4.0 EVALUATIONS

This Chapter presents the following:

- Analysis and evaluation of the results of the field investigations;
- Identification of priority catchments and scope and estimated cost of the Phase 1 Part 2 Sewer System Evaluation Survey;
- Review of CSO control alternatives; and,
- Review of CSO data at the Wellington Avenue CSO Facility and preliminary estimates of the estimated volumes required to be removed or stored for CSO reduction to achieve EPA and RIDEM regulatory thresholds.

4.1 DATA ANALYSIS AND APPROACH

Because infiltration and inflow (I/I) are different in both cause and effect, they are examined individually and are quantified based upon normal wastewater trends. Typically, wastewater flows will follow a repeating diurnal pattern in predominately residential areas. Flow will be at its lowest in the early morning hours, when users are predominately sleeping and use of the system is minimal. At waking hours, the flow begins to increase as use of the system picks up. Then, a decreasing pattern occurs until late morning or early afternoon. Following this time, flows increase as residents return from work and use the sewer system during and after dinner hours. As the night progresses into the early morning hours, flows again decrease to minimum values. Due to the regular schedules that are typically kept on weekdays (Monday through Friday), flow patterns usually do not vary much from day to day. However, on weekends and holidays, a pattern different from the one that occurs on weekdays usually develops. The diurnal pattern develops later in the morning and lasts longer into the nighttime hours. Deviations from the weekday and weekend pattern are indications that infiltration/inflow are influencing the domestic wastewater flows. In order to determine infiltration and inflow quantities, deviations are noted by picking out representative days from the wastewater flow meter data.

Once I/I quantities are determined, the results are evaluated against threshold values to determine whether further study and system rehabilitation are necessary. The results are compared from one area to another by normalizing infiltration volume by the length and diameter of sewer pipe in the study or catchment area.

Inflow is caused by wet weather flow entering the wastewater collection system through catch basins, rain leaders, sump pumps, drains, converted combined sewer appurtenances and other illicit connections to the sanitary sewer system. Inflow is typically identified by divergence and re-convergence between the wet weather hydrograph and a typical comparative dry weather hydrograph over a similar period of time.

The metering program for this project included three wet weather events that occurred during the metering period (March 28 through May 1, 2005), each of which included CSO discharge events at the Wellington Avenue CSO Facility, a dry weather period, and a recovery period. It should be noted that the recovery period, or “drain down,” period for the first large storm at the beginning of the metering period was interrupted by the second smaller wet weather event.

4.1.1 Data Analysis for Infiltration

Since the use of the wastewater collection system is usually at its minimum throughout the overnight hours, most of the flow recorded between the hours of 12 midnight and 6 AM (in the absence of rain and during a high groundwater period) is considered infiltration. Following this general rule, an infiltration analysis was performed for each catchment area. The meter data, groundwater and tide levels, and rainfall data for the complete flow metering period were collected and reviewed. For the overall metering period, the flows measured at the upstream meters and downstream meters generally balanced, indicating that overall, the system maintains most of its flow.

The dry weather period between April 15 and April 22, 2005 was reviewed and determined to be suitable for analysis. Over the eight day period, an average low flow was calculated for each metered catchment area. The rate was adjusted to account for a nominal base sanitary flow. Review of typical diurnal variation, as provided in USEPA’s Onsite Wastewater Treatment Systems Manual, indicated that the peak sanitary wastewater flow between midnight and 6:00 AM is approximately 1 gallon per capita per hour (gal/cap/hr). This rate was used with population density data (source: Rhode Island Statewide Planning Program Census Data) in each catchment to estimate the sanitary flow component and subtract it from the metered flow such that only infiltration flow remained.

TABLE 4.1
SUMMARY OF INFILTRATION ESTIMATES

Meter	Location	Infiltration Volume (gal/day)[1] (1)	Estimated Sanitary Flow (gal/day) (2)	Adjusted Infiltration Volume (gal/day) (1 - 2)	Percent of Total Infiltration[2]	Infiltration Rate (gal/day/in-dia-mile)	Preliminary Rank by Infiltration Rate
1	Opposite 97 Narragansett Avenue	335,844	5,592	330,252	20.5 %	4,267	5
2	95 Coggeshall Avenue	176,352	7,215	169,138	10.7 %	4,569	4
3	Corner of Morton Avenue and Thames St. Near Morton Park	443,500	12,922	430,579	27.4 %	5,182	2
4	Wellington Ave. (upstream of Wellington Avenue CSO Facility)	316,418	4,628	311,791	19.3 %	7,575	1
5	29 Memorial Blvd.	2,354,115		Wave Avenue Pump Station Force Main	Wave Avenue Pump Station Force Main	Wave Avenue Pump Station Force Main	Wave Avenue Pump Station Force Main
6	Thames Street near Washington Square	252,021	6,788	245,234	15.4%	2,792	6
7	7 Carroll Avenue near Morton Avenue	107,163	3,572	103,592	6.7 %	4,681	3
8	Corner of Morton Ave and Thames Street	60,932		N/A	N/A	Fort Adams Force Main	-
9	America's Cup Ave. at Thames Street	0		0	0	Not Measured, See Note 1	-

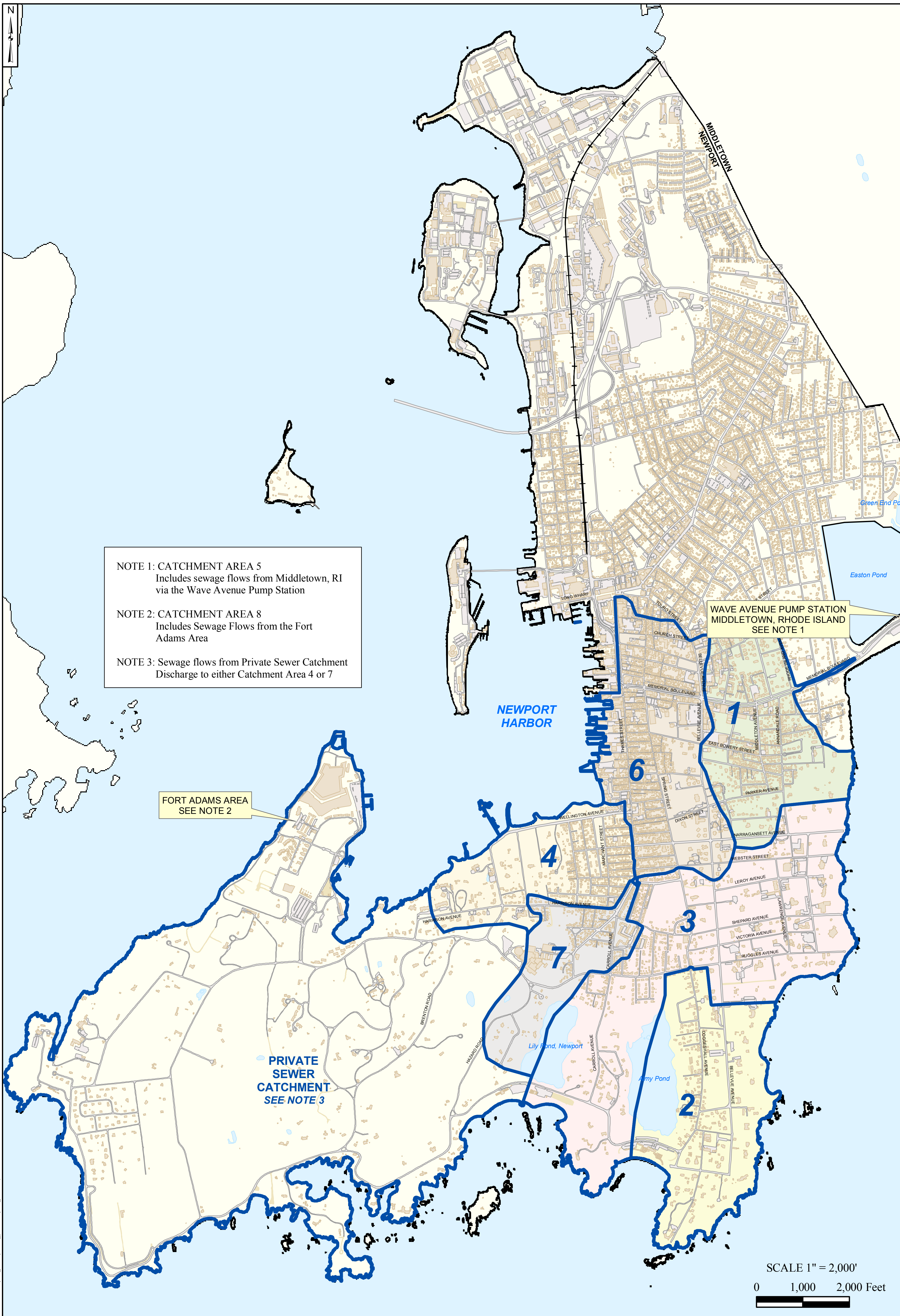
1. Infiltration volumes calculated from analysis of flow data.
2. Calculated from the total net volume in all areas except Catchment Area 5 – Wave Avenue Pump Station.

Table 4.1 presents the results of the infiltration analysis for each Catchment Area. Figure 4.1 presents the Catchment Areas. As shown in the table, force mains are assumed to have no infiltration, therefore, the "low" flows generated by Wave Avenue Pump Station (Meter 5) and Fort Adams Facility (Meter 8) were not analyzed with respect to infiltration flows. However, the upstream tributary catchments to the pump stations could and likely do contribute infiltration. Review of Table 4.1 indicates that the flow from Middletown's Wave Avenue Pump Station is the highest flow contribution of the catchments evaluated. Flows conveyed to the Wave Avenue Pump Station likely include excessive extraneous infiltration, and reduction of these flows would improve the Newport sewer system's conveyance capacity during dry weather.

Catchment Area 4, which is directly tributary to the Wellington Avenue CSO Facility, showed a correlation between astronomical high tides and high flow levels indicating the infiltration volumes in the area may be affected by the tides in Newport Harbor. As the dry weather study period for the infiltration analysis was primarily contained in an astronomically low tide period, the total infiltration may be understated, specifically during high groundwater periods occurring simultaneously with astronomically high tides.

4.1.2 Data Analysis for Inflow

For the analysis of inflow, the April 8, 2005 storm was selected because it was the largest wet weather event in the metering period which did not trigger a surcharge in any of the metered manholes and did not experience additional wet weather flows during the drain down period. The storm occurred at about 12:00 AM on Friday, April 8, with a duration of about 6.5 hours, a peak hourly intensity of 0.22 inches per hour, and total rainfall of 0.8 inches. Based on the storm's characteristics, April 7 (Thursday) from 6:00 PM through April 11 (Monday) at 11 PM was considered an acceptable representative wet weather period. To provide a representative dry weather period to use with the analysis of inflow for the April 8 storm, the period from Thursday, April 14 through Monday, April 18, was selected as the representative dry weather period. This period covered both weekday and weekend flow patterns and was deemed acceptable, however, base flows were generally lower during the representative dry weather period than the



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OCTOBER 2006

LEGEND:

- Sewer District Boundary
- Buildings
- Docks
- Paved Roads and Parking
- Unpaved Roads and Parking

FIGURE 4.1
WELLINGTON AVENUE CSO FACILITY TRIBUTARY CATCHMENT AREAS PHASE I PART I CSO CONTROL PLAN

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representative wet weather period due to the prolonged (over one week) drain down period experienced in the system following the flows generated by the large storms on March 28 (prior to our metering period) and Saturday, April 2.

To determine the rate of inflow into the system, the representative wet weather and representative dry weather periods were compared for each metered catchment area. The peripheral meter catchment areas, such as Catchment Areas 1, 2, 4, 5, 7, and 8 were measured directly, while Catchment Areas 3 and 6 were measured by subtracting upstream flows already measured by the upstream meters. For example, flows from Meters 1 and 2 were subtracted from the flow in Meter 3 (the flow metering schematic presented in Figure 3.1 will help the reader understand this relationship).

During this analysis, an anomaly was encountered in our effort to determine inflow in Catchment Area 6. Although the volumes of flow measured by the upstream meters and the two downstream meters over the full metering period were generally well balanced, as were the flow rates and volumes over the representative inflow periods analyzed, the peak inflow rate generated in Meter Catchment Area 6 was almost zero for the April 8 storm. The low inflow in Catchment Area 6 was unexpected considering the size of the catchment area, the relative age of the system, the land use, and the proximity of the system to Newport Harbor. To verify the findings of the analysis, a second analysis using the same procedure was performed using inflow volumes rather than rates, which yielded similar results. Similar results were observed using the April 2 storm as well.

While it is not possible to definitively explain this anomaly based on the information available at this time, there are several possible causes for the low flow rates and volumes that were measured in Catchment Area 6 such as:

- Storage or detention of inflow in the upstream system;
- Large volumes of delayed direct flow or indirect flow, or a combination of the two;

- Unknown interconnections within the system that divert or detain flows under high flow conditions to a location that was not metered;

- Unmarked or unknown outfalls; and,

- Damaged pipe allowing flow to escape from the system under full flow conditions.

This anomaly will require additional analysis and field investigations in the next phase of work to further define the response in Catchment Area 6 during high flow/ wet weather events. Chapter 5 includes the recommendation for further work in this catchment.

The inflow volume for each of the remaining metered catchment areas for the April 8 storm and the volumes for the areas are presented in Table 4.2. The ranking represents the prioritization of each catchment area based on inflow.

Since the America's Cup interceptor is metered at the inlet to the overflow, inflow was assumed to have entered the system somewhere upstream. Therefore, any flow not observed upstream, but measured in Meters 6 or 9 is likely originating in Catchment Area 6.

Based on further analysis of flow from Fort Adams, Meter 8 demonstrates some sensitivity to wet weather inflow. However, due to the small overall volumes of sewage pumped and inflow rates typically less than 200,000 gallons per day, even during the larger storms experienced in the metering period, Fort Adams is not considered a high priority inflow contributor at this time. Review of Table 4.2 indicates that the flow contribution from Middletown's Wave Avenue Pump Station is the highest contributor of inflow of the tributary catchments to the Wellington Avenue CSO Facility, with a metered flow of approximately 5.5 million gallons. Based on this volume of flow, the tributary catchments in Middletown to the Wave Avenue Pump Station likely contain sources of excessive inflow. The reduction of inflow to the Wave Avenue Pump Station would reduce the flow contribution to Newport's system during wet weather, which would likely reduce both the volume and frequency of system surcharging and combined sewer overflows.

TABLE 4.2
SUMMARY OF INFLOW ESTIMATES BASED ON FLOW VOLUMES

Catchment Area	Location	Wet Weather Volume (gal)[1] (1)	Dry Weather Volume (gal)[1] (2)	Net Wet Weather Inflow (gal) (1-2)	Percent of Total Inflow Volume	Preliminary Rank
1	Opposite 97 Narragansett Avenue	3,495,918	1,812,084	1,683,834	13.8 %	4
2	95 Coggeshall Avenue	1,349,000	736,000	613,000	5.0 %	5
3	Corner of Morton Ave and Thames St. Near Morton Park	6,851,073	3,265,336	2,052,146[2]	16.8 %	2
4	Wellington Ave. (upstream of Wellington Avenue CSO Facility)	4,064,988	2,048,685	2,020,000	16.5 %	3
5	29 Memorial Blvd.	19,097,170	13,651,570	5,450,000	44.5 %	1
6	Thames Street near Washington Square	31,020,350	21,456,680	Further Analysis and/or Investigation Necessary	Further Analysis and/or Investigation Necessary	To be Determined
7	7 Carroll Avenue near Morton Avenue	1,122,375	704,560	420,000	3.4 %	6
8	Corner of Morton Ave and Thames Street	507,930	540,071	0	0 %	7
9	America's Cup Ave. at Thames Street	1,708,060	249,389	0	0 %	N/A

1. The wet weather volume is from analysis of the April 8 storm. The dry weather volume is from analysis of the representative dry weather period April 14 through April 18.
2. Net Inflow calculation for Area 3= (1) –(2) - (the sum of 613,000 gallons from Catchment Area 2 and 920,591 gallons routed to Catchment Area 3 after the Narragansett Storage Conduit reached capacity.

4.2 IDENTIFICATION OF PRIORITY CATCHMENTS FOR SEWER SYSTEM EVALUATION SURVEY (SSES)

4.2.1 Priority Catchments Identified for Infiltration SSES Investigations

Based on the results of the infiltration analysis, Catchment Areas 3, 4 and 7 are priority catchments for field investigations for reduction of infiltration flows. These areas significantly exceed the infiltration threshold rate of 4,000 gal/day/in-dia-mile, which is generally accepted in the industry as a threshold rate that is cost effective to remove and requiring further work. In addition, these areas have direct impacts on flows received at the Wellington Avenue CSO Facility, either as a directly tributary flow (Catchment 4) or as a tributary flow to the diversion structure at Wellington Avenue and Thames Street. Based on this methodology, the priority catchments for detailed sewer system evaluation survey to identify inflow sources as part of Phase 1, Part 2 are presented in Table 4.3 Figure 4.2 presents the priority catchments for infiltration SSES investigations.

TABLE 4.3
PRIORITY CATCHMENTS IN NEWPORT FOR INFILTRATION SSES INVESTIGATIONS

Catchment Area	Area (acres)	Priority Rank	Length of Sewer (feet)	Number of Manholes	Number of Buildings
4	185	1	23,000	92	690
3	516	2	34,000	123	595
7	143	3	14,000	58	304
Totals	**844**		**71,000**	**273**	**1,589**

4.2.2 Priority Catchments Identified for Inflow SSES Investigations

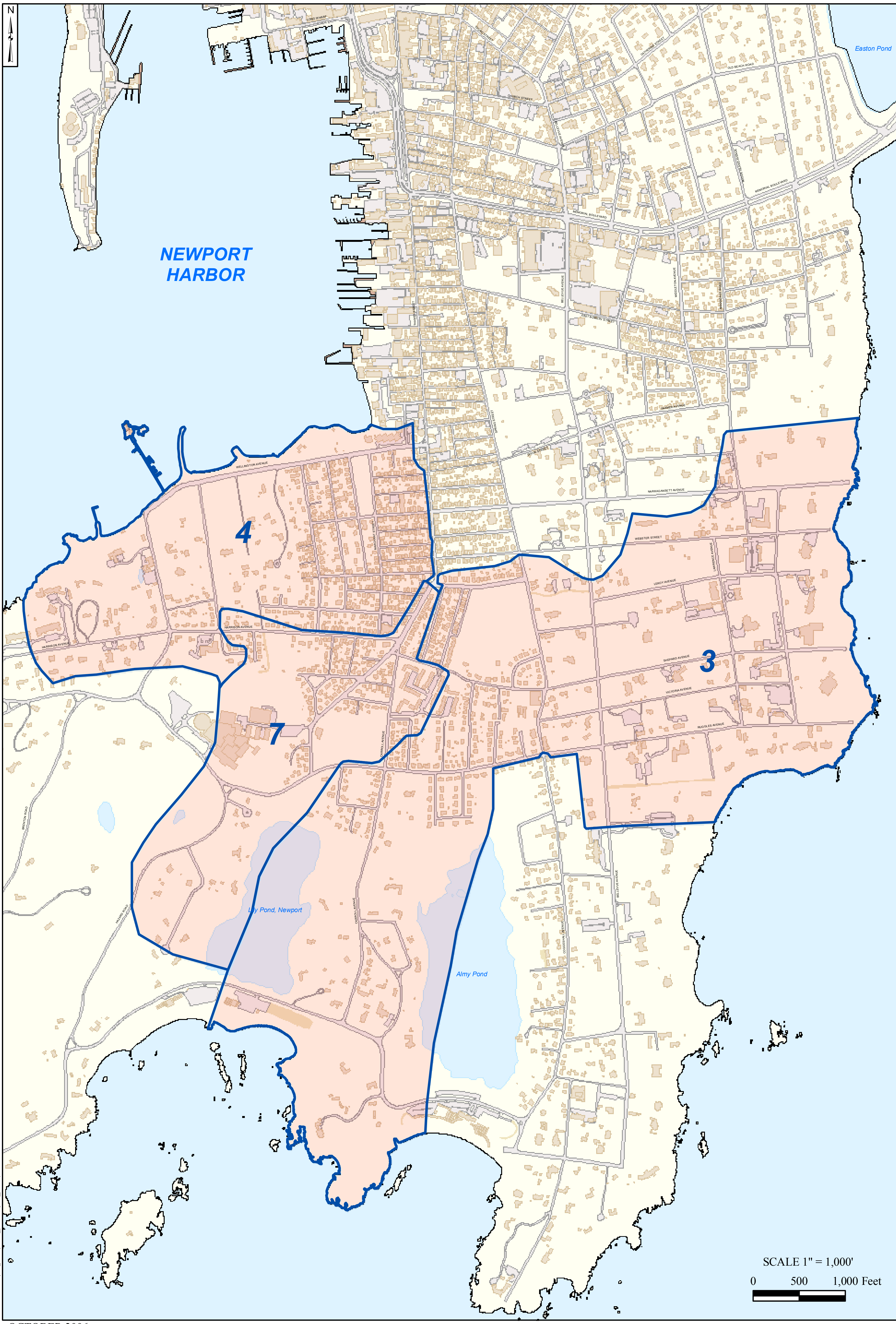
Based on experience on similar projects, the catchments that contribute 80% of the system inflow are generally considered the most cost-effective for further investigation to identify inflow sources. Based on this methodology, the priority catchments for detailed sewer system evaluation survey to identify inflow sources are presented in Table 4.4.

TABLE 4.4
PRIORITY CATCHMENTS IN NEWEPORT FOR INFLOW SSES INVESTIGATIONS

Catchment Area	Area (acres)	Priority Rank	Length of Sewer (feet)	Number of Manholes	Number of Buildings
3	516	1	34,000	123	595
4	185	2	23,000	92	690
1	223	3	33,000	115	723
Totals	**924**		**90,000**	**330**	**2,008**

Note: The highest priority catchment is Area 5, which reflects flow entirely from Middletown's Wave Avenue Pump Station

Figure 4.3 presents the priority catchments for inflow investigations.



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LEGEND:
- Priority Catchments for Infiltration Investigation
- Buildings
- Docks
- Paved Roads and Parking
- Unpaved Roads and Parking

FIGURE 4.2
PRIORITY CATCHMENTS FOR INFILTRATION SSES INVESTIGATIONS PHASE I PART I CSO CONTROL PLAN

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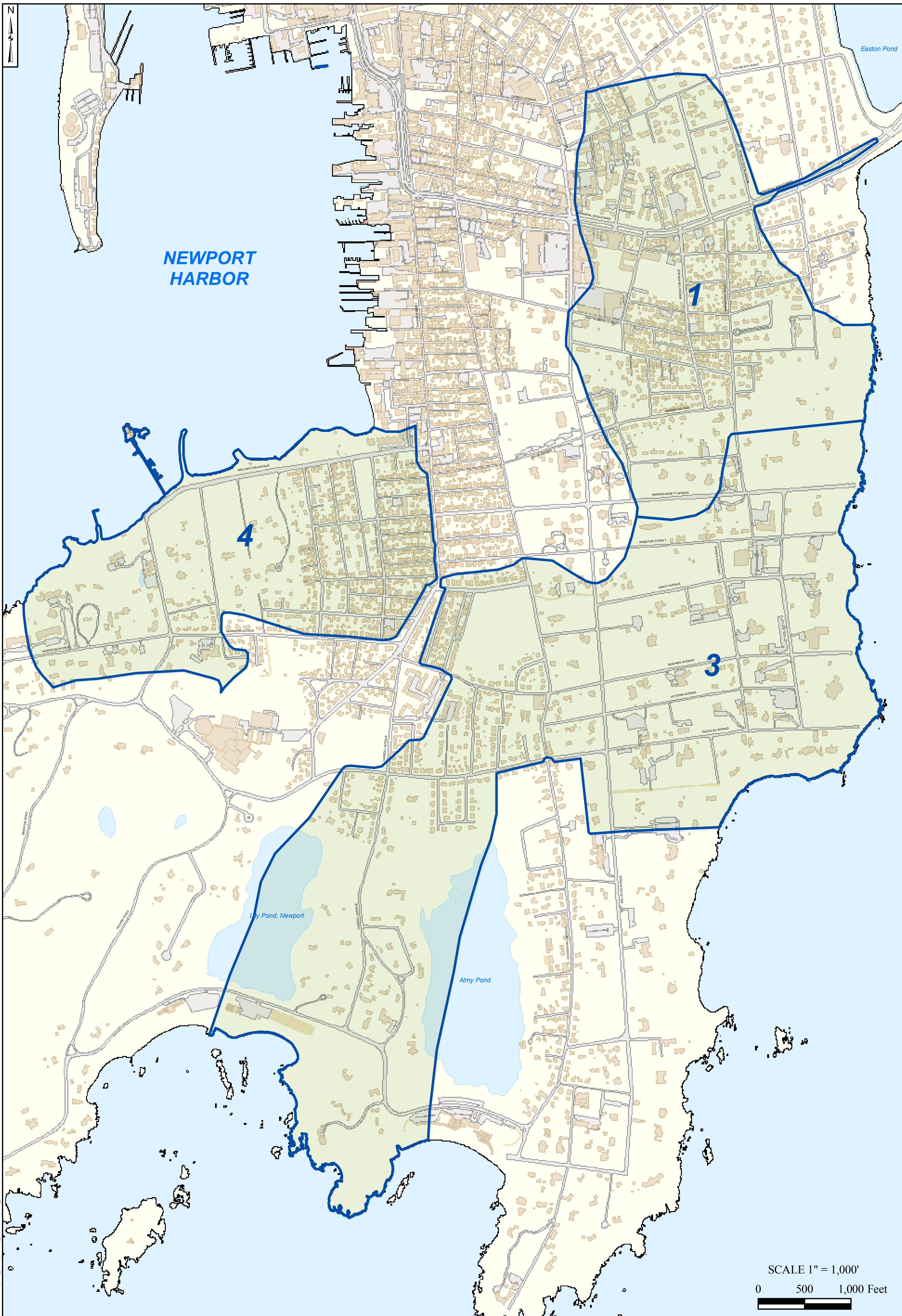

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OCTOBER 2006

LEGEND:
- Priority Catchments for Inflow Investigation
- Buildings
- Docks
- Paved Roads and Parking
- Unpaved Roads and Parking

FIGURE 4.3
PRIORITY CATCHMENTS FOR INFLOW SSES INVESTIGATIONS PHASE I PART I CSO CONTROL PLAN

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4.2.3 Estimated Cost for Phase 1 Part 2 Sewer System Evaluation Survey of Priority Catchments

Table 4.5 presents the estimated cost for the Phase 1 Part 2 Sewer System Evaluation Survey in Newport's Priority Catchments. In addition, further flow metering for Catchment Area 6 is included to determine the inflow contribution from this catchment (to address the anomaly as described in Section 4.1.2).

TABLE 4.5
ESTIMATED COSTS FOR SSES
PRIORITY CATCHMENTS 1, 3, 4 AND 7

Item	Assumption	Source	Unit Cost	Quantity	Estimated Cost
Flow Isolation (3, 4 and 7)	100% of study area footage	Infiltration	$0.40/LF	71,000	$28,400
Cleaning and Television Inspection (3, 4 and 7)	50% of flow isolation footage	Infiltration	$2.00/LF	35,500	$71,000
Manhole Inspections (1,3,4, and 7)	100% of manholes	Infiltration and Inflow	$55 each	388	$21,340
Building Inspections (1, 3 and 4)	100% of buildings	Inflow	$40 each	2,008	$80,320
Smoke Testing (1, 3 and 4)	100% of study area footage	Inflow	$0.35/LF	90,000	$31,500
Dye Testing (1, 3 and 4)	One test for every 1000 feet of smoke testing footage	Inflow	$110 each	90	$9,900
Flow Metering (Catchment Area 6)	Flow metering to determine inflow (4 week period)	Infiltration and Inflow	$2,400 each	5	$12,000
Subtotal					**$254,460**
Engineering	20%	Infiltration and Inflow	$50,892	1	$50,892
Contingency	10%	Infiltration and Inflow	$25,450	1	$25,450
Total					**$330,802**
Estimated Cost for SSES for Priority Catchments 1, 3, 4 and 7					**$331,000**

4.3 CSO CONTROL ALTERNATIVES

This section presents the CSO control alternatives evaluated as part of the Phase 1 Part 1 investigations.

4.3.1 Nine Minimum Controls and Best Management Practices

The City of Newport's collection system and wastewater treatment and pumping facilities are operated by Earth Tech. Through the service contract that the City has with Earth Tech, a number of programs have been implemented to satisfy the requirements of the Nine Minimum Controls, which are part of EPA and RIDEM's CSO Control Policy. Those programs are summarized in Table 4.6 on the following page.

In addition to these Nine Minimum Controls, the City prepared a Phase II Stormwater Management Plan in 2004. The City currently performs street sweeping and catch basin cleaning. Street sweeping of each street is performed annually, and downtown areas are swept more frequently. Catch basin cleaning is performed once every three years, with more frequent cleaning of those catch basins with chronic high sediment accumulation. The City proposes to begin inspecting and cleaning catch basins on an annual basis, using the GIS system to track the effort. The City performs catch basin inspections for illicit connections and non-stormwater discharges, including illegal dumping, and hazardous waste/material spills during the annual catch basin inspection program. Areas where floatables controls are needed will be identified as part of this program. The City is developing a strategy to ensure that design and construction of new stormwater systems incorporate additional water quality protection devices.

TABLE 4.6
CITY OF NEWPORT'S COMPLIANCE WITH EPA'S NINE MINIMUM CONTROLS

Nine Minimum Controls	City of Newport's Compliance Effort
1. Proper operation and maintenance programs for sewer systems and CSOs	The City regularly maintains the wastewater and storm drain collection system, CSO outfalls, regulators, pump stations, CSO treatment facilities and the Newport Water Pollution Control Plant. Collection system staff inspect each underground component a minimum of once every three years and perform corrective actions when deficiencies are found.
2. Maximize use of collection system storage	The City manages diversion structures to maximize flows in the interceptors and to maximize utilization of the Narragansett Avenue Storage Conduit to store system flows and reduce CSO discharges.
3. Review and modification of pretreatment requirements to ensure CSO impacts are minimized	The City has an Industrial Pretreatment Program (IPP) that has been approved by RIDEM. The IPP consists of a final pretreatment ordinance and an enforcement response plan.
4. Maximization of flow to secondary treatment plant for treatment	The system is operated to maximize flow to the Newport Water Pollution Control Plant. Recent efforts have included upgrades to the pumping capacity of the Long Wharf Pump Station and modifications to the operation of the Narragansett Avenue Storage Conduit to maximize conveyance of flow to the WPCP.
5. Elimination of CSOs during dry weather	Dry weather overflows are prohibited. Operation and maintenance activities are directed at the prevention of dry weather overflows.
6. Control of solid and floatable materials in CSOs.	Screening of influent flows is provided at the Wellington Avenue CSO Facility. Street sweeping is routinely performed. Catch basins are cleaned a minimum of once every three years.
7. Pollution prevention programs to reduce contaminants in CSOs	The City has implemented both Industrial Pretreatment Program (IPP) and a local Hazardous Waste Program to reduce discharge of chemicals and other substances that negatively impact the environment and the wastewater treatment process.
8. Public notification program to ensure that the public receives adequate notice of CSO events and impacts	The City has a CSO posting and notification program.
9. Monitoring to effectively characterize CSO impacts and the efficiency of CSO controls.	Discharge Monitoring Reports are submitted to RIDEM that include reporting of any CSO events.

4.3.2 Enhanced Sewer Separation

Presently, the wastewater collection system is predominately separated. However, as noted in this report, and based on the flow metering conducted in March 2005, the system exhibits a significant increase in flows due to both infiltration and inflow (I/I). Enhanced sewer separation includes the following I/I and sewer separation activities:

- Field investigations to identify sources of infiltration and inflow;
- Sewer system rehabilitation to repair leaky pipes and manholes to reduce impacts of infiltration;
- Disconnection and relocation of inflow sources such as sump pumps, area drains and roof drains from the sewer system; and,
- Construction of new storm drains in areas that are presently not separated, or construction of larger storm drains in areas where additional capacity is required to convey separated flows from roof drains and/or sump pumps.

Hydraulic modeling is recommended to predict to what extent enhanced sewer separation may reduce or eliminate CSOs.

4.3.3 Storage/Treatment

Storage of wet weather flows for subsequent discharge to the Wellington Avenue Facility and pumping to the WPCP, once treatment and conveyance capacity have been restored, include the following technologies:

- **In-line Storage,** which is provided in series with the existing sewer system as either construction of new tanks and/or oversized conduits to provide storage capacity, as was done with the Narragansett Avenue Storage Conduit. The oversized conduit or new tank is designed to allow dry weather flows to pass through, while flows above the design peak are restricted, causing the tank or oversized conduit to fill. This can be accomplished on an existing underused conduit with the installation of a flow regulating device.

- **Off-line Near Surface Storage**, which is constructed parallel to the existing sewer system. Storage systems can be constructed as concrete tanks or as conduits, either large round or box-culvert conduits. Storage can operate in either a retention (i.e., storage with post event pumpout) or detention (i.e., flow through during the event) mode. Stored flows are returned to the sewer system for conveyance to the WPCP, once the storm subsides and capacity again becomes available.

Similar to enhanced sewer separation, hydraulic modeling is recommended to predict to what extent storage will reduce or eliminates CSOs from the Wellington Avenue CSO Facility.

4.3.4 Storage, Conveyance and Treatment at the WPCP

Storage and conveyance of wet weather flows to the Newport WPCP was also considered as an alternative. This alternative includes the following elements:

- A storage and conveyance system consisting of a new interceptor sewer, appropriate junction structures, and pumping station(s) to discharge flows to the WPCP ; and,

- Expansion of the WPCP to add primary clarifiers and chlorination and dechlorination facilities to provide equivalent primary treatment and disinfection of the additional wet weather flow.

It is noted that this alternative would require discussions with RIDEM to determine the appropriate wet weather treatment scenario that could be permitted. Similar to separation and storage, hydraulic modeling would be needed to predict to what extent this alternative reduces or eliminates CSOs from the Wellington Avenue CSO Facility.

4.4 REVIEW OF CSO DATA AND PRELIMINARY ESTIMATES OF CSO REDUCTION

4.4.1 Regulatory Perspective

EPA's CSO Control Policy requires the CSO Control Plan to "give the highest priority to controlling overflows to sensitive areas." The Wellington Avenue CSO Facility's CSO 007 discharges in the vicinity of Kings Park Beach, which was designated a Flagship Beach in 2003 by EPA and RIDEM and is a priority for controlling CSO discharges. The Policy requires the following:

- Elimination or relocation of overflows that discharge to sensitive areas "wherever physically possible and economically achievable, except where elimination or relocation would provide less environmental protection than additional treatment;"

- If elimination or relocation is not physically possible or financially achievable, the CSO Control Plan must include measures to provide additional treatment for remaining overflows deemed necessary to meet Water Quality Standards. In addition, permitting authorities should require for each subsequent permit term, a reassessment based on new or improved techniques to eliminate or relocate overflows, or any changed circumstances that influence economic achievability.

With regard to measures to provide additional treatment as noted above, EPA requires that a range of alternatives be considered as part of the development of the CSO Control Plan. The Plan must evaluate controls that would be necessary to achieve: zero overflow events per year; an average of one to three; four to seven; and eight to twelve overflows per year.

4.4.2 Overview and Need for Hydraulic Modeling

EPA has stated that a collection system hydraulic model developed for system characterization is an appropriate tool for predicting CSO flow rates and volumes. The system model can be used to establish the system's existing hydrologic and hydraulic conditions and be calibrated and verified such that it can be used to predict CSO frequency, duration and volume and to evaluate the impacts of CSO control alternatives as proposed in the CSO Control Plan. A monitoring and modeling plan will be submitted to RIDEM prior to the start of modeling work.

According to EPA, the level of CSO abatement necessary to meet CSO control goals depends on the definition of the specific goals. A goal of complete CSO elimination means that discharges from the Wellington Avenue CSO Facility would be eliminated under all possible hydraulic and hydrologic conditions. This dictates 100% sewer separation (i.e., inflow elimination) or CSO relocation. Given the location of the Wellington Avenue CSO Facility and the configuration of the outfall, relocation is not feasible or practical. Accomplishment of 100% sewer separation also may not be attainable due to construction constraints of some individual direct connections from buildings to the sanitary sewer. Sizing storage to meet goals of providing total CSO elimination under all storm conditions would require use of a hydraulic model to perform a continuous simulation of multiple years of rainfall data to determine the predicted maximum volume of CSO anticipated at the facility and to determine the required storage.

The development of a hydraulic model of the entire Newport sewer system, including its pump stations and CSO facilities, will, at some point in the planning process, be needed to accurately predict the effectiveness of either sewer separation or storage with regard to reduction/elimination of CSOs. The model will provide an analysis tool to better understand how the system functions under varying conditions; to estimate possible CSO reductions for different alternatives, either as stand-alone or in combination; and to evaluate the cost of various alternatives.

As Part of the Phase 1 Part 2 analysis, evaluation of the most appropriate model is recommended as a first step for modeling of the City's system. Currently, there are several models available to perform hydraulic analysis of a complex sewer system, including; InfoWorks, MOUSE and XP SWMM, which are proprietary software packages that require purchase of the model with a license for its use. Each of the models is capable of utilizing GIS information for input of sewer system information. However, the City's GIS presently has manhole rim information, but does not have invert or pipe material information. This information can be collected through review of available record plans and manhole inspections to gather data in the field and then input into the GIS database prior to development of the model.

Development of a hydraulic model of Newport's sewer system would consist of the following tasks:

- Evaluation and selection of the most appropriate model;
- Flow metering and rainfall monitoring to provide model calibration and verification data;
- Field data collection to fill in gaps in missing GIS or record plan attribute data and to verify the configuration of diversion structures or other hydraulic structures;
- Input of sewer system attribute information into the GIS;
- Model development;
- Model calibration and verification to confirm accuracy of simulation of existing hydrologic and hydraulic conditions; and
- Model simulations of continuous rainfall events (i.e., one or more years of rainfall data) or design storm events (such as the 1-year 6 hour storm as required by RIDEM CSO Policy) to evaluate the effectiveness of CSO control alternatives

such as storage, conveyance and sewer separation on the reduction or elimination of CSOs at the Wellington Avenue and Washington Street CSO Facilities and Long Wharf Pumping Station.

The estimated cost to prepare a hydraulic model for the City's sewer system is as follows:

- Model evaluation and selection: $15,000
- Flow metering and rainfall monitoring to be used for model calibration and verification: $50,000
- Review available plans and perform field inspections of manholes to collect and verify data, and input sewer system attribute information into the GIS for use with the hydraulic model: $50,000
- Model development, calibration, analysis of alternatives and preparation of the modeling report: $300,000.

These costs will be further evaluated and refined based on the development of a more detailed scope of work. It is noted that the cost for the model could be reduced if only the tributary system to the Wellington Avenue CSO Facility is performed, however, it is best to have a model for the entire system in the event that further work is performed on other areas not currently under study and to understand how the City's integrated system functions under different storm events and antecedent groundwater and tidal conditions.

4.4.3 CSO Activity 1998 - 2005

Evaluation of CSO activation data at the Wellington Avenue CSO Facility from January 1998 through April 2005 was performed as part of this study. The data are summarized in Table 4.7 and are presented in Table 4.8 chronologically and in Table 4.9 ranked from the highest to the lowest volume CSO event. Review of the data indicates that during this seven year period, the average CSO volume was approximately 1.5 million gallons with a maximum CSO event volume of 24.5 million gallons. There were 156 CSO events, with 143 (equal to 92% of total) events with a volume of 4 million gallons or less. The average number of CSO events per year for this period is 21.

TABLE 4.7
CSO ACTIVITY SUMMARY
1998-2005

Volume of CSO	Number of Events	Percent of Total Events (%)
24,500,000	1	0.6
10,000,000 - 15,000,000	2	1.3
5,000,000 - 10,000,000	6	3.8
> 4,000,000	13	8.3
> 2,000,000	36	23
> 1,000,000	52	33
< 1,000,000	104	67

It is noted that the largest CSO occurred on March 30, 2001 and appears to be an anomalous event that occurred during a month with unusually large and frequent rain events. The measured rainfall during the event was 4.32 inches. In addition, the total rainfall for the month was 11.75 inches, including rain events of 2 inches and 4 inches occurring in the two weeks prior to this event. Therefore, this large CSO event likely occurred when antecedent groundwater conditions were very high and infiltration and indirect inflow (from sump pumps) into the system were at a maximum. Since 2001, improvements to the Wellington Avenue CSO Facility's pumping capacity and the optimization of the storage function of the Narragansett Storage Conduit were completed in 2003. **Review of the data indicates that the mean and median CSO volume per event and the average number of events/year have decreased after these improvements were completed in 2003.** Table 4.10 illustrates this comparison.

Table 4.8
Wellington Avenue CSO Facility CSO Discharges 1998 - 2005

Year	Day & Month of Discharge	Wellington CSO Total Discharge (gal)	Rainfall Total (in.)	Year	Day & Month of Discharge	Wellington CSO Total Discharge (gal)	Rainfall Total (in.)	Year	Day & Month of Discharge	Wellington CSO Total Discharge (gal)	Rainfall Total (in.)	Year	Day & Month of Discharge	Wellington CSO Total Discharge (gal)	Rainfall Total (in.)
1998	7-Jan	38,400	1.6	2000	11-Mar	13,598,400	4.51	2001	12-Jun	1,171,000	1.50	2003	9-Apr	209,000	0.41
	9-Jan	76,800	0.38		17-Mar	3,873,600	1.37		17-Jun	2,460,000	1.60		11-Apr	6,205,000	1.00
	23-Jan	3,818,400	2.4		28-Mar	1,264,800	1.21		5-Jul	151,000	0.55		22-Apr	870,000	1.34
	2-Feb	115,200	0.7		19-Apr	230,400	0.66		11-Jul	110,000	0.56		26-Apr	3,084,000	1.61
	18-Feb	8,217,600	2		22-Apr	10,773,600	3.28		26-Jul	1,029,000	2.62		1-May	120,000	0.17
	24-Feb	3,380,800	1.58		14-May	230,400	0.56		13-Aug	220,000	0.93		26-May	270,000	1.29
	1-Mar	153,600	0.73		24-May	266,400	0.61		20-Aug	429,000	1.07		5-Jun	1,319,000	1.18
	9-Mar	3,457,800	2.09		2-Jun	230,400	0.6		21-Sep	135,000	0.65		7-Jun	121,000	0.12
	19-Mar	2,568,000	1.85		6-Jun	460,800	1.71		16-Oct	401,000	0.00		18-Jun	120,000	0.70
	1-Apr	2,412,000	1.88		16-Jul	652,800	1.35		24-Oct	108,000	0.46		22-Jun	180,000	1.09
	17-Apr	74,400	0.91		26-Jul	499,200	2.03		18-Dec	34,000	0.80		3-Jul	180,000	0.87
	2-May	230,400	0.91		31-Jul	376,000	1.05	2002	7-Jan	52,000	0.59		24-Jul	200,000	0.96
	9-May	76,800	0.45		1-Aug	228,000	0.18		21-Jan	27,000	0.50		8-Aug	2,055,000	2.05
	10-May	3,136,800	1.22		10-Aug	345,600	0.9		3-Mar	36,000	0.80		17-Aug	2,471,000	1.31
	13-Jun	5,971,200	3.69		9-Sep	652,800	0.78		20-Mar	1,415,000	0.60		15-Oct	300,000	1.53
	30-Jun	876,000	1.82		13-Sep	76,800	0.44		26-Mar	1,451,000	0.36		29-Oct	70,000	1.19
	17-Aug	883,200	0.76		15-Sep	688,800	0.95		31-Mar	3,073,000	0.04		11-Dec	346,000	0.90
	22-Sep	38,400	1.48		19-Sep	1,307,400	1.71		25-Apr	470,000	0.08		14-Dec	500,000	1.07
1999	3-Jan	192,000	1.09		10-Nov	537,600	2.69		2-May	541,000	0.78	2004	6-Feb	140,000	1.92
	15-Jan	537,600	1.03		26-Nov	153,600	1.12		13-May	1,616,000	0.70		21-Mar	100,000	0.40
	18-Jan	115,200	0.08		14-Dec	1,790,400	1.35		18-May	2,980,000	1.88		31-Mar	4,550,000	1.71
	2-Feb	2,971,200	1.71		17-Dec	3,830,400	2.06		7-Jun	833,000	2.00		4-Apr	279,000	0.49
	18-Feb	192,000	0.87		19-Dec	609,600	0.79		29-Jul	100,000	0.69		13-Apr	2,717,000	2.01
	28-Feb	2,568,000	1.36		30-Dec	38,400	0.18		2-Sep	462,000	0.76		15-Aug	787,000	2.60
	4-Mar	466,800	0.63	2001	30-Jan	1,075,200	0.75		23-Sep	797,000	1.76		31-Aug	102,000	0.73
	6-Mar	765,600	0.47		5-Feb	1,305,600	1.46		16-Oct	297,000	1.06		18-Sep	431,000	1.90
	8-Sep	230,400	0.63		25-Feb	307,200	0.75		13-Nov	252,000	1.23		29-Sep	2,590,000	2.89
	10-Sep	648,000	1.73		5-Mar	8,071,000	1.51		17-Nov	2,880,000	1.22		19-Oct	60,000	1.12
	16-Sep	304,800	1.68		9-Mar	190,000	0.85		12-Dec	449,000	1.35		28-Nov	152,000	0.98
	4-Oct	268,800	1.3		13-Mar	4,709,000	2.05		14-Dec	264,000	1.65		7-Dec	330,000	1.23
	14-Oct	1,072,800	2.3		22-Mar	8,064,000	2.13		25-Dec	659,000	0.92		10-Dec	1,168,000	1.50
	18-Oct	1,111,200	1.66		30-Mar	24,384,000	4.32	2003	1-Jan	880,000	0.20	2005	12-Jan	152,388	0.61
	20-Oct	1,075,200	1.33		6-Apr	192,000	0.22		3-Jan	3,539,000	0.10		14-Jan	330,174	0.62
	3-Nov	614,400	1.4		8-Apr	384,000	0.72		22-Feb	4,352,000	1.45		16-Jan	203,184	0.05
	25-Nov	384,000	0.62		12-Apr	4,480,000	0.51		2-Mar	3,297,000	1.59		10-Feb	177,786	0.45
2000	5-Jan	76,800	0.79		23-May	461,000	0.31		9-Mar	216,000	0.00		8-Mar	1,066,716	1.47
	10-Jan	614,400	0.95		25-May	307,400	0.63		21-Mar	115,000	0.55		28-Mar	2,920,770	2.56
	25-Jan	345,600	0.77		2-Jun	230,000	0.99		22-Mar	307,000	0.28		2-Apr	2,412,810	1.72
	14-Feb	765,600	1.18		3-Jun	115,000	0.13		30-Mar	5,340,000	2.84		30-Apr	711,144	1.15

Table 4.9
Wellington Avenue CSO Facility CSO Discharges 1998 - 2005

Day & Month of Discharge	Wellington CSO Total Discharge (gal)	Rainfall Total (in.)	Day & Month of Discharge	Wellington CSO Total Discharge (gal)	Rainfall Total (in.)	Day & Month of Discharge	Wellington CSO Total Discharge (gal)	Rainfall Total (in.)	Day & Month of Discharge	Wellington CSO Total Discharge (gal)	Rainfall Total (in.)
March 30, 2001	24,384,000	4.32	March 20, 2002	1,415,000	0.60	May 23, 2001	461,000	0.31	February 18, 1999	192,000	0.87
March 11, 2000	13,598,400	4.51	June 5, 2003	1,319,000	1.18	June 6, 2000	460,800	1.71	April 6, 2001	192,000	0.22
April 22, 2000	10,773,600	3.28	September 19, 2000	1,307,400	1.71	December 12, 2002	449,000	1.35	March 9, 2001	190,000	0.85
February 18, 1998	8,217,600	2	February 5, 2001	1,305,600	1.46	September 18, 2004	431,000	1.90	June 22, 2003	180,000	1.09
March 5, 2001	8,071,000	1.51	March 28, 2000	1,264,800	1.21	August 20, 2001	429,000	1.07	July 3, 2003	180,000	0.87
March 22, 2001	8,064,000	2.13	June 12, 2001	1,171,000	1.50	October 16, 2001	401,000	0.00	February 10, 2005	177,786	0.45
April 11, 2003	6,205,000	1.00	December 10, 2004	1,168,000	1.50	November 25, 1999	384,000	0.62	March 1, 1998	153,600	0.73
June 13, 1998	5,971,200	3.69	October 18, 1999	1,111,200	1.66	April 8, 2001	384,000	0.72	November 26, 2000	153,600	1.12
March 30, 2003	5,340,000	2.84	October 20, 1999	1,075,200	1.33	July 31, 2000	376,000	1.05	January 12, 2005	152,388	0.61
March 13, 2001	4,709,000	2.05	January 30, 2001	1,075,200	0.75	December 11, 2003	346,000	0.90	November 28, 2004	152,000	0.98
March 31, 2004	4,550,000	1.71	October 14, 1999	1,072,800	2.3	January 25, 2000	345,600	0.77	July 5, 2001	151,000	0.55
April 12, 2001	4,480,000	0.51	March 8, 2005	1,066,716	1.47	August 10, 2000	345,600	0.9	February 6, 2004	140,000	1.92
February 22, 2003	4,352,000	1.45	July 26, 2001	1,029,000	2.62	January 14, 2005	330,174	0.62	September 21, 2001	135,000	0.65
March 17, 2000	3,873,600	1.37	August 17, 1998	883,200	0.76	December 7, 2004	330,000	1.23	June 7, 2003	121,000	0.12
December 17, 2000	3,830,400	2.06	January 1, 2003	880,000	0.20	May 25, 2001	307,400	0.63	May 1, 2003	120,000	0.17
January 23, 1998	3,818,400	2.4	June 30, 1998	876,000	1.82	February 25, 2001	307,200	0.75	June 18, 2003	120,000	0.70
January 3, 2003	3,539,000	0.10	April 22, 2003	870,000	1.34	March 22, 2003	307,000	0.28	February 2, 1998	115,200	0.7
March 9, 1998	3,457,800	2.09	June 7, 2002	833,000	2.00	September 16, 1999	304,800	1.68	January 18, 1999	115,200	0.08
February 24, 1998	3,380,800	1.58	September 23, 2002	797,000	1.76	October 15, 2003	300,000	1.53	June 3, 2001	115,000	0.13
March 2, 2003	3,297,000	1.59	August 15, 2004	787,000	2.60	October 16, 2002	297,000	1.06	March 21, 2003	115,000	0.55
May 10, 1998	3,136,800	1.22	March 6, 1999	765,600	0.47	April 4, 2004	279,000	0.49	July 11, 2001	110,000	0.56
April 26, 2003	3,084,000	1.61	February 14, 2000	765,600	1.18	May 26, 2003	270,000	1.29	October 24, 2001	108,000	0.46
March 31, 2002	3,073,000	0.04	April 30, 2005	711,144	1.15	October 4, 1999	268,800	1.3	August 31, 2004	102,000	0.73
May 18, 2002	2,980,000	1.88	September 15, 2000	688,800	0.95	May 24, 2000	266,400	0.61	July 29, 2002	100,000	0.69
February 2, 1999	2,971,200	1.71	December 25, 2002	659,000	0.92	December 14, 2002	264,000	1.65	March 21, 2004	100,000	0.40
March 28, 2005	2,920,770	2.56	July 16, 2000	652,800	1.35	November 13, 2002	252,000	1.23	January 9, 1998	76,800	0.38
November 17, 2002	2,880,000	1.22	September 9, 2000	652,800	0.78	May 2, 1998	230,400	0.91	May 9, 1998	76,800	0.45
April 13, 2004	2,717,000	2.01	September 10, 1999	648,000	1.73	September 8, 1999	230,400	0.63	January 5, 2000	76,800	0.79
September 29, 2004	2,590,000	2.89	November 3, 1999	614,400	1.4	April 19, 2000	230,400	0.66	September 13, 2000	76,800	0.44
March 19, 1998	2,568,000	1.85	January 10, 2000	614,400	0.95	May 14, 2000	230,400	0.56	April 17, 1998	74,400	0.91
February 28, 1999	2,568,000	1.36	December 19, 2000	609,600	0.79	June 2, 2000	230,400	0.6	October 29, 2003	70,000	1.19
August 17, 2003	2,471,000	1.31	May 2, 2002	541,000	0.78	June 2, 2001	230,000	0.99	October 19, 2004	60,000	1.12
June 17, 2001	2,460,000	1.60	January 15, 1999	537,600	1.03	August 1, 2000	228,000	0.18	January 7, 2002	52,000	0.59
April 2, 2005	2,412,810	1.72	November 10, 2000	537,600	2.69	August 13, 2001	220,000	0.93	January 7, 1998	38,400	1.6
April 1, 1998	2,412,000	1.88	December 14, 2003	500,000	1.07	March 9, 2003	216,000	0.00	September 22, 1998	38,400	1.48
August 8, 2003	2,055,000	2.05	July 26, 2000	499,200	2.03	April 9, 2003	209,000	0.41	December 30, 2000	38,400	0.18
December 14, 2000	1,790,400	1.35	April 25, 2002	470,000	0.08	January 16, 2005	203,184	0.05	March 3, 2002	36,000	0.80
May 13, 2002	1,616,000	0.70	March 4, 1999	466,800	0.63	July 24, 2003	200,000	0.96	December 18, 2001	34,000	0.80
March 26, 2002	1,451,000	0.36	September 2, 2002	462,000	0.76	January 3, 1999	192,000	1.09	January 21, 2002	27,000	0.50

TABLE 4.10

COMPARISON OF AVERAGE AND MEDIAN CSO VOLUME PER EVENT

Time Period	Average CSO Volume/Event (gallons)	Median CSO Volume/Event (gallons)	Average Number of CSO Events/Year
January 1998 through December 2003	1,550,000	467,000	23
January 2004 through April 2005	1,000,000	331,000	19

Further review of the data from 1998 to 2004 with regard to the number of CSO events per year, the total rainfall associated with the CSO events, and the number of events that exceed several volumetric thresholds are presented in Table 4.11

TABLE 4.11

ANNUAL CSO EVENTS, ASSOCIATED RAINFALL AND VOLUMETRIC COMPARISONS

1998-2004

Year	Number of CSO Events[1]	Total Rainfall Associated with CSO Events (inches)	Number of CSO Events that Exceed 500,000 gallons	Number of CSO Events that Exceed 2,000,000 gallons	Number of CSO Events that Exceed 4,000,000 gallons	Number of CSO Events that Exceed 5,000,000 gallons	Maximum CSO Event Volume (gallons)
1998	18	26.5	10	8	2	2	8,220,000
1999	17	19.9	9	2	0	0	2,970,000
2000	28	35.8	14	4	2	2	13,600,000
2001	26	28.1	10	6	4	3	25,000,000
2002	20	19.0	10	3	0	0	3,000,000
2003	26	25.8	11	8	3	2	6,200,000
2004	13	19.5	6	3	1	0	4,600,000

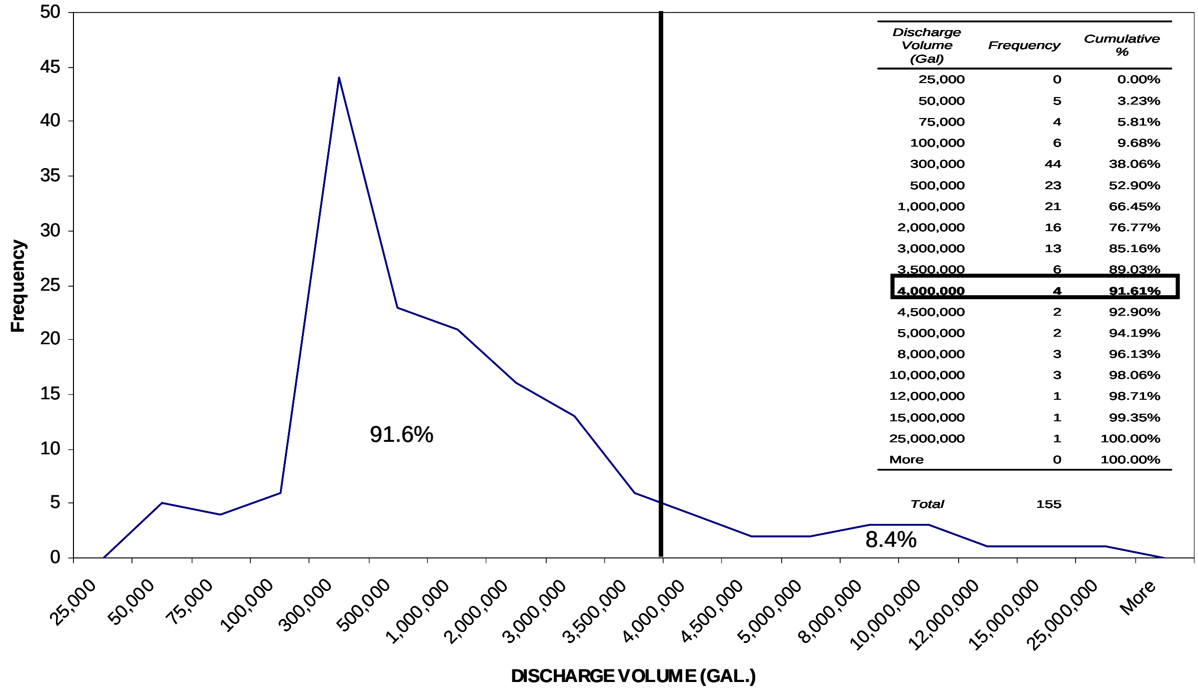
1. Total events 1998 through 2004 is 148. There were 8 CSO events through April 2005.

Analysis of the data presented in Table 4.11, indicates that removal of approximately 4,000,000 gallons of flow from the sewer system, either by enhanced sewer separation, storage, or storage and treatment at the WPCP, either separately or in combination; would dramatically reduce the frequency of CSOs at the Wellington Avenue CSO Facility by well over 90%. This is illustrated by the following histograms, as shown graphically on Page 4-26 and described below.

Figure 4.4 depicts the histogram of the frequency of events for the entire period of data (January 1998 to April 2005). It is noted that for the entire period of record, removal of 4,000,000 gallons of flow from the system would result in capture of 91.6% of the CSO events. Figure 4.5 depicts the histogram for January 2004 to April 2005, which is the time period following completion of the construction of improvements to the Wellington Avenue CSO Facility and the Narragansett Avenue Storage Conduit, and other system improvements. Review of this figure indicates that removal of 4,000,000 gallons of flow from the system would result in capture of over 95% of the CSO events.

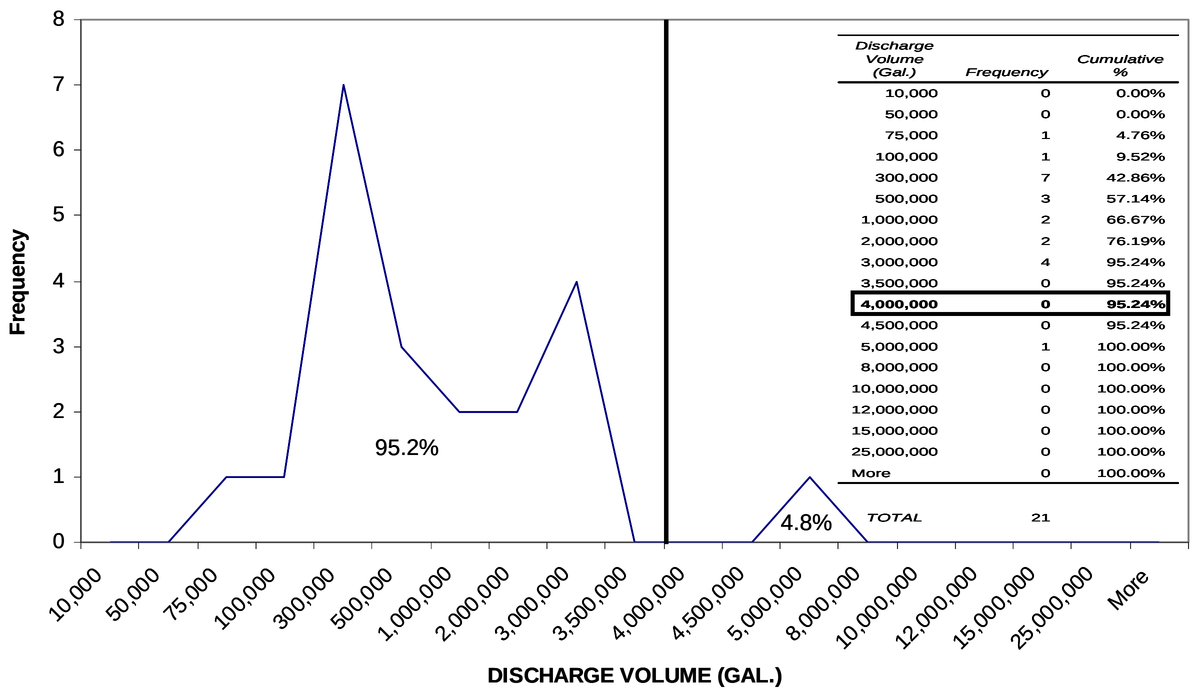
Review of Tables 4.1 and 4.2 indicates that the system presently conveys approximately 1,600,000 of infiltration and approximately 5,000,000 of inflow from Catchments 1, 2, 3, 4, 6 and 7. The storm associated with the inflow volume had a depth of 0.8 inches with a peak intensity of 0.22 inches/hour which is a typical 1 to 2 month storm. In addition, inflow from the Wave Avenue Pump Station of 5,000,000 gallons was noted during that storm. Therefore, an aggressive infiltration and inflow removal program by the City, coupled with a similar program performed by the Town of Middletown, would make a significant impact towards eliminating 4,000,000 gallons of flow from the system.

FIGURE 4.4
WELLINGTON AVENUE CSO FACILITY DISCHARGES
JANUARY 1998 THROUGH APRIL 2005



Discharge Volume (Gal)	*Frequency*	*Cumulative %*
25,000	0	0.00%
50,000	5	3.23%
75,000	4	5.81%
100,000	6	9.68%
300,000	44	38.06%
500,000	23	52.90%
1,000,000	21	66.45%
2,000,000	16	76.77%
3,000,000	13	85.16%
3,500,000	6	89.03%
4,000,000	**4**	**91.61%**
4,500,000	2	92.90%
5,000,000	2	94.19%
8,000,000	3	96.13%
10,000,000	3	98.06%
12,000,000	1	98.71%
15,000,000	1	99.35%
25,000,000	1	100.00%
More	0	100.00%
Total	155	

FIGURE 4.5
WELLINGTON AVENUE CSO FACILITY DISCHARGES
JANUARY 2004 THROUGH APRIL 2005



Discharge Volume (Gal.)	*Frequency*	*Cumulative %*
10,000	0	0.00%
50,000	0	0.00%
75,000	1	4.76%
100,000	1	9.52%
300,000	7	42.86%
500,000	3	57.14%
1,000,000	2	66.67%
2,000,000	2	76.19%
3,000,000	4	95.24%
3,500,000	0	95.24%
4,000,000	**0**	**95.24%**
4,500,000	0	95.24%
5,000,000	1	100.00%
8,000,000	0	100.00%
10,000,000	0	100.00%
12,000,000	0	100.00%
15,000,000	0	100.00%
25,000,000	0	100.00%
More	0	100.00%
TOTAL	21	

4.4.4 Estimates of CSO Reduction

Table 4.12 presents the preliminary estimates of the volume required to be removed to reduce CSOs at the Wellington Avenue CSO Facility based on the review of the CSO activity data from 1998 to 2005, as presented in Tables 4.7 through 4.11, the histograms presented in Figure 4.4 and 4.5, and using EPA's CSO Policy as discussed above. Removal of flow would be accomplished by enhanced sewer separation, including infiltration and inflow removal, storage, or storage, conveyance, and treatment at the WPCP, either separately or in combination.

TABLE 4.12
ESTIMATED VOLUMES FOR CSO REDUCTION
AT THE WELLINGTON AVENUE CSO FACILITY

CSO Frequency	Estimated Volume to be Removed to Reduce CSO (gallons)
0	5,000,000 +
1-3	4,000,000
4-7	2,000,000
8-12	500,000

It is noted that these estimates are based on a review of the CSO volume and frequency data as presented above and are preliminary. To demonstrate compliance with EPA and RIDEM CSO policies, the volumes presented in Table 4.12 will require refinement and re-evaluation in subsequent phases of the development of the CSO Control Plan as additional field information is collected and analyzed, a system model is developed, and the CSO control concepts are progressed to greater levels of detail. Also, a longer period of CSO overflow data since 2003 will allow a more detailed analysis of the impacts of the recent improvements and a further refinement in the volume reduction required to achieve a reasonable reduction in CSO frequency to meet RIDEM's CSO policy for zero discharge.