Detroit Water and Sewerage Department

Wastewater Master Plan

DWSD Project No. CS-1314

Dry Weather Flow from Footing Drains and Service Connections

Technical Memorandum
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Dry Weather Flow from Footing Drains and Service Connections

1. Purpose of Analysis

Based on 2000 population and two years of metering data from 1997 to 1999, the Detroit Wastewater Treatment Plant (WWTP) treats nearly 568 million gallons of sewage on the average dry weather day. Estimates presented in Volume 1 of the Wastewater Master Plan (WWMP) break this flow into component parts by percent. 41% of the flow is from residential domestic waste sources; 7% is waste from significant industrial users; 16% is generated by other industrial and commercial sources; and less than 1% is septage. However, the second largest single source of flow to the treatment plant on dry weather days is infiltration, or water entering the collection system from groundwater through defects in the pipe network, or from footing drains connected to the sanitary or combined sewers. 35% of the average day's dry weather flow, or about 198 million gallons, is dry weather infiltration and inflow that must be treated by the Detroit WWTP. The chart presented in Figure 1 shows the composition of dry weather flow at the Detroit WWTP.

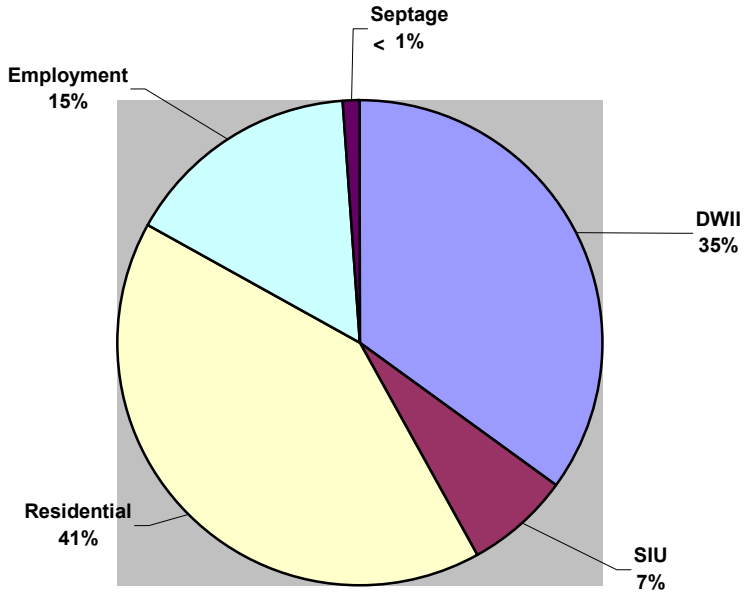

Figure 1. Composition of dry weather flow at the Detroit WWTP.

The purpose of this technical memorandum is to generally identify the areas where footing drains from homes are connected to the collection system and to evaluate the magnitude of dry weather flows generated from this source.

Also of importance to evaluating dry weather infiltration to the collection system are the thousands of miles of service connections tributary to the "public" collection system. These "house leads" connect the plumbing within a home or other structure to the community lateral sewers.

Individually they might seem insignificant to a collection system the size of Detroit's; however, collectively they may have as much impact as any other source of infiltration.

It is estimated that the total length of service connections equals, if not exceeds, the total length of public sewer within the collection system.

2. Basis of Analysis

Limited historical information is available to assist in the quantification of dry weather flows from these sources. Most prior work has been done as part of sewer system evaluation surveys (SSES) in attempts to address excessive wet weather flows cost effectively. Standard design procedures even suggest that sewers be designed with capacity to handle "normal infiltration." Past studies conducted for DWSD and a number of suburban communities were reviewed in an attempt to quantify these sources of flow. Additionally, there were efforts being undertaken, as part of the SSO studies performed as part of this Master Plan and as part of a sewer study undertaken in Ann Arbor, Michigan, which attempted to better quantify the volumes of footing drain flow that can be expected to be generated. The estimates relied heavily on this ongoing work, which was still in progress when this technical memorandum was originally published.

Information on quantities of footing drain flow was extracted from four suburban studies: three in Oakland County, and one in the Grosse Pointes. The first Oakland County D.P.W. report from August 1967 is entitled "Drain Tile – Test Pilot Projects" and compared sewer flow metered data from residential subdivisions with and without footing drain connections. The second was entitled "Footing Drain Tile Report #2" and compared flows from six areas with connected footing drains to three areas without connected footing drains. These studies were primarily focused on wet weather flow evaluation, but certain dry weather data was included.

The Appendix to the Facilities Plan for Grosse Pointe Park, Grosse Pointe Shores, Grosse Pointe City, and Grosse Pointe Farms made an attempt to quantify footing drain flows in three of the four communities through measurement of flows connected directly to accessible structures within the community.

An October 1999 report entitled "Sump Pump Removal Program Evaluation, Village of Beverly Hills" was prepared by Hubble, Roth and Clark, Inc. The report documented a study performed to quantify flow removed from the collection system after disconnecting sump pumps.

It included flow monitoring of a subdivision for one year before and five years after 63 of 83 homes had their sump pumps disconnected from the sanitary sewer. Estimates of both dry weather and wet weather flows could be derived from this report.

While the scope of this master planning effort does not allow for the empirical evaluation of footing drain flows as a means for reducing dry weather flow, two ongoing efforts for which similar data has recently been collected became available for review. One is an evaluation of sewer capacity and basement flooding problems within the city of Ann Arbor. For this study, monitoring of the collection system in problem prone areas was undertaken. The flow data allowed certain extrapolation of quantities of flow attributable to footing drains during both wet and dry weather periods. Also, since Ann Arbor is in the process of removing footing drain connections from its collection system, some data collected directly from disconnected sump pumps is becoming available.

Finally, a footing drain monitoring program has been initiated under this WWMP in an attempt to demonstrate the magnitude of impact that connected footing drains have to system capacity, especially during wet weather when SSO events are of concern. This program relies on volunteer households to install monitors within the discharge line from their sump pumps. Flows collected from footing drains into the sump are measured as they are pumped to the surface for discharge. So far, only limited data is available from this work, but dry weather flow estimates to date have been used to assist in this effort.

Much less, field-measured data is available to quantify dry weather inflows from service connections. Service connection estimates relied more heavily on projections based on length of service lines and age as a measure of condition.

3. Assumptions and Methods

Much of the basis for establishing base DWII by area relied on the metering and analysis performed by CDM under CS-1249, the GDRSS modeling effort. This study divided the collection system into districts for the purpose of metering flows and modeling the collection system and its response to dry and wet weather flows. These districts are shown in Figure 2. Based upon this work, the total DWII seen at the wastewater treatment plant has been distributed to each “source district” based on metered flows. Table 1 shows the DWII flows attributable to each meter district.

For each district, population and number of households were established from SEMCOG data within the WWMP GIS database. Specific information was solicited from local suburban system operators to determine which portions of the area were served by footing drains connected to the system. If available, actual areas identifying connected portions of the community were entered into the GIS database. For other communities, only estimates of percent connected were available. Within the City of Detroit, all homes are assumed to have connected footing drains.

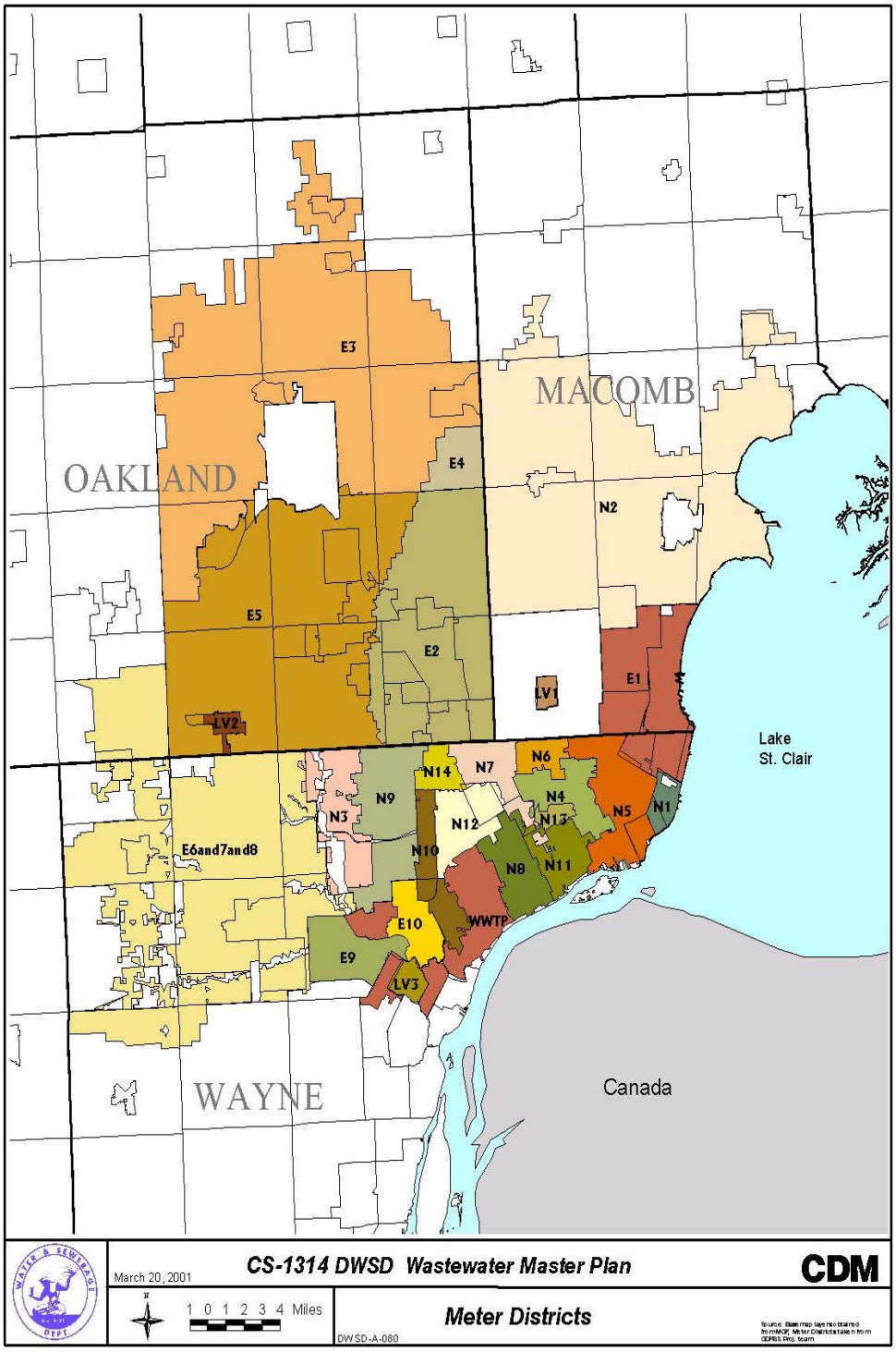

Figure 2. Meter Districts

Table 1. Dry Weather Infiltration/Inflow by district.

Suburban Areas	DWII (MGD)	City Areas	DWII (MGD)
E1	4.45	N10	13.02
E10	0.75	N11	8.76
E2	7.61	N12	5.00
E3	7.54	N13	0.98
E4	0.13	N14	2.92
E5	9.12	N3	10.83
E6_E7_E8	11.18	N4	8.07
E9	4.84	N5	19.06
LV1	0.06	N6	4.56
LV2	0.14	N7	9.28
LV3	0.18	N8	11.57
N1	3.62	N9	9.33
N2	6.34	WWTP	38.76
		TOTAL MGD (City & Suburban)	198.10

Based on these maps and/or community percentages, the GIS was used to combine municipal, footing drain, and meter district data and determine the number of footing drains estimated to be connected within each meter district. Table 2 presents these estimates.

Next, it was intended to determine the portion of the dry weather infiltration flows attributable to footing drains. For this, an average daily quantity of flow from footing drains during dry weather was estimated. Results from the studies cited above were collected and condensed to a common reporting format: Gallons per Household per Day (g/hh/d).

It is understood that conditions affecting footing drain flow vary widely throughout the area served by DWSD. The intent of this analysis is not to attempt to precisely establish footing drain flow contribution by community. In fact, flows can and will vary both between and within communities. More in-depth analysis at the local level would be required to reach community-by-community conclusions. Rather, the focus of our effort is to establish a range of potential flow reductions that could be realized by removal of footing drain flows from the sanitary sewer system.

Table 2. Footing Drain Households by District.

Suburban Areas	Households w/ FD
E1	45,457
E10	3,652
E2	256
E3	1,932
E5	47,241
E6and7and8	24,054
E9	13,317
LV1	3,646
LV2	15
LV3	4,657
N1	4,755
N2	22,781

City*	Households w/ FD
N10	29,246
N11	22,303
N12	39,380
N13	3,837
N14	13,161
N3	37,982
N4	22,876
N5	53,153
N6	9,047
N7	26,669
N8	33,494
N9	65,153
WWTP	38,101
TOTAL	**566,166**

Table 3 summarizes the results from the historical studies we have referenced along with interim results from the Ann Arbor work and the SSO sump pump monitoring. The data extracted from the two Oakland County reports suggests that up to 263 g/hh/d could be attributed to footing drain flow. The Beverly Hills report indicated an estimate of 206 g/hh/d from footing drains. The Grosse Pointes facility plan measured 364 g/hh/d in March and only 140 g/hh/d in July within Grosse Pointe Park. One measurement (September) in Grosse Pointe City resulted in 109 g/hh/d. And, in Grosse Pointe Farms flows of 220 g/hh/d (March) and 100 g/hh/d (August) were reported.

Fifteen installations in Ann Arbor were monitored. Over the monitoring period, the minimum average dry weather flow observed was 54 g/hh/d, while the maximum was 523 g/hh/d. Overall, the average observed flow was 177 g/hh/d. It might be noteworthy that these measurements were from a problem area within that city.

Currently, nine flow monitors are in place as part of the SSO study being performed under this master planning effort. Data to date is limited, but noteworthy in its variability. Of the nine monitors in place, three have recorded no flow thus far during dry weather periods. Yet, one recorded an average of 1,819 g/d. Discounting this extreme value, these flows average under 100 g/hh/d, under 120 g/hh/d discounting those locations where no flow was recorded.

Table 3. Compliation of Historical Reports and Ongoing Studies Attempting to Quantify Dry Weather Footing Drain Flows

	Study Area	Date	Estimated Footing Drain Flows [g/hh/d]
Historical Data	Oakland County	1967 - 68	263
	Grosse Pointe Park	March-77	364
		July-77	140
	Grosse Pointe City	September-77	109
	Grosse Pointe Farms	March-77	220
		August-77	100
	Beverly Hills	1999 report	206
Ongoing Field Measurements	Ann Arbor #1		126
	Ann Arbor #2		231
	Ann Arbor #3		98
	Ann Arbor #4		161
	Ann Arbor #5		118
	Ann Arbor #6		60
	Ann Arbor #7		206
	Ann Arbor #8		144
	Ann Arbor #9		523
	Ann Arbor #10		197
	Ann Arbor #12		54
	Ann Arbor #13		62
	Ann Arbor #14		281
	Ann Arbor #15		215
	Ann Arbor Average		**177**
	DWSD Area #1		0
	DWSD Area #2		0
	DWSD Area #3		97
	DWSD Area #4		1819
	DWSD Area #5		9
	DWSD Area #6		0
	DWSD Area #7		225
	DWSD Area #8		239
	DWSD Area #9		21
	DWSD Average [without #4]		**74**
	DWSD Average [without #1,2,4,6]		**118**
PROPOSED RANGE OF FLOWS FOR MASTER PLANNING			**100 to 150**

Based on these observations, and recognizing that we are looking at potential flow reductions over the entire collection system, we feel that average footing drain contributions of 100 to 150 gallons per household per day may be likely.

While these values may appear insignificant, recognize that the Master Planning effort is basing residential domestic flow at 77 gallons per capita per day. Thus, on average, removing footing drain flows would be the equivalent of reducing each household population by between 1.25 and 2 persons. The current average household size throughout the study area is only 2.3 persons.

Table 4 applies this range of potential footing drain contributions to each meter district, and computes the potential percent of dry weather inflow that may be attributable to footing drains. Within only the suburban communities, about 172,000 homes are estimated to have connected footing drains. This equates to between over 17 and almost 26 MGD in dry weather footing drain derived flow that must be treated at the Detroit WWTP. System-wide, about 570,000 households are estimated to have footing drains connected to the collection system. In total, dry weather infiltration of between 57 and 85 MGD may be attributable to footing drain connections. This represents between 29% and 44% of estimated total DWII.

Similar contributions may be expected from service connections, though there is little analytical data to substantiate the values. Volume 2 of the WWMP estimated that a total of 12,150 miles of sanitary and combined sewer make up the public sewage collection system tributary to the Detroit WWTP.

However, this is only the portion of the system in public ownership. The largest portion of the collection system, in terms of total miles of pipeline, is the service connections. Each home, business or industry that contributes sanitary flow to the system is connected by a service connection that runs from the home or business interior plumbing to a lateral sewer, usually in a street or alley adjacent to the property.

By far the largest numbers of these connections are the residential lines connecting each of the 1.16 million households in the service area to the collection system. It is estimated that over 16,372 miles of service connections, mostly on private property, are connected to the collection system.

An estimate of the total length of service connections in each meter district, and collectively through out the system was made. This estimate was made by applying a standard estimated average length to all homes constructed within a time frame. Time frames were chosen to reflect both approximate lot size and construction materials / techniques. SEMCOG data within the master plan database was used to determine the number of homes constructed in or before 1945, from 1946 through 1975, and in or after 1976.

Table 4. Potential Footing Drain DWII by Districts.

Suburban Areas		Value 100-150 g/hh/d Values in MGD		
E1		4.55	to	6.82
E10		0.37	to	0.55
E2		0.03	to	0.04
E3		0.19	to	0.29
E5		4.72	to	7.09
E6 and E7 and E8		2.41	to	3.61
E9		1.33	to	2
LV1		0.36	to	0.55
LV2		0.0015	to	0.0023
LV3		0.47	to	0.7
N1		0.48	to	0.71
N2		2.28	to	3.42
	Subtotal	17.18		25.76
City*				
N10		2.92	to	4.39
N11		2.23	to	3.35
N12		3.94	to	5.91
N13		0.38	to	0.58
N14		1.32	to	1.97
N3		3.8	to	5.7
N4		2.29	to	3.43
N5		5.32	to	7.97
N6		0.92	to	1.36
N7		2.67	to	4
N8		3.35	to	5.02
N9		6.52	to	9.77
WWTP		3.81	to	5.72
	Subtotal	39.44		59.16
Total MGD		56.62		84.92

An average service connection length of 50 feet was applied to all homes built before 1945; 75 feet to those built between 1946 and 1975; and 100 feet to homes built since 1976. Based on these estimates, 1,889 miles of service connections were installed prior to 1946; 11,292 miles were installed between 1946 and 1975; and 3,192 miles were constructed since 1976. Thus, an estimated total of 16,372 miles of residential service connection lines are tributary to the Detroit collection system. Table 5 presents estimates of the total lengths of service connections by district.

Table 5. Length of Service Connections by District.

District	Total Households	Constructed before 1945 Services (mi)	Constructed between 1946 & 75 Services (mi)	Constructed after 1976 Services (mi)
E1	72618	13.75	979.93	41.26
E10	13177	72.37	76.74	2.50
E2	124563	141.55	1503.96	70.77
E3	95609	27.16	950.66	488.91
E4	7481	0.00	32.94	97.76
E5	115032	10.89	1143.78	631.80
E6_E7_E8	185434	17.56	2186.22	561.92
E9	19482	25.83	237.99	0.00
LV1	3772	0.00	49.29	5.72
LV2	3797	0.00	53.40	0.72
LV3	4499	4.26	57.52	0.00
N1	5800	39.00	23.89	0.00
N10	26790	192.81	91.33	0.00
N11	19185	145.34	43.60	14.53
N12	32227	265.51	54.93	6.10
N13	2938	20.59	10.85	0.00
N14	13154	66.02	87.82	0.00
N2	157067	0.00	1316.33	1219.65
N3	34042	9.67	469.04	0.00
N4	19425	68.06	173.83	0.00
N5	49252	158.58	461.74	0.00
N6	9304	2.64	128.19	0.00
N7	23210	145.06	112.09	0.00
N8	28106	154.37	139.73	37.26
N9	62501	53.27	807.90	0.00
WWTP	34464	254.56	97.91	13.05
Total	**1162929**	**1888.85**	**11291.62**	**3191.97**

Service connections, especially in older areas, are notorious for misaligned joints, major cracks or breaks, and potentially significant tree root damage. All of these conditions lead to development of major sources of infiltration. Some study of wet weather infiltration through service connections has been made in other parts of the country, but no significant effort has been made to quantify dry weather infiltration from this source.

In order to estimate the potential volume of DWII entering the system from these sources, a baseline level of infiltration was established. This was assumed to be the "allowable level of infiltration for newly constructed sewers", as contained in the Ten States Standards. This allowance is 200 gallons per day per inch diameter per mile of sewer. Commonly referred to as 200 gallons per inch mile (gal/in/mi).

In areas where public sewer rehabilitation has been performed, the connection between the service connection and the sewer lateral has been noted as a particularly problematic location for infiltration. These were especially significant if pre-planned connections (sewer "Ys") were not used to connect the service, and taps were made directly to the side of the public sewer pipe. In these cases, a poor to non-existent seal is observed where the pipes connect, and flow from water in the service and lateral bedding material can readily enter the collection system. Where local water table elevation is higher than the service connection, a direct pathway for infiltration exists.

Service connections installed prior to 1945 are almost universally made of clay pipe without gasketed connections. Whatever packing was used to seal joints [if any] is likely deteriorated. In the worst of cases, these lines then can be considered to be acting as open joint pipe and thus demonstrating essentially the attributes of open joint tile footing drains. Water entering any granular bedding or backfill material surrounding the service connection would be drained through the joints into the sewer. Where service connections are below the water table high volumes of groundwater can enter the collection system through the deteriorated service connections.

Due to their age, methods and materials of construction, and the deteriorated state found where service connections of this period have been inspected, an infiltration rate of 150% to 400% of the standard was applied to service connections installed in 1945 and before. This is a rate of 300 to 800 gal/in/mi.

Within the study area, local DPWs have different approaches to service connection issues. Most assess the status of connections only or a case-by-case basis when problems are identified. The problem is often first identified by the homeowner when sewer backup occurs. Most communities will send a crew to investigate the problem and determine if a blockage exists within the public lateral sewer. If not, the homeowner is told that the problem is within the service connection and told a plumber/sewer cleaning contractor needs to be contacted. In other communities, such as Garden City, crews are able to inspect the service connections using CCTV equipment. For these inspections, it can be determined if blockage is from debris, root infestation, or pipe deterioration. Root infestation and broken/collapsed pipe are commonly found. These conditions cause both localized blockage problems and contribute to high infiltration rates.

The problem of deteriorated service connections exists nationwide. The City of Livermore, CA has identified root mass inside service connections as a major cause of structural damage to service connections and requires replacement when the problem is identified. In Sarasota, FL the city has determined that inflow/infiltration from service connections is the largest single source in the city. They are conducting a pilot project on 324 homes where service connections will be replaced via pipe bursting and installing new high-density polyethylene (HDPE) pipe.

Service connections to homes built between 1946 and 1975 were still likely to be clay pipe.

However, construction during this period typically used premium [rubber gasket] joints. Also, direct taps to lateral sewers were less likely because homes were being constructed more commonly in designed subdivisions, where sanitary "Ys" could be located at each lot. For service connections constructed between 1946 and 1975, we have assumed an infiltration rate of 200 to 300 gal/in/mi. This value is equal to 100% to 150% of the allowable rate of infiltration for newly constructed sewers under the Ten States Standards.

Since 1975, the majority of house leads have been constructed using welded joint plastic pipe. At the time of construction, these lines should experience virtually no infiltration. And, if properly connected to the lateral sewer, they should have minimal infiltration at the sewer "Y." However, over time, even these tight lines can begin to see extraneous flows. Longitudinal cracking has been noted in various degrees on plastic service connections that have been replaced.

Once started, even the smallest crack provides a pathway for root intrusion, and further cracking. While these newest connections are likely the tightest, many of the installations have been in service for 25 or more years and need to be considered as a source of DWII. For planning purposes, it was assumed that infiltration into service connections constructed since 1975 occurs at a rate of 100 to 150 gallons per inch mile of sewer, which is equal to 50% to 75% of the maximum allowable for newly constructed sewers under the Ten States Standards.

Based on the assumed infiltration rates described above, we have computed potential infiltration quantities associated with service connections by district. Table 6 presents an estimate of the DWII potentially associated with leaking service connections by district. Again, these values are presented to assist in conceptualizing the magnitude of flows potentially entering the collection system from this source. It is beyond the scope of this study to determine the specific impact of infiltration to service connections on a community-by-community basis.

Table 6. Potential DWII from Service Connections

		DWII Flow Contribution of Service Connections (Values in MGD)		
Suburban Areas		Service Connections		
E1	4.45	0.82	to	1.24
E10	0.75	0.15	to	0.33
E2	7.61	1.40	to	2.30
E3	7.54	0.99	to	1.52
E4	0.13	0.07	to	0.10
E5	9.12	1.18	to	1.79
E6_E7_E8	11.18	1.99	to	3.02
E9	4.84	0.22	to	0.37
LV1	0.06	0.04	to	0.06
LV2	0.14	0.04	to	0.06
LV3	0.18	0.05	to	0.08
N1	3.62	0.07	to	0.15
N2	6.34	1.54	to	2.31
Subtotal		*8.56*		*13.34*
City Areas				
N10	13.02	0.30	to	0.73
N11	8.76	0.22	to	0.53
N12	5.00	0.36	to	0.92
N13	0.98	0.03	to	0.08
N14	2.92	0.15	to	0.32
N3	10.83	0.39	to	0.59
N4	8.07	0.22	to	0.43
N5	19.06	0.56	to	1.06
N6	4.56	0.11	to	0.16
N7	9.28	0.26	to	0.60
N8	11.57	0.31	to	0.68
N9	9.33	0.71	to	1.14
WWTP	38.76	0.39	to	0.94
Subtotal		*4.02*		*8.17*
TOTAL MGD	198.10	12.58		21.51

4. Conclusions and Recommendations

Review of historical data, ongoing studies, and system monitoring / modeling have pointed to the fact that a significant portion of the flows within the Detroit collection system during dry weather periods are the result of infiltration. On an average dry weather day, this totals about 198 MGD, or 36% of total flow treated at the WWTP.

As redevelopment within the current service area and expansion of the service area occurs, additional demands for treatment capacity will have to be met.

As an alternative to construction of new or expanded treatment facilities, reduction of extraneous infiltration to the system should be considered.

Major sources of dry weather infiltration to the Detroit collection system are footing drains that are connected to sanitary or combined sewers and leaks in service connections, which in total make up half of the total length of sewage conveyance structures within the service area.

The potential infiltration contributions from footing drains and service connections together with total estimated DWII have been summarized by district in Table 7. It needs to be realized that these are projections of potential flows based on system-wide averages applied to individual districts. Detailed community-by-community analysis will be required to specifically quantify infiltration related flow in any specific area.

Certain differing approaches to reduction of dry weather infiltration may need to be implemented within the City of Detroit in contrast to approaches used in suburban communities. For example, wholesale disconnection of footing drains within the City may not be practical since there is no practical alternative conveyance for these flows.

Standards for new construction outside the City of Detroit currently do not allow connection of footing drains to the sanitary sewers. Significant reductions in total system infiltration could be realized if existing footing drains are disconnected from the system over time. Between 17 MGD and 26 MGD of treatment capacity could be "re-claimed", if the suburban communities redirect all of the estimated current footing drain flow away from the sewer system.

Table 7. Summary of Estimated Footing Drain and Service Connection Flows.

		DWII Contribution Range 100-150 g/hh/d Values in MGD		DWII Contribution Service Connection Total Values in MGD	
Suburban Areas		Footing Drains		Service Connections	
E1	4.45	4.55 to	6.82	0.82 to	1.24
E10	0.75	0.37 to	0.55	0.15 to	0.33
E2	7.61	0.03 to	0.04	1.40 to	2.30
E3	7.54	0.19 to	0.29	0.99 to	1.52
E4	0.13	no footing drains		0.07 to	0.10
E5	9.12	4.72 to	7.09	1.18 to	1.79
E6_E7_E8	11.18	2.41 to	3.61	1.99 to	3.02
E9	4.84	1.33 to	2.00	0.22 to	0.37
LV1	0.06	0.36 to	0.55	0.04 to	0.06
LV2	0.14	0.0015 to	0.0023	0.04 to	0.06
LV3	0.18	0.47 to	0.70	0.05 to	0.08
N1	3.62	0.48 to	0.71	0.07 to	0.15
N2	6.34	2.28 to	3.42	1.54 to	2.31
City Areas					
N10	13.02	2.92 to	4.39	0.30 to	0.73
N11	8.76	2.23 to	3.35	0.22 to	0.53
N12	5.00	3.94 to	5.91	0.36 to	0.92
N13	0.98	0.38 to	0.58	0.03 to	0.08
N14	2.92	1.32 to	1.97	0.15 to	0.32
N3	10.83	3.80 to	5.70	0.39 to	0.59
N4	8.07	2.29 to	3.43	0.22 to	0.43
N5	19.06	5.32 to	7.97	0.56 to	1.06
N6	4.56	0.90 to	1.36	0.11 to	0.16
N7	9.28	2.67 to	4.00	0.26 to	0.60
N8	11.57	3.35 to	5.02	0.31 to	0.68
N9	9.33	6.52 to	9.77	0.71 to	1.14
WWTP	38.76	3.81 to	5.72	0.39 to	0.94
TOTAL MGD	198.10	56.62	84.92	12.58	21.51

Policy should be considered that would require disconnection of footing drains, either as a community-wide program (as is the case in Ann Arbor) or at the time property changes ownership, or some other approach.

Although not as easily quantifiable, infiltration from service connections unnecessarily burdens the treatment capacity of the Detroit WWTP. Privately owned service connections are seldom inspected, and are usually only maintained when blockages occur. Within only the suburban communities, up to 13.3 MGD of treatment capacity may be taken up by infiltration to service connections. Up to of an additional 8 MGD is likely to be due to infiltration entering service connections within Detroit.

Policy should be considered that would require periodic inspection of service connections, at least at the time property changes ownership, and establish accountability for the cost of the repair or replacement of the line if conditions warrant.

Within the City of Detroit, an extensive study of infiltration and inflow sources is part of the WWMP project. It is critical that this study address dry weather infiltration as well as I/I from wet weather sources. While the contract for the I/I study does not set any specific goals to quantify the anticipated results and the contractor has not indicated a target for reduced flows, some level of quantification is needed for master planning purpose. Collection systems with older infrastructure have historically provided the most opportunities for reduction of I/I sources. These sources can then be readily assessed as to their cost effectiveness. Wet weather I/I reductions are usually more easily identified and implemented. Yet, these improvements will also yield a measure of dry weather improvement. For the purpose of the WWMP, it is assumed that a reduction in dry weather infiltration of between 15% and 20% may be able to be effected by implementation of the I/I study findings.

Suburban flows attributable to dry weather infiltration total approximately 55 MGD and between 26 MGD and 39 MGD can be reasonably assigned to footing drain and service connection sources. Through recommended disconnection and inspection, these values can be expected to decrease by about 50%.

If City of Detroit I/I efforts are able to reduce dry weather infiltration by 21 to 28 MGD and suburban systems can reduce dry weather footing drain/service connection inflow to 50% of current estimated values (13 MGD to 19 MGD), then a total "reclaimed" treatment capacity from Detroit and suburban sources of 34 MGD to 47 MGD may be achieved.