LOWELL REGIONAL WASTEWATER UTILITY

WASTEWATER COLLECTION AND TREATMENT

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March 1, 2011

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SUBJECT: LTCP Phase 1A Interim High Flow Management Plan for Lowell MA (NPDES Permit No. MA 0100633)

Gentlemen:

In accordance with Administrative Order (AO) No. 010-026, dated September 30, 2010, the Lowell Regional Wastewater Utility (LRWWU) is pleased to submit the attached document that details LRWWU's Interim High Flow Management Plan (HFMP). This submittal addresses Section IV, Item 2 (page 5) of the above-referenced AO.

Section IV, Item 2 of the AO requires the submittal of: 1) an evaluation of the maximum flow that can be provided full secondary treatment by the WWTF; 2) an evaluation of the maximum flow that can be provided at least primary treatment and disinfection by the WWTF; and 3) facility management procedures, including the WWTF, the collection system, and the CSO outfalls, to maximize the flow reaching the WWTF, maximize the in-line storage within the collection system, and minimize the volume of discharges through the CSO outfalls.

As discussed at our meeting on February 17, 2011, LRWWU is seeking additional time to submit a detailed report that addresses the first two provisions listed above (primary and secondary treatment capacities). LRWWU is requesting additional time in order to better characterize the treatment capacities of the Duck Island WWTF. LRWWU is currently implementing significant upgrades to the WWTF processes – specifically, solids processing, influent pumping, aeration system controls, primary and secondary electrical systems, and flow measurement. Considering the extent of these upgrades, past operational data that has been evaluated for the purpose of characterizing the treatment capacities of the Duck Island WWTF is insufficient.

As a result of these circumstances, LRWWU has proposed to compile new operational data over the next fifteen months and integrate this data – which will better characterize the "new" treatment processes – into a Final HFMP that will be submitted in September 2012. During the February 17th meeting, you indicated that this approach would be acceptable. Furthermore, you indicated that LRWWU must submit an Interim HFMP that addresses the requirements of the third provision of Section IV, Item 2 (interceptor storage and CSO minimization). The enclosed Interim HFMP is intended to comply with this request.

The Interim HFMP describes LRWWU's two-year initiative to document, normalize (on the same datum), modernize, and computerize our wet weather collection system operations and to educate our staff so that we maximize the amount of flow reaching the WWTF and optimize the amount of wet weather flow captured in the interceptor system, thus minimizing untreated CSOs. The Interim HFMP describes that challenges that we have faced during the past two years and the benefits that we have achieved with our efforts. The Interim HFMP includes an overview of LRWWU's diversion stations and system limitations, as well a detailed description of the High Flow Management program that led to a better understanding of the interceptor system. The report provides discussion on the methodology for monitoring interceptor levels during wet weather conditions. The review process and the data analyses that were utilized to identify opportunities and realize benefits are also described.

As a result of the HFM program, important changes have been to LRWWU's wet weather operations. Perhaps most important is the change in culture from a "take-no-chances" approach to a "safe storage" approach that minimizes CSOs while still protecting infrastructure. This aggressive approach to storage could not have been accomplished without a meticulous effort to better understand the interceptor system and how it responds during storm events. System-wide storage has been dramatically increased by adjusting gate-open set points at nearly every diversion station. A new HFM protocol has been established that emphasizes maximization of wet weather flows to the WWTF. Moreover, a major opportunity for additional interceptor storage has been identified along the North Bank Interceptor at Read Station. LRWWU is currently planning to install flow control structures at this location to realize the benefits of this additional storage.

The current wet-weather operating procedures for the collection system and WWTF have certainly improved LRWWU's ability to maximize wet weather flows to the WWTF and minimize CSO discharges. As LRWWU realizes these benefits, we will focus on evaluating the new capabilities of the WWTF. LRWWU is actively assessing the primary and secondary treatment capacities of the WWTF to verify whether the treatment capacities are more flow than the original design capacities of 62 mgd (secondary treatment) and 110 mgd (peak wet weather flow). Should the current evaluation identify additional capacity, this finding will be incorporated in the Final HFMP submittal. In the meantime, LRWWU will utilize the design capacities listed above for WWTF maximization during storm events.

Therefore, LRWWU is submitting the enclosed Interim HFMP to satisfy Section IV, Item 2 of Administrative Order No. 010-026. We will submit a Final HFMP in September 2012 that incorporates any adjustments to WWTF treatment capacities and includes any other revisions to the Interim HFMP. We trust that this Interim HFMP meets the intent of the AO to document procedures that maximize the use of existing facilities and minimize untreated CSO discharges. We will keep you informed of our progress to evaluate the potential to increase wet weather treatment capacities as we progress with the WWTF capacity analysis.

Should you have any questions, comments or concerns about this submittal, please call me or Engineering Manager Mike Stuer at (978) 970-4248

Respectfully,

Mark A. Young

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Executive Director
Lowell Regional Wastewater Utility (LRWWU)

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Exhibit 10
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Interim High Flow Management Plan

LTCP Phase 1A

Lowell Regional Wastewater Utility

March 1, 2011

Exhibit 10
AR H.7

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BACKGROUND

The Lowell Regional Wastewater Utility (LRWWU) owns and operates a combined sewer system (CSS) and the Duck Island wastewater treatment facility (WWTF). The system consists of approximately 220 miles of gravity sewers and twelve sewer pumping stations. Ten miles of large-diameter interceptors (48-inches to 120-inches in diameter), along the banks of the Merrimack and Concord Rivers, collect wastewater from the sewer system and convey it to the Duck Island WWTF. The WWTF was designed to provide secondary treatment to an average flow of 32 million gallons per day (MGD), with a short-term peak capacity of 62 MGD. Plan view of the WWTF and the LRWWU interceptor system is provided in **Figure 1**.

During wet weather conditions, a maximum flow of approximately 110 MGD is treated at the WWTF. Flow in excess of 62 MGD receives primary treatment before being bypassed around the secondary treatment system. This bypass flow is blended with secondary effluent; then the blended effluent is disinfected with chlorine and de-chlorinated with sodium hypochlorite before being discharged into the Merrimack River. Flow in excess of the WWTF wet weather treatment capacity (110 MGD) is discharged into local waterways as Combined Sewer Overflows (CSOs) at nine diversion stations. These CSO discharges relieve hydraulic surcharges in the interceptor system, preventing infrastructure and property damage and sewer back-ups into local streets and homes.

Annually, several hundred million gallons of untreated CSOs have been discharged from LRWWU's permitted CSO outfalls, depending upon rainfall conditions. LRWWU has been under a Consent Decree since 1988 to develop and implement a plan to reduce its CSO discharges to the Merrimack and Concord Rivers and to Beaver Brook. LRWWU completed a Long Term Control Plan (LTCP) for CSO mitigation in 2002 and initiated its LTCP Phase 1 Program shortly thereafter.

One priority in the LTCP program is the utilization of an existing large-diameter interceptor system to capture and store wet weather flows for later treatment at the Duck Island WWTF, rather than discharge to the local waterways. Another priority is the maximization of treatment capacity at the WWTF during wet weather events. With these priorities, LRWWU would maximize the use of its existing infrastructure so that future control facilities could be sized properly, allowing for cost-effective CSO control.

Accordingly, and in compliance with the Administrative Order dated September 2010, LRWWU has prepared this High Flow Management Plan (HFMP) to document LRWWU's progress since the development of its LTCP Phase 1 Program.

OVERVIEW OF DIVERSION STATIONS AND INTERCEPTOR SYSTEM STORAGE

The CSO diversion stations are sophisticated facilities. Several have the capability to screen flow (before downstream siphons) and to gravity discharge and/or pump CSO flow into nearby streams. All stations have multiple gates, at least one diversion gate, as well as a flow control gate that controls the flow through the station. **Figure 2** depicts a typical CSO diversion station and its features. As flow entering the station through the influent line increases during wet weather events, the level in the influent channel is measured with the ultrasonic sensor. The flow control gate and gravity diversion gate are currently programmed to open and close when certain levels in the station are reached to prevent surcharges upstream and property damage within the stations.

For many years, gates and pumps at the diversion stations were operated manually by personnel who were required to drive to each station during rain events. This meant that CSO discharges were initiated earlier and discontinued later than necessary. During this historical period (prior to 2002), there was no remote monitoring of station flows, levels or equipment status. Without this monitoring capability, it was difficult to trouble-shoot remote station problems and to understand how the interceptor system responded during storm events.

In 2002, LRWWU began work to install the initial instrumentation system to remotely operate some of its CSO diversion stations to avoid the drive and manual operation of these stations. This early work included upgrades to flow control gates to replace existing actuators that would make the gates more reliable. Gate control was established using local programmable logic controllers (PLCs) to monitor flow depths and operate the diversion gates.

In 2004, a SCADA system was implemented that improved LRWWU's ability to utilize the interceptor system for wet weather storage. The remote control of diversion gates and pumps allowed operators to instantaneously start and stop diversions based on real-time water levels at the diversion stations. Remote gate control enabled wet weather storage in the interceptors upstream of the stations, resulting in significant reduction of CSO volume and frequency. The SCADA system is also used to acquire operational data and to monitor equipment at each station. Alarms are generated at each remote station to help operators react quickly if there are any equipment failures that might otherwise go unnoticed. This avoids dry weather overflows from the stations and minimizes CSO discharges.

In 2004, as part of the Phase 1 Long Term Control Plan, the LRWWU made several improvements to the Tilden, Merrimack, and Beaver Brook diversion stations. The goal of these improvements was to increase interceptor storage and reduce CSOs at these stations. At Tilden, flow control, gravity diversion, and pump wet well gates were upgraded with continuously modulating hydraulic actuators. This allowed for more precise control of interceptor level and flow through the station. The channel walls were also increased in height by 2 feet in order to safely pass more flow through the station and maximize utilization of the 36" downstream interceptor.

The work at Merrimack station included the addition of three new circular 48" gravity diversion openings, effectively quadrupling the gravity diversion capacity. Flows from these additional gravity diversion points were controlled with new slide gates driven by continuously modulating hydraulic actuators. The flow control gate and existing gravity diversion gate were also upgraded to continuously modulating actuators. The additional diversion capacity allowed operators to maximize the use of interceptor storage capacity at Merrimack Station while maintaining the ability to divert additional flow that was conveyed from the upstream interceptor system. The continuously modulating actuators allowed for more precise control of interceptor level and flow through the station.

Major improvements were made to both the channel and gate system at the Beaver Brook diversion station. The height of both the gravity and pump diversion weirs were raised to increase flow through the station. Several gates were upgraded with modulating actuators. The station gates and pumps were also automated using PLC programming, which minimized diversions and maximized interceptor storage. Most importantly, the influent channel weirs were raised and the influent gates were automated to store wet weather flow in the upstream interceptor.

As required by the LTCP, LRWWU also looked at further refining its diversion flow measurement. In the past, diversion flow was estimated using hydrographs that were developed for each individual station. While this technique provides a good rough estimate, a more accurate measurement approach has been sought to better quantify CSOs. In 2004, LRWWU implemented direct measurement of CSOs at most diversion stations. This was a complex endeavor as the diversion stations were not originally constructed to measure CSO flow and most structures do not contain primary measuring devices.

Flow measurement was attained using Magnetic Flow meters located in the pump diversion discharge pipes and by calculating diversion flow under or over an open diversion gate. This methodology relies on the premise that flow over a gate is measured as flow over a weir, and that flow under a gate is measured as flow through an orifice. While considered more accurate than hydrographs, this method still provides a flow estimate rather than direct measurement of CSOs. LRWWU has implemented this approach at seven of its nine diversion stations. The approach requires reliable equipment, such as gate actuators, level sensors, and PLCs. A reliable SCADA system is also needed to control the equipment, transmit the data to the WWTF, and record the details of every diversion event.

Existing diversion flow measurement methods are being evaluated to determine if there is an effective alternative to the improvised orifice and weir equations that are currently used. The configuration of the stations and equipment available makes measuring CSO diversion flow very difficult. LRWWU is investigating the use of area-velocity meters in the interceptors and diversion stations as a means to measure both diversion flows (CSOs) and through-station flows. The outcome of this effort will be addressed in a separate report.

HIGH FLOW MANAGEMENT PROGRAM

Although LRWWU was able to achieve significant improvements in wet weather operations after the implementation of SCADA and the improvements described above, the system required further optimization. The potential storage available in the interceptor system was not fully utilized and occasional system surcharging was still taking place, resulting in flooding in neighborhood streets and inside the diversion stations. Therefore, the High Flow Management (HFM) Program was initiated in October 2008 to assist LRWWU in optimizing its wet weather operations. The HFM program had the following goals:

- Monitor and characterize water levels throughout the interceptor system to gain a better understanding of how the system is affected by diversion station operation and rain intensity.
- Develop a standard operating procedure during wet weather events that maximizes and balances flows into the treatment plant while maximizing interceptor storage.
- Identify and implement operational improvements that maximize storage in the collection system and further reduce CSO frequency and volume.

Exhibit 10
AR H.7

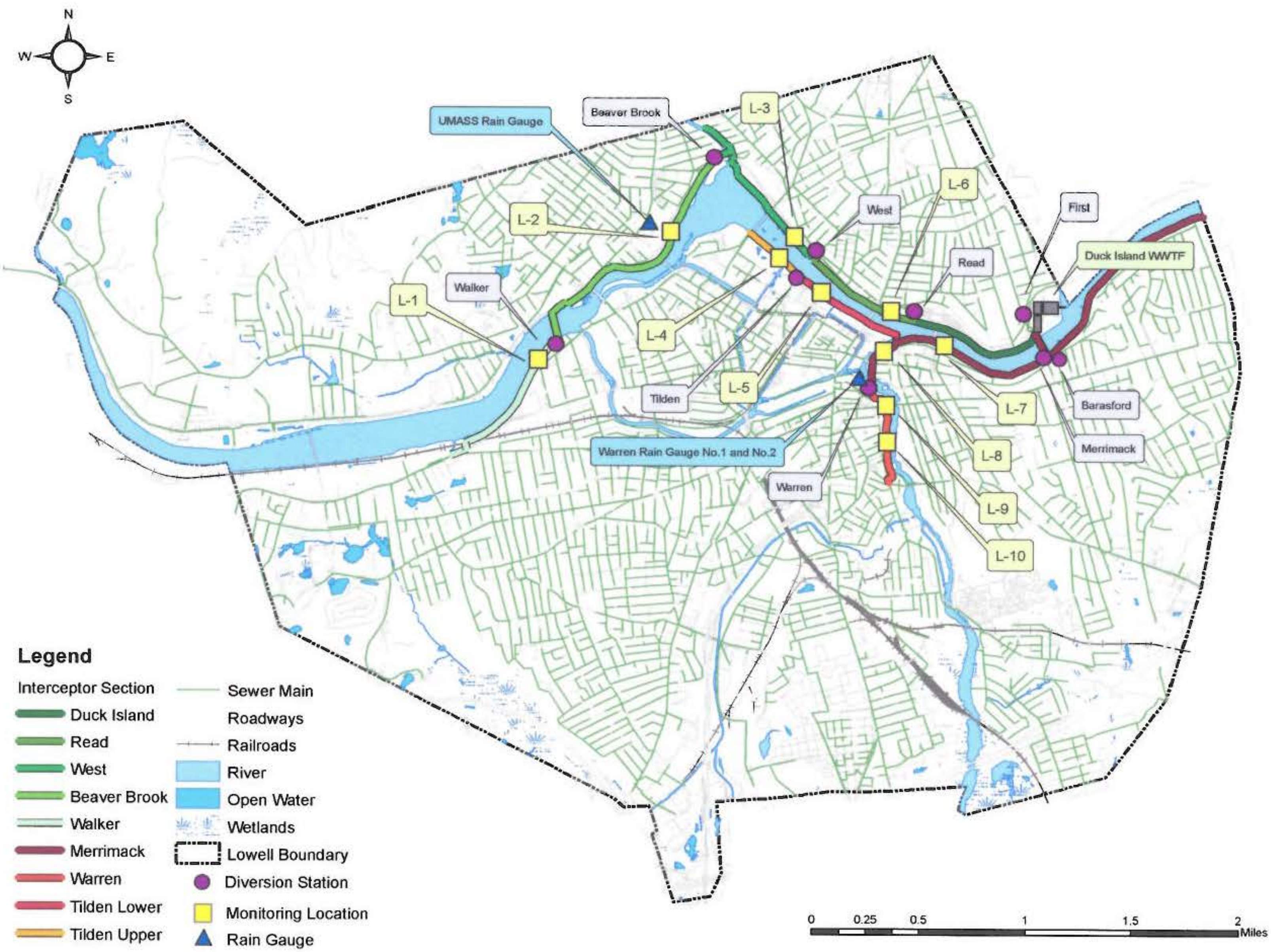

Figure 1: Map of the Lowell Interceptor System

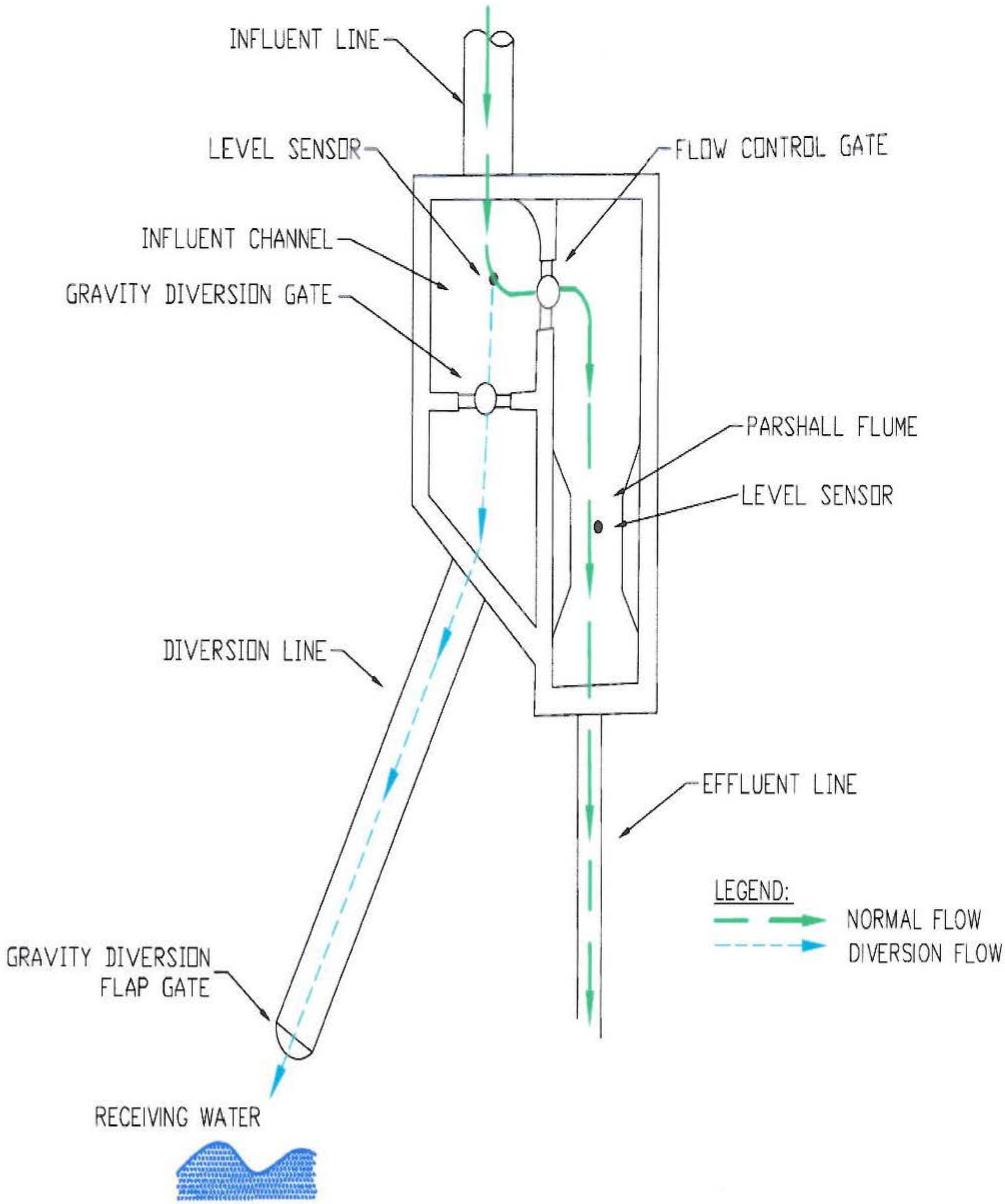

Figure 2: Typical CSO Diversion Station

Table 1: LRWWU Diversion Station Summary

Diversion Station	NPDES Outfall No.	Receiving Stream	Approximate Upstream Combined Acreage (acres)	Influent Pipe Size (inches)	Influent Capacity (MGD)	Effluent Pipe Size (inches)	Effluent Capacity (MGD)	Potential Flow Constraint (MGD)	CSO Discharge Pipe Size (inches)	Downstream Connection
North Bank Interceptor										
Beaver Brook	007	Beaver Brook	570	96	170	3 siphons (16 + 20 + 24)	25	145	Pump Diversion (84) Gravity Diversion (three 60 x 48)	North Bank Interceptor to West Station
West	008	Merrimack River	1100 (plus Dracut)	96 + 72 + 48	280	96	93	187	Gravity Diversion (96 x 72)	North Bank Interceptor to Read Station
Read	011	Merrimack River	175	60	53	30	16	37	Gravity Diversion (60)	North Bank Interceptor to WWTP
First	012	Merrimack River	90	48	37	18	3	34	Gravity Diversion (48)	WWTP
South Bank Interceptor										
Walker	002	Merrimack River	140	48	32	3 siphons (14 + 16 + 20)	8	24	Pump Diversion (54)	North Bank Interceptor to Beaver Brook Station
Tilden	027	Merrimack River	350	72	72	36	28	44	Pump Diversion (42) Gravity Diversion (48)	South Bank Interceptor to Merrimack Station
Barasford	030(1)	Merrimack River	600	84	277	48	21	256	Gravity Diversion (84)	South Bank Interceptor to Merrimack Station
Merrimack	030(2)	Merrimack River	2,941	84 + 120	204	3 siphons (30 + 36 + 48)	63	141	Pump Diversion (48) Gravity Diversion (four 48)	WWTP
Concord River Interceptor										
Warren	020	Concord River	1,626	90 + 48	348	3 siphons (30 + 30 + 30)	45	303	Gravity Diversion (90)	South Bank Interceptor to Merrimack Station

Note: Potential constraints are the difference in capacity between the upstream and downstream piping systems at each diversion station.

INTERCEPTOR SYSTEM LIMITATIONS

Despite continuous efforts to operate the interceptor system and diversion structures in a way that maximizes the flow conveyed to the WWTF and minimizes CSO discharges, wet weather events often necessitate CSO discharges before the WWTF wet weather treatment capacity is reached. Even moderate rain events contribute a significant amount of wet weather flow into the combined sewer system. This flow cannot be fully conveyed to the WWTF because of the hydraulic restrictions in the interceptor system created by the downstream interceptor capacity being only 20-30 percent of the upstream capacity. The configuration of the interceptor system is summarized in **Table 1**.

All diversion stations currently operate in a fully automatic mode based on local water levels at the station, controlled by a programmable logic controller (PLC). At the Merrimack and West stations, the diversion gates (as well as pumps at the Merrimack station) are automatically operated and the flow control gates are manually set and remotely controlled by the WWTF operator. This control method allows the operator to maximize flow to the WWTF adjusting the flow control gates at either of the two major interceptors. The Merrimack flow control gate is used to control flow into the plant from the South Bank Interceptor and the West flow control gate is used to control flow from the North Bank Interceptor. The approach that the operator takes to manage these gates has a direct effect on interceptor storage, plant flow and ultimately diversion frequency and volume.

To assist in further system characterization during wet weather conditions, plan and profile drawings of each CSO station were produced. These drawings, which include flow paths and estimated water levels, can be found in **Appendix A**. Accurate elevations in the stations and the interceptor system are important since the system is controlled based on water levels. To obtain accurate elevations in the stations and of other system components, a complete survey of the Lowell collection system was completed. One common datum was established (NAVD 1988) so that all water levels could be easily compared. Detailed drawings of the stations were a critical component of the interceptor monitoring effort described below. They were used to interpret interceptor level data and visualize what happens in the system when water level reaches critical elevations in the stations.

INTERCEPTOR LEVEL MONITORING METHODOLOGY

An interceptor level monitoring program focusing on water levels in the interceptor system during wet weather conditions was implemented to further characterize the system. The interceptor level monitoring program utilized existing level sensors in various diversion stations, as well as temporary level sensors installed and maintained by ADS Environmental Services for a period of one year, from April 2009 through April 2010. The temporary monitoring program consisted of ten monitoring locations, which were selected based on historical surcharging, interceptor depth of burial, and indications of interceptor storage capacity. Temporary interceptor monitoring locations are depicted in **Figure 1**. The primary reasons for choosing the monitoring locations are listed below in **Table 2**. During the year-long monitoring period, ADS Environmental Services collected instantaneous level data from the monitoring locations (via a cellular system and a web-based reporting site) and performed maintenance visits every six weeks to ensure that the sensors were functioning properly. ADS monitoring data was collected in 5-minute intervals and integrated with level data that was already being collected from the diversion stations through SCADA.

At the beginning of the project, there was some discussion about the best way to monitor wet weather condition in the interceptor system: flow versus level. Level monitoring was selected as the more effective approach for the following reasons:

- Level in the interceptor system shows more clearly the portion of the interceptor that is utilized and therefore is more representative of available storage capacity.
- Open-channel flow measurement in a large-diameter pipe may be impacted by turbulent flow conditions and may not be sufficiently accurate for gate control.

- Diversion station gates operate on levels; diversion level data was readily available for comparison and integration. Plotting diversion level data collected from the SCADA system with ADS level data allowed for a better evaluation of the correlation between temporary level data and level data from the diversion stations.

The temporary monitoring program also provided the ability to view real-time interceptor level data during storm events. When used in conjunction with WWTF and diversion station data, this proved to be very valuable when implementing operational changes. Being able to view the data on a real-time basis gave LRWWU personnel a more complete picture of the system and enabled them to anticipate the timing of diversions. The availability of this information contributed to several major changes to the wet weather operating strategy for the WWTF and the diversion stations. The level data was integrated with other level, flow, gate, and precipitation data being collected through SCADA to create High Flow Management Charts. Evaluating interceptor system responses to high flow conditions showed how operational changes affected storage capacity during storms. This information gave operators more understanding of the interceptor system and more confidence operating the system under high flow conditions.

Table 2: Temporary Interceptor Level Monitoring Locations

Monitoring Point	Location	Reason
L-1	Upstream of Walker	To determine the effect of Walker Station on storage capacity of the 48"inch Walker Interceptor.
L-2	Upstream of Beaver Brook	Monitor storage capacity of 84" Beaver Brook Interceptor.
L-3	Upstream of West	Monitor storage capacity of 96" West Interceptor and the effect of West Operations on CSO reduction.
L-4	Upstream of Tilden	Monitor storage capacity of 72"Tilden Upper Interceptor and to monitor effect of Tilden Operations on flooding at L-4.
L-5	Downstream of Tilden	This point in the system has had historical flooding problems. It was monitored to determine how set point changes at Tilden and Merrimack Stations affect flooding issues.
L-6	Upstream of Read	To monitor storage and evaluate the need for Interceptor control point at Read Station.
L-7	Upstream of Merrimack	Monitor storage capacity of the 120" Merrimack Interceptor.
L-8	Downstream of Warren	Evaluate if storage is maximized between Warren and Merrimack Stations.
L-9	Upstream of Warren	Converging point of 3 large diameter mains. This point was monitored to determine if it was the cause of upstream flooding issues and to monitor storage upstream of Warren Station.
L-10	Lawrence Street	Monitor the effect of Warren Station on flooding issues.

Precipitation data was also recorded and used in characterization of individual rain events as part of the HFM program. LRWWU compiles its own rain data in addition to precipitation reports obtained from UMass Lowell. Rain gage locations are shown on the system map provided in **Figure 1**. The rain gage used for the High Flow Management program is located on top of the Warren diversion station. It was chosen because of its accuracy, existing SCADA integration, and a central location in the City of Lowell that provides the most representative rainfall data for the collection system.

DATA ANALYSIS

Available flow and level data relevant to the WWTF, CSO diversion stations, and the ten new monitoring locations in the interceptor system was compiled and analyzed. Summary charts were created using new and existing data to analyze how the combined system reacts to wet weather conditions. A separate set of summary charts was produced for each event, which was defined as a day of precipitation when a diversion occurred in the interceptor system or when secondary treatment was bypassed at the WWTF. Each event data set consisted of 17 HFM charts illustrating level changes in the interceptor system as a result of changes in rainfall and system flows. The HFM charts were developed for eight of the nine CSO stations and the WWTF. No charts were developed for the First Street diversion station because this station is inoperable. An example set of charts for the January 25-26, 2010 storm event is attached in **Appendix B**. The charts were plotted for the duration of the storm event, with some events lasting several hours and others multiple days. Relevant rainfall data collected from the rain gage located at the Warren Diversion Station is depicted on the *CSO Diversion Flows and Precipitation* chart. The categories of charts that were created are described below and summarized in **Table 3**.

- Gates and Flows – these charts illustrate station flow and diversion flow in correlation with flow control and diversion gate positions.
- Levels and Flows – these charts illustrate station and interceptor levels in correlation with station flows, as well as WWTF flows.
- Gates and Levels – these charts illustrate station and interceptor levels in correlation with flow control and diversion gate positions.
- Levels – for some stations, it was necessary to create charts that only illustrate levels in the station, upstream and/or downstream interceptors, and levels at West and/or Merrimack Stations.
- System Flows and Precipitation – system charts were created to show the WWTF influent flow throughout the storm and precipitation.

Table 3: Types of Charts Created for the High Flow Management Program

Station	Flows and Gates	Levels and Flows	Levels and Gates	Levels	Upstream Interceptor Level	Flows and Precipitation
System	X					X
Barasford		X	X		X	
Beaver Brook		X	X		X	
Merrimack	X			X	X	
Read		X			X	
Tilden	X			X	X	
Walker	X	X			X	
Warren	X			X	X	
West	X	X			X	

The charts, in conjunction with the station profile drawings, were useful in developing an understanding of how each component in the combined sewer system reacts during a wet weather event and how system changes could affect the capture and storage of wet weather flow. The charts were reviewed and discussed at monthly HFM workshops. The HFM project team members were:

Aaron Fox, LRWWU Engineering Supervisor
Brandon Kelly, LRWWU Engineer
Mike Stuer, LRWWU Engineering Manager
James Drake, CDM Project Manager
Alexandra Kulinkina, Woodard & Curran Engineer
Tom Schwartz, Woodard & Curran Project Manager
Tom Kawa, LRWWU Operations Superintendent
Eric Willet, LRWWU Operations Supervisor

The charts for each wet weather event for the previous month were analyzed in detail during the HFM meetings to develop a mutual understanding of how the system responded during wet weather events. Based on the analysis and conclusions, recommended operational/procedural changes, as well as any structural improvements relevant to high flow management, were recorded in the *High Flow Management Milestones* attached in **Appendix C**. In many cases, system improvements were implemented immediately and subsequent storm data allowed the HFM project team to analyze the impacts of these improvements on wet weather operations.

The following paragraphs provide examples of how the HFM charts were used to evaluate system responses to wet weather events and the conclusions that were drawn from the analyses. The corresponding figures referenced in the analyses are included in **Appendix D**.

Observation: Correlation between water levels in the interceptor and in the stations

The summary charts consistently showed a strong correlation between the water levels in the upstream interceptor and the water levels in the diversion stations. The project team used this correlation to set open and close set points for diversion and flow control gates to maximize interceptor storage. For example, raising the diversion gate open set point as high as possible allows for maximum storage in the upstream interceptor. The consistency of the correlation between upstream interceptor levels and diversion station levels gave the project team confidence that raising set points in the stations would not create excessive system surcharging upstream. Furthermore, the automated gate control system maintained precise control of diversion gates, demonstrating that interceptor storage could be maximized safely, without flooding the stations or causing system damage. Ultimately, it was concluded that interceptor storage is safely maximized at approximately one foot below the crown of the pipe. When an influent channel reaches the one-foot-from-crown level, diversion gates are programmed to automatically open. **Figure D-1** shows an example of the correlation between the upstream interceptor level at location L-4 and the influent channel level at Tilden station. Based on this correlation, LRWWU established the Tilden diversion gate-open set point at five feet above the influent channel invert, or one foot below the influent channel crown. The Tilden gate set points were raised on November 24, 2009 (refer to *High Flow Management Milestones* in **Appendix C**).

Figure D-2 represents similar observations of the correlation between the upstream interceptor level at Location L-9 (upstream of Warren Diversion Station) and the influent channel level at the Warren diversion station. Using these observations, the diversion gate-open set point at Warren was set at 6.5 feet above the influent channel invert, or approximately 1 foot below an access way into the station. As can be seen in the charts, the influent channel level never exceeds the elevation of 6 feet above the invert (59 ft NAVD). The Warren diversion gate-open set points at were adjusted on April 5, 2010 (refer to High *Flow Management Milestones* in **Appendix C**).

Observation: WWTF flow not maximized when diversions occur

One of the objectives of the HFM program was to maximize flow to the WWTF before diverting at West and Merrimack diversion stations. The WWTF is able to treat 110 MGD of flow (including secondary bypass). In the early stages of the program, the charts indicated that diversions occurred at these two major stations before plant capacity was reached. **Figure D-3** illustrates that a diversion occurred at West diversion station when the plant flow was at approximately 62 MGD. **Figure D-4** shows that at this particular time during the storm (approximately 1 AM), West diversion station was diverting. The flow control gate at West station was approximately 10% open during this diversion; however, the gate opening could have been increased to convey more flow to the WWTF, relieving the station and potentially avoiding a diversion. It is also evident from **Figure D-3** that a secondary bypass was not activated during this diversion, which occurs when the plant is treating approximately 60 MGD of flow.

These observations resulted in the addition of "Plant Flow Not Maximized" alarms onto the SCADA screens at Merrimack and West diversion stations. These alarms are intended to alert operators that diversions at these two stations should not occur before the plant capacity is reached. In order to increase flow to the WWTF, the operator is instructed to further open the flow control gates at West and/or Merrimack. A "Diversion Pending" alarm indicates when the water level is 6 inches below the diversion gate open set point. A "Diversion in Progress" alarm indicates that the water level has reached the set point and/or the gate opened causing a diversion. These alarms are intended to be triggered when the WWTF is operating below 110 MGD.

Observation: Storage may be available in the interceptor upstream of West CSO Diversion Station

In the past, the West diversion station was not used to control storage in the upstream North Bank Interceptor. The diversion gate was operated in a conservative manner to avoid upstream surcharging. During the evaluation process, the HFM project team realized the storage potential of a 4,500-foot segment of the 96-inch diameter North Bank Interceptor upstream of West station. To take advantage of this storage capacity, LRWWU automated remote control of the diversion gate at West. On March 29, 2009, both the diversion gate and the flow control gate were upgraded with REXA gate actuators, which allowed more flexible and responsive modulation of these two large sluice gates during storms. The automation of the diversion gate enabled safe utilization of upstream interceptor storage while preventing surcharging incidents along the interceptor. Further optimization of the station operation was achieved in May of 2009 when it was determined that the flow control gate at West Diversion Station should be partially closed at the start of storm events to maintain storage in the 96-inch diameter interceptor, while still passing wet weather flow to the WWTF. **Figure D-5** illustrates the system response when the West diversion station was operated using diversion gate modulation that maintained storage in the upstream interceptor. In this figure, prior to a diversion event, the flow control gate is at 50% open, which passes all of the wet weather flow to the WWTF. As the storm continues, the flow control gate is lowered to 10% open. In this instance, the diversion gate is adjusted very infrequently. With this way of operating the station, the upstream water level at L-3 approaches the crown of the pipe briefly and then drops to below 4 ft (53 ft NAVD) as a diversion occurs. Thus, interceptor storage is not maintained. **Figure D-6** shows better interceptor utilization, as the upstream level at L-3 is maintained between 9 and 10 feet (55 and 56 ft NAVD) throughout the storm event while a diversion occurs. In this instance, the flow control gate is kept below 10% open in anticipation of the storm and the diversion gate is modulating much more frequently.

Observation: More wet weather flow could be conveyed downstream at key diversion stations resulting in fewer diversions

Siphon channel level monitoring at Warren Diversion Station indicated that maintaining a higher siphon channel level could be accomplished without flooding the station. The project team concluded that conveying more flow downstream during a storm event reduces the volume and frequency of CSO discharges from Warren station. In the past, Warren station often diverted prematurely because the peak flow exceeded the assumed capacity of the siphons. Conveying more flow through the station was accomplished by raising the flow control gate close set point from approximately 2.5 feet below the channel crown to 1 foot below the channel crown, enabling the station to handle short-duration peak flows without CSO discharges.

Similar benefits were obtained at Tilden, Walker and Beaver Brook diversion stations. Flow through the stations was maximized by controlling the flow control gates using level in the flume located after the gate.

Originally these gates were controlled using flow measurement through the flume which proved difficult due to challenges in accuracy of flow measurement and ability to use the data to determine when maximum flow through the flume was reached. Using level measurement instead, it was easy to see that the flow through the station was maximized when the level was as high as safely possible. The flow control gate would stay open until the level at the flume approached the floor elevation. Once the gate began to close, it maintained the flume level within one foot of the station floor, the maximum flow that could pass through the station without flooding. As part of the HFM project the flume instruments were programmed to display both flow and level as opposed to only flow.

Observation: North Bank Interceptor storage between Read and West diversion stations is not fully utilized

As observed in **Figure D-7**, the level in the interceptor segment upstream of Read Diversion Station during wet weather events is only slightly higher than during average daily flows. The maximum level at the upstream L-6 monitoring location during the December 9, 2009 storm is approximately 49 feet. This means that only 3 feet of the 8-ft interceptor is utilized.

Figure 3 illustrates the configuration of the interceptor between Read and West stations. The Read Interceptor is a 3,100-foot long 96-inch interceptor with a minimal slope. At the end of this interceptor segment is a seven foot drop manhole. This makes it impossible to store in this interceptor using the plant wet well, which is downstream of the Read Interceptor. If a flow -control gate were installed at this location, the portion of the North Bank Interceptor from West station downstream to Read station could be utilized for inline storage during wet weather events. This 3,000 foot segment of 96-inch diameter pipe could be utilized for inline storage during wet weather events providing approximately 1 million gallons of additional storage.

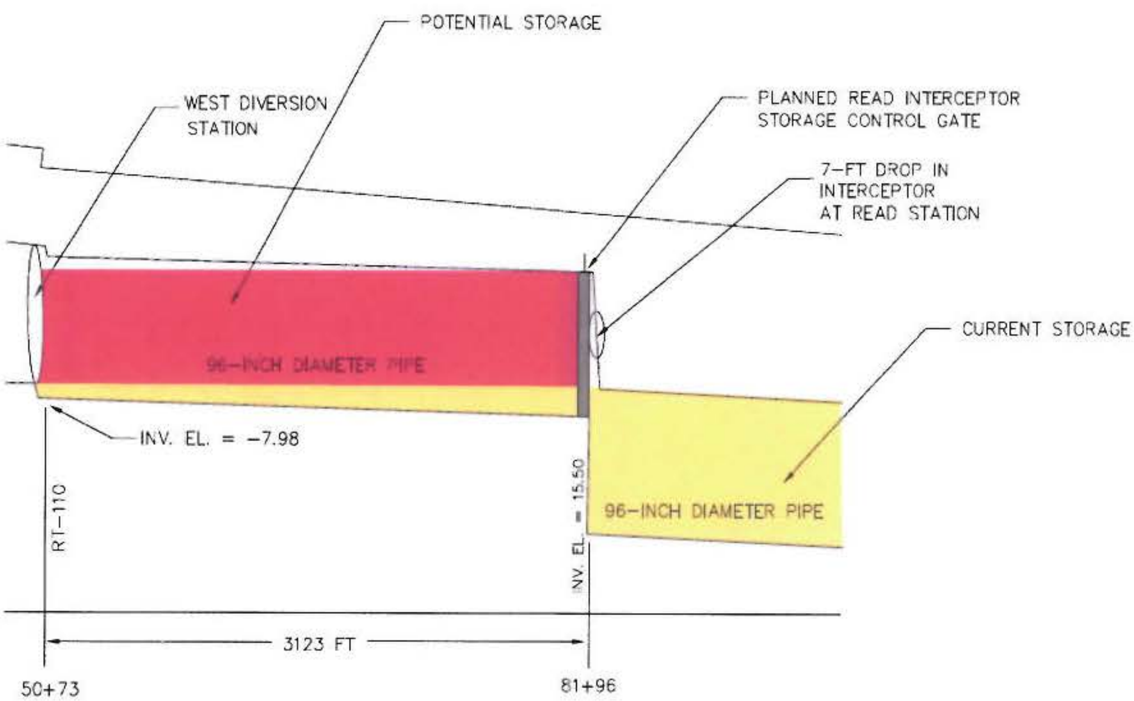

Figure 3: Interceptor Configuration Upstream of Read Diversion Station

Observation: Automation of flow control gates at West and Merrimack Diversion Stations may be more efficient than manual operation

During the December 12-13, 2010 storm event, it was observed that flows from Merrimack and West diversion stations were not well balanced. A diversion occurred at the Merrimack diversion station while storage was not maximized at West. **Figure D-8** shows that although WWTF capacity was reached, a diversion occurred at the Merrimack station at approximately 5:30 PM on December 12 while the flow control gate at West station remained at 30%. In **Figure D-9**, it is evident that the level in the West diversion station reached a maximum of only 49 feet before Merrimack station diverted. The flow control gate at West station should have been manipulated to allow for more storage. Following this event, the LRWWU staff decided to automate the flow control gates at West and Merrimack diversion stations to standardize their operation. This automation was incorporated into the standard operation procedures described below as the *High Flow Management Protocol.*

HIGH FLOW MANAGEMENT – REVIEW PROCESS

To illustrate how programmatic changes in operations affected the system's response to wet weather events, **Figures D-10** through **D-13** are described below:

Figure D-10 illustrates a storm event that occurred on May 6, 2009 in the beginning of the HFM program. During this storm, diversions occurred in the system while the WWTF flow was below 60 MGD and did not reach the bypass activation level. Because of system choke-points, it is often difficult to convey wet weather flow quickly enough to avoid these diversions. During the May 6, 2009 event, Tilden and Warren stations diverted while the WWTF flow barely reached 40 MGD. During this event, no diversions occurred at Merrimack or West diversion stations. Merrimack and West are the two stations where conveying flow to the WWTF could directly avoid a diversion.
Because of flow constrictions, passing flow through the other stations (including Tilden and Warren) has an indirect effect on local diversions. Understanding gained through the HFM program eventually led the project team to conclude that by increasing the flow through Warren and Tilden, as well as utilizing available upstream storage, CSO discharges from these two stations could have been minimized. At the time of the storm event depicted in **Figure D-10**, LRWWU plant personnel were cautious of storing upstream of Warren station because of a lack of understanding about upstream surcharging conditions. At the time, it was not known to what extent gate operations at Warren diversion station contributed to this upstream surcharging. Similar concerns existed at Tilden diversion station. Moreover, a lack of system understanding contributed to an overly conservative approach to interceptor storage in these locations.

To address the findings from the May 6 wet weather event, the following changes were made to gate controls in the system:

1. Gate-open set points for diversion gates at Warren diversion station were raised from 3 ft below the influent channel crown to 1 ft below the crown to enable additional upstream storage.
2. Gate-close set points for flow control gates at Warren diversion station were raised from 2.5 ft below the channel crown to 1 ft to allow for more flow to pass through the station downstream to Merrimack diversion station and eventually, to the Duck Island WWTF.
3. Gate-open set points for diversion gates at Tilden diversion station were raised from 1.5 ft below the influent channel crown to 1 ft below the crown to enable additional upstream storage.

As the HFM program progressed, WWTF flow during rain events increased with a higher utilization of secondary bypass. Although the LRWWU personnel had always been trying to maximize the WWTF capacity, this program made deficiencies in operations more evident and ways to increase plant capacity prior to diversions were realized and implemented. The benefits of the above changes can be observed in the October 28, 2009 event depicted in **Figure D-11** and described below. During this storm event, WWTF flow reached the bypass activation point but the bypass was immediately followed by a diversion. West station diverted when the plant flow was at 85 MGD, or before it had reached its full capacity of 110 MGD.

During this rain event, Warren diversion station did not divert. Also, WWTF flow was higher than in the past, indicating that the operators were becoming more comfortable with the operational changes to maximize flow to the WWTF before storing in the interceptor system. Although there was an improvement in wet weather operations, the same deficiency in operating the flow control gates at Merrimack and West Stations can be noted.

In response to these events, further improvements were made:

1. Development of a formal protocol to maximize wet weather flow to the WWTF (Influent Plant Flow > 110 MGD) before initiating any diversions at either Merrimack or West stations. This approach is implemented by always confirming the WWTF influent flow when a "Diversion Pending" alarm is received at Merrimack or West stations. If WWTF influent flow is less than 110 MGD, then the flow control gate at the station with the pending diversion is to be incrementally opened to increase wet weather flow to the WWTF. The WWTF influent flow rate is now displayed on the West and Merrimack SCADA control screens for quick reference.
2. The following approach was implemented to maximize interceptor storage: diversion gate-open and modulation set point values, while varying from station to station, will be the same within each individual station; diversion gate open/modulation set points are typically set one foot below the crown of the upstream pipe; diversion gate actuators capable of continuous modulation will be installed at all diversion stations.

Figure D-12 represents improved operations of the WWTF and interceptor system that only resulted in bypass activation, completely avoiding diversions on December 9, 2009. **Figure D-13** represents the most recent observation of improved operations where no diversion occurred in the system until WWTF flow reached 100 MGD. This progression of HFM charts demonstrates how maximizing interceptor storage and maximizing flow to the WWTF has reduced CSO diversions that can be avoided through these improved operations, therefore reducing the total diversion frequency and volume.

BENEFITS OF THE HIGH FLOW MANAGEMENT PROGRAM

The High Flow Management program helped LRWWU gain a much better understanding of the interceptor system and how it reacts during a storm. One of the major benefits of the HFM program was that it allowed the LRWWU staff to see a strong correlation between the interceptor levels and levels in the diversion stations. This understanding resulted in increased confidence when raising set points in the stations to maximize storage in the interceptor system. From ongoing chart review, it was determined that when setting the diversion gate-open set points, a standard of one foot below the influent channel crown would allow operators to safely maximize upstream interceptor storage. This standard was adapted at each station to maximize storage in the entire system. The storage gain in the interceptor system is summarized in **Table 4**.

A better understanding of the system and how it reacts during storms has led to major changes in wet weather operations. Several approaches were tested during the level monitoring program and the system's responses were discussed at the monthly workshops. The approach of storing in the interceptor system first in order to minimize bypass activation was tested. This approach proved less effective at reducing diversion frequency than conveying as much flow as possible to the WWTF as a first priority.

In addition to standardizing wet weather operations, the HFM program also helped to bridge the gap between the LRWWU engineering department and the operations staff. Both groups gained a better understanding of the overall system and developed an appreciation for each group's role in wet weather management. Moreover, the working relationship between the two groups was strengthened by the collaborative effort of evaluating wet weather operations. During the program, representatives of both groups participated in the workshops where data was analyzed and conclusions were reached. The entire operations staff was consulted on the changes that were made during the HFM program and the demonstrated successes and failures of the changes were discussed between all parties involved. At the conclusion of the HFM program, the results of the program, and the *High Flow Management Protocol* were discussed with all operators so that everyone involved in wet weather operations could understand why operational changes were made, what the impact of those changes were, and how the *High Flow Management Protocol* was developed.

Table 4: Storage Benefits of the High Flow Management Program

Interceptor Name	Interceptor Diameter (ft)	Interceptor Operating Level (ft from invert)		Storage Benefit
		Before	After	
Duck Island	8	No Controlled Storage	No Controlled Storage	No Change
Read	8	No Controlled Storage	No Controlled Storage	Planned
West	8	No Controlled Storage	10	Substantial
Beaver Brook	8	8	8	No Change
Merrimack	10	8.8	9.2	Moderate
Warren	7.5	3.5	6.5	Substantial
Tilden	6	4.5	5	Moderate
Walker	4	2	4	Substantial

Operational Upgrades

Several changes in wet weather operations resulted from the HFM program including station upgrades, maximizing interceptor storage, maximizing flow through the stations (downstream to the WWTF), and changing the set points in the stations.

Station Upgrades:

- Automated the gravity diversion gate control at West diversion station and programmed the gate to maintain interceptor storage during wet weather events.
- Standardized gate actuators at all diversion stations to a model rated for continuous modulation (REXA gate actuators).
- Programmed the parshall flume sensors at Tilden, Walker and Beaver Brook diversion stations to display both flow and level. The flow control gates are now controlled using level rather than flow. Because of inaccurate flow measurement in surcharged flumes, controlling gates with level proved to be more precise and ultimately enabled conveying more flow through the station. Passing more flow through diversion stations, particularly in those stations that create system choke points, resulted in fewer and smaller CSO discharges. Level-based control also made it easier for operators to visualize station conditions, providing better indication of surcharging within the station or adjacent interceptors.
- The pump diversion weir at Walker diversion station was raised by 2 feet to increase storage upstream of the station and thus reduce diversions at this station.

Maximizing Interceptor Storage and Flow to the WWTF:

- In the past, flow control gates at Merrimack and West diversion stations were controlled manually by operators to balance flows from both interceptors (North Bank and South Bank) to the Duck Island WWTF. As a result of the HFM program, these flow control gates are now automated, ensuring that flow to the WWTF and storage in the interceptor system is maximized.
- Maximizing flow through the diversion stations, especially Beaver Brook, Tilden, and Warren, has reduced diversions. As more flow is conveyed to the WWTF in the beginning of the storm, the interceptors have available capacity for forthcoming wet weather flow.

- Adjusting diversion-gate and flow-control set points in the diversion stations maximized interceptor storage and flow through the stations. The set points were determined by monitoring water levels in the stations and in the interceptor system to make sure that maximum flow through stations and upstream interceptor storage is maintained without causing station flooding or surcharging in the interceptor system.
- To add more storage to the interceptor system, the HFM program recommended the installation of flow control gates in the North Bank Interceptor at Read diversion station. This capital improvement, with an estimated cost of $2 million, would utilize approximately 3,000 feet of a 96-inch interceptor segment between Read and West stations, resulting in an additional one million gallons of storage.

Taking all HFM program observations and system improvements into consideration, the following *High Flow Management Protocol* was adopted as the standard operating procedure for LRWWU during wet weather conditions. The *HFM Protocol* is provided below and represented graphically in **Figure 4**.

LOWELL REGIONAL WASTEWATER UTILITY
<u>HIGH FLOW MANAGEMENT PROTOCOL</u>
March 1, 2011

The following operational protocol is being initiated in February of 2011 and is based upon the findings of LRWWU's High Flow Management program.

- All remote gates with "Auto" functionality have been programmed to <u>safely maximize storage and minimize CSO diversions</u>. The remote gates and pumps are to be left in "Auto" unless otherwise notified. If the gates are not in "Auto", they must be placed in "Auto".
  - The Walker Flow Control Gate and Beaver Brook Gravity Diversion Gates are left in "Hand", because they are inoperable.
- The local weather forecast is continuously monitored to anticipate the storm arrival time, duration, and amount of potential rainfall. Until the Primary Influent Flow approaches 110 MGD, the West Flow Control Gate should be left at 20% open and the Merrimack Flow Control Gate should be left at 30% open. This is the standard position for these gates and allows for wet-weather flow to pass through the stations.
- The Primary Influent Flow at Duck Island WWTF is maximized to **110 MGD**.
  - It is important that the Primary Influent Flow is brought to 105 MGD before adjusting the Flow Control Gates at Merrimack and West.
  - Secondary Bypass is activated when Primary Influent Flow is roughly 60 MGD.
- Once the flow into the treatment plant has been maximized, the North Bank and South Bank Interceptors are utilized for wet weather storage. This is done by adjusting the Flow Control Gates at West and Merrimack.
  - The effects on the Primary Influent Flow Rate are observed and a Primary Influent Flow of 110 MGD is maintained throughout the wet weather event.
- After BOTH the Primary Influent Flow and Interceptor Storage have been maximized, the West and Merrimack Diversion Structures will initiate CSO diversions if interceptor levels rise above the gate-open set points at these locations.
  - The other Diversion Stations divert automatically based on local conditions at these stations.
- The Merrimack and West Flow Control Gates are continually adjusted throughout the storm event in order to <u>first</u> maintain maximum flow to the treatment plant and <u>then</u> maintain maximum storage within the interceptors.

- The Merrimack Flow Control Gate is adjusted in 5% increments, with a 5-minute observation time between adjustments. The West Flow Control Gate is adjusted in 2% increments, with a 10-minute observation time between adjustments.
- Once the Primary Influent Flow is maximized, storage must be maintained in both interceptors throughout the storm event.
- When the Plant Influent Flow Rate drops BELOW 110 MGD, the interceptor levels at Merrimack and West are compared and the Flow Control Gate associated with the HIGHER interceptor level is OPENED. The adjustment will be done in prescribed increments (see above bullet).
- When the Plant Influent Flow Rate rises ABOVE 110 MGD, the interceptor levels at Merrimack and West are compared and the Flow Control Gate associated with the LOWER interceptor level is CLOSED. The adjustment will be done in prescribed increments (see above bullet).

- The maximum Primary Influent Flow of 110 MGD must be maintained until the interceptors have returned to normal levels and all CSO diversions have ceased.
- Immediately following a secondary bypass or a CSO Diversion, all parties listed on the Downstream Notification List, including the EPA, DEP, and downstream water users and fisheries, are contacted.
- The Diversion / Bypass Log and the Head Operator's Log are updated with diversion data throughout the rain event.

CSO Overview Screen

To support the *HFM Protocol*, a CSO Overview Screen was developed for the SCADA system and implemented. The layout of the screen is shown in **Figure 5**. The screen was designed to provide the operators with an overview of the diversion stations, the interceptor system and the WWTF. This overview screen proved to be invaluable during wet weather events. A graphical representation of the system helps the operator quickly assess the current system conditions, reducing time spent reading text or deciphering numeric values during stressful conditions. The CSO Overview Screen acts as a simplified navigation tool, allowing operators to move from one screen to another by clicking on different areas of the screen. In addition to its usefulness during wet weather events, the CSO Overview Screen also helps infrequent users gain a basic understanding of the interceptor system.

Lowell Regional Wastewater Utility

High Flow Management Protocol

March 1, 2011

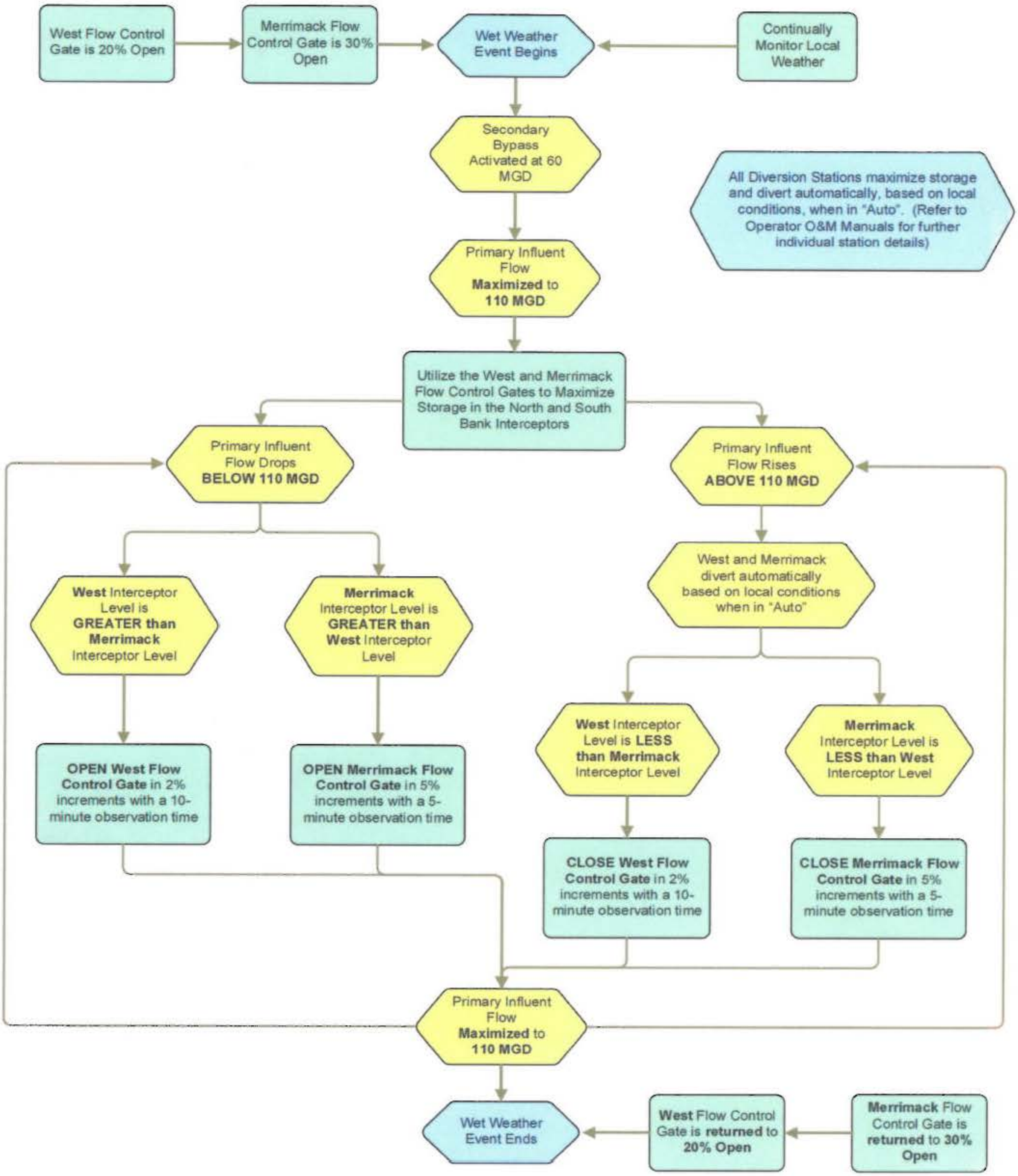

Figure 4: High Flow Management Protocol

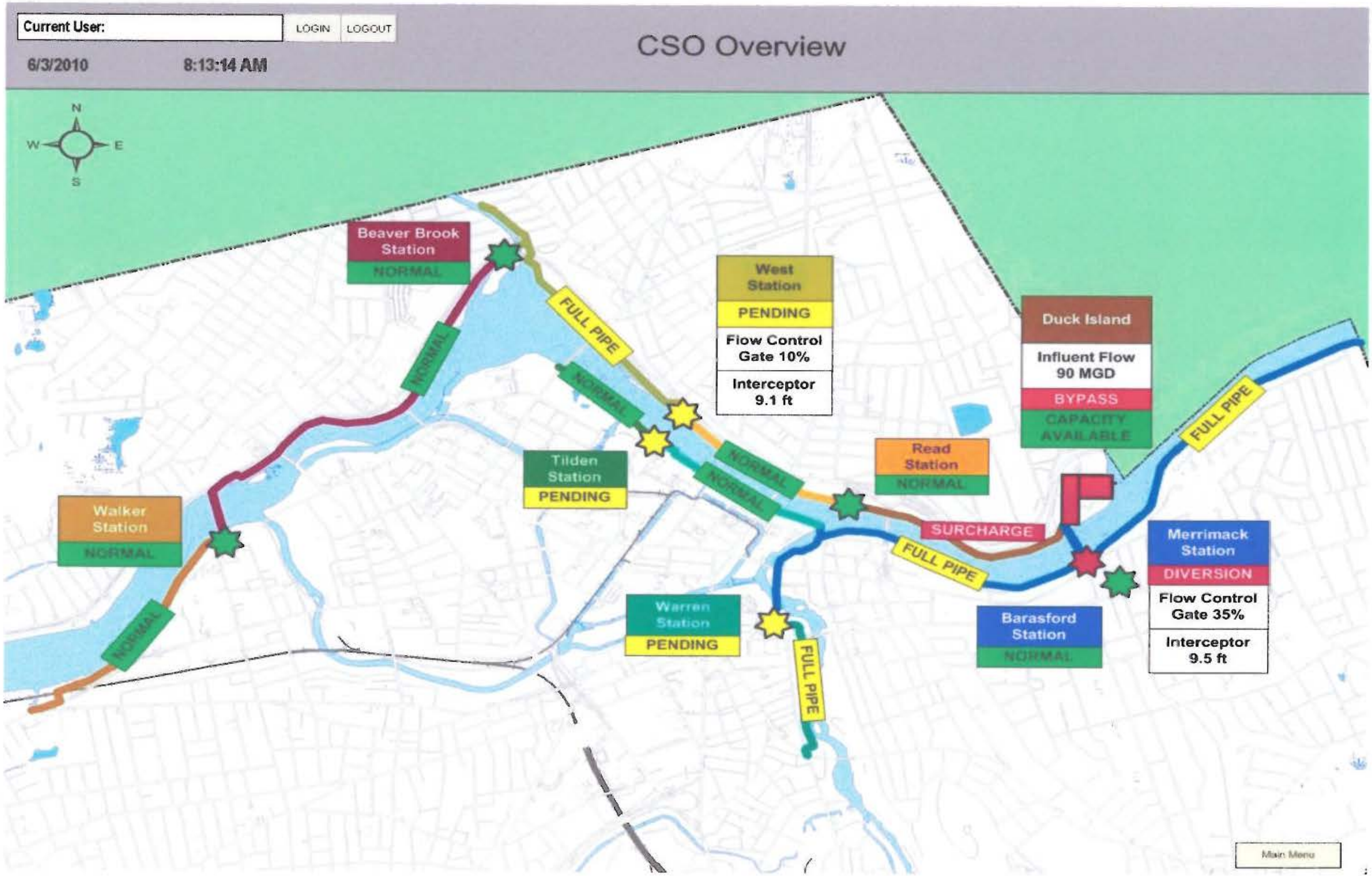

Figure 5: CSO Overview Screen

CONCLUSIONS

High Flow Management Cultural Shift: As the HFM program progressed, it brought about a shift in the way plant personnel approached controlling the remote diversion structures. The HFM program consisted of monthly team meetings, daily assessments of system responses to wet-weather conditions, HFM chart review, familiarization of the entire project team with the interceptor system, development of written HFM protocol, and periodic operator meetings to update them on changes to wet-weather operations. This meticulous evaluation approach, which involved the LRWWU engineering and operations staff as well as engineering consultants, has changed the culture of wet weather operations at LRWWU. The increased system understanding and involvement of the entire project team in decision making and implementation of operational standards has re-shaped the mindset from a "take-no-chances" approach to a "safe storage" approach that balances CSO minimization and property protection.

Evolution of Storage-Bypass-Diversion Philosophy: In the initial stages of the HFM program, the project team considered the approach of maximizing storage first, then initiating bypass when necessary and then diverting as a last resort. This is referred to as the storage-bypass-diversion approach, which intended to minimize unnecessary secondary bypass during less severe storms. After this approach was tested during several storms, it was concluded that it is not effective for the following reasons: stations upstream of the WWTF are more likely to divert when the interceptor is full; while storing, less flow reaches the WWTF so the maximum treatment capacity may not be reached. This operational approach often resulted in diversions in the system while the WWTF was operating under peak capacity, an undesirable outcome.

Through the program, the project team began realizing that a bypass-storage-diversion approach provides a more consistent way of operating the system, independently of the severity of the rain event. This approach involved first maximizing flow through the WWTF including secondary bypass, before initiating storage in the interceptor. This change in mentality took some time because the focus of the operations and engineering staff has always been on maximizing storage and avoiding bypass as much as possible. The hesitancy to change the approach was exacerbated by the difficulty of balancing flows between the North and South Bank Interceptors by means of the flow control gates at West and Merrimack.

The HFM program enabled the project team to test different operational approaches and observe how the system reacted. After evaluating many different storms, the project team agreed that maximizing storage as a first priority is too complex and maximizing flow to the WWTF provides the most consistent results considering varying conditions and multiple operators. The most important characteristics of the bypass-storage-diversion approach are its simplicity and the ability to avoid diversions while the WWTF flow is not maximized. This approach optimizes the treatment capacity of the WWTF and maintains available storage in the interceptor system for subsequent wet weather flows resulting from prolonged storm events.

Benefits of Gate Modulation: During HFM meetings, it was concluded that continuous gate modulation allows for more precise control of station flow and interceptor level. Based on this conclusion, the old diversion and flow control electric gate actuators were replaced with REXA gate actuators rated for continuous modulation. This change was implemented at West, Barasford, Merrimack, Tilden, Warren, and Walker (planned). Being able to maintain exact levels in the interceptor and stations enabled the minimization of CSOs by holding maximum storage levels.

System-Wide Gate Control Set Point Adjustments: Throughout the HFM program, gate set points were adjusted to either maximize flow through the station or maximize storage in the interceptor system. In the beginning of the program, it was uncertain which set points safely optimized system operation. As the program progressed, additional observations increased the confidence of all parties involved to push the system further than was previously acceptable. The diversion gate set points were raised to control the interceptor level within one foot below the crown, which resulted in increased storage upstream of most stations. The flow control gate set points were also raised to maximize flow through the stations.

At Warren Diversion Station, the flow through the station was controlled to within one foot of the station floor. The Barasford flow control gate, which is manipulated based on Merrimack Interceptor level, was maximized to remain open as long as the Merrimack Interceptor was not on the verge of diverting. At Walker, Beaver Brook and Tilden, it was decided that programming the flow control gates based on flume level rather than flume flow would be a more accurate and reliable way to maximize flow through the stations. This change enabled the flow through these stations to be brought within one foot of the lowest point in the station floor.

Progression of Gate Control at West and Merrimack Stations: Like the other stations, West and Merrimack diversion stations were manually operated until 2002. When the benefits of automated gate control were realized, the Merrimack diversion gates, along with others, were automated. Through the HFM Program, the opportunity for additional interceptor storage upstream of West Station was identified. In 2009, as part of this HFM program, the diversion gate at West Station was also automated. Before this time, the West diversion gate was operated as either fully open or fully closed. With this improvement, both stations would divert automatically when the diversion set points were reached. This strategy provided the operators with a "safety net" that promoted storage without causing damage from surcharging. It also allowed the operators to concentrate on manipulating the flow control gates and maximizing the flow to the WWTF.

The next challenge that the HFM program addressed was balancing the flows received at the Duck Island WWTF from the North and South Bank interceptors. The preference had always been to store at Merrimack Station rather than at West because of uncertainty with the impacts of manipulating the West Station flow control gate. Because of this uncertainty, storage at West was not utilized in the past. As part of this program, the HFM protocol emphasizes a balanced use of both Merrimack and West to control flow to the WWTF and maximize interceptor storage in both the North Bank and South Bank interceptors. This led to optimization of interceptor storage and overall minimization of CSOs from both stations.

The ultimate protocol for balancing flows from both interceptors and minimizing diversions from West and Merrimack was developed through the HFM program. As a result of this program, automated control of the flow control gates at Merrimack and West has been implemented to further optimize the storage upstream of both stations. The gates are now programmed to balance flows to the WWTF from each station while maintaining the maximum plant flow of 110 MGD. The result is a HFM protocol that completely utilizes the existing collection system during wet weather conditions.

Opportunities for Additional Interceptor Storage: Many improvements were made during the HFM program to optimize interceptor system storage. These improvements, described above, were augmented by changes to Walker Station, where the diversion weir was raised by two feet. The raised weir has resulted in more upstream storage and minimization of diversions at Walker. The weir extension was installed in a temporary manner to ensure that the adjustment did not result in upstream flooding. Because the temporary weir has proved to be effective, a permanent steel weir extension is planned. REXA actuators are also being considered at Walker station to enable gate modulation of the flow control gate.

In addition to implementing enhanced interceptor storage throughout the system, the HFM Program identified an important opportunity to significantly increase interceptor storage in one location. This opportunity is the installation of flow control structures in the North Bank Interceptor at Read Station. Currently, there is no flow control at Read, where a seven-foot elevation drop leaves more than 3,000 feet of 96-inch diameter pipe nearly empty during wet weather events. LRWWU is currently planning a three-phase project at Read Station, with storage being implemented first, followed by a flood pumping station and a wet weather treatment facility in subsequent phases. An additional one million gallons of interceptor storage is targeted, which is the basis for constructing a storage-pumping-diversion-treatment facility at this site. The anticipated completion date of the interceptor storage phase of this project is March 2012. When the Read Station Interceptor Storage project is completed, LRWWU will be fully utilizing its entire interceptor system for wet weather storage. Full utilization of the existing infrastructure will ensure a cost-effective LTCP, allowing for maximum benefit of future investments to eliminate CSOs.

Evaluation of WWTF Treatment Capacity: The HFM program is not only seeking to optimize wet-weather storage in the interceptor system, but also striving to fully utilize the treatment capacity of the Duck Island WWTF. In order to do this, a capacity study is being undertaken to quantify peak capacities for both primary and secondary treatment processes. Much work has been already done to evaluate treatment capacities; however, in order to properly quantify these capacities, it is necessary for LRWWU to collect more data.

Recent changes to the treatment processes and the flow measurement devices at the WWTF have rendered past data insufficient. LRWWU is seeking additional time to compile new data that better characterizes the treatment processes that are being upgraded. In September 2012, LRWWU will submit a Final High Flow Management Plan (HFMP) that will include a complete evaluation of WWTF treatment capacities and a review of the North Bank Interceptor Storage Project at Read Station. Any new information that revises this Interim HFMP will also be included in the Final HFMP submittal.