is likely that the 058 combined overflow pipe will remain active. In order to reduce or eliminate the overflows in this overflow pipe, source control reduction will likely be necessary in the neighborhoods contributing from upstream of the Lake Avenue pilot area.

Lake Model #2b (Master Model Existing Revised – Local Flow Only) – This model contains flows generated solely in the study area. It was created with the intent of determining the frequency and volume of overflows caused by surface flows generated within the study area when no upstream or backwater impacts are present.

4.3 MODELING SUGGESTED ALTERNATIVES

Permeable Pavement & Bioretention

Lake Model #3a (Alt 1 – Local Flow Only) – Same configuration as Larchmont Model #3a (Alt 1 – Local Flow Only), including permeable pavement and storage under the sidewalk only (not driveway aprons).

Lake Model #3b (Alt 1) - Model includes the same permeable pavement and storage LID mentioned in 3a, but includes backwater and upstream impacts.

Lake Model #4a (Alt 2 - Local Flow Only) – This model has a similar configuration to Larchmont Model #4a, including bioretention.

Lake Model #4b (Alt 2) – Model includes the same bioretention and storage LID mentioned in 4a, but includes backwater and upstream impacts.

Lake Model #5a (Alt 3 – Local Flow Only) - Model includes the two cumulative LID approaches mentioned in models 2a and 3a. No backwater or upstream impacts are loaded in the model, isolating the effect of the permeable pavement and bioretention on the flows generated within the Larchmont study area.

Lake Model #5b (Alt 3) - Model includes the same two LID approaches mentioned in 5a, but includes backwater and upstream impacts.

Downspout Disconnection

The challenges faced in modeling downspout disconnection along Lake are similar to those faced along Parkwood. However, since there is no separate storm sewer for flows to enter along Lake by inflow/infiltration, there are no RTK loadings present. Therefore, any flows which are splashed have the chance to infiltrate the ground, but once the ground becomes saturated and runoff occurs, those runoff flows will come right back to the combined sewer through catch basins. Regardless, the group's suggestion to model downspout disconnection was explored.

Similar to Parkwood Models #2a and #2b, the Lake models were run with RCs representing an average 1,630 square foot roof per property being splashed to the pervious lawns of each catchment.

Lake Model #6a (Disconnected Downspouts by RCs) – This model includes RCs representing house rooftops throughout the Lake study area. The average rooftop area per parcel in the Lake Study Area is approximately 1,630 square feet. The model simulates all rooftops being splashed (routed to the pervious portion of the catchment), and allowed to infiltrate based upon hydrologic conditions.

Lake Model #6b (Disconnected Downspouts by RCs – Local Flows Only) – Same as Model #6a except; Storm sewers from the upstream drainage area (including Bunts Road, Chase Avenue, and Hathaway Avenue sewers) were disconnected, such that only local flows were generated from the model.

CSO Storage at Marathon Property

Lake Model #7a (IWWIP3 CSO Storage) - Planning level assumptions were made based upon existing system flows and hydraulics to include a CSO storage facility at the Marathon Property on Lake Avenue. In order to achieve zero overflows without making any source control improvements, a typical planning level approach could involve making the following adjustments:

- Raise the CSO 058 OF weir by 0.6 ft.
- Construct a storage facility on the Marathon Gas Property (15' deep x 150' long x 60' wide)
- Provide conveyance to the facility (6' x 4' box) with an inlet invert at the elevation of the existing overflow weir
- Provide dewatering to MH 002C723 along the Edgewater Drive interceptor sewer with a 48 hour dewatering rate

At a planning level, it appears that a pump-less tank system is possible, but further analysis would be necessary. A planning level profile view is provided below in Figure 1.3.

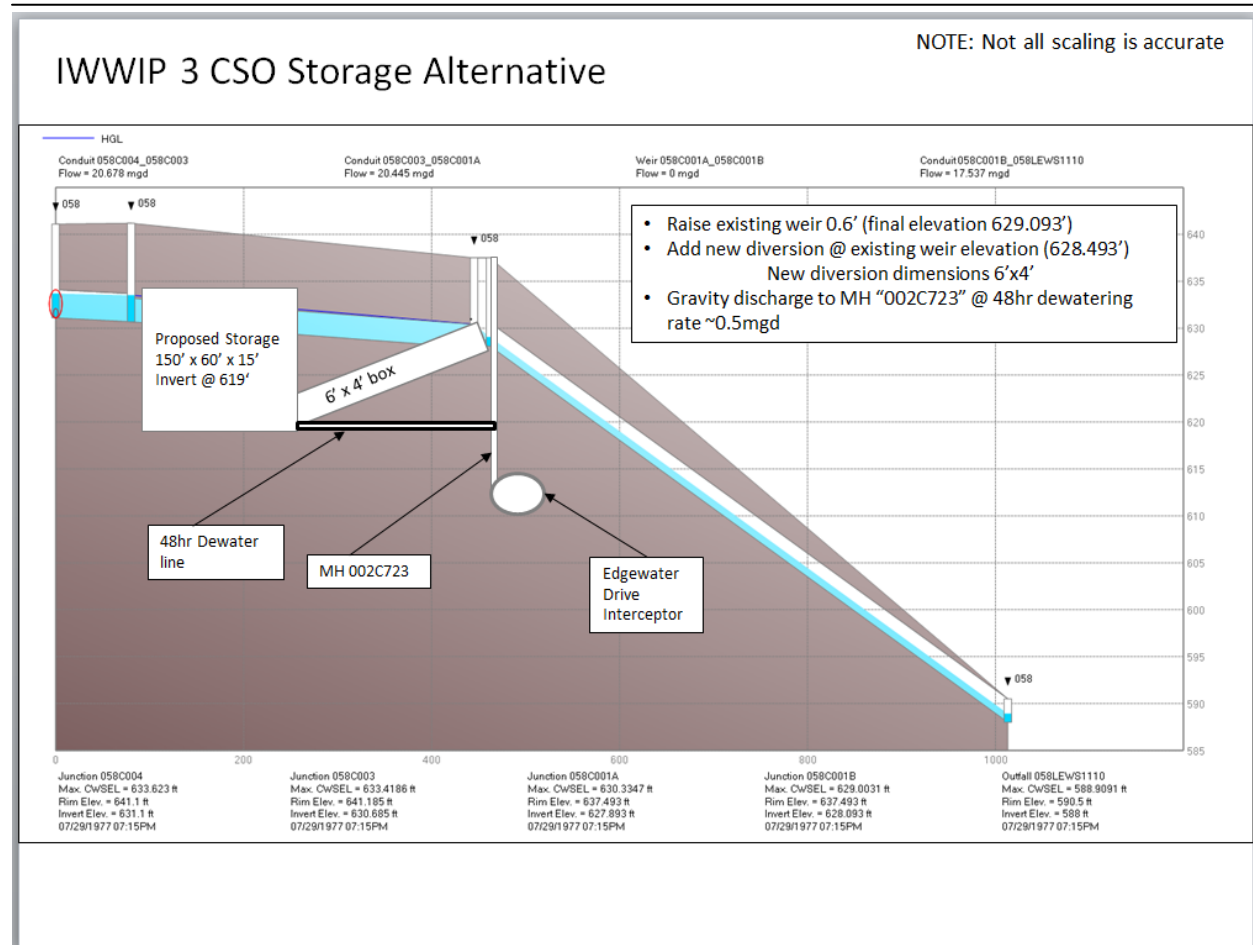


Figure 4-1: Storage Alternative Conceptual Profile

4.4 RESULTS

Table 4-1: Lake Study Area Results

Description	Combined Node	Combined Node	Overflow Pipe	Overflow Pipe	Overflow Pipe
Model	Peak Flow (mgd)	Total Flow (mg)	Peak Flow (mgd)	Total Flow (mg)	# OFs
<i>Examining Existing Conditions (Most Downspouts Clogged)</i>					
#1a Existing Conditions Model – Total System Flows	20.43	24.06	17.47	2.243	9
#1b Existing Conditions Model with children catchments – Total System Flows	20.45	23.59	17.54	2.293	9
#2a Analyzing downstream/upstream impacts – No Local Flows	17.41	6.092	14.36	1.487	7
#2b Analyzing downstream/upstream impacts –Local Flows Only	5.244	18.8	2.432	0.0918	2
#3a Permeable sidewalk w/ storage – Local Flows Only	2.46	15.72	0	0	0 ✓
#3b Permeable sidewalk w/ storage – Total System Flows	19.66	20.56	16.79	1.885	8 ✕
#4a Bioretention in tree-lawn – Local Flows Only	1.847	13.37	0	0	0 ✓
#4b Bioretention in tree-lawn –Total System Flows	17.47	18.21	14.43	1.564	7 ✕
#5a Permeable sidewalk & bioretention – Local Flows Only	0.0475	13.27	0	0	0 ✓
#5b Permeable sidewalk & bioretention – Total System Flows	17.47	18.11	14.43	1.501	7 ✕
<i>Downspout Disconnection</i>					
#6a Disconnected Downspouts by RCs – Local Flows Only	5.84	20.54	3.042	0.1383	2 ✓
#6a Disconnected Downspouts by RCs – Total System Flows	20.48	25.31	17.56	2.456	12 ✕
<i>CSO Storage Facility</i>					
#7a CSO Storage Facility at Marathon Gas Property – Total System Flows	18.91	23.55	0	0	0 ✓

5.0 BIRDTOWN STUDY AREA

The alternatives suggested by the Birdtown working group included Bioretention on private and school owned property, Bioretention within the right of way, green roofs on re-built garages, permeable pavement on public property, East End Diversion, East End Detention, and Sewer Separation. Each of the alternatives was modeled to determine their impacts on the system.

The Birdtown Study Area is comprised of the following streets, south of Madison Avenue and East of Halstead Avenue; Magee Avenue, Lark Street, Robin Street, Quail Street, Dowd Avenue, Halstead Avenue, Thrush Street, and Plover Street. Additionally, one alternative required that the Madison Park property adjacent to the West of Halstead Avenue be included as well for considering Permeable Pavement. The streets included in the study area each have sewers that ultimately send flows to Madison Avenue. Once the flows reach Madison Avenue they flow primarily to the sewer along W 117th, however, these flows also influence overflow frequency and volume at two nearby locations: An overflow at the intersection of Madison and Elbur Avenues, and an overflow at the intersection of Madison Avenue and Lewis Drive. Several streets adjacent to the west of Birdtown also flow into the Madison Avenue sewer upstream of Birdtown near the Elbur and Lewis overflow locations.

The Birdtown neighborhood consists only of combined sewers. During wet weather events, flows travel north along each contributory street until they reach Madison Avenue. It is noticeable that the sewer along Madison suffers from capacity issues, most notably from a choke down point near the intersection of Madison and Lewis. Overflows at Lewis and Elbur relieve flows which can't pass the choke point, where the diameter changes from approximately 4 ft down to 2 ft.

5.1 MODEL DEVELOPMENT: EXISTING CONDITIONS

Birdtown Model #1a (Master Model) – This model is the calibrated existing conditions model which preceded this project. This model has been used historically to predict overflows for the City and will be used for gauging benefits of the proposed alternatives.

5.2 MODELING SUGGESTED ALTERNATIVES

Birdtown Model #2: Harrison Elementary School Bioretention

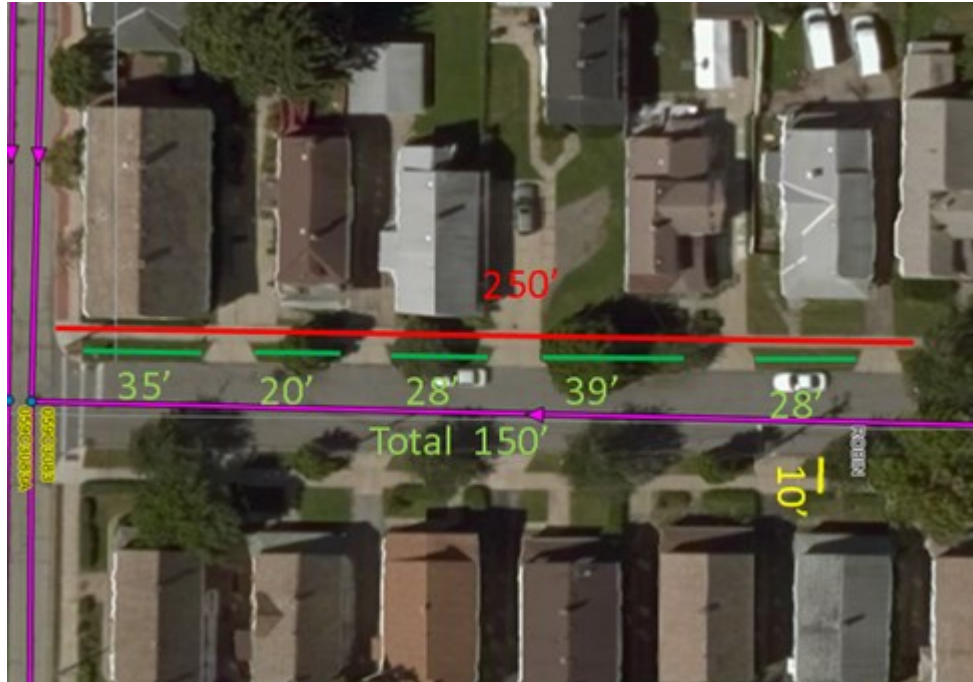
This model computes flows assuming that the North lawn at Harrison Elementary School has been converted to 4200 square feet (SF) of bioretention with an underdrain. It was assumed that 16000 SF of school rooftop was re-routed to the feature along with approximately 5000 SF of impervious roadway. An underdrain system would be provided due to the lack of hydraulic conductivity allowed by the clay soils beneath the study area.

Birdtown Model #3: Vacant Lots Bioretention

Using only aerial imagery, CT identified 7 parcels which do not have buildings, and therefore were considered developable vacant lots. There may be more than this, but without more information only the parcels which are obviously vacant were chosen. Similar to model #2, street flows would be diverted based upon area estimated by CT to flow by gravity along the street, to the vacant site. This resulted in a total of approximately 20,000 square feet of impervious (street) drainage. This alternative could be optimized if downspouts of adjacent homes were redirected to the bioretention feature, in addition to identifying more parcels in total to be included in the analysis. Underdrain systems would be provided due to the lack of hydraulic conductivity allowed by the clay soils beneath the study area.

Birdtown Model #4: Curbside Bioretention

This model includes bioretention in the tree lawn and under the sidewalks utilizing the “Silva Cell” concept suggested by the group. It was assumed that 150ft of bioretention (10’ wide) would occur for every 250 feet of residential street centerline. It should be acknowledged that this is a best case scenario, as the homes are tightly spaced in the study area and it may not be feasible to include 150’ of bioretention for each 250’ of centerline as shown in the Figure 7. This is generally all of the available tree lawn area with the exception of driveways and aprons. The 150’/250’ was taken from a sample in the study area along Robin Street, which can be seen in Figure 7 below. The result was approximately 59,000 total SF of bioretention in the study area. Underdrain systems would be provided due to the lack of hydraulic conductivity allowed by the clay soils beneath the study area.



Birdtown Model #4b: Curbside Bioretention Extended

Birdtown Model #5: One-Way Street Bioretention

Birdtown Model #6: Fire Hydrant Bump-out Bioretention

This model includes 162 SF of bioretention, in the Right of Way, at each fire hydrant in the study area. This concept attempts to provide bioretention bump-outs while preserving existing parking spaces. The 162 SF was derived assuming a 9' x 18' parking space. The area treated by each bioretention was assumed to be approximately five times (5x) the bioretention area, though this would likely vary on an individual basis given the true topography. The result was approximately 5,000 SF of bioretention in the study area. Underdrain systems would be provided due to the lack of hydraulic conductivity allowed by the clay soils beneath the study area.

Birdtown Model #7: Green Roof Garages

The Green Roof Garages model explores the best case scenario of having all garage roofs in the study area reconstructed (assumedly as each fails over time), with green roofs incorporated into the new garage designs. A sample of garage roof tops in the study area revealed an average footprint of approximately 3950 square feet of garage rooftop per acre, and then each subcatchment's acreage was multiplied by 3950 SF to arrive at a total green roof area of 223,000 SF within the study area.

Birdtown Model #8: Madison Park Permeable Pavement

This model explores benefits from converting the southeast parking lot at Madison Park from asphalt to permeable pavement with an understorage bed. The resulting total square footage of converted surface would be approximately 50,000 SF. An underdrain system would be provided due to the lack of hydraulic conductivity allowed by the clay soils beneath the study area.

Birdtown Model #9a NEORSD Flows - East End Diversion Option

The diversion option includes routing all dry weather sanitary flows south of Edgewater that are routed along 117th Street to NEORSD sewers. All wet weather flows except for some of Madison west of Lewis are routed to NEORSD sewers. The wet weather flows west of Lewis to NEORSD are limited to approximately 1mgd. The remainder is routed north and joins the interceptor downstream of CSO-059 at Nicholson.

The diversion of flows results in reducing the number of overflows at CSO 059 to 4 events during the typical year. The reduction in wet weather flows is not significant enough to develop capacity improvements to the interceptor downstream

Birdtown Model #9b NEORSD Flows - East End Detention Option

The detention option includes developing a detention basin, control structures, and wet weather pump station that will replicate similar overflow conditions of the diversion option at CSO 059.

A detention basin of approximately 15 MG would be required to reduce CSO 059 overflows to 4 events per year. The detention basin would cover an area of approximately 2.5 acres and require a 25 mgd wet weather pump station. The storage would be released at a controlled rate as capacity is available downstream in the interceptor and at the WWTP.

Birdtown Model #10: Sewer Separation

Assuming a new storm system is built in the study area to collect and convey all surface/catch basin flows from the study area to the lake, this model focuses on the effect said alternative would have on the existing combined system contributing towards the W. 117th street conveyance sewer.

Birdtown Model #11: Composite

The Composite model computes flows by combining the following models; #2 Harrison Elementary School Bioretention, #3 Vacant Lots Bioretention, #4 Curbside Bioretention, #6 Fire Hydrant Bump-out Bioretention, #7 Green Roof Garages, and #8 Madison Park Permeable Pavement.

Birdtown Model #12: Madison Extra 24"

This is Model #1a plus an additional 24" combined pipe at a pinch point along Madison Avenue. The intent is to see if additional capacity in this point location improves overflow and overall system performance. The system profile along Madison from Bunts Road to West 117th is shown below in Figure 9.

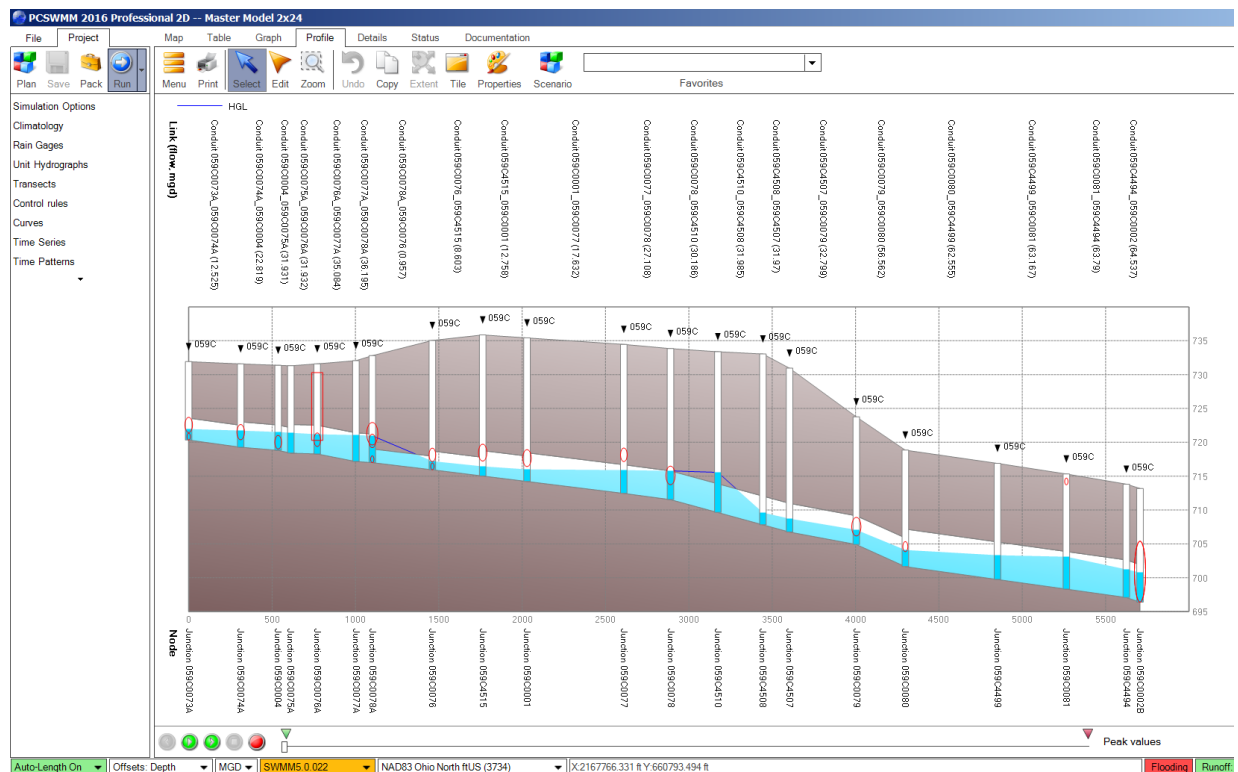


Figure 5-2: System Profile along Madison from Bunts Road to West 117th with Additional 24" Combined Sewer Pipe

Birdtown Model #13: Madison Extra 24" with Curbside Bioretention

This model is the same as model 4B, plus an additional 24" combined pipe at a pinch point along Madison Avenue. The intent is to see if additional capacity in this point location plus widespread curbside bioretention in the contributory area improves overflow and overall system performance. The system profile along Madison from Bunts Road to West 117th is shown below in Figure 10.

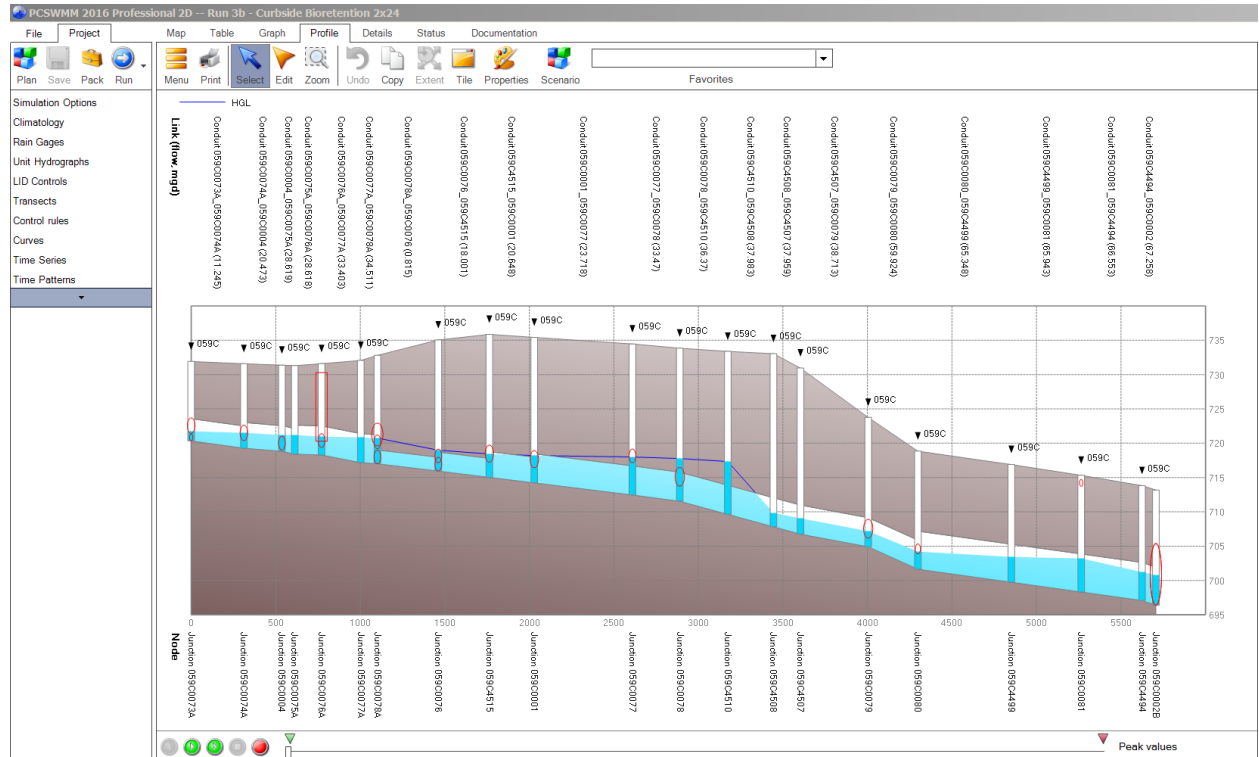


Figure 5-3: System Profile along Madison from Bunts Road to West 117th with Bioretention and Additional 24" Combined Sewer Pipe

5.3 RESULTS

The table included in the results section of this report was included for the sake of comparing the alternatives suggested by the public. Additional analysis was required and has been incorporated into the submitted IWWIP. Table 5-1 reports results at the two Birdtown overflows, and also a combined sewer manhole leaving Birdtown to encompass all exiting flows. The results provided for the Birdtown Study Area are each inclusive of total system flows

Table 5-1: Birdtown Study Area Results

Description	Madison & Lewis Overflow Pipe	Madison & Lewis Overflow Pipe	Madison & Elbur Overflow Pipe	Madison & Elbur Overflow Pipe	Combined Manhole 059C4499
Model	# OF Events	Total Flow (mg)	# OF Events	Total Flow (mg)	Total Flow (mg)
1a Master Model	103	53.43	26	0.85	312.937
2 Harrison Elementary School Bioretention	103	53.43	26	0.85	312.339
3 Vacant Lots Bioretention	103	53.43	26	0.85	312.217
4 Curbside Bioretention	103	53.43	26	0.85	306.455
4b Curbside Bioretention Extended (Run 3b)	99	46.10	19	0.63	302.885
5 One-way Streets w/ Bioretention	103	53.43	26	0.85	305.272
6 Fire Hydrant Bump-out Bioretention	103	53.43	26	0.85	312.301
7 Green Roof Garages	103	53.43	26	0.85	300.000
8 Permeable Pavement at Madison Park	103	53.43	26	0.85	312.128
9 NEORSD Alternatives a & b	n/a	n/a	n/a	n/a	n/a
10 Sewer Separation	103	53.43	26	0.85	260.700
11 Composite: Runs 2, 3, 4, 6, 7, & 8	103	53.43	26	0.85	292.000
12 Madison Extra 24"	70	26.76	18	0.70	339.749
13 Madison Extra 24" with Curbside Bioretention Extended	18	4.11	4	0.24	345.206