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APPENDIX

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INTRODUCTION

The City of Arden Hills is required to prepare a Comprehensive Plan that aligns with the Metropolitan Council's Metropolitan System Plan every ten years per Minnesota Rule 473.858. One component of the Comprehensive Plan is the Sanitary Sewer Plan, which describes the existing sanitary sewer system and outlines the timing and sequence of future improvements. The Sanitary Sewer Plan allows the City and the Metropolitan Council to build and improve their sanitary sewer collection and treatment systems in the most efficient and cost-effective manner.

The City of Arden Hills is entirely within the 2040 Metropolitan Urban Service Area (MUSA), so sanitary sewer interceptors and treatment are provided by the Metropolitan Council Environmental Services (MCES) system. The City is responsible for local wastewater collection and conveyance, which has historically been self-supporting through fees paid by users.

The City of Arden Hills' Sanitary Sewer Plan was developed to conform to the Metropolitan Council's Thrive MSP 2040 Water Resources Policy Plan. The Thrive MSP 2040 Plan was approved in May 2015 and outlines regional goals for the wastewater system, including environmental sustainability, water reuse, and water conservation. Additionally, the Thrive MSP 2040 Plan includes population, household, and employment projections, and projected wastewater flows.

As a result of projected population and land use changes in Arden Hills, the Metropolitan Council estimates that sanitary sewer flows will increase approximately 19 percent between now and 2040. The greatest increase in flow is expected from the development of the Twin Cities Army Ammunition Plant (TCAAP) site in the north part of the City. This Sanitary Sewer Plan outlines the locations in which the Metropolitan Council can expect to see increased wastewater flows, allowing the Council to determine if capacity upgrades will be required at regional wastewater treatment plants and interceptors. This plan also serves as a guiding document for City infrastructure improvements and expansion.

BACKGROUND

The City of Arden Hills is located in Ramsey County north of the Twin Cities. Arden Hills is bordered by the Cities of Shoreview, Roseville, New Brighton, and Mounds View. Much of Arden Hills is residential, with commercial, industrial, and office development located along its eastern border and Interstate Highway 694. Approximately 11 percent of the area of the City is occupied by lakes and wetlands.

Arden Hills has been designated entirely as a suburban community. This designation indicates that the City experienced continued growth through the 1980s and 1990s. The Metropolitan Council expects Arden Hills to, “plan for forecasted population and household growth at average densities of at least 5 units per acre for new development and redevelopment ... and to target opportunities for more intensive development near regional transit investments.”

EXISTING SANITARY SEWER SYSTEM

The City of Arden Hills’ sanitary sewer system is a collection system only, as described previously. The existing sanitary sewer system is shown in **Figure 1**. The system collects and conveys the City’s wastewater to five MCES Meters (M051, M052, M054, M059, and M203) and their associated MCES Interceptors (1-RV-432, 1-RV-432, 1-RV-431, 2-NB-100, and 4-NS-524), as shown in **Figure 2**. MCES Meter M203 does not currently receive flow from Arden Hills, but is planned to receive future flows from the TCAAP development.

All of the wastewater collected in the City of Arden Hills is conveyed through the MCES system to the MCES Metropolitan Wastewater Treatment Plant (WWTP) located southeast of St. Paul on the Mississippi River. The Metropolitan WWTP has a capacity of 251 MGD, provides advanced secondary treatment with chlorination/dechlorination, and discharges treated effluent to the Mississippi River. It also generates energy from the residual biosolids for in-plant use.

Service Districts

The sanitary sewer system has been divided into eighteen (18) sewer districts. These districts, shown in **Figure 2**, correspond to the fourteen (14) lift stations, two existing gravity networks (MCES 54, MCES 59), and two future networks for the TCAAP development (North, South). The Arden Hills Army Training Site (AHATS) discharges via a private forcemain into district MCES 59.

Gravity Sewer

The City of Arden Hills’ gravity sewer system consists of 8-inch to 21-inch diameter polyvinyl chloride (PVC) pipe, reinforced concrete pipe (RCP), vitrified clay pipe (VCP), and cured-in-place pipe (CIPP). Nearly the entire system has been televised over the last twenty years, and approximately one quarter of the pipes in the system have been lined over the last fifteen years.

Lift Stations

The City's current system includes fourteen lift stations, as summarized in **Table 1**. All but one of the City's lift stations are either new or have been rehabilitated since 1990; the rehabilitation of Lift Station 11 was completed in 2017.

Table 1. Existing Lift Station Summary

Lift Station	Location	Year Built	Pump Rehab.	Wet Well Rehab.	Controls Rehab.
LS 1	Cleveland Ave N near Elmer L. Anderson Memorial Tr	1961	2012	2012	2012
LS 2	New Brighton Rd in Charles Perry Park	1983	2011	2003	2011
LS 3	Lake Johanna Blvd near Siems Court	1999	-	-	-
LS 4	Ridgewood Rd and Arden Pl	1998	2013	2005	2013
LS 5	Tony Schmidt Regional Park and Lake Johanna Blvd	1977	2011	2003	2011
LS 6	Lake Johanna Blvd south of Stowe Ave	Unknown	1996	-	1996
LS 7	Shorewood Dr	Unknown	2004	2004	2013
LS 8	Ingerson Rd	1976	2011	2001	2011
LS 9	Ridgewood Rd and Edgewater Ave	Unknown	2013	2005	2013
LS 10	Cleveland Ave N and County Rd E2	1989	-	-	-
LS 11	Hwy 96 and Prior Ave N near Arden Manor Park	1971	2017	2017	2017
LS 12	Thom Dr and New Brighton Rd	1970	2012	2012	2012
LS 13	Karth Lake Dr and Pleasant Dr	Unknown	2012	2012	2012
LS 14	Hamline Ave N and Paul Kirkwood Dr	1995	-	-	-

Community Treatment Systems

There are no public or private community treatment system within the City of Arden Hills. All properties within the City are served by the public collection system or by individual sewage treatment systems.

Intercommunity Flows

The City of Arden Hills has intercommunity sanitary sewer connections with three other communities, as listed in **Table 2** and indicated in **Figure 2**. The City has not entered into any intercommunity service agreements since Dec. 31, 2008. However, the City does plan to enter into a new Joint Powers Agreement with Mounds View and MCES for TCAAP sewer ownership, maintenance, and billing.

Table 2. Intercommunity Flows

City	Flow TO Arden Hills	Flow FROM Arden Hills
Mounds View	-	TCAAP Area
Roseville	58 services	53 services
Shoreview	-	2 services
Total	58 services	55 services + TCAAP

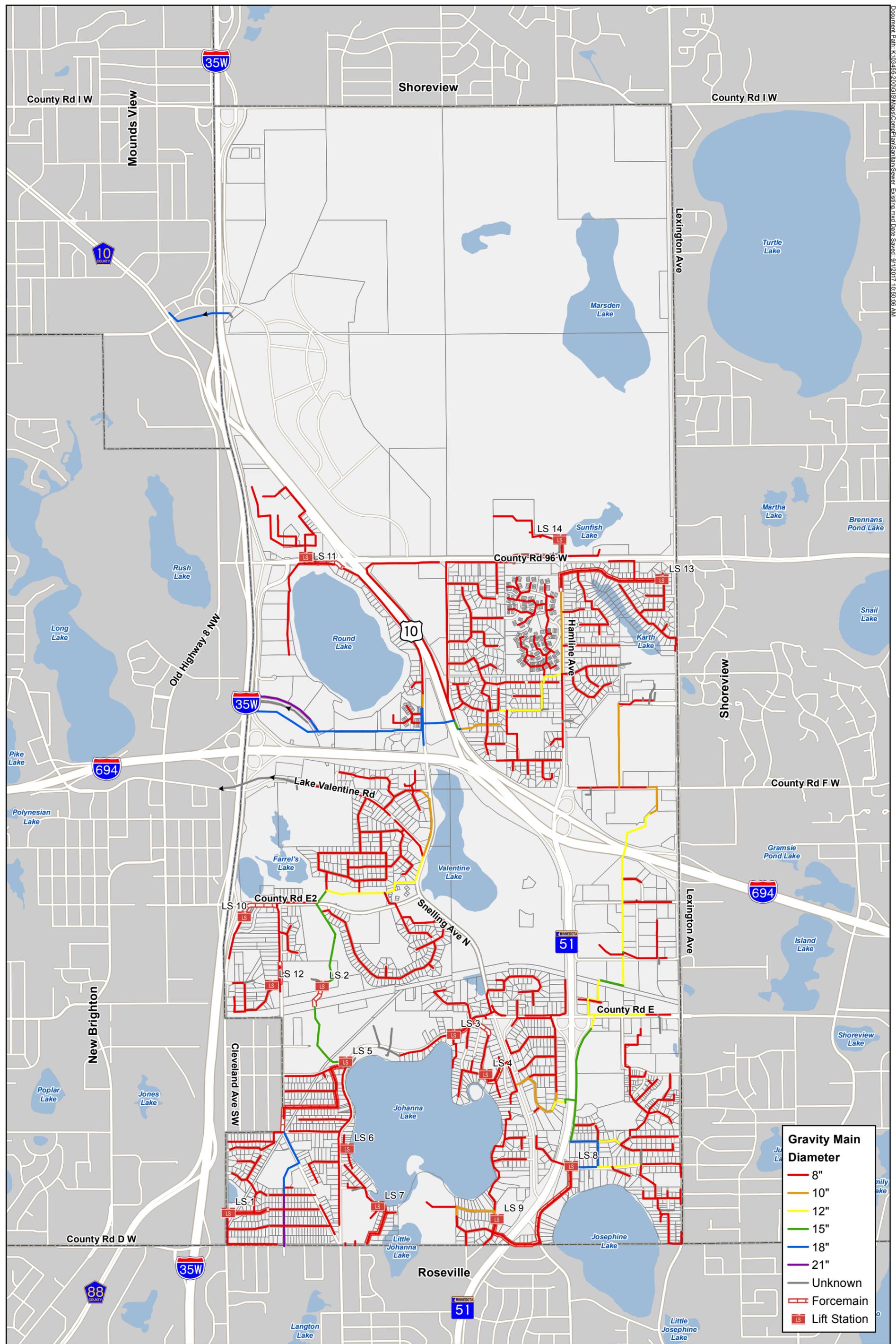
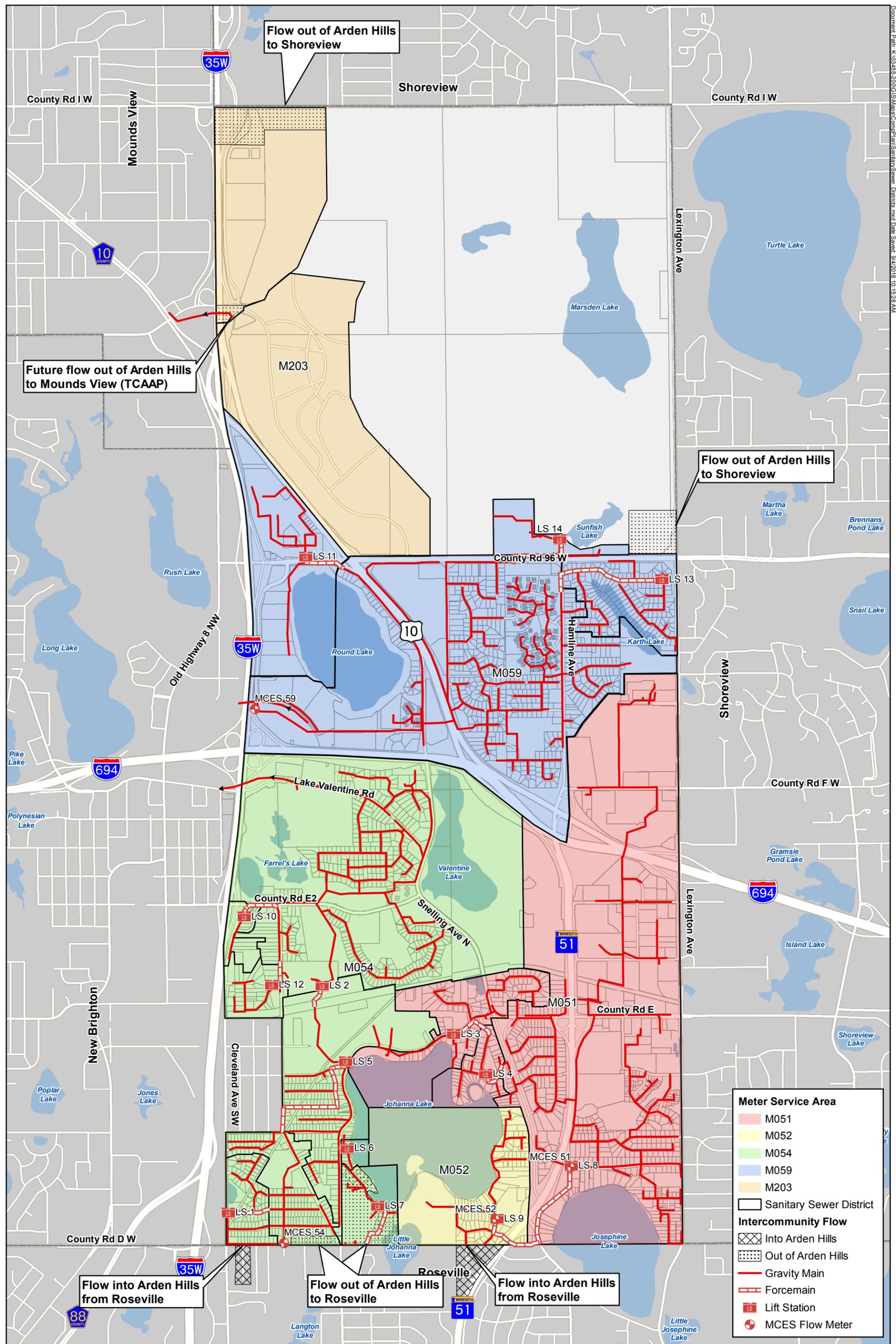


Figure 1 - Existing Sanitary Sewer System
2040 Comprehensive Plan
Arden Hills, MN



0 2,000 Feet
1 inch = 2,000 feet





Meter Service Area

- M051
- M052
- M054
- M059
- M203

Sanitary Sewer District

Intercommunity Flow

- Into Arden Hills
- Out of Arden Hills
- Gravity Main
- Forcemain
- Lift Station
- MCES Flow Meter

Figure 2 - Sanitary Sewer Districts
 2040 Comprehensive Plan
 Arden Hills, MN

N

0 2,000 Feet
 1 inch = 2,000 feet



Individual Sewage Treatment Systems

Nearly all properties within the City of Arden Hills are served by the public collection system. Currently, there are only two (2) individual sewage treatment systems (ISTS) in operation in the northwest corner of the City. The locations of these ISTS are shown in **Figure 3**. The two properties are:

- 5400 Highway 8 (State of Minnesota)
- 5420 Highway 8 (State of Minnesota)

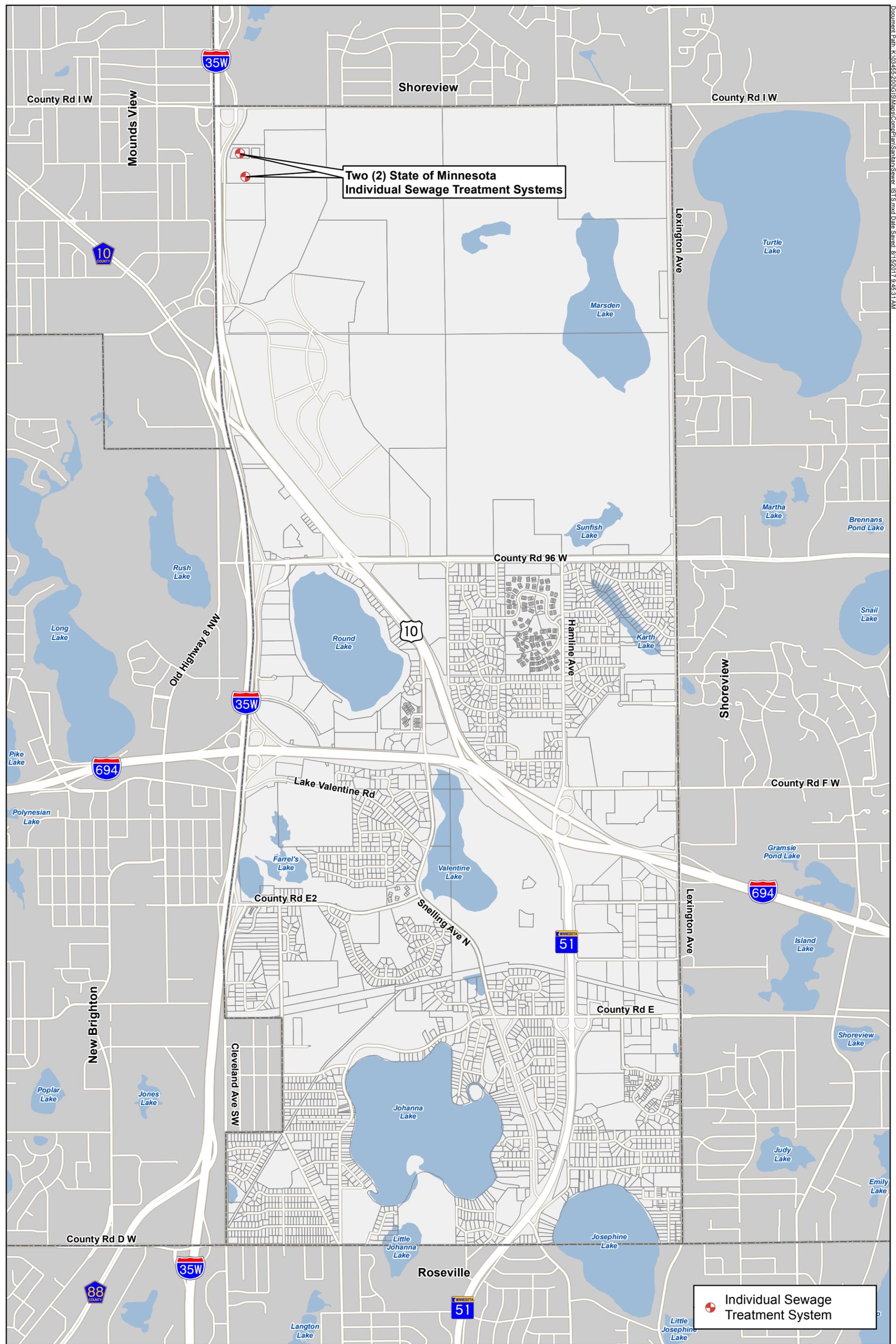
These two State of Minnesota properties are exempt from City requirements. The TCAAP development includes a proposed sanitary sewer extension which will be able to serve these two facilities, enabling the abandonment of their ISTS.

The City Code requiring connection to the public collection system is excerpted below.

1010.02 Connections Required.

Subd. 1 Existing Buildings. Any building used for human habitation and located on property adjacent to a sewer main, or in a platted block through which the system extends, shall be connected to the municipal sanitary sewer system within two (2) years from the date on which a connection is available to the building.

Subd. 2 New Buildings. All buildings constructed after the adoption of this code within the City on property adjacent to a sewer main or in a platted block through which the municipal sanitary sewer system extends, shall be provided with a connection to the sewer system for the disposal of all human wastes.



Two (2) State of Minnesota Individual Sewage Treatment Systems

Individual Sewage Treatment System

Figure 3 - Individual Sewage Treatment Systems
 2040 Comprehensive Plan
 Arden Hills, MN



0 2,000 Feet
 1 inch = 2,000 feet



FORECASTS

Population

The Metropolitan Council publishes population and sewer usage forecasts for each city in the Metropolitan Area. These forecasts serve to help cities prepare infrastructure for growth and to promote continued maintenance of municipal infrastructure. The forecast data in **Table 3** is from the Metropolitan Council's Local Planning Handbook Community Page for Arden Hills and includes the total and sewer population, number of households, and employment. In the case of Arden Hills, where effectively the entire City is sewer, these values are the same.

Table 3. Population Projections

Year	Total & Sewered		
	Population	Households	Employment
2010	9,552	2,957	12,402
2020	10,000	3,200	15,000
2030	12,000	4,100	16,300
2040	13,500	4,600	17,500

These projections are separated by MCES Meter Service Area in **Tables 4-A** and **4-B**.

Table 4-A. Projections by Meter Service Area & Interceptor

Year	M051 1-RV-432			M052 1-RV-432			M054 1-RV-431		
	Pop.	Hhds.	Empl.	Pop.	Hhds.	Empl.	Pop.	Hhds.	Empl.
2010	1,999	619	7,158	264	82	1,579	3,334	1,032	1,361
2020	1,999	619	7,258	264	82	1,579	3,334	1,032	1,361
2030	2,184	682	7,278	264	82	1,579	3,334	1,032	1,361
2040	2,184	682	7,298	264	82	1,579	3,334	1,032	1,361

Table 4-B. Projections by Meter Service Area & Interceptor

Year	M059 2-NB-100			M203 4-NS-524		
	Pop.	Hhds.	Empl.	Pop.	Hhds.	Empl.
2010	3,955	1,224	2,304	0	0	0
2020	3,956	1,264	2,324	447	203	2,478
2030	4,008	1,368	2,414	2,210	936	3,668
2040	4,008	1,368	2,504	3,710	1,460	4,758

Wastewater Flows

All of the wastewater flow from the City of Arden Hills is treated at the Metropolitan WWTP, and any increase in wastewater flow will be treated at the Metropolitan WWTP as well. **Table 5** lists the projected total average wastewater flow for Arden Hills from MCES and from this Sanitary Sewer Plan. Note that the projections used in this report are greater than the MCES projections since they rely on flow estimates for each parcel of developable land.

Table 5. Total Wastewater Projections

	2020 Average Flow (MGD)	2030 Average Flow (MGD)	2040 Average Flow (MGD)
MCES	0.93	1.04	1.09
Sanitary Sewer Plan	0.90	1.13	1.37

MGD = millions of gallons per day

SANITARY SEWER DESIGN CRITERIA

Land Use

The City's existing and 2040 land use maps were used in the development of this plan. Detailed information and figures regarding Arden Hills' land use is included in the City's 2040 Comprehensive Land Use Plan. Using existing land use, metering data, and future land use information, current and future flows were calculated and divided by service area as described below.

Estimated Average Flows – Existing

To estimate the flows in trunk mains throughout the City, metering data was obtained from the Metropolitan Council. Flows were assigned proportionally to each service district based on the acreage of residential, mixed use, commercial/industrial/office, and institutional land within each area and typical flows per acre for each particular land use.

Estimated Average Flows – 2040 Build Out

Once average flows were estimated, future flows were projected based on the planned 2040 land use from the Land Use Plan. Parcels that are planned to be developed were assigned wastewater flow rates in accordance to their land use type. **Table 6** lists the assigned flows, which include design considerations for inflow and infiltration (I/I). Refer to the Inflow and Infiltration section of this report for more information about I/I as it relates to Arden Hills' sanitary sewer system.

Table 6. Assumed Wastewater Generation by Land Use Type

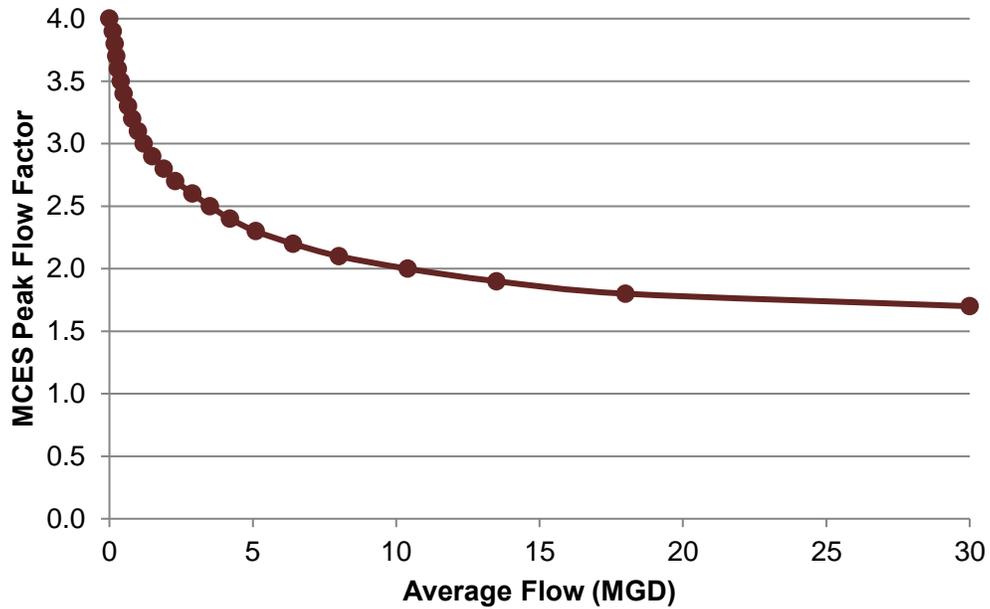
Land Use	Average Flow (gpd/acre)
Low Density Residential	720
Neighborhood Residential	900
Medium Density Residential	1,350
High Density Residential	1,890
Town Center	7,380
Public/Institutional	250
Commercial/Industrial/Office	800

Future flows from areas of redevelopment were added to existing flows to determine if existing pipe capacities will be sufficient. In locations in which development will lead to pipes that are under capacity, recommendations are made to address the issue. Areas that will need to be served in the future were evaluated to determine the required sewer diameters and improvements to serve these areas.

Peak Flow Factors

To ensure that the sanitary sewer system is capable of handling flow fluctuations throughout the day, peak flow factors are assigned based on average flows. The peak factors are provided by the Metropolitan Council and are based on average flow volumes. Pipes that serve small generator customers are more likely to experience large fluctuations in flows. Therefore, the peak factor decreases as average flow increases. The Metropolitan Council peak flow factors used in this report are shown in **Figure 4** below. These factors include consideration of inflow and infiltration.

Figure 4. MCES Peak Factors for Sanitary Sewer Design



SANITARY SEWER TRUNK RECOMMENDATIONS

The proposed future sewer system for the City of Arden Hills, including gravity mains, forcemains, and lift stations, is shown in **Figure 5**, as follows. The required infrastructure additions were determined based on the areas that the City is planning to redevelop by 2040. This report includes only oversized sewer lines (greater than 8-inch) and does not depict lateral lines. The design and siting for lateral lines should be completed in conjunction with development plans and platting. The location of such lines will be dependent on parcel layout and the design of new roads. It is possible that small scale lift stations will be required within developments.

The exact alignment of the proposed mains and lift stations may change during the design phase of each project. The purpose of this report is to provide the City with a document that can be used to plan for large infrastructure additions and replacements.

Lift Station Analysis

The estimated 2040 peak flows and subsequent remaining capacity for each of the City's fourteen (14) lift stations are shown in **Table 7**. The peak flows listed include the pumping rates of any lift stations directly upstream in order to be conservative. All lift stations are projected to have adequate pumping capacity to convey peak wastewater flows through the year 2040.

Table 7. Projected 2040 Peak Flows by Lift Station

Lift Station	Pumping Capacity (gpm)	2040 Peak Flow (gpm)	Remaining Capacity (gpm)
LS 1	240	28	212
LS 2	970	647	323
LS 3	240	52	188
LS 4	240	218	22
LS 5	660	473	187
LS 6	80	3	77
LS 7	220	86	134
LS 8	1,170	1,050	120
LS 9	280	81	199
LS 10	80	21	59
LS 11	350	204	146
LS 12	120	33	87
LS 13	460	87	373
LS 14	180	16	164
LS 15	*	1,010	*

gpm = gallons per minute

**Future lift station to serve the TCAAP development south of County Road H. The 2040 peak flow projected in this report is less than that listed in the TCAAP Site Redevelopment Infrastructure Preliminary Design Report from June 2015 because a lower flow per SAC unit of 180 gallons per day was used.*

Trunk Sewer Analysis

The estimated 2040 peak flows and subsequent remaining capacity in the City's trunk sewer lines are shown in **Table 8**. Trunk sewers of sub-districts served by a small network of 8-inch gravity main are not included in this analysis. None of the trunk gravity sewers are expected to exceed their capacity by the year 2040.

Table 8. Trunk Sewer Capacity Analysis

District	Location	Diameter	Capacity (gpm)	2040 Peak Flow (gpm)	Remaining Capacity (gpm)
LS 2	Perry Park	15"	1,120	647	473
LS 5	Yard Waste Collection Site	15"	1,120	473	647
LS 8	Ingerson Rd	18"	1,630	1,050	580
LS 9	Ridgewood Rd	10"	520	81	439
MCES 54	N Prior Ave	21"	2,250	605	1,645
MCES 59	Gateway Blvd	18"	1,630	1,223	407

gpm = gallons per minute

MCES Interceptor Facility Forecasts

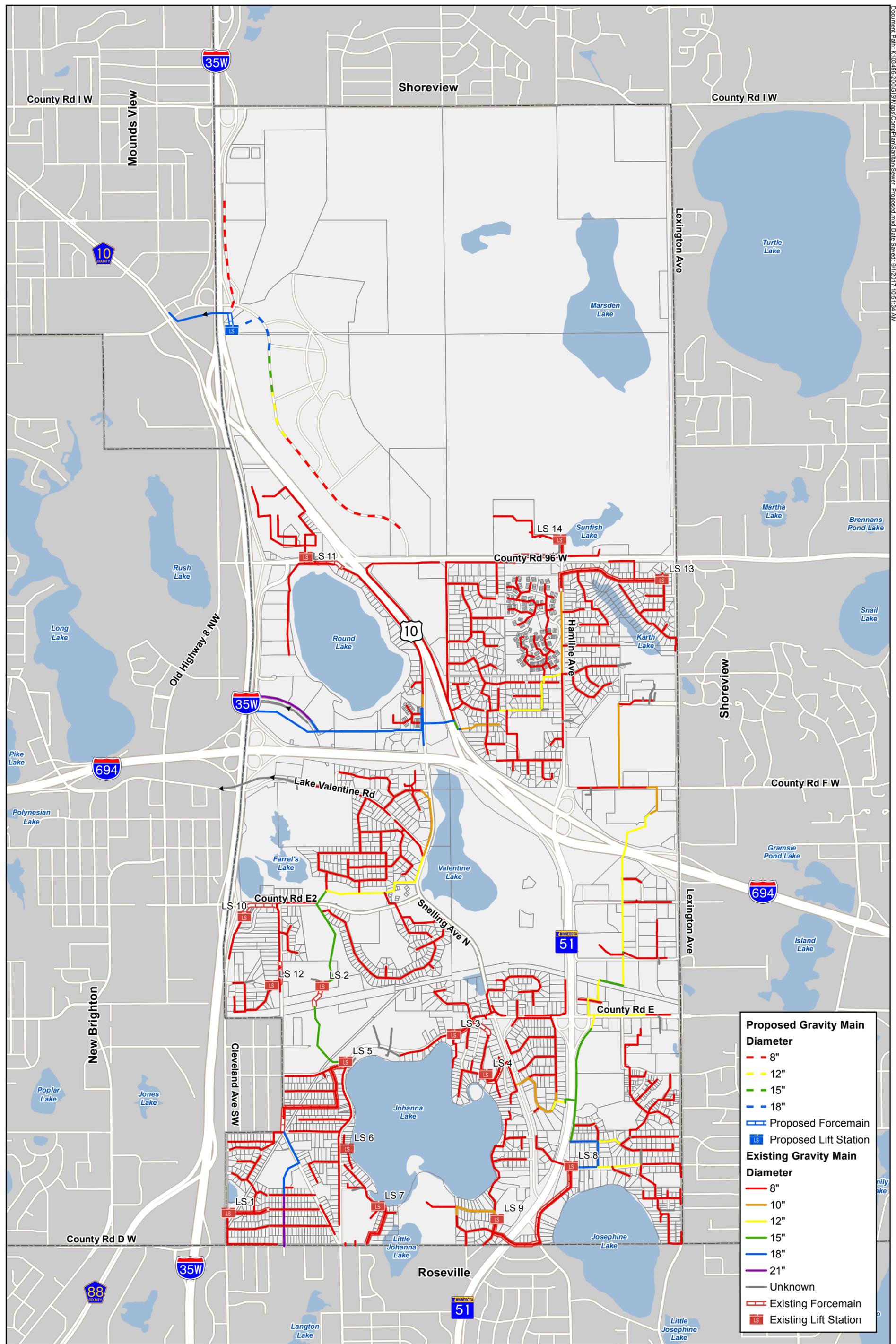
The MCES Interceptors used by the City of Arden Hills and the 2040 forecasted flows to those interceptors are listed in **Table 9**. The wastewater flow projections listed include only the flow generated within the City of Arden Hills.

Table 9. Projected 2040 MCES Interceptor Use

MCES Meter	MCES Interceptor	2040 Average Flow (MGD)	2040 Max Flow (MGD)
M051	1-RV-432	0.37	1.34
M052	1-RV-432	0.03	0.12
M054	1-RV-431	0.19	0.73
M059	2-NB-100	0.31	1.13
M203	4-NS-524	0.46	1.61

Individual Sewage Treatment Systems

As future development occurs and the sanitary sewer system is expanded to cover the northern portion of the City, the two (2) remaining State of Minnesota ISTS in the northwest corner of the City can be disconnected and properly abandoned.



Proposed Gravity Main Diameter

- 8" (Red line)
- 12" (Yellow line)
- 15" (Green line)
- 18" (Blue line)

Proposed Forcemain

- Proposed Forcemain (Blue dashed line)

Proposed Lift Station

- Proposed Lift Station (Blue square with 'LS')

Existing Gravity Main Diameter

- 8" (Red line)
- 10" (Orange line)
- 12" (Yellow line)
- 15" (Green line)
- 18" (Blue line)
- 21" (Purple line)
- Unknown (Grey line)

Existing Forcemain

- Existing Forcemain (Red dashed line)

Existing Lift Station

- Existing Lift Station (Red square with 'LS')

Figure 5 - Proposed Sanitary Sewer System
2040 Comprehensive Plan
Arden Hills, MN



0 2,000 Feet
1 inch = 2,000 feet



INFLOW AND INFILTRATION

General

Inflow is water, typically stormwater, which enters the sewer system through broken manhole covers, sewer cleanouts, sump pumps, foundation drains, and rain leaders. **Infiltration** is water, typically groundwater, which leaks into the sewer system through cracks in the sewer mains, laterals, joints, and manholes.

Water from inflow and infiltration (I/I) can consume available capacity in the wastewater collection system and increase the flow into treatment facilities. In extreme cases, the added flow can cause bypasses or overflows of raw wastewater. This extra flow also requires a larger capacity in the city's collection and treatment components, which results in increased capital, operation and maintenance, and replacement costs. As a sewer system ages and deteriorates, I/I can become an increasing burden on a City's system. Therefore, it is imperative that I/I be reduced whenever it is cost effective to do so.

In 2006, the MCES began an Ongoing I/I Program which requires communities within their service area to eliminate excessive I/I. The MCES establishes annual I/I goals for each community discharging wastewater into the Metropolitan Disposal System (MDS) based on average daily flows, adjustments for community growth, and I/I mitigation peaking factors.

The City of Arden Hills was assessed a surcharge in 2007 and initiated an I/I identification program that year to diagnose the extent and location of the I/I and to prepare a reduction plan. The City also had exceedances in MCES Metershed M051 from a June 21, 2013 storm and in MCES Metersheds M051 and M054 from a June 19, 2014 storm. Over the past ten years, the City has performed flow monitoring, smoke testing, televising, manhole rehabilitation, sump pump inspections, sewer lining, and sewer replacement. The City has relied on the Metropolitan Council's Municipal I/I Grant Program to accomplish many of these activities and will continue to apply for these grants as funding becomes available. More details on these activities is provided in the I/I Reduction section.

Flow metering data is available for the MCES Meters that measure the City's wastewater flow, and an analysis of this data as it relates to I/I is presented on the following page. The City's strategies, programs, investments, and goals for reducing I/I are listed in this section as well.

I/I Analysis

Arden Hills' sanitary sewer system currently consists of approximately 49 miles of gravity main, 14 lift stations, and 3.6 miles of forcemain. Approximately 26 percent of the gravity mains have been lined in the last fifteen years, primarily in the southern half of the system. Approximately 38 percent of the residential housing in the City was constructed before 1970. The only I/I evaluation that has been done for pre-1970 era private services is the televising of their wye connection during the trunk main televising listed in **Table 11** in the next section. I/I reduction activities are discussed in greater detail in the next section.

The amount of clearwater flow generated within the City was estimated by calculating the average annual and peak month I/I rates, equal to the average wastewater flow minus the base wastewater flow, using data from 2012-2016. The average flow, both annual and monthly, was calculated from MCES meter data. The peak month flow was determined for each year from 2012-2016, and then those peak month flows were averaged to give the value listed in **Table 10**. The base flow was calculated as the difference between average dry weather flow and groundwater infiltration, based on hourly meter data from a period of nine days of dry weather (three days since a rain event) and high groundwater level (spring) in March 2017. The groundwater infiltration rate was calculated as the average flow from 1:00-6:00 AM over the same nine-day period.

Table 10. Estimated I/I Rate

Metershed	M051	M052	M054	M059	Total
Average Flow (MGD)	0.345	0.029	0.192	0.261	0.826
Peak Month Flow (MGD)	0.498	0.039	0.278	0.318	1.134
Base Flow (MGD)	0.142	0.015	0.078	0.108	0.344
Average Annual I/I Rate (MGD (%))	0.202 (59%)	0.014 (48%)	0.114 (59%)	0.153 (58%)	0.482 (58%)
Peak Month I/I Rate (MGD (%))	0.356 (71%)	0.024 (62%)	0.201 (72%)	0.210 (66%)	0.790 (70%)

There are approximately 11 miles of vitrified clay pipe (VCP) in the City that have not yet been lined, located primarily in the residential areas east of Lake Johanna and west of Valentine Lake. These pipe segments are more susceptible to infiltration and are likely the most significant public I/I source. All of these pipes are planned to be lined over the next five years.

Private sources, such as leaking service laterals or unidentified, illicit sump pump or foundation drain connections, likely contribute a minimal portion of the remaining I/I. The City televises the wye connection of service laterals in conjunction with its sewer lining and rehabilitation projects in an effort to identify private I/I sources, however there may be faults in private systems that are not captured at the time of televising. The City may consider conducting flow monitoring immediately before and after its sewer lining projects to quantify the impact of the lining and to identify private I/I sources.

I/I Reduction

The City's strategy for preventing excess I/I includes requiring all development to conform to City standards. Arden Hills City Code prohibiting the discharge of stormwater to the sanitary sewer system and requiring the disconnection of existing I/I sources is excerpted below.

Subd. 8 Prohibited Connections of Surface Water and Ground Water Discharge Facilities to the City's Sanitary Sewer System.

A. No person, owner, lessee or occupant of any parcel of land, building, or premises shall discharge, or permit to be discharged, directly or indirectly, into the sanitary sewer system any surface water or groundwater including water from roofs, yards, lawns, streets, alleys, groundwater sump pumps, footing tile, or other natural precipitation.

...

Subd. 10 Removal of Prohibited Connections; Surcharge; City Reimbursement. Any person, owner, lessee or occupant, and any plumber or building contractor who has presently made or permitted to be made, or shall make or permit to be made, any connection or installation in violation of subdivision 8, shall immediately remove such connection or correct such an installation. ...

The City has several programs in place to both identify and reduce I/I and has completed projects nearly every year since 2007 to that end. A summary of these I/I reduction projects and their costs, as known, is given in **Table 11**. Several of these projects were made possible by grant funding through the Metropolitan Council's Municipal I/I Grant Program. The City will continue to apply for these grants as funding becomes available.

Table 11. I/I Reduction Activities

Year	Project	Cost (if known)
2008	I/I Investigation, I/I Study by Bonestroo	
	Flow monitoring, smoke testing, televising, lift station pump calibration	
	Manhole Rehabilitation Project	
	Sewer Lining Project	
2009	Sump pump inspections, manhole inspections, televising	
	Manhole Rehabilitation Project	
	Sewer Lining Project	\$82,989.50
2010	Sump pump inspections, manhole inspections	
	Sewer Lining & Replacement Project (chimney seals)	\$111,765.00
2011	Sump pump inspections	

	Sewer Lining Project	\$399,444.50
2012	Grant applications for 2013	
2013	Sewer Lining Project	\$625,526.05
2014	Grant applications for 2015	
2015	Sewer Lining Project	\$507,465.50
2017	Sewer Lining Project	\$200,000.00
2018	Street & Utility Project (sewer lining and spot repairs)	<i>Est.</i> \$285,600

I/I Implementation

The City will continue to implement the investigation and rehabilitation activities listed in **Table 12**. The City has ongoing reviews of flows and discussions with consulting engineers to develop the next stage of improvement plans and has planned for the I/I reduction investments listed in **Table 13**. As mentioned previously, the approximately 11 miles of remaining unlined VCP pipe will be a priority for rehabilitation over the next five years. In addition, the system will continue to be televised and repaired every other even year in conjunction with the City's street improvement projects. Significant improvements have been made over the last ten years, and the City of Arden Hills remains committed to identifying and eliminating sources of I/I in its sanitary sewer system.

Table 12. I/I Implementation

Investigation	Rehabilitation
Smoke testing to reveal direct inflow sources	Disconnect catch basins, realign manholes covers
Physical survey of manholes	Properly seal manholes
Internal televising of sewers	CIPP line or replace sewers
Rain leader inspections	Reroute roof drains to ground
Sump pump inspections	Reroute sump pump discharge to ground
Foundation drain inspections	Reroute to sump pump discharging to ground
Service lateral inspections	Repair or replace leaking services
Follow up inspections	As necessary

COST ESTIMATES AND FINANCING

The bulk of the improvements to the City's sanitary sewer system will be made in conjunction with TCAAP development, including new trunk gravity mains and one lift station. The City has also budgeted for routine I/I reduction work and other system maintenance and rehabilitation. The proposed capital improvements to the sanitary sewer system and their estimated costs are listed in **Table 13**.

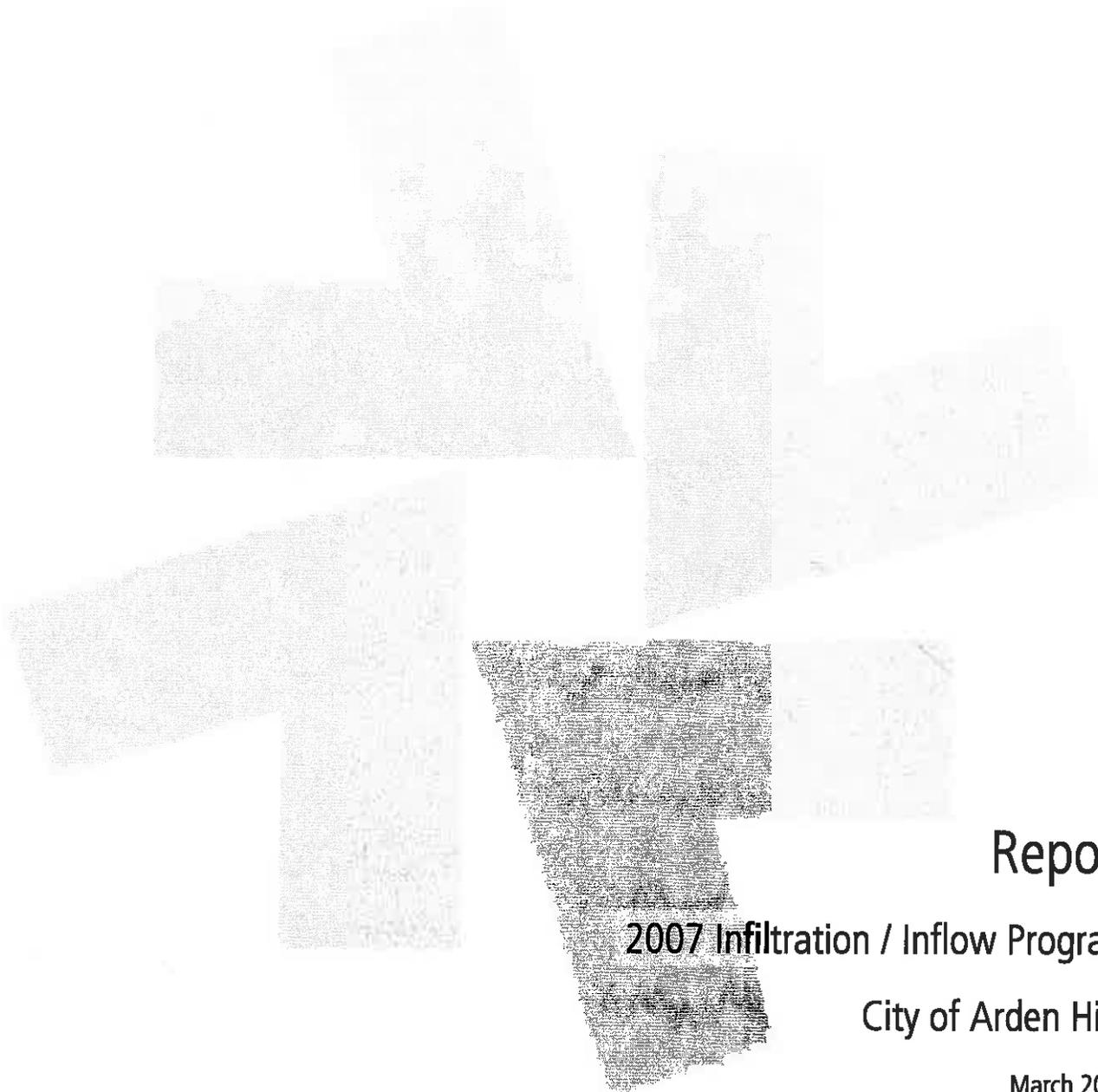
Table 13. Capital Improvements

Year	Item	Estimated Cost
2019	Sewer Lining and Rehabilitation	\$200,000
2019	TCAAP Spine Rd Trunk Sewer & Lift Station	\$1,200,000
2020	Sewer Lining and Rehabilitation	\$200,000
2021	Sewer Lining and Rehabilitation	\$400,000

SUMMARY AND OUTCOMES

The analysis provided in this Sanitary Sewer Plan is aimed to provide the City of Arden Hills and the Metropolitan Council assistance in planning for wastewater collection and treatment, including the planned development of the TCAAP area. It is anticipated that the design flows and criteria outlined will be used for utility planning as development continues within the City. Tables and figures can be utilized to create budget-level estimates and schematic representations of infrastructure improvements, with specific sizing and routing to be determined during the design phase.

APPENDIX 1
I/I Study



Report

2007 Infiltration / Inflow Program

City of Arden Hills

March 2008

Project Number: 353-07103

City of Arden Hills
March 2008

2335 Highway 36 W
St. Paul, MN 55113

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March 17, 2008



Ms. Kris Giga, PE
City of Arden Hills
1245 W Hwy 96
Arden Hills, Mn 55112-5743

Re: 2007 I/I Program
City of Arden Hills
Bonestroo File No.: 353-07103-0

Dear Ms. Giga,

We are pleased to present the City of Arden Hills with this report on the 2007 Infiltration/ Inflow Program. This project consisted of an initial sanitary sewer collection system analysis effort with the ultimate goal of reducing the amount of clear water in the City system. This clear water results in MCES charges for treatment in addition to a surcharge for the peak flow rate.

Based on the analyses completed we have provided some guidance subsequent analytical steps and identification procedures, which can then be followed by rehabilitation of clear water sources. These are basic steps and will be subject to future modification and adaptation as more data are developed. The City's goal of I/I reduction will require a long term commitment to continuously observe conditions and rehabilitate sources as they are identified or they occur.

Thank you for the opportunity to work on this project and get to know some of the City staff. We are available to discuss the contents of this report with you and other interested parties at any mutually convenient time.

Sincerely,
BONESTROO

Charles Janski
Charles Janski
Project Manager

I hereby certify that this Report was prepared by me or under my direct supervision and that I am a duly Licensed Professional Engineer under the laws of the State of Minnesota.

Charles Janski

Charles R. Janski, P.E.

Date: 3/21/08 Reg. No.: 14596

I. Introduction and Purpose

Infiltration / Inflow (I/I) is defined as clear water that enters a sanitary sewer system. Infiltration is clear water that seeps into the pipe network from groundwater, and Inflow is clear water that is directly related to rainfall or runoff events. I/I is a term used to describe all clear water without attempting to differentiate its source. This clear water does not require treatment until it is mixed with the wastewater already in the sanitary sewer pipe. Once it is mixed, the combined flow must be conveyed to a treatment facility for treatment before it can be discharged back into the surface water network.

The I/I in the system can increase the normal flow in the system enough to stress the conveyance capacity of the pipe network, pumping stations, and the wastewater treatment facilities. In the seven county metropolitan area, the Metropolitan Council Environmental Services (MCES) provides an interceptor sewer system to collect the wastewater from over 100 communities and convey it to one of eight MCES wastewater treatment facilities located around the metropolitan area. Communities own and operate their own local sanitary sewer systems to collect the wastewater from individual buildings within their service area. Any clear water (I/I) entering a local collection system is conveyed to and through the MCES system and directly impacts the available capacity of the MCES interceptor and treatment facilities.

The Metropolitan Council appointed a Task Force to identify solutions to the regional I/I problem. The Task Force worked from April 2003 to May 2004 and developed recommendations which were adopted by the Metropolitan Council as Policy in 2004. The Policy established the I/I Surcharge Program that is now in effect with the intent to avoid "hundreds of millions" of dollars in regional infrastructure costs.

The MCES currently monitors wastewater flows from all the tributary communities in the service area. With the I/I Surcharge Program an additional step was initiated to monitor peak flow conditions. Briefly, the program establishes a three year average flow for each community or "metershed" within the system. A peaking factor (multiplier) is applied to the average flow to determine an allowable peak flow. The peaking factor was previously adopted by the MCES for design purposes and it ranges from 4.0 for average flows less than 110,000 gallons per day (gpd) to 1.7 for flows over 30.0 million gallons per day (mgd). The MCES reviews hourly flow data from each meter during runoff events and compares the actual "peak hourly" flow to the allowable peak flow. If the actual peak is higher than the allowable peak, the extra flow is considered "excessive" and subject to the I/I surcharge rate of \$350,000 per mgd (this rate is annually increased by an inflation factor). The I/I surcharge is calculated for the highest peak recorded by the MCES and the surcharge amount is subdivided into five (5) years of annual payments. If a greater peak is recorded in the five year period, the surcharge amount can be recalculated and increased for the remaining years in the 5 year program term. Surcharges began in 2007 and will run through 2011.

The City of Arden Hills is subdivided into three "metersheds" for measuring and recording wastewater flow. The combined total "excess" peak flow of these three metersheds was 1.43 mgd on October 4, 2005. Using this peak flow rate, the City's I/I surcharge was calculated to be \$500,500 which is to be collected at an annual rate of \$100,100. The City has the option to pay the surcharge amount to the MCES, or make I/I reduction improvements to their system that will directly off set the surcharge amount. If the City expends less than the annual surcharge amount, the balance will be collected by the MCES and held in an account for future I/I improvement work. At the end of the five year program if there are any funds remaining in the community's MCES account, they will be turned over to the MCES as a "demand" charge and the MCES will use the funds for regional system improvements. At the end of the five year I/I Surcharge Program, the MCES will continue annual charge communities for peak flows in excess of the allowable flow, but the funds will go directly to the MCES budget and will not be available to the Community for I/I reduction efforts. The goal is to make enough I/I improvements between 2007 and 2011 to eliminate the excess peak flow and therefore eliminate the I/I surcharge entirely.

The purpose of this study and report is to begin the process of quantifying the I/I in the Arden Hills sanitary sewer system, isolating areas with the most significant problems, and preparing a plan of action for additional work to identify and remove sources of the I/I in order to eliminate the need for the MCES I/I Surcharge in the future.

II. Background

According to the Metropolitan Council Water Resource Management Policy Plan, the City of Arden Hills is expected to grow in population from 9,652 in 2000 to 22,500 in 2030 and grow in households from 2,959 in 2000 to 8,000 in 2030 (Note that the current Arden Hills Comprehensive Plan, which has not been adopted yet, anticipates a 2030 population of 13,500 people and 4,600 households. The reduction is due to a less aggressive development schedule for the TCAAP Area). This growth will increase the demands on the local and regional infrastructure including the wastewater collection and treatment systems that are the subject of this report.

Wastewater flow from the City of Arden Hills is measured and recorded by the MCES at four separate meter sites (M051, M052, M054, and M059) located as shown on Figure 1. The existing Arden Hills sanitary sewer system includes approximately 232,300 feet of 8 inch to 21 inch diameter sewer pipe divided into four districts or "meter sheds" as shown in Table 1.

Meter Number	Range of pipe diameters (in)	Length (ft)	Comments
M051	8"-18"	66,100	
M052	8"	8,900	
M054	8"-21"	71,300	
M059	8"-21"	82,600	
Unmetered (LS 7)	8"	3,400	
Total		232,300	

The total wastewater from the City of Arden Hills is estimated by summing the total flow from each of the four meters and adding an estimate for the un-metered area served by lift station 7. The annual average daily flows for the metered areas for each of the past three years are listed in Table 2.

Meter Number	2004	2005	2006	MCES 3Yr Avg	Allowable Peak
M051	0.448	0.432	0.435	0.44	1.54
M052	0.038	0.039	0.038	0.04	0.16
M054	0.198	0.197	0.183	0.19	0.27
M059	0.317	0.312	0.286	0.32	1.15
Total	1.001	0.980	0.942	0.99	

The annual average daily flow has declined slightly each year during this monitoring period.

During runoff conditions following a rain event or snowmelt period, the flows increase markedly due to infiltration and inflow (I/I) entering the sanitary sewer system. In September 2007, the City wastewater flow peaked in response to a 1.83 inch rainfall event. The peak hourly flows recorded at each MCES meter site are listed in Table 3.

Meter Number	Peak Hourly Flow Rate in mgd
M051	1.20
M052	0.10
M054	0.57*
M059	1.38*

*Note: Calculated peak flow rate exceeds allowable flow listed in Table 2

III. Temporary Flow Metering

Temporary flow meters were installed in three manholes to subdivide the meter sheds of Meters M054 and M059 in an attempt to isolate I/I flows to smaller areas and focus rehabilitation efforts. The locations of the temporary meters are shown on Figure 1. The temporary meters consisted of a transducer placed in the flow channel, connected to a flow meter/ data logger. The flow meter collects readings of flow depth and velocity from the submerged transducer. These values are then input into a formula and a flow rate is estimated. The three temporary flow meters were installed in the system from July 19, 2007 to August 29, 2007. This period was generally dry; however 2.05 inches of rainfall were received over a two day period on August 27 and 28, 2007. The flow data from the temporary meters are summarized in Table 4.

	Meter 1	Meter 2	Meter 3
Dry Weather Flow (8/23/07)	0.42 *	0.07	0.13
Peak Hourly Flow (8/28/07)	1.15*	0.15	0.27

*Note: Temporary meter number 1 was installed to divide the Meter 059 Meter Shed and attempt to isolate possible I/I sources. This meter was operating for about 8 weeks so no long term average flow data are available; however, some dry weather and peak data are available for evaluation. The flow data recorded at meter 1 suggest flow rates in excess of those recorded at the downstream meter M059 and therefore the data are considered unreliable for comparison at this time.

IV. Data Analysis

The flow meters provide basic flow quantification and can be used in a number of ways to estimate an I/I quantity and make some predictions about possible sources of the I/I based on the flow patterns. The data can also be combined with other available City data to prioritize areas and maximize rehabilitation efforts.

The data analysis included a number of steps as described below. The actual analysis for each "meter shed" is presented in a series of Figures in the Appendix, and the results are summarized in Table 5.

Background Data.

- o The estimated number of "Residential Equivalent Connections (REC)" and the length of the sanitary sewer tributary to the meter location were obtained from the City graphical information system (GIS).
- o The Monthly Flow data from the past three years were obtained from the MCES for their meters.
- o Data from the temporary meters were compiled.

Parameters for Comparison

- o Estimate annual I/I volume and treatment cost using "base" flow analysis
 - The average daily wastewater flow from January is assumed to be a "base" flow that includes a minimal amount of infiltration.
 - The average daily flow from January is subtracted from the annual average daily flow and the annual I/I volume and treatment cost are calculated.
- o Per Connection flow rate
 - The annual average daily flow, January daily flow, and the peak month daily flow are divided by the number of Equivalent Residential Connections (ERC).

- Estimate I/I rates and per connection contributions using hourly flow data and early morning minimum flow rates.
 - In general, the flow in a sanitary sewer during the early morning hours (3:00- 5:00 AM) is a reasonable estimate of infiltration because there is minimal sanitary use of the system at that time. This estimate can be affected by water softener recharge cycles or commercial/ industrial uses that continue throughout the night
 - The early morning flow rate for a dry weather (non-rainfall) day is subtracted from the total flow for the day to calculate an average daily "wastewater" flow for a dry weather (non-rainfall) day.
 - The estimated infiltration rate is divided by the "inch-miles" of sewer pipe that are tributary to the location
 - The calculated wastewater flow rate is divided by the number of connections to determine a "per connection" rate.
- Estimate Inflow rates.
 - By definition, inflow generates a peak flow condition as a result of a rainfall or runoff event.
 - During the temporary metering period, 2.05 inches of rain were received on August 27 and 28, 2007. A more significant 1.83 inch rainfall occurred on September 19, 2007 after the temporary meters were removed. The August event will be used for the temporary meter locations and the September event will be used for the MCES meter locations.
 - The inflow rate is estimated by noting the peak hourly flow rate during the rainfall period and the time of occurrence.
 - The flow rate for the same time period on a dry day is then subtracted from the peak hourly flow on the rainfall day to separate out the portion of the flow attributable to the rainfall event. This value is the peak hourly inflow rate.
- Calculate an adjusted peak flow rate.
 - Determine the normal peak hourly wastewater flow on a dry weather day.
 - Add the peak hourly inflow rate to the peak hour wastewater flow rate to determine a "worst case" peak rate that could occur if the two events were simultaneous. This value is the adjusted peak flow rate.
 - Calculate a peak flow to average flow ratio for comparison with MCES guidelines.
- Calculate inflow rate in gpd per connection and per inch mile of sewer for comparison purposes.

The remaining item in the data analysis is the review of the flow graph itself. The flow graph figures provide a graphic comparison of the dry weather flow versus the wet weather peak flow in each meter area. The shape of the graph or the "flow response" can be an indicator of the type of I/I sources that may be responsible for the clear water flow. The rapid rise and decline as demonstrated in Figure 3 Meter 051 would suggest a direct type connection that contributes flow for a short time during the runoff event and then stops operating after the runoff ceases. A rapid increase and a slow decline demonstrated in Figure 11 Meter 054 suggests a more extended flow contribution from a very long service area (long transport time in the pipes), or a foundation drain/ sump pump type connection that requires an extended time after the end of the runoff event for the flow to percolate through the soil to the collector pipe.

TABLE 5 - SUMMARY OF METERSHED DATA

Metershed Identification Number	M051	M2	M3	M051-M2-M3	M052	M054	M059	M1	LS 11	M059-M1
Background Characteristics										
Acreage										
Connections	904				112	1,079	1,149			
Pipe Length	66,130	10,600	24,860	30,670	8,970	71,250	82,590	48,670	10,170	33,920
Diameter range	8"-18"	8"-12"	8"-15"	8"-18"	8"	8"-21"	8"-21"	8"-21"	8"	8"-21"
Pipe inch-miles	117.1	20.1	38.9	58.1	13.6	122.9	142.5	77.4	15.4	65.1
Flows										
Averages										
2006 Annual average (mgd)	0.435				0.038	0.183	0.286			
May-Sep 2007										
Dry Day (mgd)	0.453	0.074	0.133	0.246	0.043	0.181	0.230	0.420		(0.190)
Est. Infiltration (mgd)	0.240	0.029	0.052	0.159	0.024	0.077	0.101	0.073		0.028
Infil/ in-mi (gpd/in-mi)	2,050	1,433	1,326	2,737	1,765	625	707	946		(239)
WWV per connection (gpd/conn)	236				170	97	112			
Peak										
MCES "Allowable"	1.54				0.16	0.27	1.15			
May-Sep 2007										
Peak Hour flow (mgd)	1.20	0.15	0.27	0.78	0.10	0.57	1.38	1.15		0.23
Est Inflow (mgd)	0.80	0.06	0.21	0.53	0.06	0.38	1.13	0.78		0.35
Adjusted Peak (mgd)	1.49	0.16	0.49		0.14	0.65	1.45	1.53		
Calc. P/A Ratio	3.29	2.16	3.68		3.26	3.59	6.29	3.64		
Inflow per Conn (gpd/conn)	884				500	354	980			
Inflow per in-mi (gpd/in-mi)	6,824	2,925	5,275	9,122	4,114	3,105	7,905	10,016		(2,111)
Cost Summary										
Annual I/I Cost	33,300				2,800	9,000	1,100			
Annual I/I Surcharge Cost										
Total Annual I/I Cost	33,300				2,800	9,000	1,100			
I/I Cost per Foot of Pipe	\$ 0.50				\$ 0.31	\$ 0.13	\$ 0.01			
I/I Cost per Connection	\$ 36.84				\$ 25.00	\$ 8.34	\$ 0.96			

V. Summary of Analysis

Table 5 provides a summary of all the data developed in the previous paragraphs. The MCES II Surcharge program is focused on the "Inflow" portion of the clear water and the highest costs for the City of Arden Hills are associated with flow in this category; however, it is important to consider the infiltration portion as well since both infiltration and inflow result in treatment costs to the community.

Using the data included in Table 5, the matrix in Table 6 is developed to prioritize areas for additional work. The various factors were ranked numerically from low to high with the low number reflecting the worst case, so the lowest sum will be the highest priority for additional work.

Table 6. - Prioritization Ranking Matrix					
Area	Infiltration/ in-mi	P/A Ratio	Inflow/ in-mi	Sum	Priority
Meter M051	1	3	2	6	2
Meter 2	3	4	6	13	5
Meter 3	4	2	3	9	3
Meter M052	2	3	4	9	3
Meter M054	5	2	5	12	4
Meter M059	5	1	1	7	1
Meter 1*	5	2	4	8	2

* Note: Current data from Meter 1 are not suitable for comparison with other meter sheds.

Meter Area M051 is the highest priority for additional work with emphasis on the area between M051, Meter 2 and Meter 3. However, the area served by Meter M059 had the highest Inflow Related rankings and therefore should be considered the highest priority for the I/I Surcharge reduction efforts.

VI. Potential I/I Sources to consider

The flow response demonstrated in Figures 3, 5,7,9,11,13, and 15 provide one indicator of the type of I/I sources that can be anticipated in the service area. The type of sources in turn define the type of further investigative methods that should be considered in the various areas. It is impossible to completely define the sources at this stage of the process but we would anticipate that the sources will be more clearly identified as the investigation effort proceeds.

Figure 3 - Meter 051 Flow chart indicates a short duration quick spike in flow with the flow remaining elevated slightly for an extended period of time. This flow pattern suggests a possible mixture of some direct inflow sources, such as catch basins, area drains, low manholes, or roof drains, with some longer acting sources such as sump pump connections, direct footing drainage tile, or leaking service pipes.

Figure 5 - Meter M2 flow chart shows an immediate sharp spike with the flow remaining elevated for more than a day following the peak event. This flow pattern suggests primarily longer acting type sources such as sump pumps, direct footing drain tiles, or leaking sewer service pipes.

Figure 7 - Meter M3 flow chart shows an immediate sharp spike with very little long term flow impacts. This pattern suggests some direct inflow sources, such as catch basins, area drains, low manholes, or roof drains, with possibly a small number of longer acting sources such as some sump pump connections, direct footing drainage tile, or leaking service pipes.

Figure 9 - Meter 052 flow chart indicates a short duration quick spike in flow with the flow remaining elevated slightly for an extended period of time. This flow pattern suggests a possible mixture of some direct inflow sources, such as catch basins, area drains, low manholes, or roof drains, with some longer acting sources such as sump pump connections, direct footing drainage tile, or leaking service pipes.

Figure 11 - Meter 054 flow chart shows an immediate sharp spike with the flow remaining elevated for more than a day following the peak event. This flow pattern suggests primarily longer acting sources such as sump pumps, direct footing drain tiles, or leaking sewer service pipes.

Figure 13 - Meter 059 flow chart indicates a short duration quick spike in flow with the flow remaining elevated slightly for an extended period of time. This flow pattern suggests a possible mixture of some direct inflow sources, such as catch basins, area drains, low manholes, or roof drains, with some longer acting sources such as sump pump connections, direct footing drainage tile, or leaking service pipes.

The flow spike is significantly higher than the normal flow during the same period which supports the relative severity of the inflow in this service area.

Figure 15 - Meter M1 flow chart indicates a short duration quick spike in flow with the flow remaining elevated for an extended period of time. While the data are considered questionable, the flow pattern should reflect the flow response in the manhole location. This pattern suggests a possible mixture of some direct inflow sources, such as catch basins, area drains, low manholes, or roof drains, with some longer acting sources such as some sump pump connections, direct footing drainage tile, or leaking service pipes.

VII. Preliminary Conclusions

The peak flow analysis indicates that there is inflow in each of the four primary metersheds while the September 18, 2007 event resulted in a possible "flow exceedence" event at meters M054 and M059 only. The projected peak flow rate at M051 was very near the allowable peak rate, but did not exceed the rate.

The work completed to date is the first step identifying and removing the I/I in the collection system. Additional investigation will be necessary to further identify sources and complete rehabilitation to reduce the I/I flow rates.

Based on the flow response, it is anticipated that private property type sources including sump pumps, direct foundation drains, and possibly deteriorated sewer service connections provide a portion of the inflow in each service area; however, in areas M1 and M054 these connections may be the major contributors. In Area M2, the flow response is similar but the service area is primarily commercial / industrial so the number of foundation drain type connections is probably limited and this response may be due to a low manhole or area drain that drains slowly after a rainfall event.

In areas M051, M3, M052, and M059, the flow response suggests that there are some direct type connections in addition to some private property sources.

The current data are not sufficient to specifically identify sources for the inflow, however, they can be used to plan subsequent data collection and inflow investigation efforts.

VIII. Recommendations for next steps

The flow data collected during 2007 generally provided some background information and response data for a limited storm event following a very dry summer period. We would recommend conducting additional flow metering at each of the temporary meter sites to try and record the response to a larger (2") rainfall event during more normal groundwater conditions. In addition, all of the lift stations should be calibrated so the running time data can be used to subdivide the flows within the larger MCES meter areas. There are five lift stations in the M054 service area that may be able to further isolate the suspected private property type sources.

Table 7 includes a summary of typical I/I sources, investigative procedures that are designed to identify these sources, and rehabilitation options typically associated with the particular source. This is not an exhaustive list but can be considered a guide for the next steps in the I/I identification and rehabilitation process.

Table 7 - Summary of Typical I/I Source, Investigation Procedures, and Rehabilitation Options			
Infiltration or Inflow	Potential Source	Investigative Procedures	Rehabilitation Options
Inflow	Manhole Covers	Smoke Test Physical Survey	Replace Cover Raise Cover Seal Cover Rim Area
Inflow	Area Drains	Smoke Test	Re-route flow to storm sewer or surface discharge
Inflow	Roof Drains	Building Inspection Smoke Test Dye Test	Re-route flow to storm sewer or surface discharge
Infiltration/ Inflow	Deteriorated Adjustment Rings	Manhole Inspection	Replace rings and seal Install sealing product (Chimney seal, Infi-shield)
Infiltration/ Inflow	Sump Pump Connection	Basement Inspection	Re-route discharge out of basement to surface
Infiltration/ Inflow	Direct Foundation Drains	TV inspection of service pipe	Re-route to sump pump and discharge outside basement to surface
Infiltration/ Inflow	Leaking Service pipe	TV inspection of service pipe	Replace service pipe Install CIPP Liner
Infiltration	Manhole wall seepage	Manhole Inspection	Grout Injection Replace Manhole Install Manhole Liner
Infiltration	Pipe Joint Leakage	Televise sewer main	Joint Grouting CIPP Lining Pipe Replacement

In the service areas for meters M1, M2, and M054, initial investigation efforts should be focused on possible private property type sources. Investigation should include sump pump surveys of individual properties and televising individual service lines during wet conditions. Some communities have had reasonable success televising the service lines from the main sewer using a remote camera. This process is less expensive and significantly less intrusive than attempting to televise services from the basement of a property. In consideration of the potential problems with basement access, we would recommend attempting to televise several service lines in several areas of these service areas to test the procedure and view the results prior to widespread implementation of a program. Since sump pump inspections can be a difficult project and the cost implications can be significant, the program should be implemented throughout the entire community with priority areas defined by the identified inflow areas.

In the service areas for meters M3, M051, M052, and M059, initial investigative efforts should be focused on direct inflow sources, with smoke testing, physical survey of manholes, roof leader inspections, and dye testing as necessary. Manholes located in roadside ditch areas such as those repaired along Hwy 10 can be a significant source of inflow and all manholes located on easements or off paved road areas should be inspected for flooding potential and damaged rings. Sump Pumps are also considered a direct inflow source and they will generate a significant flow spike so a survey in these areas will provide some useful information as well as providing a "complete" inspection.

Inflow defects that are identified should be repaired as soon as feasible after identification to reduce the inflow as much and as quickly as possible. This will reduce the MCEs treatment charges as well as assist in further evaluation of the system since other defects may become evident when some of the flow is removed.

These investigation recommendations are a starting point and problems identified or defects noted may require additional investigation or other unique investigative techniques. The results of each procedure should be reviewed and evaluated to determine the next step in the investigative effort.

IX. Schedule

A. 2008 Plan

- Install flow meters for peak wet weather period to attempt to capture several rainfall events
- Calibrate pumps at each of the collection system lift stations
- Evaluate flows from each lift station area and compare to flows at temporary meters and MCES flow meters.
- Conduct physical survey of manholes located in "off-road" locations
- Complete rehabilitation of any identified manhole inflow sources
- Experiment with televising sewer service lines in 10 – 20 locations

B. 2009 Plan

- Conduct sump pump surveys of 50 % of the sewer service area.
- Follow up on sewer service line inspection based on experience from 2008
- Evaluate flows throughout system using lift station metering points and MCES Meters
-

C. 2010 Plan

- Conduct sump pump surveys of remaining 50% of the sewer service area
- Evaluate flows throughout system using lift station metering points and MCES Meters.
- Consider sewer replace programs if defective services are identified.

D. 2011 Plan

- Complete any remaining rehabilitation projects

Appendix

Figures 1 through 15

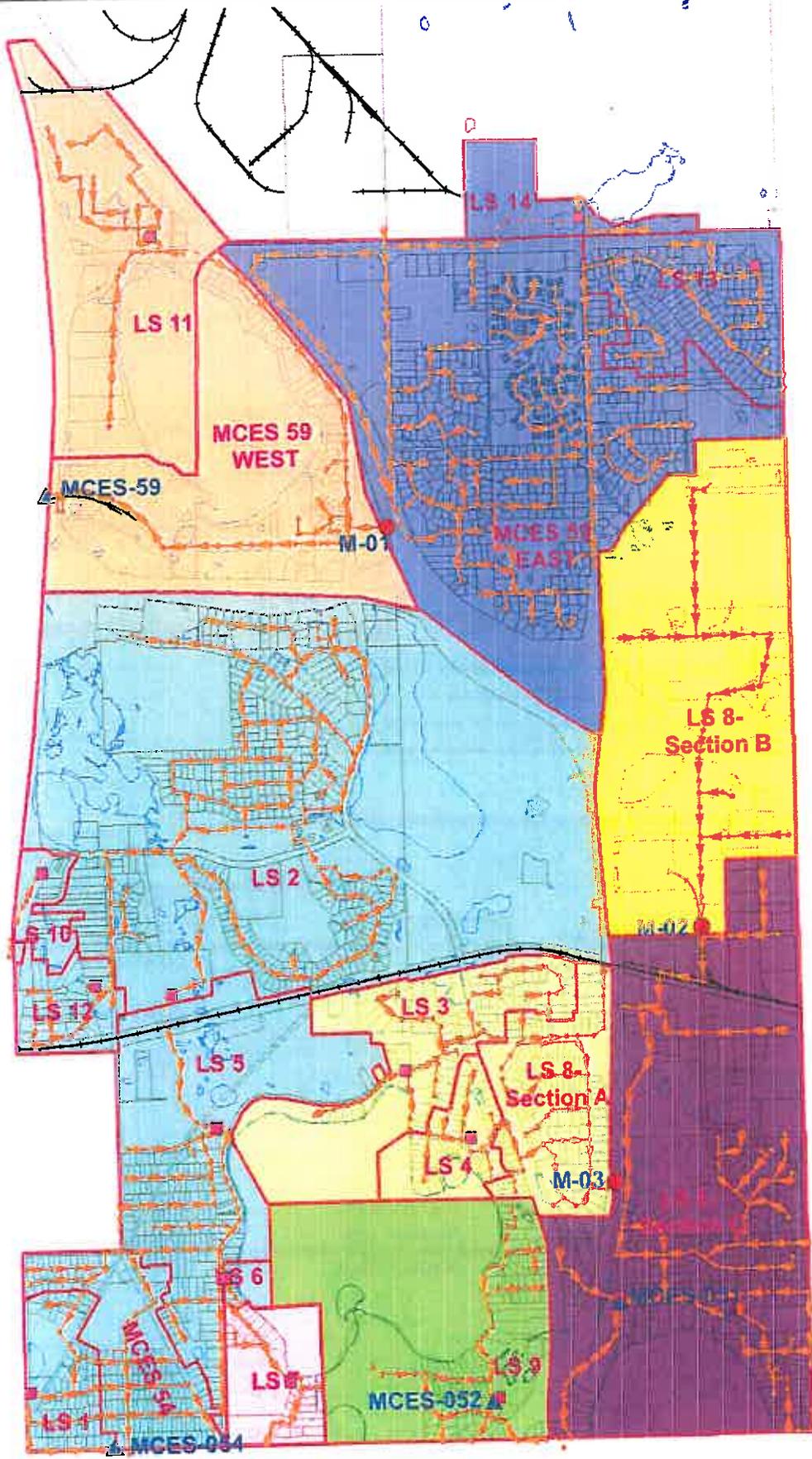


Figure 1

- LEGEND:**
- Meter Area M54
 - Meter Area M3
 - Meter Area M91
 - Meter Area M62
 - Meter Area M89
 - Meter Area M1
 - Meter Area M2
 - Unmetered Area
 - Service Area
 - Lift Station
 - SanitaryManhole
 - SanitaryPipe
 - ForceMain
 - Meter Council Meter
 - Temporary Meter



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Map prepared by: [unreadable]
 Date: [unreadable]
 Scale: [unreadable]
 Projection: [unreadable]
 Contour Interval: [unreadable]
 Elevation: [unreadable]
 Source: [unreadable]
 Author: [unreadable]
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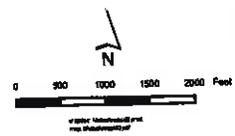


FIGURE 2 ESTIMATION OF INFILTRATION / INFLOW

Meter Shed **M051**

Estimated Residential Equivalent Connections
Inch Miles of Sewer pipe (w/o services)

904
117.1 in-mi

Method 1 - Assume no I/I in January

Monthly Flow Data (mgd)

	Annual Average	January	Peak Mo.	I/I (mgd)	(MG annual)	(%)
2004	0.448	0.362	0.540 June	0.086	31.39	19.20%
2005	0.432	0.367	0.534 Oct	0.065	23.73	15.05%
2006	0.435	0.408	0.579 May	0.027	9.86	6.21%
					<u>64.97</u>	<u>13.48%</u>

2006 rate	\$	1,543
Total Cost	\$	100,249
Annual	\$	33,416 (3 yr avg)

Calculated GPD per connection

	Annual Average	January	Peak Mo.
2004	496	400	597
2005	478	406	591
2006	481	451	640

Method 2 - Assume early morning low flow is entirely infiltration (clear water)

May - September 2007

8/30/2007 Daily Flow		453,000 gpd
Dry Day - Early Morning Flow	10,000 gph	240,000 gpd
Net Wastewater		213,000 gpd
Infiltration rate: (EMF/in mi)		2,050 gpd/in mi
Wastewater per connection:		236 gpd/connection

Peak Flow 9/20/07

Peak Hour Rate:	20:00 hrs	49,861 gph	1.197 mgd
Dry day flow at time		16,568 gph	0.398 mgd
INFLOW		33,293 gph	0.799 mgd
Normal Peak			0.690
Adjusted Peak			1.49 mgd
Calc. P/A Ratio			3.29
Inflow per connection		884 gpd/connection	
Inflow per in mile		6,824 gpd/in mi	

Figure 3 - Arden Hills M051

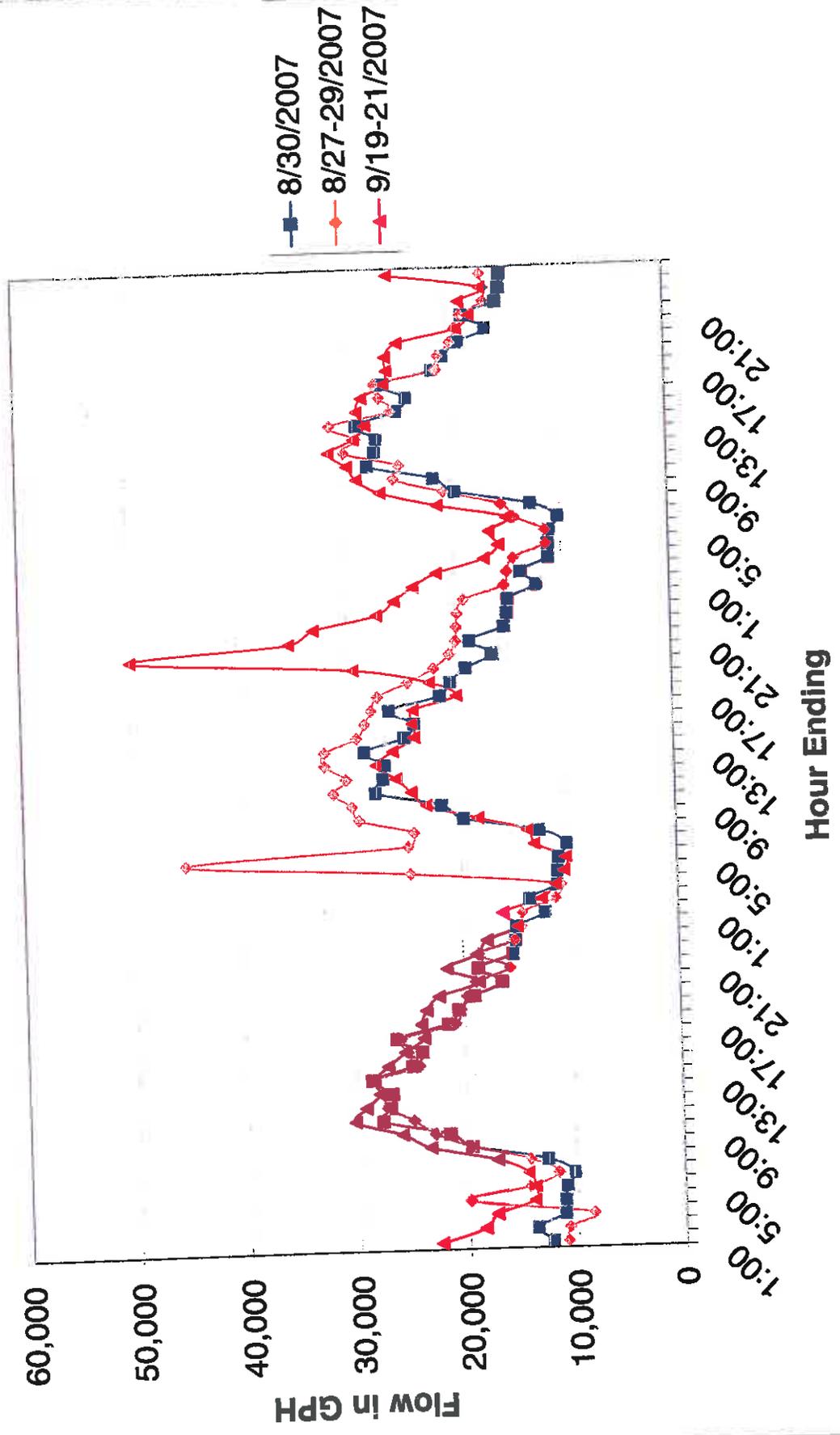


FIGURE 4 ESTIMATION OF INFILTRATION / INFLOW

Meter Shed **M2**

Estimated Residential Equivalent Connections
Inch Miles of Sewer pipe (w/o services)

20.1 in-mi

Method 1 - NOT APPLICABLE FOR TEMPORARY METERS

Monthly Flow Data (mgd)			
	Annual Average	January	Peak Mo.
2004			
2005			
2006			

Calculated GPD per connection			
	Annual Average	January	Peak Mo.
2004	#DIV/0!	#DIV/0!	#DIV/0!
2005	#DIV/0!	#DIV/0!	#DIV/0!
2006	#DIV/0!	#DIV/0!	#DIV/0!

Method 2 - Assume early morning low flow is entirely infiltration (clear water)

May - September 2007

8/23/2007 Daily Flow		73,700 gpd
Dry Day - Early Morning Flow	1,200 gph	28,800 gpd
Net Wastewater		44,900 gpd
Infiltration rate: (EMF/in mi)		1,433 gpd/in mi
Wastewater per connection:		#DIV/0! gpd/connection

Peak Flow 8/28/07

Peak Hour Rate: 08:55 hrs	6,400 gph	0.154 mgd
Dry day flow at time	3,950 gph	0.095 mgd
INFLOW	2,450 gph	0.059 mgd
Normal Peak		0.100
Adjusted Peak		0.16 mgd
Calc. P/A Ratio		2.17
Inflow per connection	#DIV/0! gpd/connection	
Inflow per in mile	2,925 gpd/in mi	

Figure 5 - Arden Hills Site 2

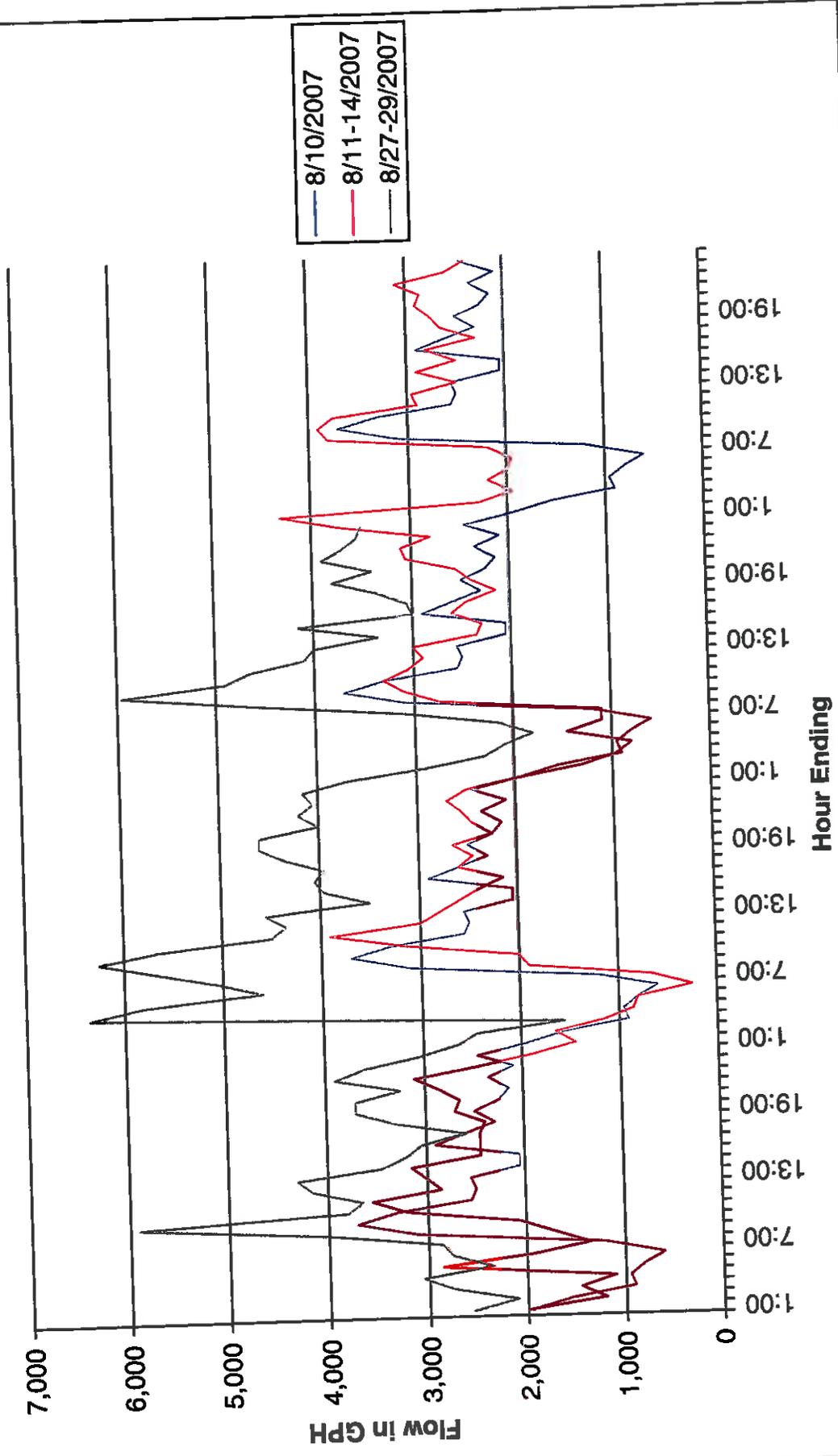


FIGURE 6 ESTIMATION OF INFILTRATION / INFLOW

Meter Shed **M3**

Estimated Residential Equivalent Connections
Inch Miles of Sewer pipe (w/o services)

38.9 in-mi

Method 1 - NOT APPLICABLE FOR TEMPORARY METERS

Monthly Flow Data (mgd)			
	Annual Average	January	Peak Mo.
2004			
2005			
2006			

Calculated GPD per connection			
	Annual Average	January	Peak Mo.
2004	#DIV/0!	#DIV/0!	#DIV/0!
2005	#DIV/0!	#DIV/0!	#DIV/0!
2006	#DIV/0!	#DIV/0!	#DIV/0!

Method 2 - Assume early morning low flow is entirely infiltration (clear water)

May - September 2007

8/23/2007 Daily Flow		133,050 gpd
Dry Day - Early Morning Flow	2,150 gph	51,600 gpd
Net Wastewater		<u>81,450 gpd</u>
Infiltration rate: (EMF/in mi)		1,326 gpd/in mi
Wastewater per connection:		#DIV/0! gpd/connection

Peak Flow 8/28/07

Peak Hour Rate:	03:55 hrs	11,100 gph	0.266 mgd
Dry day flow at time		2,550 gph	0.061 mgd
INFLOW		<u>8,550 gph</u>	<u>0.205 mgd</u>
Normal Peak			0.280
Adjusted Peak			0.49 mgd
Calc. P/A Ratio			3.68

Inflow per connection **#DIV/0!** gpd/connection
 Inflow per in mile **5,275** gpd/in mi

Figure 7 - Arden Hills Site 3

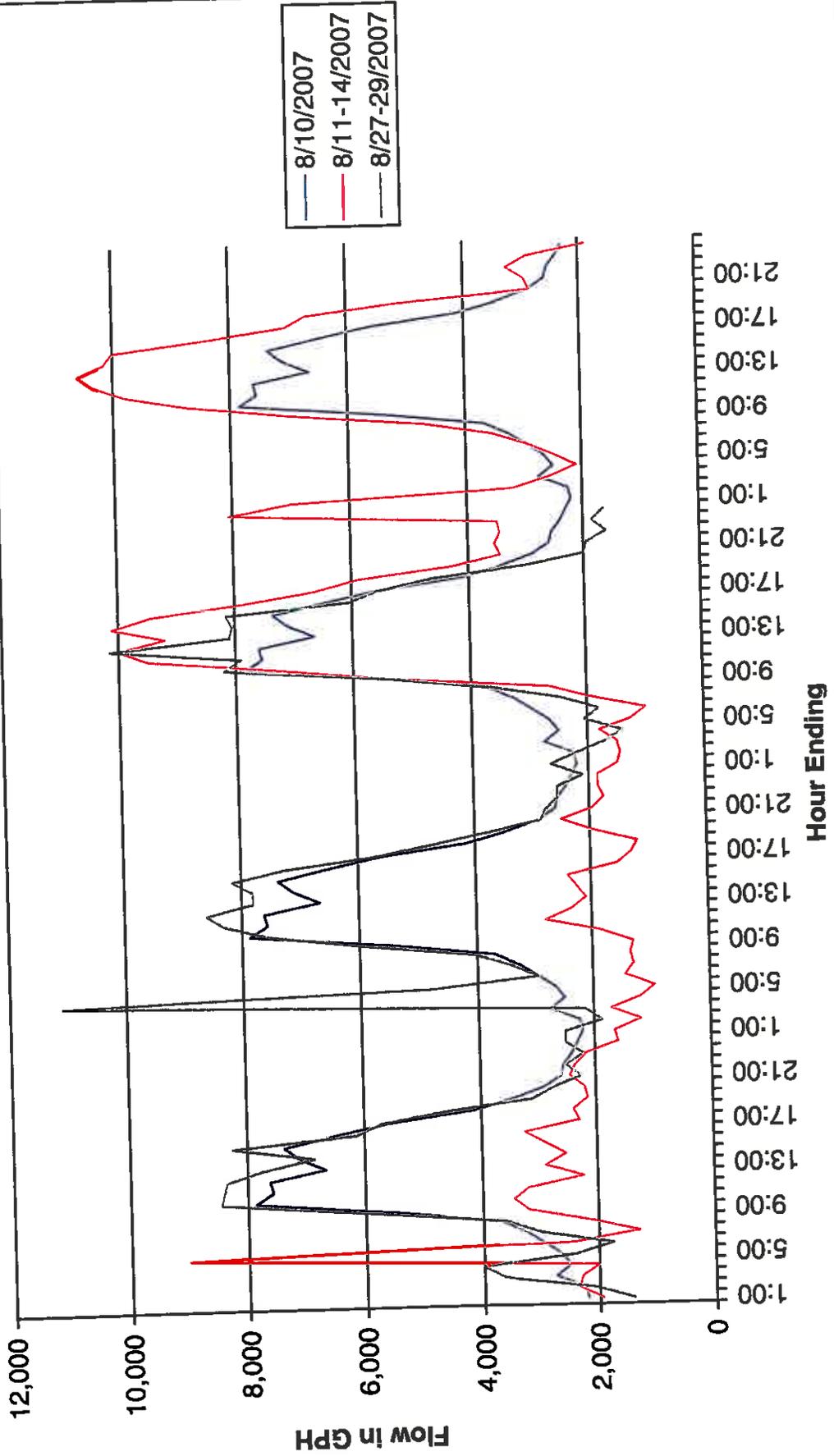


FIGURE 8 ESTIMATION OF INFILTRATION / INFLOW

Meter Shed **M052**

Estimated Residential Equivalent Connections
Inch Miles of Sewer pipe (w/o services)

112
13.6 in-mi

Method 1 - Assume no I/I in January

Monthly Flow Data (mgd)

	Annual Average	January	Peak Mo.
2004	0.039	0.030	0.047 June
2005	0.039	0.035	0.043 June
2006	0.038	0.036	0.043 Sep

I/I (mgd)	(MG annual)	(%)
0.009	3.29	23.08%
0.004	1.46	10.26%
0.002	0.73	5.26%
	5.48	12.87%

Calculated GPD per connection

	Annual Average	January	Peak Mo.
2004	348	268	420
2005	348	313	384
2006	339	321	384

2006 rate \$ 1,543
Total Cost \$ 8,448
Annual \$ 2,816

Method 2 - Assume early morning low flow is entirely infiltration (clear water)

May - September 2007

8/30/2007 Daily Flow **43,000** gpd
 Dry Day - Early Morning Flow **1,000** gph **24,000** gpd
 Net Wastewater **19,000** gpd
 Infiltration rate: (EMF/in mi) **1,765** gpd/in mi
 Wastewater per connection: **170** gpd/connection

Peak Flow 9/20/07

Peak Hour Rate: 19:00 hrs 4,302 gph 0.103 mgd
 Dry day flow at time 1,971 gph 0.047 mgd
INFLOW 2,331 gph 0.056 mgd
 Normal Peak 0.080
 Adjusted Peak **0.14** mgd
 Calc. P/A Ratio 3.26

Inflow per connection **500** gpd/connection
 Inflow per in mile **4,114** gpd/in mi

Figure 9 - Arden Hills M052

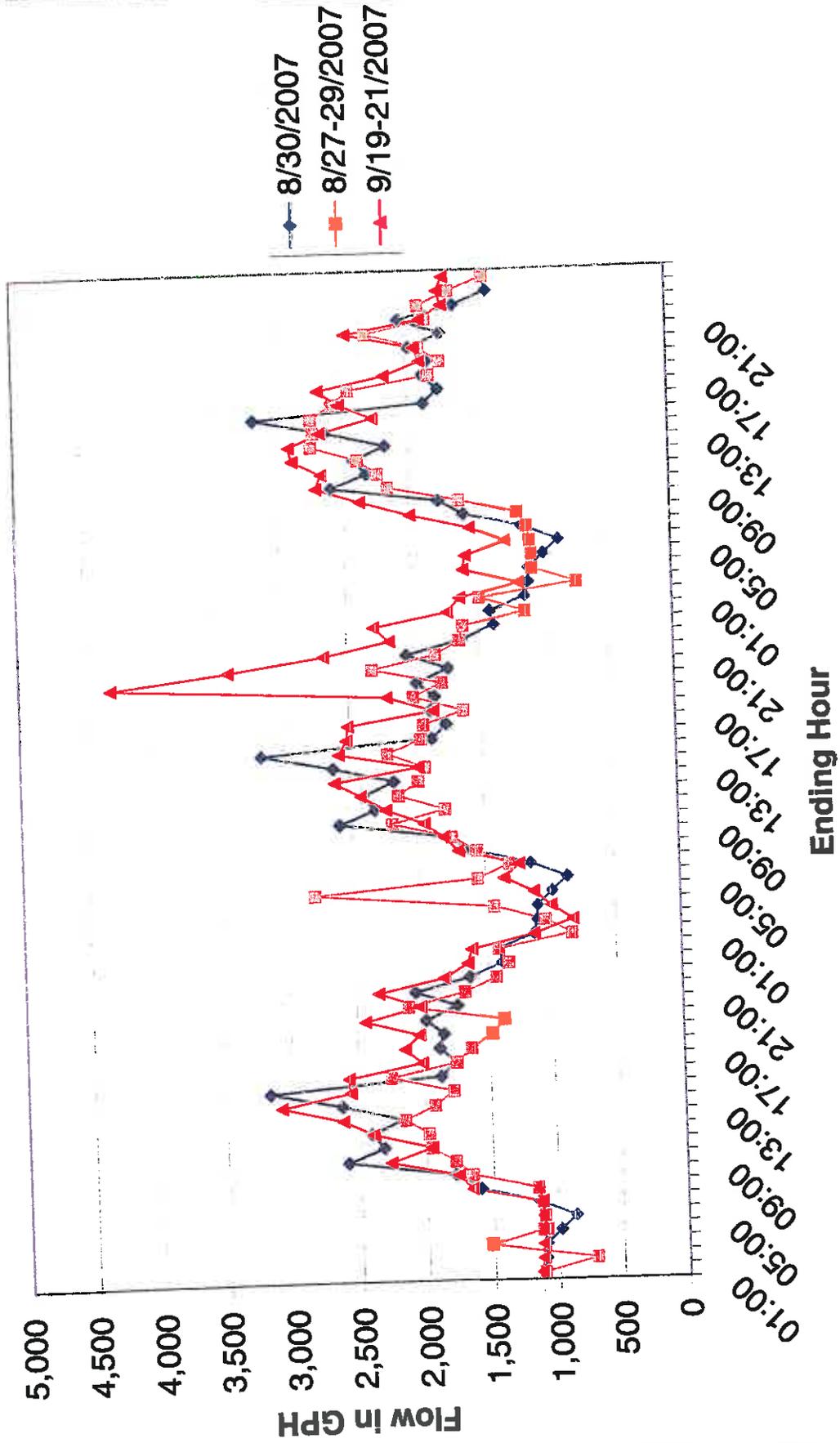


FIGURE 10 ESTIMATION OF INFILTRATION / INFLOW

Meter Shed **M054**

Estimated Residential Equivalent Connections **1079**
 Inch Miles of Sewer pipe (w/o services) **122.9** in-mi

Method 1 - Assume no I/I in January

Monthly Flow Data (mgd)

	Annual Average	January	Peak Mo.	I/I (mgd)	(MG annual)	(%)
2004	0.198	0.175	0.264 June	0.023	8.40	11.62%
2005	0.197	0.172	0.278 Oct	0.025	9.13	12.69%
2006	0.183	0.184	0.264 May	-	-	0.00%
					17.52	8.10%

Calculated GPD per connection

	Annual Average	January	Peak Mo.	2006 rate	Total Cost	Annual
2004	184	162	245	\$ 1,543	\$ 27,033	\$ 9,011
2005	183	159	258			
2006	170	171	245			

Method 2 - Assume early morning low flow is entirely infiltration (clear water)

May - September 2007

8/30/2007 Daily Flow **181,000** gpd
 Dry Day - Early Morning Flow **3,200** gph **76,800** gpd
 Net Wastewater **104,200** gpd
 Infiltration rate: (EMF/in mi) **625** gpd/in mi
 Wastewater per connection: **97** gpd/connection

Peak Flow 9/20/07

Peak Hour Rate: 20:00 hrs **23,767** gph **0.570** mgd
 Dry day flow at time **7,869** gph **0.189** mgd
INFLOW 15,898 gph **0.382** mgd
 Normal Peak **0.270**
 Adjusted Peak **0.65** mgd
 Calc. P/A Ratio **3.59**
 Inflow per connection **354** gpd/connection
 Inflow per in mile **3,105** gpd/in mi

Figure 11 - ArdenHills M054

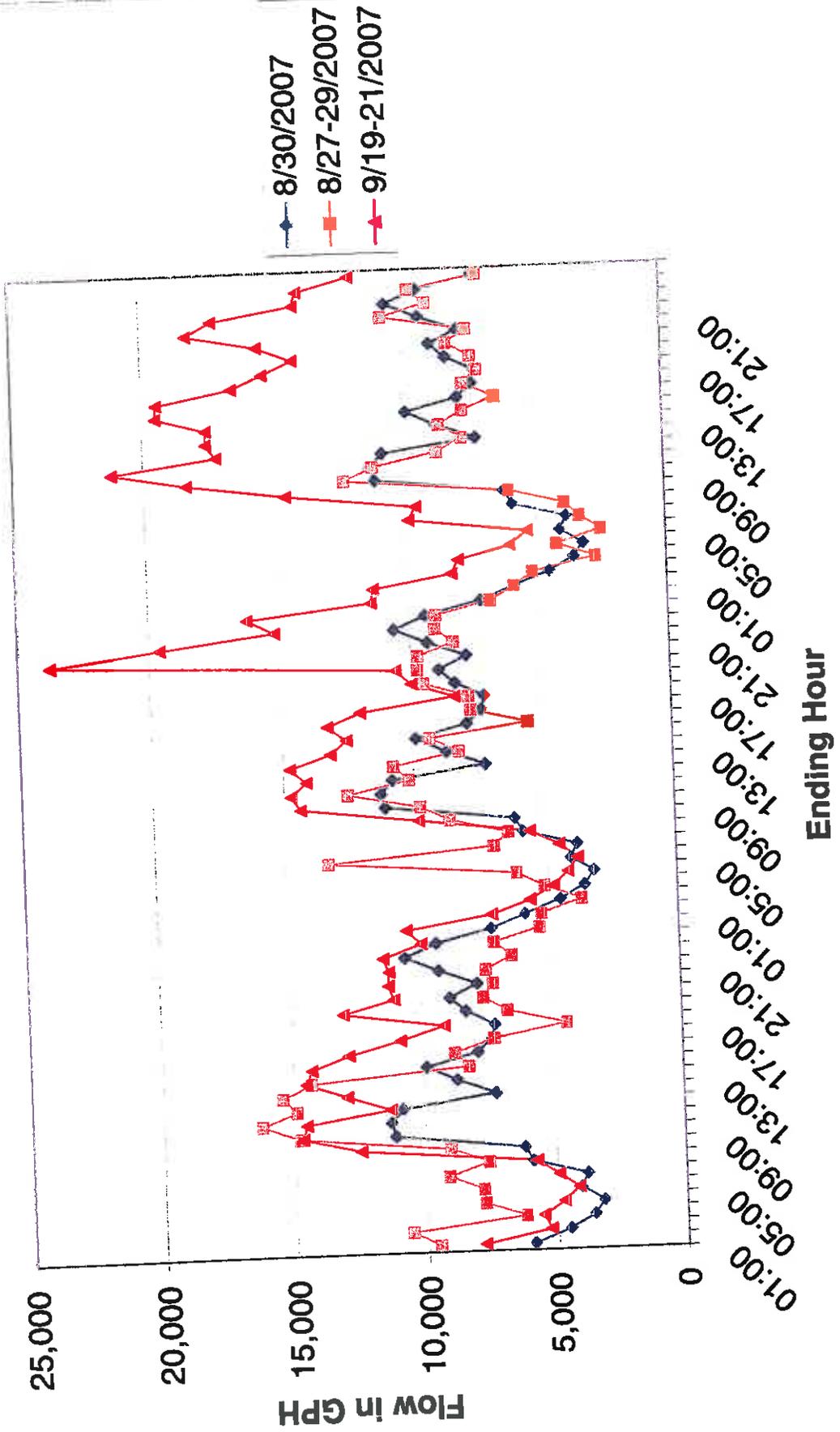


FIGURE 12 ESTIMATION OF INFILTRATION / INFLOW

Meter Shed **M059**

Estimated Residential Equivalent Connections **1149**
 Inch Miles of Sewer pipe (w/o services) **142.5** in-mi

Method 1 - Assume no I/I in January

Monthly Flow Data (mgd)

	Annual Average	January	Peak Mo.	I/I (mgd)	(MG annual) (%)
2004	0.317	0.313	0.371 June	0.004	1.46 1.26%
2005	0.312	0.310	0.337 Oct	0.002	0.73 0.64%
2006	0.286	0.321	0.380 May	-	- 0.00%
					2.19 0.63%

2006 rate \$ 1,543
 Total Cost \$ 3,379
 Annual \$ 1,126

Calculated GPD per connection

	Annual Average	January	Peak Mo.
2004	276	272	323
2005	272	270	293
2006	249	279	331

Method 2 - Assume early morning low flow is entirely infiltration (clear water)

May - September 2007

8/30/2007 Daily Flow **230,000** gpd
 Dry Day - Early Morning Flow **4,200** gph 100,800 gpd

 Net Wastewater 129,200 gpd

 Infiltration rate: (EMF/in mi) **707** gpd/in mi

 Wastewater per connection: **112** gpd/connection

Peak Flow 9/20/07

Peak Hour Rate: 20:00 hrs 57,398 gph 1.378 mgd
 Dry day flow at time 10,465 gph 0.251 mgd

 INFLOW **46,933** gph **1.126** mgd

 Normal Peak **0.320**
 Adjusted Peak **1.45** mgd
 Calc. P/A Ratio **6.30**

Inflow per connection **980** gpd/connection

Inflow per in mile **7,905** gpd/in mi

Figure 13 - Arden Hills M059

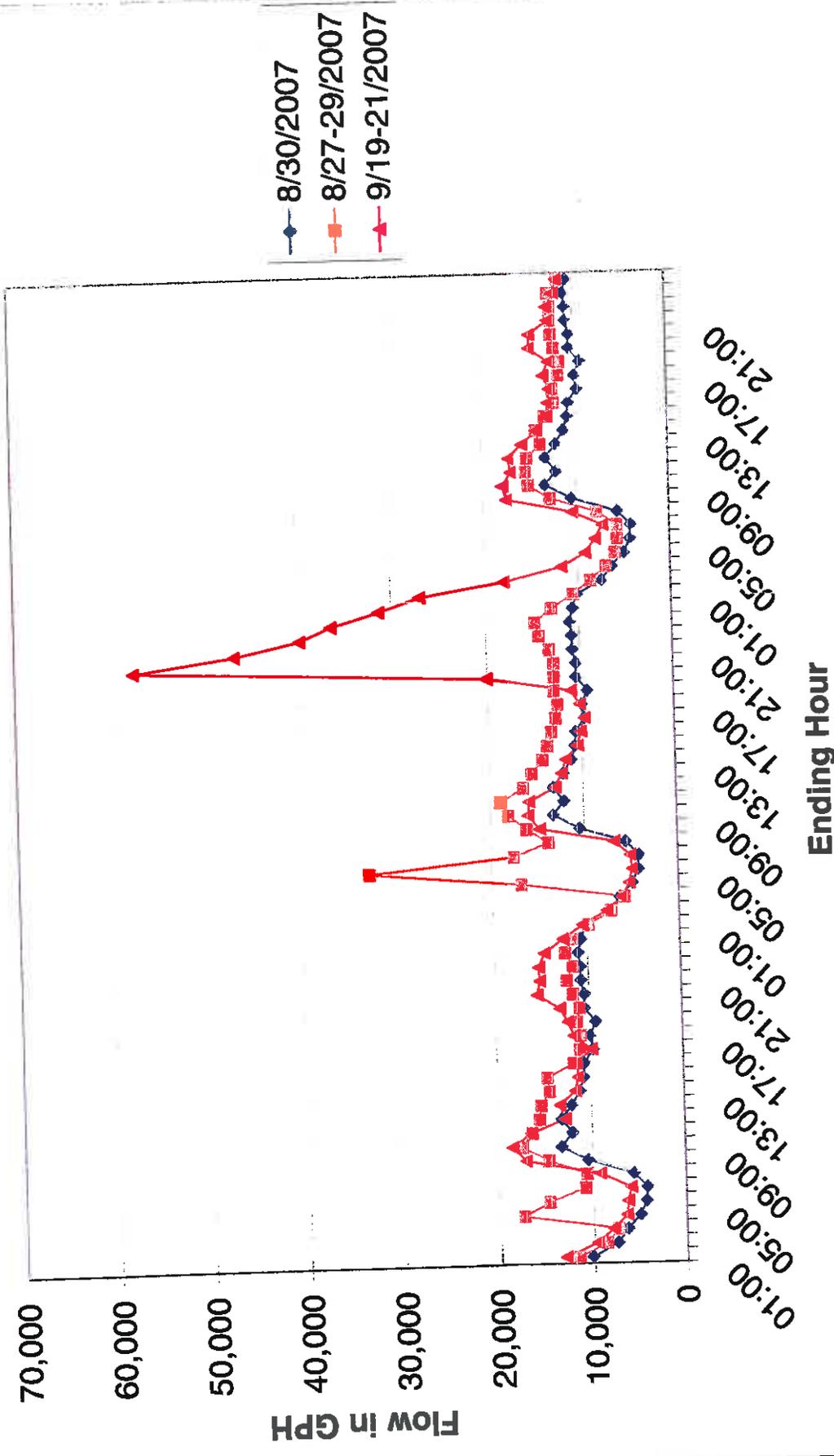


FIGURE 14 ESTIMATION OF INFILTRATION / INFLOW

Meter Shed **M1**

Estimated Residential Equivalent Connections
Inch Miles of Sewer pipe (w/o services)

77.4 in-mi

Method 1 - NOT APPLICABLE FOR TEMPORARY METERS

Monthly Flow Data (mgd)			
	Annual Average	January	Peak Mo.
2004			
2005			
2006			

Calculated GPD per connection			
	Annual Average	January	Peak Mo.
2004	#DIV/0!	#DIV/0!	#DIV/0!
2005	#DIV/0!	#DIV/0!	#DIV/0!
2006	#DIV/0!	#DIV/0!	#DIV/0!

Method 2 - Assume early morning low flow is entirely infiltration (clear water)

May - September 2007

8/23/2007 Daily Flow		419,500 gpd
Dry Day - Early Morning Flow	3,050 gph	73,200 gpd
Net Wastewater		<u>346,300</u> gpd
Infiltration rate: (EMF/in mi)		946 gpd/in mi
Wastewater per connection:		#DIV/0! gpd/connection

Peak Flow 8/28/07

Peak Hour Rate:	08:55 hrs	48,100 gph	1.154 mgd
Dry day flow at time		15,800 gph	0.379 mgd
INFLOW		32,300 gph	0.775 mgd
Normal Peak			0.750
Adjusted Peak			1.53 mgd
Calc. P/A Ratio			3.65
Inflow per connection		#DIV/0! gpd/connection	
Inflow per in mile		10,016 gpd/in mi	

