WRIGHT-PIERCE
Engineering a Better Environment

TECHNICAL MEMORANDUM

TO:	Pete Clark, Town of Falmouth	DATE:	June10, 2008
FROM:	Paul Birkel, W-P	PROJECT NO.:	10876C
SUBJECT:	Falmouth on The Green - Sewer Study		

1.0 Introduction

The Town of Falmouth retained Wright-Pierce (W-P) to conduct a limited sewer system evaluation study on the sewer system owned and operated by the Falmouth on the Green (FOG) Homeowners Association. The purpose of this study was to define the likely causes of high system flows during periods of high groundwater, snow melt and wet weather conditions. With this information in hand, the FOG Homeowners Association can make improvements to the system that will ready it for final acceptance by the Town.

1.1 Background

Over the past few years, the Town has been asked to accept the FOG sewer system infrastructure by the FOG Homeowner's Association. The Town has delayed such acceptance due to concerns associated with peak hydraulic loading during periods of high groundwater, snow melt and wet weather events. Once accepted, the Town will be responsible for all future expenditures for operations, maintenance and eventual upgrades associated with the sewers and pumping stations. Thus, it is important to the Town that extraneous flows, above and beyond that acceptable for a system of this age, be removed from the sewer system and that any major deficiencies be corrected by the FOG Homeowner's Association before accepting the system as a public asset.

Falmouth on the Green is served by a mix of gravity sewer and low pressure sewer force mains. The collection system discharges to five wastewater pump stations with the final station, Baltusrol Pump Station, discharging through a long force main on Winn Road and into the public sewer system. The original Falmouth on the Green system was a septic tank effluent collection system. Each home had its own septic tank for gravity deposition and degradation of wastes. Effluent from each septic tank ultimately reached the Leachfield Pump Station where it was distributed over several subsurface effluent disposal fields. Failure of that disposal system led FOG to fund the construction of a sewer force main along Winn Road and redirection of all flows to the Baltusrol Pump Station for subsequent pumping into this force main and into the public sewer system. With the connection to the public system, the vast majority of the individual septic tanks remained in service.

In February 2007, Wright-Pierce issued a technical memorandum that defined the baseline water consumption within FOG and established the acceptable peak day wastewater rates that included an allowance for acceptable inflow and infiltration. During this evaluation we also made several

observations after reviewing various reports and assessments completed on the collection system. In our memorandum, we suggested that the main source of extraneous water may possibly be through the septic tanks (leaky connections, access covers, etc.). As the focus of the February 2007 memorandum was on development of acceptable flows and review of past investigatory practices, it was deemed important to thoroughly assess the condition of the FOG sewer system. As a means to assist the Town in assuring that the mainline sewers and manholes are in good physical shape and not contributing significantly to the high flows during the peak wet weather periods of the year, and to further collect information to either support or rule out the septic tanks as a major source of extraneous water, we developed a general approach to quantify any issues with the wastewater collection system in the FOG development. This work was conducted in the summer of 2007 and spanned through the late spring of 2008. The following paragraphs outline the study methodology utilized.

1.2 Study Methodology

A limited sewer system evaluation study was conducted in the FOG subdivision that included the review of past reports and sewer system video; the isolation of Turnberry Lane and review of flow meter data; and traditional investigations defined below. The following summarizes the work conducted.

1.2.1 Smoke Testing

The FOG sewer system consists of a blend of gravity sewer and low pressure sewers. Smoke testing is a technique used on gravity collection systems to identify areas of cross connection between sewer and storm drain; cracked pipe or sewer services; leaky manholes; or any other potential areas where extraneous water can enter the system and smoke can leak out including through septic tanks. Smoke is blown into the system between isolated points in the system and observations are made relative to its exit. For smoke testing to be effective it must be done during periods of low groundwater and very dry conditions. The best time of the year is late summer. Smoke testing was conducted in the summer of 2007 on the entire gravity collection system or just over 12,000 linear feet of mainline gravity sewer. A summary memorandum of the findings was prepared and is located in the Appendix and the results are further discussed in section 2 of this report.

1.2.2 Review of Past Sewer System Video Tapes and Logs

Eastern Pipe Services conducted a video inspection of the gravity collection system for FOG in the late 1990s. While video of sewers at any time of the year can be helpful, dependant upon the goals of the study, this work was done in the

fall during periods of low groundwater. Thus, it is typically not the best time of year to identify sources of extraneous water entering the system. The springtime during periods of snowmelt and ground thaw yield the best results. However, to check the quality of the evaluation and condition of the mainline sewers these tapes and logs were provided to W-P for viewing and review. A summary memorandum of the findings was prepared and is located in the Appendix and its findings discussed in section 3 of this report.

1.2.3 Review of the Turnberry Lane Flow Meter Data

After meetings between the Town, W-P and members representing the FOG Homeowners Association concerning W-P's memorandum of February 2007 in which W-P stipulated that the likely major source of extraneous water entering the system could be through the septic tanks, it was agreed to install a flow meter at the junction manhole at Birkdale and Turnberry Lane on the Turnberry Lane line to test this theory. Turnberry is served by a dedicated low pressure sewer system. Like all the other homes in FOG, each individual home has a septic tank. The difference on Turnberry is that each home has a "pumping system" that discharges into a common line known as a low pressure sewer system. This line remains pressurized at all times thus no water can infiltrate into it. The low pressure sewer runs down Turnberry Lane and discharges into the gravity sewer system on Birkdale Road. Thus, any source of extraneous water entering the system would have to be limited to between the home and the septic tank. Comparison of rain events and/or spring thaw to flow from the homes on Turnberry Lane will allow a correlation between increased flow and the source of the flow being the septic tanks, if one exists. Data has been continuously collected from this meter since May 2007. Additionally, the results from the Turnberry Lane flow meter were compared against pump run times, draw down tests and corresponding flows from the pump stations within FOG to allow greater comparisons and potentially draw conclusions between what is seen at Turnberry Lane and what is happening elsewhere in the system. This information is discussed in section 4 of this report.

1.2.4. Manhole Inspections

The FOG sewer system includes 80 manholes that connect sections of gravity sewer pipe as well as receive low pressure sewer discharges. All manholes were inspected and observed for sources of extraneous water entering the manholes. Inspections identified the condition of the cover, concrete risers and joints, inverts and tables. In areas where water was entering the manhole, estimates were provided for the flow rate. Inspection reports were prepared for each and are included in the Appendix and discussed in section 5 of this report.

1.2.5 Flow Isolation

Flow isolation is a sewer system evaluation technique in which a team of individuals blanket the sewer system with portable flow meters during a period of rain and minimal wastewater discharge such as during the nighttime hours. Manholes are popped and flows are instantaneously gauged. The purpose of the flow isolation is to determine if there is a "smoking gun" or locations where flows are more excessive than others. It can be useful in determining where to expend additional investigation funds or where to target specific investigations such as video inspections or dye testing. In FOG our hope was to limit the scope of video inspection work. The results from our two monitored events are in the Appendix and discussed in section 6 of this report.

1.2.6 Video Inspection of the Gravity Sewer System

Video inspection of the sewer system allows a direct view into the gravity sewer system. It can identify defects such as separated or displaced joints, cracked pipe or root intrusion, or other potential sources of extraneous water that can enter the system. It also allows observation of flows entering the gravity sewer from the individual homes. In instances where there is a steady stream of clear, clean water it can be indicative of extraneous water entering the system. This can be through cracked service connection pipe or root intrusion or in the case of FOG, water entering through the septic tanks. Based on the inconclusive results of the flow isolation in conjunction with the attractive rate offered by the Eastern Pipe Services, the entire gravity collection system was observed via video. Video inspection included detailed logs of the inspection and video, as well as digital stills, of observed defects. This report was prepared separately for the Town by Eastern Pipe Service and is under a separate cover. Section 7 of this report summarizes the findings of the video inspection results.

2.0 Smoke Testing

Smoke testing of the entire FOG gravity collection system was performed in September 2007. The collection system was broken down into a number of smaller sections and the smoke testing was completed in eleven setups or tests. Before each smoke test, the gravity sewer section to be tested was isolated using 8" sewer plugs provided by the Town. Once the area to be tested was isolated, smoke was blown into the system using a smoker and liquid smoke. After the smoke had time to make its way through the system, personnel from W-P and the Town walked along the sewer line and around each residence looking for areas where smoke was escaping from the system.

A smoke testing log form was completed for each setup noting all information pertinent to the test including date and time, area tested, location of sewer plugs, houses inspected, whether or not the standpipes were venting for each residence, as well as any other issues discovered. A copy of the technical memorandum was provided to the Town and representatives of the FOG Homeowners Association. These have also been included as Appendix A. The problems that were found were documented using photographs and sketches with dimensional swing ties to identified problems. These have been included as part of the smoke testing logs. The information below summarizes the main identified trends. Problems noted within the logs should be investigated and corrected.

A number of deficiencies or potential deficiencies were noted from the smoke testing. Greater than 13% of the houses (12 of 88) in the FOG system were identified as having leaking septic tanks. Another interesting observation was that 45% of the homes did not smoke up through the sewer vent pipes at each home. One would hope to have a greater number of tanks identified as this was one of the leading theories surrounding the source of extraneous water entering the system. Should this be determined to be the main culprit of extraneous flows entering the FOG system, there are several possible explanations for the lower number of identified leaky tanks via the smoke testing. First, the configuration of the internals of the installed septic tank could limit both the potential to leak smoke and to prevent smoke from passing through into the internal plumbing and out the vent lines. Some septic tanks include a baffle on the effluent end of the septic tank whereas the effluent line tees down into the tank below the water surface creating a permanent water seal that would prevent smoke from both leaking from any exit points in the tank and from reaching the house. Additionally, several sections of the subdivision are in low lying areas susceptible to high water ground tables. Thus, if the soil is saturated or near saturation smoke would not escape. Our field personnel noted that a number of lawns were very damp or "squishy" under foot during their testing of the system.

Other potential deficiencies included roof drain leaders which were run into the ground. In many instances we have found that when roof leaders are run beneath the surface they are connected to the sewer service. We have subsequently been informed that FOG has investigated each of the

roof drains identified and confirmed that these daylight on the property and are not connected to the sewer system.

3.0 Review of Past Sewer System Video and Logs

In November 1999 Eastern Pipe Services was contracted by Dirigo Management Company to conduct a video inspection of the gravity collection system. Wright-Pierce was provided the original logs and video and asked to review and comment on the videos and to ensure that deficiencies encountered were accurately noted. This task was completed in late September 2007 and a copy of the technical memorandum provided to the Town and representatives of the FOG Homeowners Association. This is located in Appendix B of this report.

In general, the logs accurately showed the location of most service laterals and noted deficiencies observed in the video tapes. From our observations there were a number of pipes which appeared to be separated, but that were not listed as such in the log. These could possibly contribute extraneous flows into the sewer system. However, due to the time of year and the fact that the preceding month as well as the month of November 1999 had rainfall below average, it was not clear whether these separated or displaced joints or pipes not fully "pushed home" during installation actually contribute extraneous flow into the sewer system. It should be noted that at least one leaky pipe joint was noted in our review that was not identified by Eastern Pipe and should be repaired using an insitu chemical grouting method to prevent leakage.

Other observations from a review of the logs and video include that a number of sections of sewer had significant amounts of solids deposition. This could potentially be from excess flows originating at the septic tanks causing some solids washout during storm events. Also there were a few inline deficiencies noted where extraneous water was entering the sewer system but no defect noted in the logs. As such it would be prudent to review the information contained in Appendix B and address the sources identified as extraneous water entering the system.

From a review of the video logs it was clear with the number of potential issues identified that it would be reasonable to further investigate via video at least several segments of line during ideal groundwater conditions in the Spring of 2008.

4.0 Review of Turnberry Lane Flow Meter Data

The low pressure sewer on Turnberry Lane serves 12 homes off the upper part of Birkdale Road. As noted earlier in the report, each home has both a septic tank as well as an effluent pump station to discharge overflow from the septic tank into the gravity collection system on Birkdale Road via a small diameter common low pressure sewer. After review of the W-P Technical memorandum on flows dated February 2007, it was agreed to take steps to confirm or deny the theory that the septic tanks are likely a large contributor of excess flows into the sewer system.

To accomplish this, a flow meter was installed on the low pressure sewer discharge in the junction manhole at the intersection of Turnberry and Birkdale Road.

The Turnberry flow meter was installed after the April 16, 2007 Patriot's Day storm. Once installed, calibrated and put into service this meter began collecting information on May 9, 2007. Data for analysis for this report was collected through May 9, 2008, however the meter continues to collect flow information. Since this date we have experienced little to no rainfall thus the data set collected represents the best available data for analysis and comparison purposes. The flow meter collects instantaneous flow data once every second and the average of these individual readings is calculated and recorded every two minutes. Thus, significant data exists which will allow us to define typical flows for various periods during the year as well as compare flow data taken by the Turnberry meter to actual rainfall events.

Table 1 is a summary of typical flows from Turnberry Lane that are not influenced by rainfall. These dates were selected based on a review of the data for stretches of days where no rainfall occurred. We attempted to define the "normal" flow for each month, where possible. In some instances, data was not available from the flow meter due to faulty battery conditions or stretches of wet weather which did not permit the ability to average several days of dry weather flow data.

Table 1
Turnberry Lane Flows
Normal Flows Not Influenced by Rainfall

Dates	Turnberry Flow Meter (Average Daily Flow, gallons)
5/21/07-5/27/07	1,734
6/15/07-6/23/07	1,664
7/29/07-8/5/07	1,647
9/2/07-9/9/07	1,742
10/01/07-10/05/07	1,408
11/8/07-11/14/07	1,682
1/4/08-1/8/08	1,411
4/19/08-4/26/08	1,120

Table 2 summarizes the normal and storm-related flow conditions based on a review of rainfalls that exceeded 1" on any given day. Consideration was given to include days where rainfall may be carried over into a second day and thus was included even if rainfall was less than 1" for a particular day. Additionally, in calculating the peaking factors, the normal daily flow from the corresponding month in Table 1 was utilized to account for observed monthly or seasonal fluctuations.

Table 2
Turnberry Lane Flows
Normal, Storm Conditions and Peaking Factor

Date	Rainfall	Turnberry Lane Flow Meter		
		Storm-Daily Flow	Normal Daily Flow	Daily Peaking Factor
6/3/2007	0.52	2,202	1,664	1.32
6/4/2007	2.12	2,445	1,664	1.47
7/9/2007	1.13	1,664	1,647	1.01
7/15/2007	1.34	2,026	1,647	1.23
8/6/2007	2.29	1,815	1,647	1.10
9/11/2007	1.65	1,859	1,742	1.07
9/27/2007	1.21	1,830	1,742	1.05
10/12/2007	3.91	3,515	1,408	2.50
2/1/2008	1.08	1,707	1,411	1.21
2/2/2008	0.47	2,099	1,411	1.49
2/13/2008	2.54	3,381	1,411	2.40
3/8/2008	1.59	4,244	1,411	3.01
4/28/2008	1.09	1,863	1,120	1.66
4/29/2008	2.25	3,084	1,120	2.75

In reviewing the Turnberry flow meter data it is very clear that flows from Turnberry Lane are influenced by rainfall. Daily peaking factors ranged from just over 1 to 3 times the normal daily flow. The daily variation in peaking factor during storms is also strongly influenced by the time of year in which they occur. During the late Spring, Summer and early Fall the peaking factors when it rains are much lower than during the Spring when rains are traditionally heavier, the ground water table is highest, and snow melt is occurring. When rains occur in the summer months the soils tend to have a much higher absorptive capacity and thus less water is available to be directed into the sewer system through various sources of leaks. Thus, typically the highest peaking factors are associated with late Fall through late Spring. In the case of October 12, 2007, the rainfall was significant (3.91") and once the ground was saturated the excess water could be directed to the sewer system.

As discussed in section 2 of this report, because a low pressure sewer is always pressurized, extraneous water can only enter the system between the home and the septic tank. Septic tanks are not water tight and offer several areas of possible entry including the access covers. The increased storm-related flows and peaking factors are significant even though the volumes are relatively low. The corresponding peaking factors may be indicative of the system as a whole in response to rainfall events.

To more thoroughly understand the impacts of rainfall on the Turnberry Lane area it is prudent to review some of the more significant rainfalls over the past year.

4.01 Significant Storm Event Review

Of the rain events in excess of 1", a few standout that are worthy of further review and additional investigation. These events are:

Table 3
Significant Rainfall Events over the Past Year

Date	Rainfall
10/12/07	3.91"
02/13/08	2.54"
03/08/08	1.59"
04/29/08	2.25"

Rainfall data is available through the National Weather Service. It is typically reported in inches per day, with the day starting at midnight and ending at 11:59PM. What this reported data does not tell you is when during the day the rainfall occurred, what the relative intensity was or whether the event started in one day and carried over to another. Therefore the ability to collect hourly rainfall data on the days in which significant rainfall occurred that coincides with a dramatic pick up in system flows is very valuable to correlate to measurements taken at the Turnberry flow meter. To assist us in this process, hourly rainfall data was secured through the Portland Water District for a rainfall gauging station located at the Northgate Fire Station in Portland. The following paragraphs outline the findings for each event.

October 12, 2007

The rain event on October 12th was a significant event that came in two distinct waves of rain. From 1:00 to 4:00AM, we received about 1.3". From noon until 6PM, we received another 2" of rain. The peak intensity of the storm occurred between 2-3 AM where almost 0.90" of inch was measured.

We reviewed the flows measured by the Turnberry flow meter during each of the two major intervals of the storm. We also compared these flows against the same time period the day before the storm. For the first storm interval of 1:00-4:00 AM, the flow during the rainfall was 3 times greater than the day before. In reviewing the second interval

from noon to 6 PM, flows were *4.75 times greater* than the same time period the day before.

We believe that the first portion of the storm saturated the ground followed by another high intensity rainfall in the afternoon which then allowed more water to reach the sewer system through the septic tanks accounting for the higher peaking factor of 4.75.

February 13, 2008

The majority of the rainfall occurred between 2PM and midnight. When comparing the flows measured during this rain storm to the same timeframe both the day before and day after the storm, flows during the storm period were between 2.5 and 2.75 times greater over the same period, respectively.

March 8, 2008

On March 8th 85% of the rainfall measured for that calendar day occurred between the hours of 3PM and 11PM. When comparing the flows measured during this rain storm to the same timeframe both the day before and day after the storm, flows during the storm period were 2.5 times greater over the same period.

April 29, 2008

This event contributed about 2.25 inches of rainfall. In reviewing the hourly precipitation data, 2/3rd of the rain occurred between midnight and 6:00AM on March 29th. When comparing this time period against the same time period the night before, flows were up by a factor of 2.3. Additionally while the night before there was little to no flow, the flow meter captured several pockets of peak flows.

Rain Event Summary

Whether focused on a comparison of peak day factors during rain events to normal flows or observing the specific time intervals when the rainfall occurred against similar time period on dry days, it is clear that extraneous water is entering the system. The most logical point of entry in a low pressure sewer is the septic tanks.

With information on how the Turnberry system responds to rain events it is logical then to compare how the system as a whole responds to rainfall as well.

4.1 Comparison of Turnberry Lane to Pump Station Data

To ascertain a comparison of the Turnberry data to the remaining system as a whole we reviewed pump run times, drawdown tests and establish daily flows for three of the pump stations within FOG. These were the:

- Birkdale Pump Station, which receives flow from Turnberry Lane;
- Leachfield Pump Station, which receives flow from the Birkdale PS, Hazeltine PS, Falmouth Country Club and a portion of Inverness Road; and
- Baltusrol Pump Station, which is the main pump station which conveys all flows from FOG to the public sewer system.

Pump draw down tests were conducted by Town staff to determine the actual pumping rates. The Town's radio telemetry system monitors pump run times through its 20 second polling cycle on the radio system. With pump rates in hand and the actual pump run times, the daily flow rate can be established for each station. The data in Table 5 represents the normal flows from each pump station that were not influenced by rainfall. These are for the same time periods covered under the Turnberry Flow Meter assessment.

Table 4
Pump Station Flows
Normal Flows Not Influenced by Rainfall

Dates	Birkdale PS (Gallons per day)	Leachfield PS (Gallons per day)	Baltusrol PS (Gallons per day)
5/21/07-5/27/07	11,467	19,440	25,883
6/15/07-6/23/07	10,256	19,700	26,588
7/29/07-8/5/07	9,463	19,084	26,983
9/2/07-9/9/07	9,417	19,822	29,853
10/01/07-10/05/07	9,181	19,940	25,403
11/8/07-11/14/07	9,879	21,936	28,024
1/4/08-1/8/08	10,929	18,421	24,677
4/19/08-4/26/08	8,856	17,201	21,596

Tables 5, 6 and 7 represent summaries of the storm events presented in the Turnberry Lane Flow meter section along with the associated peaking factors for each storm compared to that of Turnberry lane for each individual pump station.

Table 5
Birkdale Pump Station Flows - Normal, Storm Conditions and Peaking Factor

Date	Rainfall	Birkdale PS			Turnberry
		Storm-Daily Flow	Normal Daily Flow	Peaking Factor	Peaking Factor
6/3/2007	0.52	12,393	10,256	1.21	1.32
6/4/2007	2.12	25,606	10,256	2.50	1.47
7/9/2007	1.13	11,205	9,463	1.18	1.01
7/15/2007	1.34	11,249	9,463	1.19	1.23
8/6/2007	2.29	12,657	9,463	1.34	1.10
9/11/2007	1.65	16,353	9,417	1.74	1.07
9/27/2007	1.21	9,167	9,417	0.97	1.05
10/12/2007	3.91	35,822	9,181	3.90	2.50
2/1/2008	1.08	11,455	10,929	1.05	1.21
2/2/2008	0.47	24,963	10,929	2.28	1.49
2/13/2008	2.54	33,474	10,929	3.06	2.40
3/8/2008	1.59	40,336	10,929	3.69	3.01
4/28/2008	1.09	12,877	8,856	1.45	1.66
4/29/2008	2.25	48,133	8,856	5.44	2.75

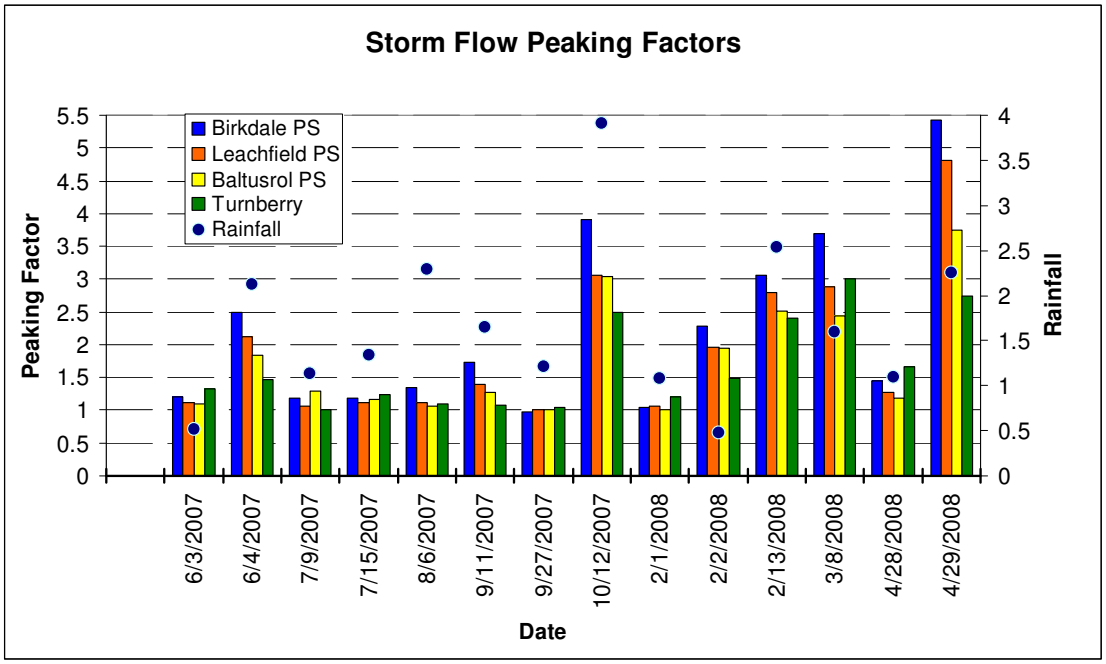
Table 6
Leachfield Pump Station Flows
Normal, Storm Conditions and Peaking Factor

Date	Rainfall	Leachfield PS			Turnberry
		Storm-Daily Flow	Normal Daily Flow	Peaking Factor	Peaking Factor
6/3/2007	0.52	22,013	19,700	1.12	1.32
6/4/2007	2.12	41,649	19,700	2.11	1.47
7/9/2007	1.13	20,280	19,084	1.06	1.01
7/15/2007	1.34	21,389	19,084	1.12	1.23
8/6/2007	2.29	21,424	19,084	1.12	1.10
9/11/2007	1.65	27,577	19,822	1.39	1.07
9/27/2007	1.21	19,812	19,822	1.00	1.05
10/12/2007	3.91	61,084	19,940	3.06	2.50
2/1/2008	1.08	19,691	18,421	1.07	1.21
2/2/2008	0.47	36,261	18,421	1.97	1.49
2/13/2008	2.54	51,321	18,421	2.79	2.40
3/8/2008	1.59	53,097	18,421	2.88	3.01
4/28/2008	1.09	21,944	17,201	1.28	1.66
4/29/2008	2.25	82,600	17,201	4.80	2.75

Table 7
Baltusrol Pump Station Flows
Normal, Storm Conditions and Peaking Factor

Date	Rainfall	Baltusrol PS			Turnberry
		Storm-Daily Flow	Normal Daily Flow	Peaking Factor	Peaking Factor
6/3/2007	0.52	29,083	26,588	1.09	1.32
6/4/2007	2.12	49,075	26,588	1.85	1.47
7/9/2007	1.13	34,972	26,983	1.30	1.01
7/15/2007	1.34	31,698	26,983	1.17	1.23
8/6/2007	2.29	28,607	26,983	1.06	1.10
9/11/2007	1.65	37,893	29,853	1.27	1.07
9/27/2007	1.21	30,021	29,853	1.01	1.05
10/12/2007	3.91	77,110	25,403	3.04	2.50
2/1/2008	1.08	25,067	24,677	1.02	1.21
2/2/2008	0.47	48,067	24,677	1.95	1.49
2/13/2008	2.54	61,924	24,677	2.51	2.40
3/8/2008	1.59	60,088	24,677	2.43	3.01
4/28/2008	1.09	25,426	21,596	1.18	1.66
4/29/2008	2.25	81,034	21,596	3.75	2.75

The following graph outlines a comparison of peaking factors for the pump stations and Turnberry Lane over the storms monitored in the above tables.



The following observations can be made from a review of the data in general. First, there appears to be a strong correlation between the peaking factor at Turnberry Lane and at the remainder of the pump stations included for the assessment. While there are instances where there is separation between the peaking factors such as with the April 29th storm (Turnberry peaking factor lower than the rest) this may be explained by both other minor sources of flow entering the system that otherwise is not available to enter the Turnberry system, such as infiltration through manhole defects, service connections or gravity sewers and the fact that Turnberry Lane is sited at a higher elevation than downstream sections of Birkdale Road and has a free draining topography. Lower portions of Birkdale are low lying, located adjacent to a nearby brook and exhibited saturated soils even in August 2007 when the smoke testing was conducted by Wright-Pierce. This may further explain why the Birkdale pump station exhibits a higher peaking factor than the other pump stations as well.

In summary, we feel the data supports the theory that the septic tanks are the largest contributor of infiltration in the system and that their subsequent removal will greatly reduce storm-related high flows.

5.0 Manhole Inspections

The purpose of the manhole inspections was to evaluate the integrity of the existing sanitary manholes as well as to determine if the manholes are a source of extraneous water entering the system. Wright-Pierce along with assistance from the Town inspected a total of 80 sanitary manholes during a two day period from May 19 to May 20, 2008.

It was determined that the nearly all of the sanitary manholes are generally in good condition, however several minor issues where discovered. The individual manhole inspection sheets located in Appendix D provide more information. In general, the observed issues can be summarized as follows.

- Manhole FCC27 on Birkdale showed evidence of leakage in the shiplap joints for both the cone section and the barrel sections.
- Manhole FCC39 on Hoylake has a wet area on the wall of the manhole above the invert out. This could contribute extraneous water during high groundwater tables.
- Manholes FCC42 and FCC43 on Medinah have many spots along the shiplap joints that appear to be plugged with expandable foam in an attempt to stop leaks. These plugs appear to be, at best, retarding the infiltration. The expandable foam should be replaced with hydraulic cement.
- Manhole FCC53 on Baltusrol has noticeable flow while the preceding manhole, FCC52, is the initial manhole for that run and had zero flow at the time of inspection. The Town performed video inspection of the sanitary line between these manholes and found the

pipe joints to be in good shape, however considerable flow was observed from the individual house services along that segment.

- Manhole FCC55 showed evidence of leakage in the cone shiplap joint just above and to the right of the invert out location.

A general assessment of the system would conclude that the manholes as a whole collectively are in good condition. It does not appear that the manholes as a whole are a significant or even noticeable contributor to extraneous infiltration into the system. Since none of the manhole covers have holes in them, the cover, rim and grade rings are also in good condition, these are not expected to contribute to extraneous flows during times of snow melt or high groundwater conditions. However, the few manholes with evidence of leakage should be repaired to ensure they do not contribute extraneous flows to the system.

6.0 Flow Isolation

Wright-Pierce in conjunction with Town staff attempted to conduct three separate flow isolation events. The first event never materialized as the predicted rainfall did not come and the isolation attempt was called off. However, we were able to conduct two events. One was on April 4th and the other on April 29th.

April 4th Monitoring Event

On April 4th flows were gauged between the hours of 8:00PM and 9:30PM. While we had hoped for a greater rainfall the measured precipitation was 0.5" between the hours of 6:00PM to 10:00PM that night at the Portland Jetport. The data collected was flow rate in gallons per minute or GPM. In general, manholes were accessed at the highest point in the associated gravity subsection and flow gauged working toward the pump station. Of the flows gauged within the collection system, one would expect to find minor differences in flow between manholes associated with water use. As the gauging event was conducted in the early evening and water use can impact measurements we looked for significant differences in flows as a barometer for possible problem areas.

Of the areas observed on April 4th, the sections of sewer on Birkdale Road beneath its intersection with Carnoustie Drive exhibited slightly higher flows as compared to the other sections of sewer in the subdivision. Flows entering the station from up above were measured at 14 GPM and flows from southern portion of Birkdale, Hoylake and Prestwick were gauged at 7 GPM.

April 29th Monitoring Event

On April 29th flows were gauged between the hours of 4:00AM and 6:30AM. The measured precipitation was 1.3" of rain during the hours of 2:00AM to 8:00AM that morning at the Portland Jetport. Of the areas observed on April 29th, the sections of sewer on Birkdale Road beneath its intersection with Carnoustie Drive exhibited higher than expected flows as compared to the other sections of sewer in the subdivision. Flows entering the station from up above were measured at 26 GPM and flows from southern portion of Birkdale, Hoylake and Prestwick were gauged at 15 GPM.

Monitoring Event Summary

The Birkdale pump station takes in the highest concentration of homes in the subdivision and thus it is expected that flows would be higher along this section of sewer, however, flows gauged during the April 29th storm event suggest flows there were of higher magnitude than other areas. Other areas such as Baltusrol Circle, Medinah Circle and Inverness Road had minor flow swings in between manholes that were questionable as well. All in all the goal of the flow gauging was to determine if a "smoking gun" existed that would cause us to focus to our video inspection efforts on particular sections. Whereas this was not the case, the results of the flow gauging were inconclusive.

7.0 Video Inspection

Video inspection quotes were secured by the Town. W-P expectations for video costs were approximately $1.5-$2/linear foot which includes a light cleaning before the video work is started. The Town procured a quote from eastern Pipe Service for $0.92/linear foot. Since the flow gauging did not find conclusive areas of significant problems, the inspection costs were significantly below typical market costs, our review of the original video noting a number of questionable pipe joints and segments, and the importance of ensuring that no major defects existed in the collection system, the Town decided to video the entire subdivision.

Video inspection work was conducted between April 23rd and April 29th. W-P was onsite periodically with members from Eastern Pipe to observe the quality of the inspection and to focus attention of the inspectors on areas of concern noted by our review of the original inspection reports for work conducted in November 1999. Our assessment is that the work was conducted both effectively and efficiently.

The report produced by Eastern Pipe Services is provided under separate cover and not included within this report. A letter summarizing their findings is included in Appendix F. In general, Eastern Pipe found the mainline sewer to be in very good condition with no obvious signs of infiltration. Pipe was installed in 13' sections and appeared to have gaskets in place. Sanitary

wyes with gaskets were used for connecting most individual sewer services to the mainline sewers. The pan and tilt camera used for the inspections stopped at each service connection and the camera was rotated to view up the service lateral. No obvious signs of infiltration were noted coming from the immediately visible sections of service lateral. The manholes used for camera access were in reasonable condition with no signs of leakage.

What did Eastern Pipe find? A few sections of pipe were noted as having been repaired using Fernco-type couplings and showed some offset but no apparent leakage. A number of sections of pipe were noted as having faulty or displaced joints, similar to what W-P identified in reviewing the past logs from 1999. Eastern Pipe did not note any infiltration at these displaced or faulty joints. Based on our observations it does not appear that these displaced joints contribute excess water during high ground water tables in the Spring.

They also encountered several areas where the sewer took a dip and standing water was found. While this is not desirable, it is not uncommon to find stretches of minimal slope sewer with dips. Finally, a significant portion of the sewer was found to have heavy staining, which may be indicative of infiltration into the septic tanks during periods of heavy rain over the years washing solids out into the system.

8.0 Conclusions and Recommendations

As part of the limited sewer system evaluation, we have conducted the majority of investigatory techniques to "flush out" and identify problems and issues within the collection system. The only item not included in our scope of study was to perform house to house inspections to verify the internal plumbing and assure that no sump pumps are connected to the sewer service. We understand that FOG has conducted their investigation and inspection for illegal connections.

With the data collected from each our investigations along with our past knowledge of the system and the particular issues that exist we offer the following conclusions:

1. Smoke testing confirmed that 13% of the homes in fact have leaky septic tanks which contribute extraneous water to the sewer system during periods of high ground water and/or during rain events.

2. Almost 50% of the homes did not push smoke up through their sanitary vent pipes. A likely cause of this is trapped effluent pipes leaving the septic tanks. If this is the case, then the septic tanks would not yield smoke during the test.

3. Wet ground in low lying areas such as on Birkdale may have prevented the exiting of smoke through leaky septic tanks or pipes.

4. A review of past video logs conducted in November 1999 yielded several minor deficiencies not noted in the logs. These should be reviewed and corrected. Additionally, the video indicated a significant amount of dark staining in the lines which could be the result of solids washout of the septic tanks during wet weather flows.

5. A review of the accumulated flow meter data for Turnberry Lane shows a clear correlation between rain events and significant increases in flow. On larger rain events peak day factors ranged from 2.5 to 3. The only sources of infiltration on Turnberry Lane are between the home and the septic tank, with the septic tank being the likely source.

6. On Turnberry Lane during heavy storms once the ground becomes saturated the peaking factor between dry weather flows for the same period the day before the storm compared to the storm event approached 5 times the normal flow.

7. A review of the pump station flows during the same periods explored for the Turnberry Lane data yielded that the stations experienced peak day factors of 2.5 to over 5. While this does not match the Turnberry peaking factors exactly, there is a definite correlation.

8. Other minor observed defects in the collection system are contributing some infiltration accounting for some of the differences in peaking factors between Turnberry and the rest of the system.

9. Site specific conditions, such as the fact that Turnberry Lane sits on higher ground and drains better than other areas such as lower Birkdale Road may promote lower peaking factors.

10. Manhole inspections noted several minor issues that may contribute some level of infiltration during storm events which should be addressed.

11. Video inspection during a period of higher ground water table yielded that the system largely is in good condition, however, there are a number of displaced joints that should be spot repaired. The contractor noted clean clear flow coming from the sanitary services further supporting the theory that the extraneous water entering the system is off private property.

12. While the sanitary services were not inspected it is reasonable to conclude that the majority of extraneous flow is originating from private sources between the main line gravity sewer or low pressure sewer and the home.

Moving forward we recommend the following:

1. For gravity sewer connections, fill the septic tanks and pipe straight through to eliminate the tanks as a source of extraneous water intrusion. We believe that this could lead to significant wet weather flow reductions.

2. For low pressure or pumped connections, the septic tank will need to be eliminated from the flow path. Depending on how constructed, the effluent pump may be located within a chamber in the septic tank or in separate tank. We suggest that new watertight pump chambers be provided to ensure that extraneous water does not enter the collection system.

3. The only portion of evaluation study not included in this work was a house to house inspection of internal building plumbing to ensure that sump pumps are not connected to the sewer. It may be prudent that internal plumbing is inspected at the same time that the services are piped through the septic tanks and inspected by the Town.

4. The Birkdale pump station is undersized for the peak flow it currently receives as evidenced by high wetwell levels during wet weather events. The Birkdale Pump Station serves at least 65 homes and utilizes a 4" force main. Current data suggest that the pumps are capable of 44 gpm. At a minimum, the station should be sized to handle either 1 gpm/home or a forcemain velocity of 3 feet per second (FPS) whichever generates the higher flow. At a forcemain velocity of 3 FPS in a 4" forcemain, each pump should be sized to convey 120 GPM. Thus this station should be upgraded to meet typical industry design standards with respect to capacity.

5. Leachfield Pump Station is similar to that of Birkdale. It takes in Birkdale plus 26 homes off Inverness, the Falmouth Country Club and the Hazeltine pump station which serves 12 homes. Current capacity at this station per the Stevens report is 75 gpm. This station should be sized to handle the combined flows from these sources.

6. Increasing the capacity at each station will address the current deficiencies noted of high wet well levels during wet weather and even occasional overflows at the Leachfield pump station. Increased pump capacity at Leachfield would also allow total discontinuance of the manual operation of pumping excessive flow to the old leachfield system.

7. All the pump stations within the public collection system on this side of Town contain emergency power provisions to prevent sanitary sewer overflows during power interruption. Many of the pump stations within the Town that do not have emergency power provisions have significant wet well storage which allows the Town to utilize

their portable generator effectively over a number of stations during power outages to prevent sanitary sewer overflows. However, information provided suggests that pump station wet wells within the FOG system are very small and provide little storage capacity during wet weather. Without suitable storage, a portable genset may need to be parked at one station during a storm preventing its use over a number of stations. We would suggest that some consideration be given to emergency power provisions at the stations.