King County

Department of
Natural Resources and Parks
Wastewater Treatment Division

Project Initiation Document

Project Identification

Project Name:	Sunset/Heathfield Pump Station Replacement and Force Main Upgrade
Project Number:	423373 Subproject Number: 888
	(Note: This is the CSI Project and Sub Project Numbers for the Development Phase of the project through 2008. Project budget estimate based on planning level project cost estimate has been submitted for the 2009 Budget under project # 2009-007)
Basis for Project:	Updated Conveyance System Improvement (CSI) Program (June 2007). The CSI Program Update identifies and prioritizes capacity-related needs within the regional conveyance system; and, identifies planning-level project descriptions and estimates to address identified needs.
Project Manager:	To Be Assigned by MCIP/Project Implementation

Submitted By:

Mark Buscher, CSI Program Manager

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Planning Level Project Description

The Sunset/Heathfield Pump Stations Replacement and Force Main Upgrade is intended to increase the peak pumping capacity of the two pump station system to utilize the maximum available capacity in the regional gravity sewer systems directly upstream and downstream of the pump stations' and force main discharge point. The 2007 CSI Program Update project recommendation is for replacing the current pump stations and either paralleling the existing force mains or replacing the existing smaller force main. Analyses of the gravity sewer systems upstream and downstream of the pump stations indicate that the pumping capacity of the stations could be increased to as much as 31 mgd. An aerial photo map of the project area is included as Attachment 1.

Additional information and analysis during detailed project planning could identify a more efficient solution to provide the needed additional capacity.

Project Need/Justification

The Sunset/Heathfield Pump Stations and Forcemain system have a current peak capacity of approximately 18 mgd based on system testing performed in 2001. This peak capacity represents an estimated 5 to10-yr. peak flow level of service for year 2000 conditions. Documented sewered population growth in the service area since 2000 indicates that the level of service is less than that at this time. This level of service is below the 20-year peak flow design standard stated in RWSP Conveyance Policies in place to minimize overflows in the separated conveyance system. The Sunset/Heathfield system conveys flows from the Issaquah Interceptor, a 24 to 36 inch diameter gravity sewer in Lake Sammamish to the Eastgate Trunk. The Eastgate Trunk conveys flows from the pump stations, along with other local inflows, by gravity, to the Lake Hills Interceptor which eventually connects to the Eastside Interceptor (ESI) north of

downtown Bellevue. A map of the South Sammamish Planning Basin showing the location of the Stations relative to the upstream and downstream gravity systems is contained as Attachment 2.

The Sunset/Heathfield Pump Station Replacement and Force Main Upgrade was selected for implementation based on prioritization criteria developed with the Municipal Water Pollution Abatement Advisory Committee (MWPAAC). A detailed description of the criteria and their application is contained in the 2007 CSI Program Update and summarized below. A full copy of the program up date can be accessed at: http://dnr.metrokc.gov/wtd/csi/csi-docs/ProgramUpdate/index.htm

Chapter 5 of the 2007 CSI Program Update summarizes the factors used in prioritization and their application to specific projects. Section 5.5.1 of the Program update discusses the factors that lead to the selection of the Sunset/Heathfield project to move forward into implementation. The stations have reached peak capacity operating conditions at least once per year during storms over the last three wet seasons. In addition growth in the upstream service area continues to outpace initial assumed projections. The initial projections have been updated for the City of Issaquah service area. The higher Average Wet and Dry weather flow (AWWF and ADWF) resulting from sewered population increase has led to more reliance on the large pumps in the facilities. This reliance on the large pumps is affecting overall reliability, performance, and efficiency of the system. Discussions with WTD staff also indicate that the Sunset and Heathfield pump stations have higher than normal callout maintenance that is increasing the overall operating costs for the facilities.

Consequences of Delaying the Sunset/Heathfield Project

The current schedule for implementation of the Sunset/Heathfield project anticipates an 8 year project cycle (2008 through 2015) with construction occurring in 2013 and 2014. This schedule is reflected in the annual spending estimate in Servoy for the submitted 2009 budget. (projects numbers 423373 sub 888 for 2008 and 2009-007 for 2009 through 2015)

Further project delays will result in decreases in the year current peak flow level of service at the stations due to peak capacity limitations of the current pumps. The lower level of service will result in an increased risk of overflowing to Lake Sammamish, a valuable regional resource, during peak flow conditions.

Increased reliance on the large pumps for average flows will result in higher maintenance and station operation costs. Additional run time on the large pumps also presents a greater risk of failure of the large pumps resulting in significantly reduced capacity and reliability of the stations.

Relationship to Previous CSI Planning

Work at the Sunset and Heathfield Pump Stations was identified during the initial CSI Planning efforts for the South Sammamish Planning Basin in 1999 through 2003. The initial CSI program produced a series of reports, 210 through 260, that documented service area conditions, existing wastewater facilities, capital alternatives to manage wastewater flows into the future, and the process used to refine and select alternatives. The reports are available on the internet at http://dnr.metrokc.gov/wtd/csi/library_1999-

2003.htm#slakesamm.

The Task 260: South Sammamish Report, provides a summary of the reports and selected capital project alternatives to provide 20 year peak flow capacity over time for the planning area. The initial CSI program identified 5 projects to address capacity needs over time based on available flow and population information at the time.

The planned projects from the initial CSI program were revisited in 2005 and 2006 and modified using updated peak flow and population growth information developed for both the I/I program in 2000 through 2005 and again during the 2007 CSI Program Update. The resulting analysis modified some of the facilities and identified two additional projects based on previously unidentified capacity needs. Selected alternative project costs were also worked up using updated TABULA construction costs. A summary comparison of the 2007 CSI Program Update to the projects identified in the 2001 Task 260 Report are contained in Table 1 on the following page.

All of the projects proposed for the South Sammamish Planning basin will contribute to providing 20 year peak capacity over time. The development of alternatives during the initial basin planning looked at projects and facility upgrades that avoided paralleling either Issaquah Section 1 (the lake line) or the Eastgate Trunk/Lake Hills Interceptor system. Investigations outlined in the Task 240 report and refined in the Task 250 report showed that paralleling the lake line and or diverting flows away from the Eastgate/Lake Hills system, sending the flows directly to the ESI, were likely much more costly than performing upgrades and providing storage in the service area.

The Sunset/Heathfield Pump Station Replacement and Forcemain Upgrade Project was selected over some of the less expensive solutions at this time based on the following reasons:

- Storage and diversion projects, while reducing and shaving peak flows demands on the pump stations, do not address ongoing maintenance and reliability issues at the Sunset/Heathfield Pump Stations

- The Sammamish Plateau Diversion project will serve an area that is currently lightly sewered and diverts 1 to 2 mgd in the short term. While this will improve the level of service at the pump stations, increasing the capacity of the stations by 10 to 12 mgd, and increasing their reliability, will have a greater potential to reduce sanitary sewer overflows. The diversion eventually has the potential to divert 5 to 10 mgd as the service area develops and is sewered.

- The outcome of the initial I/I projects may influence the approach and eventual costs of the Issaquah Storage and Eastagate Storage projects. The design and construction of conveyance projects should occur after the potential for I/I reduction has been investigated and implemented, if their implementation is determined to be cost effective relative to the capital conveyance projects. The initial I/I projects are expected to be complete in 2010.

Table 1. Crosswalk of 2007 CSI Program Update to 2001 CSI South Sammamish planning basin 260 Report.

2007 CSI Update Project name	Total Project Cost (2006$)[1]	Coresponding 2001 260 report project name	Total Project Cost (2006$)[2]	Comments
Sunset/Heathfeild Pump Station Replacement and Forcemain Upgrade	**$56.7M**	Minor Pump Station Improvements (*increase capacity to 24 mgd through pump and motor upgrades only, no forcemain work*)	$1.3M	CSI program update assumes greater capacity increase than the minor upgrades identified in the Task 250 and Task 260 reports
Sammamish Plateau Diversion	$24.8M	Sammamish Plateau Diversion North	$22.6M	Updated tabula information
Issaquah Storage	$22.9M	Issaquah Storage	$21.2M	Storage volume increase based on flow data from the I/I program A Potential I/I reduction project in upstream basin may reduce the size of this planned facility
Sammamish Plateau Storage	$33.2M	Sammamish Storage	$21.2M	Storage volume increase based on flow data from the I/I program
Issaquah Creek Highlands Storage	$2.4M	Issaquah Highlands Relief Sewer	$5.4M	Planning level cost estimates for storage are lower than the relief sewer.
Eastgate Storage	$23.8M	Not previously Identified	N/A	Potential I/I reduction project in upstream basin may reduce the size of or eliminate this facility
Issaquah Section 2 Parallel	$2.8M	Not previously Identified	N/A	Potential I/I reduction project in upstream basin may eliminate the need for this facility.

1. Developed with updated Tabula costs
2. Inflated using nominal 3% per year from 2001 using Tabula version 1 costs

Capacity Analysis Used to Determine Current Level of Service and Upgraded Pump Station Peak Capacity

The capacity and performance of the Sunset/Heathfield Pump Station and Forcemain system has a direct influence on the performance of the gravity systems directly upstream and downstream of pump forcemain system.

Inadequate pumping capacity in the system will cause peak flows to back up into the Issaquah Section 1 pipeline causing surcharged flow condition with the potential for overflows into Lake Sammamish.

Too much pumping capacity in the system will overwhelm the Eastgate Trunk directly downstream of the Sunset Forcemain discharge. In addition to the pump station flows,

the Eastgate Trunk also receives flows from the local system that must be factored into the analysis.

The analysis that estimates the current 5 to 10 year level of service of the current Sunset/Heathfield system and the upgraded pump system capacity is included in Attachment 3.

In summary the upgraded pump stations should be able to pump a peak flow of up to 31 mgd to maximize the capacity of the Issaquah section 1 (lake line) pipe just upstream of the Sunset Pump Station. This peak flow rate also limits the impacts down stream on the Eastgate Trunk and further downstream in the Lake Hills Interceptor. To fully meet 20-year peak flow capacity for the entire South Sammamish regional conveyance system the other identified CSI projects listed in table 1 will need to phased in over time.

Project Deliverables

The project should deliver upgraded or new facilities that increases the capacity of the Sunset/Heathfield Pump Station and Force Main conveyance system to a capacity of up to 31 mgd from the existing 18 mgd.

Operation of the new or upgraded pump stations must be integrated with the flow conditions in the Eastgate Trunk. The Eastgate Storage project is a future project that will limit flow to the Eastgate Trunk during peak flow events. The Eastgate area may also be selected as an initial I/I reduction project. Both of these projects will change the peak flows entering the Eastgate Trunk from this area. The new or upgraded Sunset/Heathfield Pump Stations will need to monitor flows in the Eastgate Trunk and integrate the information into the pump control strategy to control flows from the pump stations. This will ensure that adequate capacity is available in the Eastgate Trunk and downstream facilities for both the pump station discharge and peak flows generated in the Eastgate service area. These controls and communication systems will be used before and after the completion of the planned Eastgate Storage project and/or the potential initial I/I reduction project.

Applicable Balanced Scorecard Quadrant

The Planned Sunset/Heathfield project applies to the business quadrant on the balanced score card.

The planned project will construct wastewater facilities in our system to avoid overflows and meet environmental standards. Delivering the project will involve partnering and collaboration with the City of Bellevue to ensure that the project minimizes local impacts and solves regional conveyance needs as we implement projects to serve the South Lake Sammamish Planning area.

Initial Project Schedule

Initiation: Start 1st QR 2008,

The Schedule for all additional project phase/process schedules will be determined by the Project Manager

Planning Level Cost Estimate

Construction Cost Estimate:

Name (pump stations)	Facility Description	Peak Capacity *(mgd)*	TDH *(ft)*	2006 Construction Estimate
Heathfield Pump Station	Pump Station	29-31	145	$10,130,000
Sunset Pump Station	Pump Station	29-31	150	$10,250,000
Subtotal:				***$20,380,000***
Name (forcemains)	**Facility Description**	**DIA *(in)***	**Length *(ft)***	**2006 Construction Estimate**
RE*ISSAQ1.HEATHFIEL(1)FM	Pipe	24 in.	1,668	$660,000
SE 35th Pl and SE Eastgate Way	Jack and Bore	24 in.	60	$280,000
Vasa Creek	Microtunnel	24 in.	100	$600,000
RE*ISSAQ1.SUNSET(1)FM	Pipe	24 in.	3,333	$1,270,000
Culvert 1	Jack and Bore	24 in.	25	$260,000
Vasa Creek	Microtunnel	24 in.	100	$600,000
Subtotal:				***$3,670,000***
Total:				***$24,050,000***

The construction cost estimate was developed using TABULA. More detailed information on the assumptions for the planning level cost estimate is included as Attachment 4.

Estimated Total Project Cost:
The present project cost is estimated to be $56.7M. The current project cost estimate is based on the WTD cost model in the servoy budgeting tool. The project construction cost was input during the 2009 budget process in January 2008. Costs are split between project 423373 sub-project 888 for year 2008 spending and 2009-007 for spending in years 2009 and beyond. During budget adoption for 2009 the project will receive a stand alone capital project number.

The total project cost is greater than the $51M listed in the 2007 CSI Program Update. The primary reason for the increased cost is how the project contingency was applied to the Program Update project. In the CSI Program Update the project contingency was applied to the construction cost. In the current project cost estimate the project contingency of 40% was applied to the sum of construction, construction contingency, sales tax, and allied costs as is done in WDT capital budget estimating.

Capacity Needs Addressed by the Project:
Vasa Park Force Mains/Sunset-Heathfield Pump Stations

Year 20-yr Peak Flow exceeds capacity:
<2000

Estimated Level of Service in 2000
5 to 10 yr

Upstream Projects Affecting Project:
Flow reduction resulting from Issaquah Creek Highlands Storage, Issaquah Storage, Sammamish Plateau Storage, and the Sammamish Plateau Diversion will mitigate the extent of the required upgrade for this project.

Downstream Projects Affected By Project:
none

Preliminary Project Alternatives Evaluation:

Storage
Potential flow reduction using storage is planned to be provided by upstream storage projects.

Pipeline Diversion
The Sammamish Plateau Diversion will remove some of the projected peak flow from this basin, reducing the size of pump station upgrade required.

Pipeline Replacement
The age and condition of the existing force-mains do not warrant replacement at the time of the latest facility inspections. Subsequent inspection of the existing force-mains may reveal conditions that warrant replacement.

Relationship to Initial I/I Projects

Currently there are two potential initial I/I projects that influenced the prioritization of the South Sammamish basin projects. As noted in Table 1 the potential projects are located in the sewer service areas contributing flow to the Eastgate Storage project and the Issaquah Section 2 Parallel project and the Issaquah Storage project.

Identified Stakeholders

This is a preliminary list and additional stake holders may be identified during project level planning and development by the project team.

- Internal
    - South Offsite, Facilities Inspection, Modeling, Planning, Asset Management.
- External
    - City of Bellevue for ROW Use and Environmental permitting, identification and confirmation of local line service connections, and community relations.
    - Neighborhood residents and businesses

Identified Permitting, Site, Facility Condition, and Coordination Issues

The following bullet items related to permitting site, facility condition, and coordination issues have been identified during planning level review of the identified projects. Additional permitting, site and facility conditions, and coordination issues are likely to arise during project level planning and development.

- The current emergency overflow is incorporated in the existing Issaquah Interceptor Section 1. Relocation or siting of a new emergency overflow may present permitting difficulties with the Washington State Department of Ecology based on language in the Criteria for Sewage Works Design (Orange Book) C2-1.8.4
- Shoreline Permit. The Sunset Pump station site is located in a area subject to shoreline permits.
- Coordination with WTD staff to determine the current status of the pump station/force main system condition and operations will be needed to establish the baseline conditions of the current system
- Detailed investigation of the existing pump stations and force mains systems to provide a common baseline of the current pump station condition and provide the basis for a decision to upgrade the pump stations (use existing sites) or site and construct one or two new pump station facilities. Issues identified during planning level analysis are listed below. This is a preliminary list and will likely be expanded during project planning and development.
    - Capacity test of the Sunset/Heathfield pump station
        - Verify the findings from the previous CSI tests in 2001
            - Various steps need to take place prior to test
                - Calibrate sensors and meters
                - Tune impellers
                - Estimate storage time requirements
            - Test need to include various operational pump to force main scenarios
        - Compare to commissioning tests after the most recent pump and/or motor replacements
    - Inventory/survey/life cycle costs/expected useful fife of existing equipment in the stations and/or force mains
        - Review for last major upgrade
        - What is current condition of the force mains and headers
            - What will it take to perform this inspection?
                - External technologies?
                - Sonar for Force mains
                - Is the suction or header or forcemain partially plugged?
        - Current odor control upstream and at the station
        - Power
            - Including emergency power
        - INC
        - HVAC

- Additional Modeling and Analysis Work
    - Detailed identification of inflow points and peak flows to the system in order to ensure that adequate capacity is provided relative to demand. This work will involve meetings and field inspection, coordinated with the City of Bellevue.
    - Final design hydraulic analysis utilizing proposed wetwell set points as a downstream boundary, detailed inflow demands on the proposed system as upstream boundary conditions, and performance of the influent trunk pipe system and overflow weir in peak flow and pump station shut down conditions. The analysis should incorporate storage and surcharged flow analyses due to the complex interactions wetwell influent gate at the sunset pump station.
    - Analysis of the Eastgate Trunk and Lake Hills Interceptor downstream from the forcemain discharge with and without anticipated flow reductions from the Eastgate storage project or the initial I/I project for use in determining control strategies and allowable peak flows.
    - Pump sizing and design can be aided through the use of long duration times series flows that capture average wet and dry weather diurnal patterns and a variety of storm scenarios.
    - Analysis of I/I reduction opportunities incorporating the results of the initial I/I reduction projects.

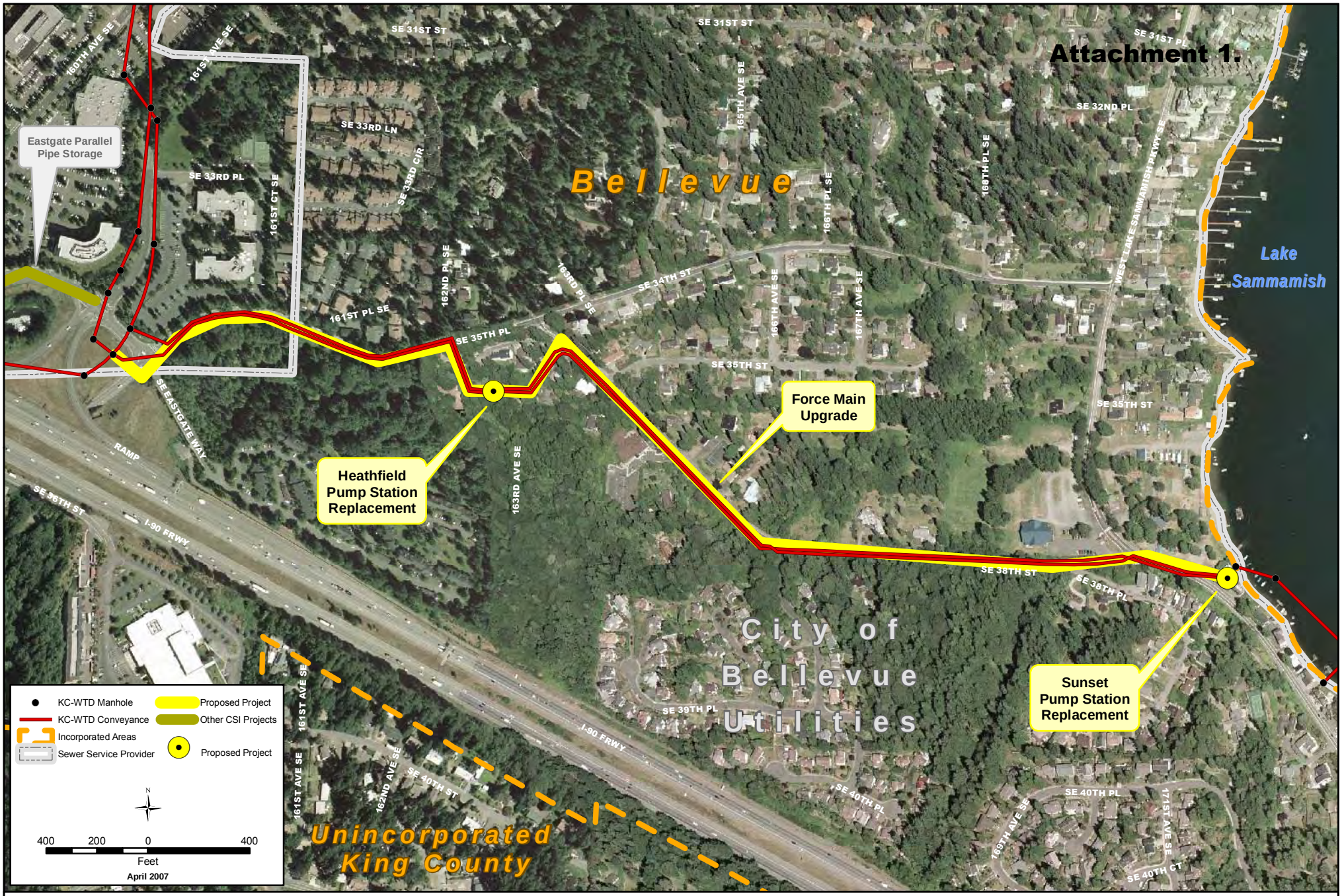
Attachments

Attachment 1. Aerial photo map of the project area

Attachment 2. South Sammamish Planning Basin Proposed Projects

Attachment 3. Hydraulic Analysis of the Conveyance System Limiting the Sunset-Heathfield Capacity Upgrade

Attachment 4. Tabula Cost Estimate Information for the Heathfield and Sunset Pump stations and forcemains



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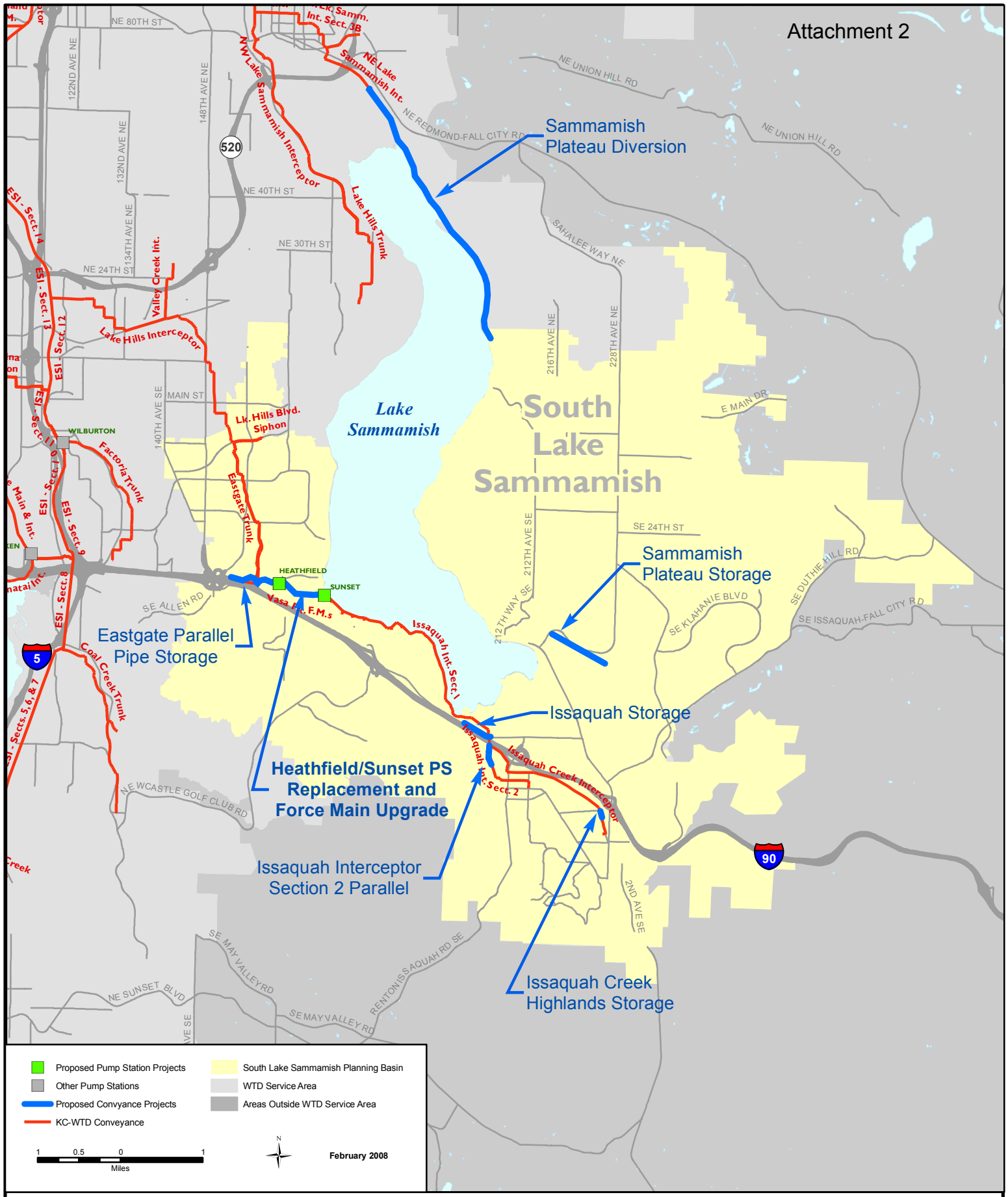
Heathfield/Sunset Pump Station Replacement and Force Main Upgrade

South Lake Sammamish Planning Basin

Attachment 2



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Shaun O'Neil 20080215

South Lake Sammamish Planning Basin Proposed Projects

Attachment 3.

Hydraulic Analysis of the Conveyance System Limiting the Sunset-Heathfield Capacity Upgrade

Prepared by: Carl Slack

February 2008

1.0 Purpose

The purpose of this technical memorandum is to document the hydraulic analysis used to determine the upstream and downstream conveyance system flow restrictions that limit capacity upgrades to Sunset and Heathfield Pump Stations. This includes a description of the hydraulic model, evaluation criteria and methodology, results, current level of service, and recommendations.

2.0 Hydraulic Model Evaluation

The conveyance system upstream and downstream of Sunset-Heathfield Pump Stations include transitioning pipe diameters, junctions, and bending angles which result in significant hydraulic losses. To account for these head losses when estimating capacity, as well as to evaluate flows under surcharge conditions, methods more sophisticated than the traditional Manning's equation are required. For this reason, the Danish Hydraulic Institute (DHI) MOUSE model was used to evaluate the capacity of the conveyance system upstream and downstream of Sunset-Heathfield Pump Stations under steady, gradually varied flow conditions.

2.1 Model Description

A numerical model of King County WTD conveyance system in the wastewater service areas of South Sammamish, Issaquah, and the western portion of Bellevue was prepared for subsequent analyses. This includes the Issaquah Creek Interceptor, Issaquah Interceptor – Sections 1 and 2, Eastgate Trunk, and Lake Hills Interceptor. The model extended over 12 miles from Issaquah to the Eastside Interceptor in Bellevue, and consisted of pipeline ranging in diameter from 8 inches to 56 inches, a submerged lakeline, over 200 manholes, an overflow structure, and two pump stations (see Figures 2.1 and 2.2).

Properties of conveyance facilities, such as pipe length, pipe diameter, invert elevations, overflow weir elevation, cover depth, and connection details were obtained from historical "As-Built" drawings found in WTD Engineering Records. Coordinate locations of conveyance facilities were provided by WTD GIS staff. Connecting inflow points were then identified from local service line coverage in GIS.

2.2 Flow Projections

Monitoring data collected during the 2000 – 2002 wet seasons under the King County Regional I/I Control Program formed the basis for these flow projections. This flow data was used to calibrate a MOUSE runoff and I/I model to simulate dry weather flows and infiltration & inflow (I/I) response to rainfall and various soil moisture conditions. Results from 86 mini-basin MOUSE models were used to evaluate the wastewater service area in this analysis. Population data was derived for the component model basins. Population estimates for year 2000 and forecasts through 2030 by the Puget Sound Regional Council (PSRC) were allocated to these model basins and extrapolated to the year 2050, which is considered "saturation". Base flows for these model basins were derived using flow factors that are applied to the residential population and commercial and industrial employment forecasts.

The model basin was also used to divide up the future I/I flows from areas not yet sewered in the year 2000. This was done on an area-based apportionment to the pipe model.

Existing (year 2000) I/I was evaluated in the I/I Program by mini-basin. The peak 20-year I/I was estimated for each mini-basin in the component model basins. The mini-basin locations were used to determine the location of inflows into the MOUSE HD model (see Table 2.1). The 20-year peak mini-basin I/I flows and the dry weather and new construction I/I were used to determine the relative magnitude of flows entering the conveyance system at each location. Flow projections for the wastewater service area are listed in Table 2.2. Additional details related to flow projections and assumptions can be found in Appendix A of the June 2007 CSI Program Update.

2.3 Head Losses and Boundary Conditions

The model accounts for friction loss along pipes and at manholes to determine head loss. Pipes with diameters of 48 inches or less were assigned a Manning's 'n' value of 0.013. Larger diameter pipes were assigned a Manning's 'n' value of 0.012.
Individual manhole head loss coefficients were specified at every manhole in place of default values provided by DHI. Their values, determined by WTD modeling staff consensus, are listed in Table 2.3.

The model then uses these head losses to calculate the hydraulic grade line relative to a boundary water level. At the downstream end of the Issaquah Interceptor – Section 1, two boundary water levels at the Sunset Pump Station were proposed. The first elevation of 111 ft Metro datum corresponded to historical water levels observed in the pump station wet well during peak operations of approximately 18 mgd. The second elevation of 113 ft Metro datum corresponded to the crown of the influent pipe into the wet well. At the downstream end of the Lake Hills Trunk, this boundary water level was set to a predetermined elevation of 234.41 ft Metro datum in the Eastside Interceptor – Section 13. This elevation was determined from previous hydraulic modeling of peak 20-yr flows in the Eastside Interceptor in 2050 with all proposed conveyance system improvements and Brightwater STP conveyance revisions online.

3.0 Evaluation Criteria

The King County WTD Offsite Facilities Operations Manual reports a peak capacity of 18 mgd for both Sunset and Heathfield Pump Stations. This operational limit was verified from observation of historical data during peak flows. Proposed capacity upgrades to meet future flow projections, however, are limited by upstream and downstream flow restrictions.

Upstream of Sunset Pump Station, flow to the pump stations is limited to the capacity of the Issaquah lakeline. Because the pump stations cannot pump more flow than the lakeline can deliver, the capacity of the lakeline effectively serves as a limiting criteria for the pump station capacity. Several storage facilities upstream of the lakeline have been proposed to limit the projected flows listed in Table 2.2 to the capacity of the Issaquah lakeline.

Downstream of Sunset-Heathfield Pump Stations, it was determined that both the Eastgate Trunk and Lake Hills Interceptor would reach capacity at the same time. Consequently, downstream system capacity could not be increased without paralleling or replacing their entire length. Projected downstream flows could only be reduced by peak shaving at the proposed Eastgate Storage conveyance system improvement. Subsequent optimization is recommended to finalize the sizing, peak reductions, and scheduling for Eastgate Storage as well as all proposed storage facilities in the Issaquah/Sammamish service area. This analysis should follow revised PSRC population forecasts, and a detailed flow measurement campaign.

The conveyance system upstream and downstream of the Sunset-Heathfield Pump Stations were evaluated separately. Upstream flows represented current use of the conveyance system.

These inflows were proportionately scaled relative to the baseline peak 20-yr inflows in 2000 (see Table 3.1). Downstream flows represented future use of the conveyance system. They consisted of the projected peak 20-yr inflows in 2050 with peak shaving at Eastgate Storage. During evaluation of this downstream system,, only inflows from Heathfield Pump Station and peak shaving at Eastgate Storage were varied.

3.1 Evaluation Scenarios

Two scenarios were proposed to evaluate the aforementioned flow criteria:

1) Flow is allowed to fill the pipe to the crown without surcharging (i.e. full pipe), and
2) Flow is allowed to surcharge the pipe to either the lid of the manhole (i.e. imminent flooding), or crown of a local connecting pipe.

The first scenario provides the capacity to be used for the design of conveyance system improvements. The second scenario indicates how much flow can be conveyed under extreme conditions. Basement elevations along the pipeline were not evaluated to assess the backup potential under the latter condition. Due to this uncertainty, results from Scenario 2 will be included for comparison only, not as an acceptable operating condition. Additional scenarios, such as surcharge to the crest of the overflow weir, would result in significant upstream flooding and were not considered further.

A 14-day time series used to introduce inflows into the model is shown in Figure 3.1. Flows are increased from zero to their final value during the first 7 days, and then maintained for the remaining 7 days to ensure that the system has reached “steady-state” conditions. Proposed inflows were iteratively evaluated by the model until the criteria for each scenario had been met.

4.0 Results

4.1 Upstream Conveyance System Results

The upstream model determined that 33 mgd and 29 mgd at boundary water levels 111 ft and 113 ft, respectively, could be delivered to Sunset Pump Station for Scenario 1 (no surcharging). Flows were limited by manholes RE*ISSAQ1.R17-16 and RE*ISSAQ1.R17-07 at boundary water levels 111 ft and 113 ft, respectively (see Figures 4.1 and 4.2). Flows of 41 mgd and 40 mgd at downstream water levels 111 ft and 113 ft, respectively, could be delivered to Sunset Pump Station for Scenario 2. Here, flow was limited by imminent flooding at flushing manhole RE*ISSAQ1.R17-31 at both boundary water levels. Note that neither scenario overflowed the weir crest elevation of 128 ft (Metro datum) located in manhole RE*ISSAQ1.R17-20.

4.2 Downstream Conveyance System Results

The downstream model determined that peak 20-yr flows in 2050 from the Heathfield Pump Station would be limited to 24 mgd and 27 mgd when Eastgate Storage shaves 2 mgd and 5 mgd for the peak flow, respectively for Scenario 1. Flows were limited by a parallel pipe reach capacity of 31.7 mgd located between manholes RE*EGATE.R11-67 and RE*EGATE.R11-60 (see Figure 4.4). The significant surcharge between manholes RE*EGATE.R11-71 and RE*EGATE.R11-67 would be addressed by the proposed inline Eastgate Storage. It should be noted that prior to implementation of this storage facility, flows from Sunset-Heathfield would have to be limited during peak flow conditions to avoid overflows in the Eastgate Trunk.

4.3 Current Level of Service

A level of service analysis was performed to assess the risk of exceeding the existing 18 mgd capacity in year 2000 conditions. A line of best fit was first regressed from a 60 year time series of peak flows at Sunset Pump Station simulated by a calibrated MOUSE RDII hydrologic model (see Figure 4.7). The capacity was then plotted on this regressed line to return a corresponding 9-yr return period, or level of service. Given the recent growth in Issaquah and the Sammamish Plateau, it is expected that there is currently a lower level of service.

5.0 Recommendations

Based on the flow restrictions in the Eastgate Trunk, a peak capacity in the range of 29 mgd to 31 mgd is recommended for both the Sunset and Heathfield Pump Stations and force mains.

Prior to adopting these capacities for design purposes, supplemental modeling may be required to account for the following:

1) Refined modeling using GIS coverages and field review should ensure that all local sewer connections have been included to accurately reflect local inflow points.

2) Vertical datums used by King County and local agencies should be reviewed for consistency.

3) The upstream capacity, and subsequent results, should be re-examined if pre-design specifications recommend a peak operating wet well level above 113 ft.

4) The downstream capacity, and subsequent results, should be re-examined if alternative conveyance system improvements to the Eastgate Storage Project are to be considered.

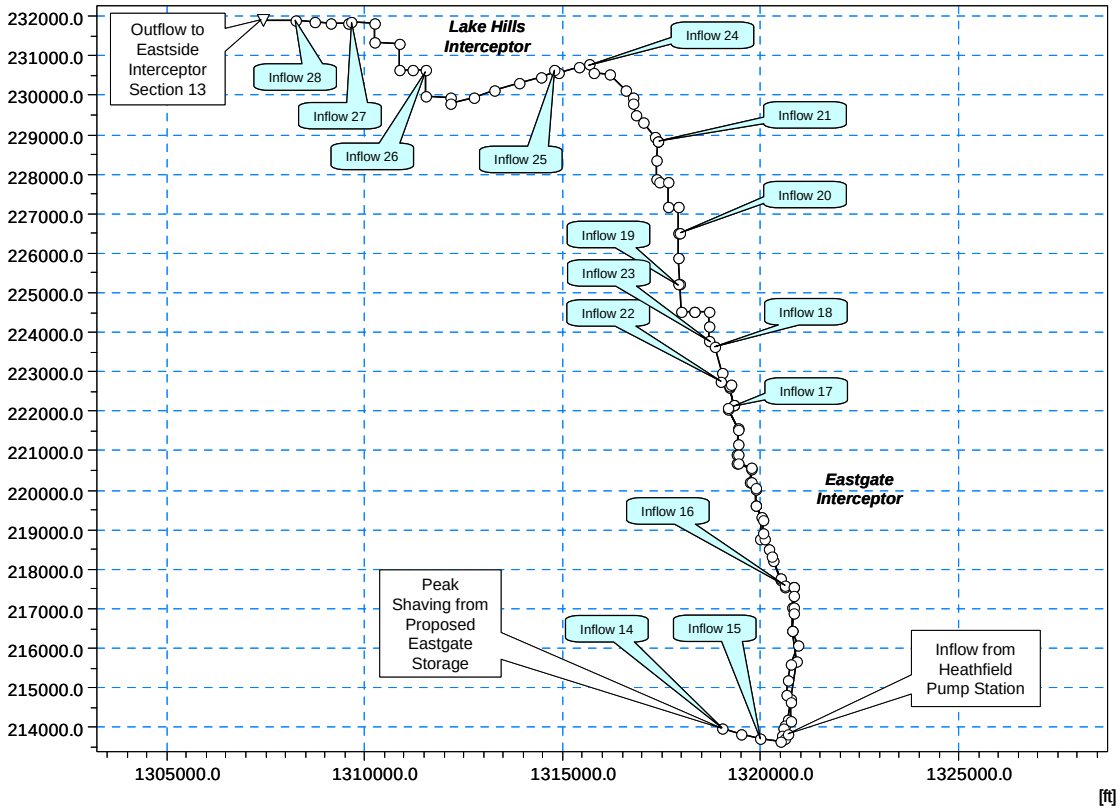

Figure 2.1: Plan View of Downstream MOUSE Model
(Eastgate and Lake Hills Interceptors)

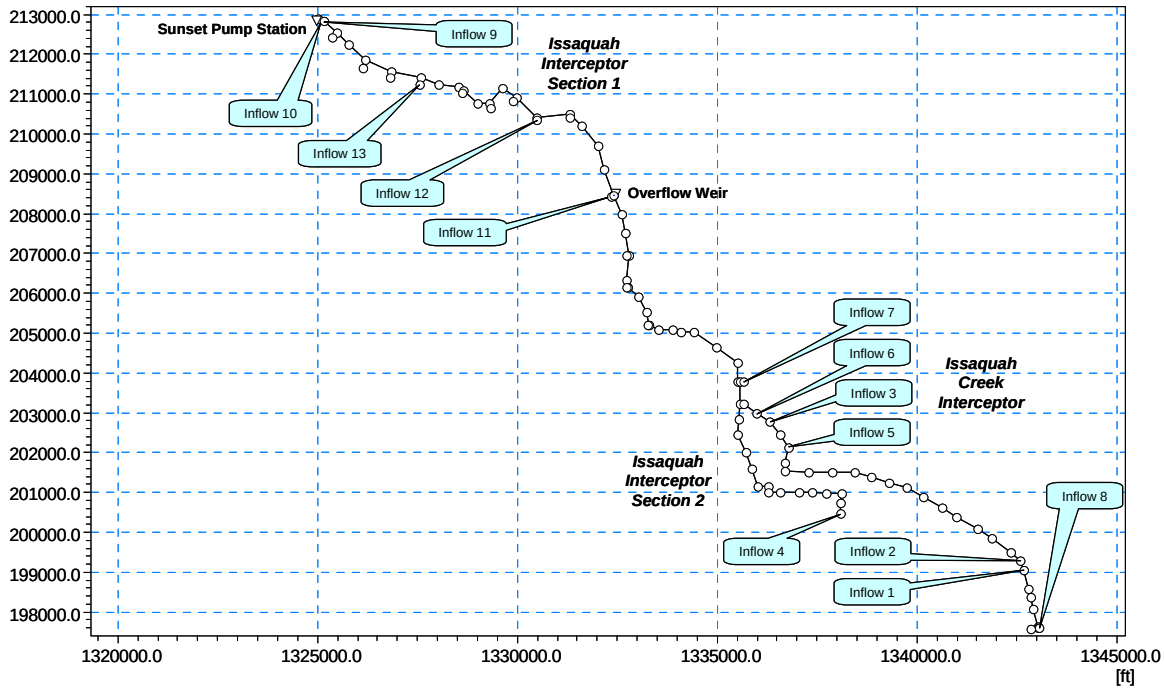

Figure 2.2: Plan View of Upstream MOUSE Model
(Issaquah Creek and Issaquah Interceptors – Section 1 and Section 2)

Inflows		Tributary Minibasins
Index	**Facility Name**	**Minibasin Names**
1	RE*ISSCK.R17-66	ISS013
2	RE*ISSCK.R17-57A	ISS007
3	RE*ISSCK.R17-40A	ISSCK39A
4	RE*ISSAQ2.R17-51	ISS002, ISS003, ISS004, ISS008, ISS014
5	RE*ISSAQ2.R17-42	ISS001, ISS009
6	RE*ISSAQ2.R17-39	ISSAQ038
7	RE*ISSAQ2.R17-36A	ISS012, SAM001, SAM002, SAM003, SAM004, SAM005, SAM007, SAM008, SAM009, SAM010, SAM011, SAM0
		SAM014, SAM015, SAM016, SAM017, SAM018, SAM019, SAM020, SAM020, SAM021, SAM022, SAM023, SPDI
8	RE*ISSAQ2.R17-68	ISS005, ISS006
9	RE*ISSAQ1.R17-02	BEL041, BEL079
10	RE*ISSAQ1.R17-01	BEL038, BEL039, BEL040, BEL042, BEL043, SPK001
11	RE*ISSAQ1.R17-20A	BEL037
12	RE*ISSAQ1.R17-15A	BEL115
13	RE*ISSAQ1.R17-07A	BEL001, BEL003, BEL004, BEL009, BEL113
14	RE*EGATE.R11-71	BEL011, BEL012, BEL014, BEL015, BEL016, BEL031, BEL032, BEL081
15	RE*EGATE.R11-69A	EGATE69A
16	RE*EGATE.R11-57	BEL101
17	RE*EGATE.R11-43B	BEL044, BEL109
18	RE*BLVDSIPH.06	BEL051, BEL052
19	RE*LKHILLS.RO3-40A	BEL059
20	RE*LKHILLS.RO3-38A	BEL058
21	RE*LKHILLS.RO3-31B	BEL060
22	RE*LKHILLS.RO3-48	BEL055, BEL056, BEL057
23	RE*LKHILLS.RO3-45	LKHLS045
24	RE*LKHILLS.RO3-22	BEL068, BEL116, RDM003
25	RE*VALLEY.69	BEL061, BEL062, BEL063, BEL064, VALEY070
26	RE*LKHILLS.RO3-11	BEL073, BEL074
27	RE*LKHILLS.RO3-05	BEL111
28	RE*LKHILLS.RO3-01	LKHLS001

Table 2.1: Inflow Locations for Minibasins

Decade	Inflow Point		Flow Components					Peak Flows	
	Index	Facility Name	Model Basin	Model Basin Apportionment by Land Area (%)	Peak Diurnal Base Flow (mgd)	T=05yr Inflow/ Infiltration (mgd)	T=20yr Inflow/ Infiltration (mgd)	T=05yr Peak Flow (mgd)	T=20yr Peak Flow (mgd)
2000	1	RE*ISSCK.R17-66	M_ISSCK39A	7%	0.04	0.11	0.15	0.15	0.19
	2	RE*ISSCK.R17-57A	M_ISSCK39A	18%	0.10	0.65	0.76	0.75	0.86
	3	RE*ISSCK.R17-40A	M_ISSCK39A	13%	0.07	0.26	0.30	0.33	0.37
	4	RE*ISSAQ2.R17-51	M_ISSAQ038	62%	0.47	2.14	2.85	2.61	3.32
	5	RE*ISSAQ2.R17-42	M_ISSAQ038	24%	0.18	0.19	0.26	0.37	0.44
	6	RE*ISSAQ2.R17-39	M_ISSAQ038	14%	0.11	0.82	1.10	0.93	1.21
	7	RE*ISSAQ2.R17-36A	M_SPDIST01, M_SAM005, M_SAM023	100%, 100%, 100%	2.58	3.08	3.99	5.66	6.57
	8	RE*ISSAQ2.R17-68	M_ISSCK39A	62%	0.34	1.30	1.53	1.64	1.87
	9	RE*ISSAQ1.R17-02	M_BELSUNSET	25%	0.15	0.55	0.80	0.70	0.95
	10	RE*ISSAQ1.R17-01	M_BEL038, M_BELSUNSET	65%, 75%	0.74	1.81	2.46	2.55	3.20
	11	RE*ISSAQ1.R17-20A	M_BEL038	21%	0.09	0.05	0.07	0.14	0.16
	12	RE*ISSAQ1.R17-15A	M_BEL038	14%	0.06	0.05	0.06	0.11	0.13
	13	RE*ISSAQ1.R17-07A	M_BEL113	100%	0.34	1.52	2.08	1.86	2.42
		Total Flow at Sunset Pump Station						*17.81*	*21.68*
	14	RE*EGATE.R11-71	M_EGATE69A	91%	0.67	4.56	6.41	5.23	7.08
	15	RE*EGATE.R11-69A	M_EGATE69A	9%	0.07	0.29	0.41	0.36	0.48
	16	RE*EGATE.R11-57	M_LKHLS045	7%	0.11	0.03	0.04	0.14	0.15
	17	RE*EGATE.R11-43B	M_LKHLS045	23%	0.37	0.56	0.68	0.92	1.05
	18	RE*BLVDSIPH.06	M_LKHLS045	22%	0.35	0.30	0.38	0.66	0.73
	19	RE*LKHILLS.RO3-40A	M_LKHLS001	12%	0.28	0.67	0.85	0.95	1.13
	20	RE*LKHILLS.RO3-38A	M_LKHLS001	3%	0.07	0.09	0.11	0.16	0.18
	21	RE*LKHILLS.RO3-31B	M_LKHLS001	7%	0.16	0.62	0.80	0.79	0.96
	22	RE*LKHILLS.RO3-48	M_LKHLS045	33%	0.53	0.25	0.33	0.78	0.86
	23	RE*LKHILLS.RO3-45	M_LKHLS045	15%	0.24	0.00	0.00	0.21	0.21
	24	RE*LKHILLS.RO3-22	M_LKHLS001, M_RDM003	18%, 100%	1.19	0.60	0.80	1.79	1.99
	25	RE*VALLEY.69	M_VALEY070, M_LKHLS001	100%, 11%	1.11	2.16	2.73	3.28	3.84
	26	RE*LKHILLS.RO3-11	M_LKHLS001	17%	0.40	0.33	0.43	0.73	0.82
	27	RE*LKHILLS.RO3-05	M_LKHLS001	7%	0.16	0.07	0.09	0.23	0.26
	28	RE*LKHILLS.RO3-01	M_LKHLS001	25%	0.58	0.83	1.07	1.42	1.65
		*Total Flow to RE*ESI13.RO2-49*						*34.19*	*41.56*
2010	1	RE*ISSCK.R17-66	M_ISSCK39A	7%	0.12	0.19	0.25	0.31	0.37
	2	RE*ISSCK.R17-57A	M_ISSCK39A	18%	0.30	0.88	1.04	1.18	1.35
	3	RE*ISSCK.R17-40A	M_ISSCK39A	13%	0.22	0.41	0.49	0.63	0.71
	4	RE*ISSAQ2.R17-51	M_ISSAQ038	62%	0.76	3.00	3.95	3.77	4.71
	5	RE*ISSAQ2.R17-42	M_ISSAQ038	24%	0.29	0.48	0.62	0.78	0.92
	6	RE*ISSAQ2.R17-39	M_ISSAQ038	14%	0.17	1.04	1.38	1.22	1.55
	7	RE*ISSAQ2.R17-36A	M_SPDIST01, M_SAM005, M_SAM023	100%, 100%, 100%	3.30	5.75	7.35	9.05	10.65
	8	RE*ISSAQ2.R17-68	M_ISSCK39A	62%	1.05	2.02	2.42	3.07	3.47
	9	RE*ISSAQ1.R17-02	M_BELSUNSET	25%	0.14	0.60	0.87	0.74	1.01
	10	RE*ISSAQ1.R17-01	M_BEL038, M_BELSUNSET	65%, 75%	0.68	1.99	2.70	2.67	3.38
	11	RE*ISSAQ1.R17-20A	M_BEL038	21%	0.08	0.06	0.08	0.14	0.16
	12	RE*ISSAQ1.R17-15A	M_BEL038	14%	0.05	0.06	0.07	0.11	0.13
	13	RE*ISSAQ1.R17-07A	M_BEL113	100%	0.37	1.74	2.37	2.11	2.74
		Total Flow at Sunset Pump Station						*25.77*	*31.13*
	14	RE*EGATE.R11-71	M_EGATE69A	91%	0.69	4.94	6.94	5.63	7.63
	15	RE*EGATE.R11-69A	M_EGATE69A	9%	0.07	0.32	0.45	0.39	0.51
	16	RE*EGATE.R11-57	M_LKHLS045	7%	0.10	0.03	0.04	0.14	0.15
	17	RE*EGATE.R11-43B	M_LKHLS045	23%	0.34	0.61	0.75	0.95	1.09
	18	RE*BLVDSIPH.06	M_LKHLS045	22%	0.32	0.34	0.43	0.67	0.75
	19	RE*LKHILLS.RO3-40A	M_LKHLS001	12%	0.27	0.72	0.92	0.99	1.19
	20	RE*LKHILLS.RO3-38A	M_LKHLS001	3%	0.07	0.10	0.13	0.17	0.19
	21	RE*LKHILLS.RO3-31B	M_LKHLS001	7%	0.16	0.67	0.86	0.83	1.01
	22	RE*LKHILLS.RO3-48	M_LKHLS045	33%	0.49	0.30	0.38	0.78	0.87
	23	RE*LKHILLS.RO3-45	M_LKHLS045	15%	0.22	0.00	0.00	0.20	0.20
	24	RE*LKHILLS.RO3-22	M_LKHLS001, M_RDM003	18%, 100%	1.18	0.68	0.90	1.86	2.08
	25	RE*VALLEY.69	M_VALEY070, M_LKHLS001	100%, 11%	1.06	2.50	3.15	3.56	4.21
	26	RE*LKHILLS.RO3-11	M_LKHLS001	17%	0.38	0.37	0.48	0.75	0.85
	27	RE*LKHILLS.RO3-05	M_LKHLS001	7%	0.16	0.08	0.11	0.24	0.26
	28	RE*LKHILLS.RO3-01	M_LKHLS001	25%	0.56	0.91	1.17	1.47	1.73
		*Total Flow to RE*ESI13.RO2-49*						*42.59*	*51.68*
2020	1	RE*ISSCK.R17-66	M_ISSCK39A	7%	0.13	0.22	0.28	0.35	0.41
	2	RE*ISSCK.R17-57A	M_ISSCK39A	18%	0.34	0.97	1.15	1.30	1.49
	3	RE*ISSCK.R17-40A	M_ISSCK39A	13%	0.24	0.46	0.55	0.70	0.79
	4	RE*ISSAQ2.R17-51	M_ISSAQ038	62%	0.84	3.37	4.42	4.21	5.26
	5	RE*ISSAQ2.R17-42	M_ISSAQ038	24%	0.32	0.58	0.75	0.91	1.07
	6	RE*ISSAQ2.R17-39	M_ISSAQ038	14%	0.19	1.15	1.52	1.34	1.71
	7	RE*ISSAQ2.R17-36A	M_SPDIST01, M_SAM005, M_SAM023	100%, 100%, 100%	4.48	8.56	10.89	13.04	15.38
	8	RE*ISSAQ2.R17-68	M_ISSCK39A	62%	1.16	2.27	2.72	3.43	3.88
	9	RE*ISSAQ1.R17-02	M_BELSUNSET	25%	0.15	0.66	0.94	0.81	1.09
	10	RE*ISSAQ1.R17-01	M_BEL038, M_BELSUNSET	65%, 75%	0.72	2.17	2.94	2.90	3.66
	11	RE*ISSAQ1.R17-20A	M_BEL038	21%	0.09	0.07	0.09	0.16	0.18
	12	RE*ISSAQ1.R17-15A	M_BEL038	14%	0.06	0.06	0.08	0.12	0.14
	13	RE*ISSAQ1.R17-07A	M_BEL113	100%	0.45	1.96	2.66	2.41	3.11
		Total Flow at Sunset Pump Station						*31.66*	*38.16*
	14	RE*EGATE.R11-71	M_EGATE69A	91%	0.77	5.33	7.48	6.10	8.25
	15	RE*EGATE.R11-69A	M_EGATE69A	9%	0.08	0.35	0.48	0.42	0.56
	16	RE*EGATE.R11-57	M_LKHLS045	7%	0.11	0.04	0.05	0.14	0.16
	17	RE*EGATE.R11-43B	M_LKHLS045	23%	0.35	0.66	0.81	1.00	1.15
	18	RE*BLVDSIPH.06	M_LKHLS045	22%	0.33	0.37	0.46	0.70	0.79
	19	RE*LKHILLS.RO3-40A	M_LKHLS001	12%	0.29	0.78	0.99	1.07	1.28
	20	RE*LKHILLS.RO3-38A	M_LKHLS001	3%	0.07	0.11	0.14	0.18	0.21
	21	RE*LKHILLS.RO3-31B	M_LKHLS001	7%	0.17	0.72	0.92	0.89	1.09
	22	RE*LKHILLS.RO3-48	M_LKHLS045	33%	0.50	0.33	0.42	0.82	0.91
	23	RE*LKHILLS.RO3-45	M_LKHLS045	15%	0.23	0.00	0.00	0.21	0.21
	24	RE*LKHILLS.RO3-22	M_LKHLS001, M_RDM003	18%, 100%	1.29	0.73	0.97	2.02	2.26
	25	RE*VALLEY.69	M_VALEY070, M_LKHLS001	100%, 11%	1.15	2.85	3.59	4.00	4.74
	26	RE*LKHILLS.RO3-11	M_LKHLS001	17%	0.41	0.40	0.52	0.81	0.93
	27	RE*LKHILLS.RO3-05	M_LKHLS001	7%	0.17	0.09	0.12	0.26	0.29
	28	RE*LKHILLS.RO3-01	M_LKHLS001	25%	0.60	0.99	1.27	1.59	1.87
		*Total Flow to RE*ESI13.RO2-49*						*49.66*	*60.18*

Table 2.2: Flow Projections by Decade for Service Area (Flows reflective of no CSI Projects constructed upstream.)

Decade	Inflow Point		Flow Components					Peak Flows	
	Index	Facility Name	Model Basin	Model Basin Apportionment by Land Area (%)	Peak Diurnal Base Flow (mgd)	T=05yr Inflow/ Infiltration (mgd)	T=20yr Inflow/ Infiltration (mgd)	T=05yr Peak Flow (mgd)	T=20yr Peak Flow (mgd)
2030	1	RE*ISSCK.R17-66	M_ISSCK39A	7%	0.13	0.23	0.30	0.36	0.43
	2	RE*ISSCK.R17-57A	M_ISSCK39A	18%	0.34	1.03	1.23	1.37	1.57
	3	RE*ISSCK.R17-40A	M_ISSCK39A	13%	0.24	0.49	0.58	0.73	0.83
	4	RE*ISSAQ2.R17-51	M_ISSAQ038	62%	0.85	3.58	4.69	4.43	5.54
	5	RE*ISSAQ2.R17-42	M_ISSAQ038	24%	0.33	0.62	0.79	0.95	1.12
	6	RE*ISSAQ2.R17-39	M_ISSAQ038	14%	0.19	1.22	1.61	1.41	1.80
	7	RE*ISSAQ2.R17-36A	M_SPDIST01, M_SAM005, M_SAM023	100%, 100%, 100%	5.48	11.56	14.67	17.04	20.15
	8	RE*ISSAQ2.R17-68	M_ISSCK39A	62%	1.17	2.41	2.90	3.58	4.06
	9	RE*ISSAQ1.R17-02	M_BELSUNSET	25%	0.15	0.71	1.01	0.86	1.17
	10	RE*ISSAQ1.R17-01	M_BEL038, M_BELSUNSET	65%, 75%	0.73	2.36	3.19	3.09	3.91
	11	RE*ISSAQ1.R17-20A	M_BEL038	21%	0.09	0.08	0.10	0.17	0.19
	12	RE*ISSAQ1.R17-15A	M_BEL038	14%	0.06	0.07	0.09	0.13	0.15
	13	RE*ISSAQ1.R17-07A	M_BEL113	100%	0.52	2.19	2.96	2.71	3.48
		Total Flow at Sunset Pump Station						*36.82*	*44.40*
	14	RE*EGATE.R11-71	M_EGATE69A	91%	0.82	5.73	8.03	6.55	8.85
	15	RE*EGATE.R11-69A	M_EGATE69A	9%	0.08	0.37	0.52	0.45	0.60
	16	RE*EGATE.R11-57	M_LKHLS045	7%	0.11	0.04	0.06	0.15	0.16
	17	RE*EGATE.R11-43B	M_LKHLS045	23%	0.35	0.71	0.86	1.06	1.21
	18	RE*BLVDSIPH.06	M_LKHLS045	22%	0.33	0.40	0.50	0.74	0.83
	19	RE*LKHILLS.RO3-40A	M_LKHLS001	12%	0.30	0.84	1.07	1.14	1.37
	20	RE*LKHILLS.RO3-38A	M_LKHLS001	3%	0.08	0.12	0.15	0.19	0.22
	21	RE*LKHILLS.RO3-31B	M_LKHLS001	7%	0.18	0.77	0.98	0.95	1.16
	22	RE*LKHILLS.RO3-48	M_LKHLS045	33%	0.50	0.36	0.45	0.86	0.96
	23	RE*LKHILLS.RO3-45	M_LKHLS045	15%	0.23	0.00	0.00	0.21	0.22
	24	RE*LKHILLS.RO3-22	M_LKHLS001, M_RDM003	18%, 100%	1.39	0.79	1.05	2.17	2.43
	25	RE*VALLEY.69	M_VALEY070, M_LKHLS001	100%, 11%	1.24	3.21	4.04	4.45	5.28
	26	RE*LKHILLS.RO3-11	M_LKHLS001	17%	0.43	0.44	0.57	0.87	1.00
	27	RE*LKHILLS.RO3-05	M_LKHLS001	7%	0.18	0.10	0.13	0.28	0.31
	28	RE*LKHILLS.RO3-01	M_LKHLS001	25%	0.63	1.07	1.37	1.70	2.00
		*Total Flow to RE*ESI13.RO2-49*						*56.01*	*67.89*
2040	1	RE*ISSCK.R17-66	M_ISSCK39A	7%	0.13	0.24	0.32	0.38	0.45
	2	RE*ISSCK.R17-57A	M_ISSCK39A	18%	0.34	1.09	1.30	1.43	1.64
	3	RE*ISSCK.R17-40A	M_ISSCK39A	13%	0.25	0.51	0.62	0.76	0.87
	4	RE*ISSAQ2.R17-51	M_ISSAQ038	62%	0.86	3.79	4.97	4.65	5.83
	5	RE*ISSAQ2.R17-42	M_ISSAQ038	24%	0.33	0.66	0.84	0.99	1.17
	6	RE*ISSAQ2.R17-39	M_ISSAQ038	14%	0.19	1.29	1.71	1.49	1.90
	7	RE*ISSAQ2.R17-36A	M_SPDIST01, M_SAM005, M_SAM023	100%, 100%, 100%	6.26	12.66	16.08	18.92	22.34
	8	RE*ISSAQ2.R17-68	M_ISSCK39A	62%	1.18	2.56	3.07	3.73	4.25
	9	RE*ISSAQ1.R17-02	M_BELSUNSET	25%	0.15	0.75	1.07	0.91	1.23
	10	RE*ISSAQ1.R17-01	M_BEL038, M_BELSUNSET	65%, 75%	0.73	2.51	3.38	3.24	4.11
	11	RE*ISSAQ1.R17-20A	M_BEL038	21%	0.09	0.08	0.11	0.17	0.19
	12	RE*ISSAQ1.R17-15A	M_BEL038	14%	0.06	0.08	0.10	0.13	0.15
	13	RE*ISSAQ1.R17-07A	M_BEL113	100%	0.55	2.34	3.16	2.89	3.70
		Total Flow at Sunset Pump Station						*39.68*	*47.83*
	14	RE*EGATE.R11-71	M_EGATE69A	91%	0.87	6.07	8.51	6.95	9.38
	15	RE*EGATE.R11-69A	M_EGATE69A	9%	0.09	0.40	0.55	0.48	0.64
	16	RE*EGATE.R11-57	M_LKHLS045	7%	0.11	0.05	0.06	0.15	0.17
	17	RE*EGATE.R11-43B	M_LKHLS045	23%	0.35	0.75	0.92	1.11	1.27
	18	RE*BLVDSIPH.06	M_LKHLS045	22%	0.34	0.43	0.53	0.77	0.87
	19	RE*LKHILLS.RO3-40A	M_LKHLS001	12%	0.32	0.89	1.13	1.20	1.45
	20	RE*LKHILLS.RO3-38A	M_LKHLS001	3%	0.08	0.12	0.16	0.20	0.24
	21	RE*LKHILLS.RO3-31B	M_LKHLS001	7%	0.18	0.82	1.04	1.00	1.23
	22	RE*LKHILLS.RO3-48	M_LKHLS045	33%	0.51	0.39	0.49	0.89	0.99
	23	RE*LKHILLS.RO3-45	M_LKHLS045	15%	0.23	0.00	0.00	0.22	0.23
	24	RE*LKHILLS.RO3-22	M_LKHLS001, M_RDM003	18%, 100%	1.52	0.82	1.10	2.34	2.61
	25	RE*VALLEY.69	M_VALEY070, M_LKHLS001	100%, 11%	1.28	3.43	4.32	4.71	5.60
	26	RE*LKHILLS.RO3-11	M_LKHLS001	17%	0.45	0.47	0.60	0.92	1.05
	27	RE*LKHILLS.RO3-05	M_LKHLS001	7%	0.18	0.11	0.14	0.29	0.33
	28	RE*LKHILLS.RO3-01	M_LKHLS001	25%	0.66	1.14	1.45	1.79	2.11
		*Total Flow to RE*ESI13.RO2-49*						*59.93*	*72.64*
2050	1	RE*ISSCK.R17-66	M_ISSCK39A	7%	0.13	0.25	0.32	0.38	0.46
	2	RE*ISSCK.R17-57A	M_ISSCK39A	18%	0.35	1.10	1.32	1.45	1.66
	3	RE*ISSCK.R17-40A	M_ISSCK39A	13%	0.25	0.52	0.63	0.77	0.88
	4	RE*ISSAQ2.R17-51	M_ISSAQ038	62%	0.86	3.85	5.05	4.72	5.91
	5	RE*ISSAQ2.R17-42	M_ISSAQ038	24%	0.33	0.68	0.87	1.01	1.21
	6	RE*ISSAQ2.R17-39	M_ISSAQ038	14%	0.20	1.31	1.72	1.50	1.92
	7	RE*ISSAQ2.R17-36A	M_SPDIST01, M_SAM005, M_SAM023	100%, 100%, 100%	7.00	13.57	17.23	20.57	24.23
	8	RE*ISSAQ2.R17-68	M_ISSCK39A	62%	1.19	2.61	3.13	3.80	4.32
	9	RE*ISSAQ1.R17-02	M_BELSUNSET	25%	0.16	0.76	1.08	0.91	1.23
	10	RE*ISSAQ1.R17-01	M_BEL038, M_BELSUNSET	65%, 75%	0.73	2.53	3.41	3.26	4.14
	11	RE*ISSAQ1.R17-20A	M_BEL038	21%	0.09	0.09	0.11	0.17	0.20
	12	RE*ISSAQ1.R17-15A	M_BEL038	14%	0.06	0.08	0.10	0.13	0.16
	13	RE*ISSAQ1.R17-07A	M_BEL113	100%	0.57	2.38	3.21	2.96	3.78
		Total Flow at Sunset Pump Station						*41.64*	*50.10*
	14	RE*EGATE.R11-71	M_EGATE69A	91%	0.92	6.10	8.54	7.02	9.46
	15	RE*EGATE.R11-69A	M_EGATE69A	9%	0.09	0.40	0.56	0.49	0.65
	16	RE*EGATE.R11-57	M_LKHLS045	7%	0.11	0.05	0.06	0.15	0.17
	17	RE*EGATE.R11-43B	M_LKHLS045	23%	0.35	0.75	0.92	1.11	1.28
	18	RE*BLVDSIPH.06	M_LKHLS045	22%	0.34	0.43	0.53	0.77	0.87
	19	RE*LKHILLS.RO3-40A	M_LKHLS001	12%	0.33	0.89	1.13	1.22	1.46
	20	RE*LKHILLS.RO3-38A	M_LKHLS001	3%	0.08	0.12	0.16	0.21	0.24
	21	RE*LKHILLS.RO3-31B	M_LKHLS001	7%	0.19	0.82	1.04	1.01	1.24
	22	RE*LKHILLS.RO3-48	M_LKHLS045	33%	0.51	0.39	0.49	0.90	1.00
	23	RE*LKHILLS.RO3-45	M_LKHLS045	15%	0.23	0.00	0.00	0.22	0.23
	24	RE*LKHILLS.RO3-22	M_LKHLS001, M_RDM003	18%, 100%	1.64	0.80	1.08	2.44	2.71
	25	RE*VALLEY.69	M_VALEY070, M_LKHLS001	100%, 11%	1.33	3.50	4.41	4.83	5.74
	26	RE*LKHILLS.RO3-11	M_LKHLS001	17%	0.47	0.47	0.61	0.94	1.07
	27	RE*LKHILLS.RO3-05	M_LKHLS001	7%	0.19	0.11	0.14	0.30	0.34
	28	RE*LKHILLS.RO3-01	M_LKHLS001	25%	0.69	1.14	1.46	1.83	2.15
		*Total Flow to RE*ESI13.RO2-49*						*62.16*	*75.19*

Table 2.2 (cont): Flow Projections by Decade for Service Area (Flows reflective of no CSI Projects constructed upstream.)

Description	Head Loss Coefficient
Standard Manhole (Diameter < 4ft)	0.08
Standard Manhole (Diameter >= 4ft)	0.05
Bend Angle Supplement:	$+ (\theta^2 / 90°^2) / 2$
Pipe Expansion Supplement:	+ 0.30
Pipe Contraction Supplement:	+ 0.20
Pipe Junction Supplement	+ 0.50
Pipe Bifurcation Supplement	+ 0.20

Table 2.3: Manhole Head Loss Coefficients

Index	Inflow Location	Peak 20-yr Flow in 2000 *(mgd)*	Percentages of Peak 20-yr Flow in 2000 *(%)*	Scenario 1 (no surcharge) (wlev = 111 ft) Inflow *(mgd)*	Scenario 1 (no surcharge) (wlev = 113 ft) Inflow *(mgd)*	Scenario 2 (imminent flooding) (wlev = 111 ft) Inflow *(mgd)*	Scenario 2 (imminent flooding) (wlev = 113 ft) Inflow *(mgd)*
1	RE*ISSCK.R17-66	0.19	1%	0.28	0.25	0.35	0.34
2	RE*ISSCK.R17-57A	0.86	4%	1.32	1.15	1.62	1.57
3	RE*ISSCK.R17-40A	0.37	2%	0.57	0.50	0.70	0.68
4	RE*ISSAQ2.R17-51	3.32	15%	5.07	4.43	6.24	6.06
5	RE*ISSAQ2.R17-42	0.44	2%	0.67	0.59	0.83	0.80
6	RE*ISSAQ2.R17-39	1.21	6%	1.84	1.61	2.27	2.20
7	RE*ISSAQ2.R17-36A	6.57	30%	10.04	8.76	12.35	11.98
8	RE*ISSAQ2.R17-68	1.87	9%	2.85	2.49	3.51	3.41
9	RE*ISSAQ1.R17-02	0.95	4%	1.45	1.26	1.78	1.73
10	RE*ISSAQ1.R17-01	3.20	15%	4.89	4.27	6.02	5.84
11	RE*ISSAQ1.R17-20A	0.16	1%	0.24	0.21	0.30	0.29
12	RE*ISSAQ1.R17-15A	0.13	1%	0.19	0.17	0.24	0.23
13	RE*ISSAQ1.R17-07A	2.42	11%	3.70	3.23	4.55	4.42
	Total	***21.68***	***100%***	***33.11***	***28.90***	***40.74***	***39.54***

Table 3.1: Proportionally-Scaled Inflows into MOUSE Model

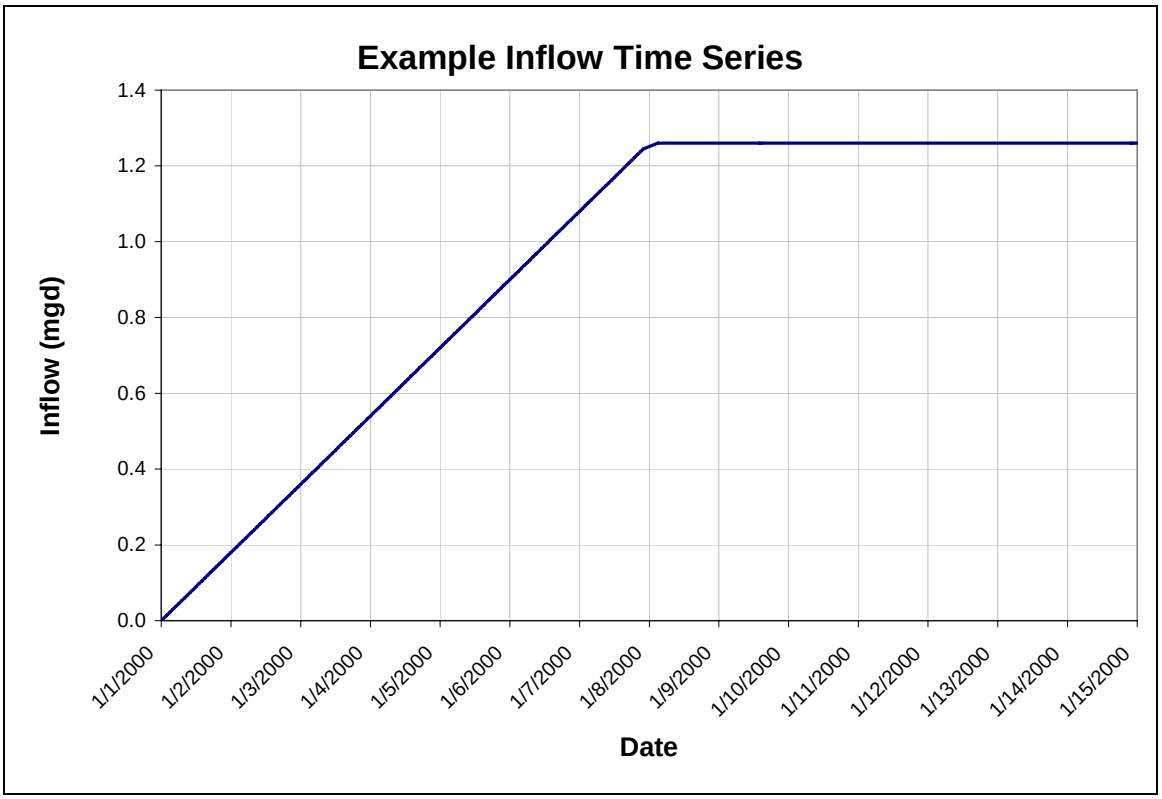

Figure 3.1: Example of an Inflow Time Series for the MOUSE Model

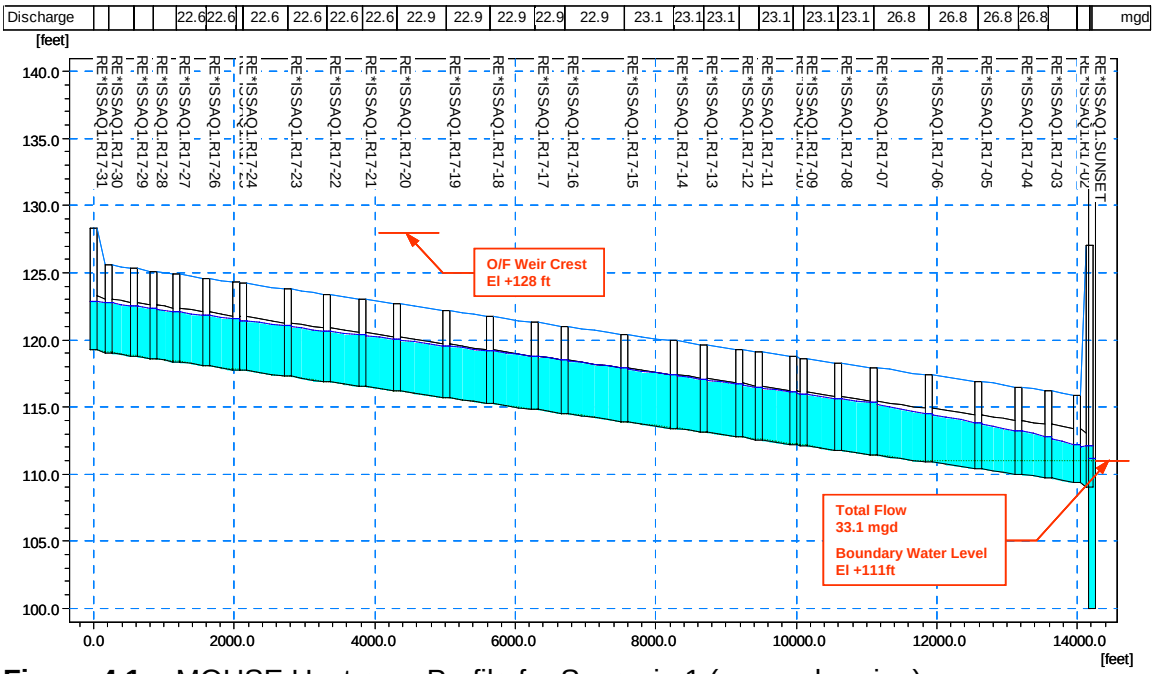

Figure 4.1: MOUSE Upstream Profile for Scenario 1 (no surcharging) at Boundary Water Level 111 ft

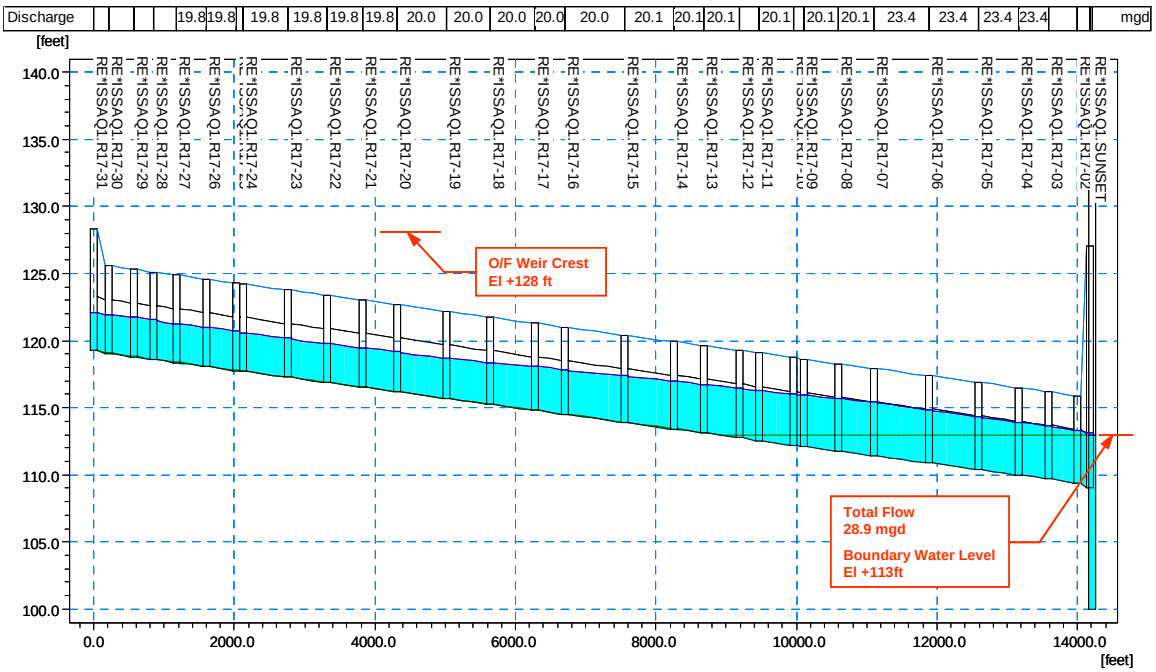

Figure 4.2: MOUSE Upstream Profile for Scenario 1 (no surcharging) at Boundary Water Level 113 ft

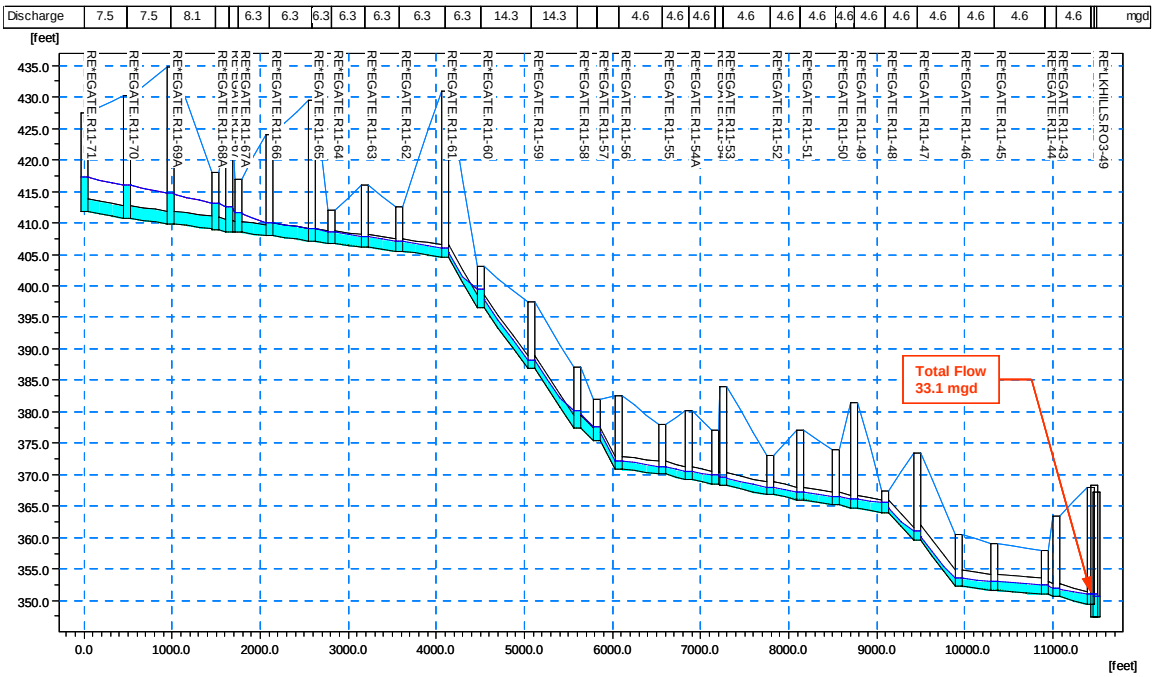

Figure 4.3: MOUSE Downstream Profile of the Eastgate Trunk (older parallel) for Scenario 1 (no surcharging)

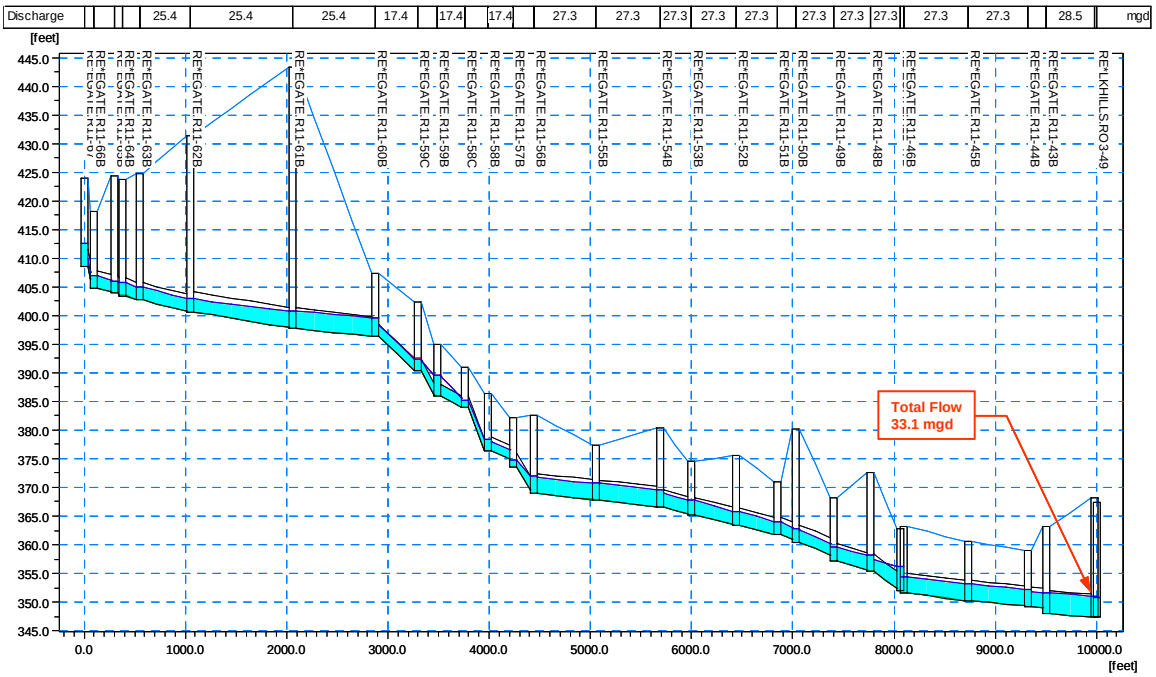

Figure 4.4: MOUSE Downstream Profile of the Eastgate Trunk (newer parallel) for Scenario 1 (no surcharging)

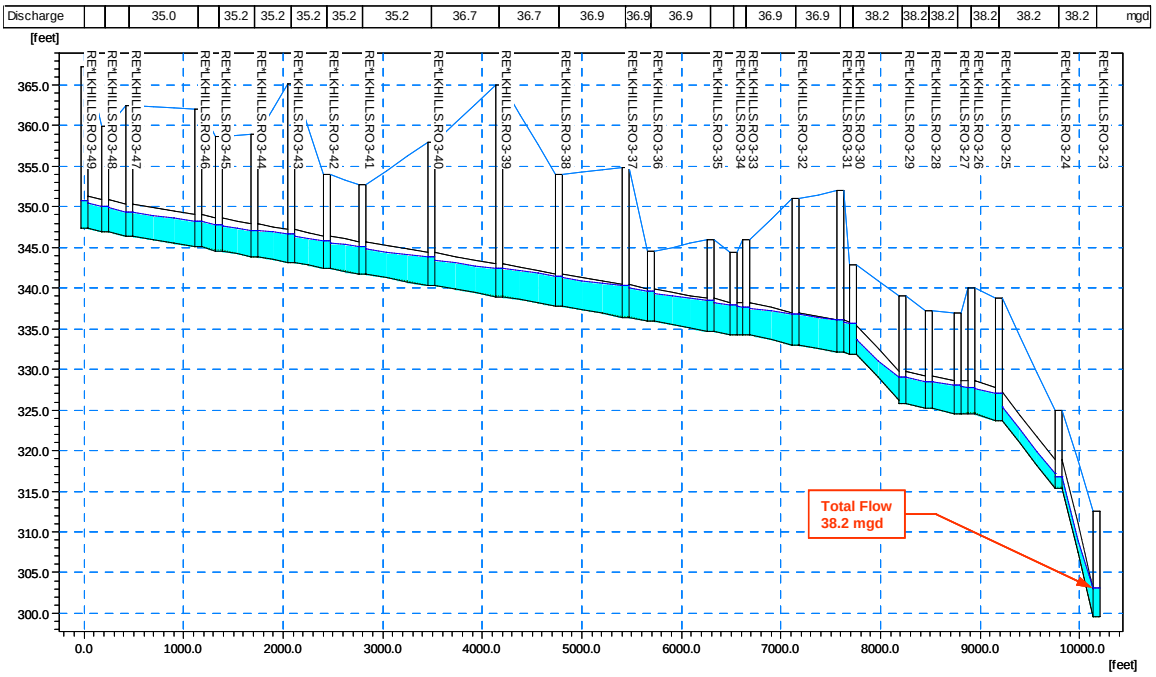

Figure 4.5: MOUSE Downstream Profile of the Lake Hills Interceptor for Scenario 1 (no surcharging)

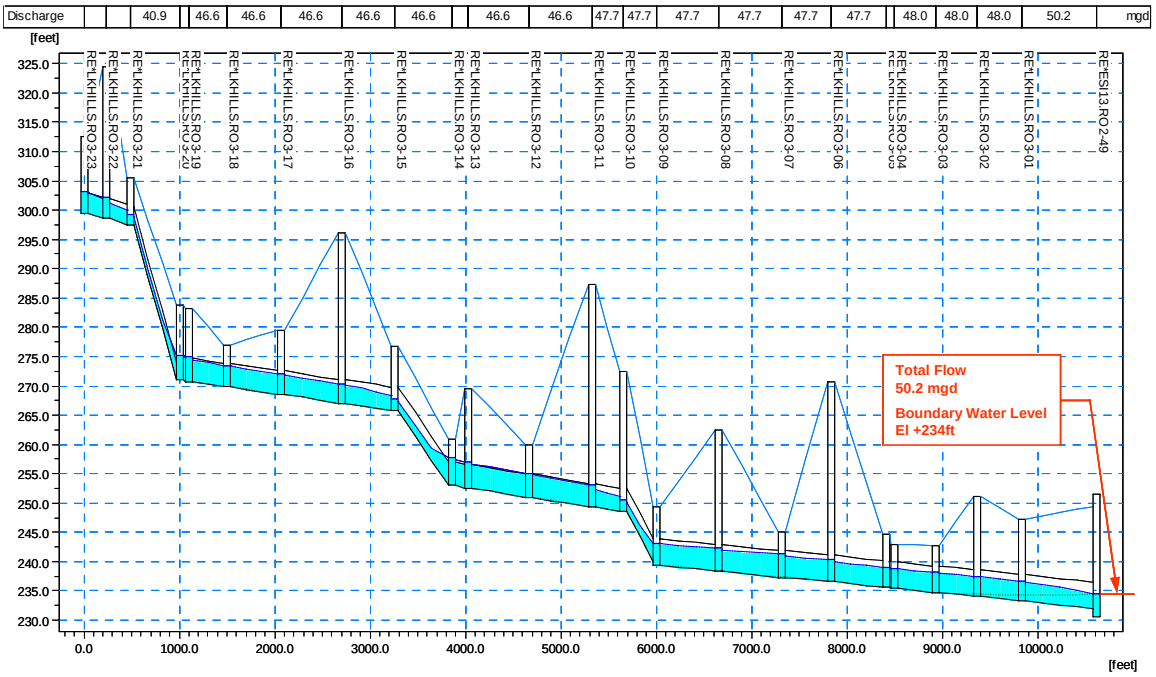

Figure 4.6: MOUSE Downstream Profile of the Lake Hills Interceptor for Scenario 1 (no surcharging)

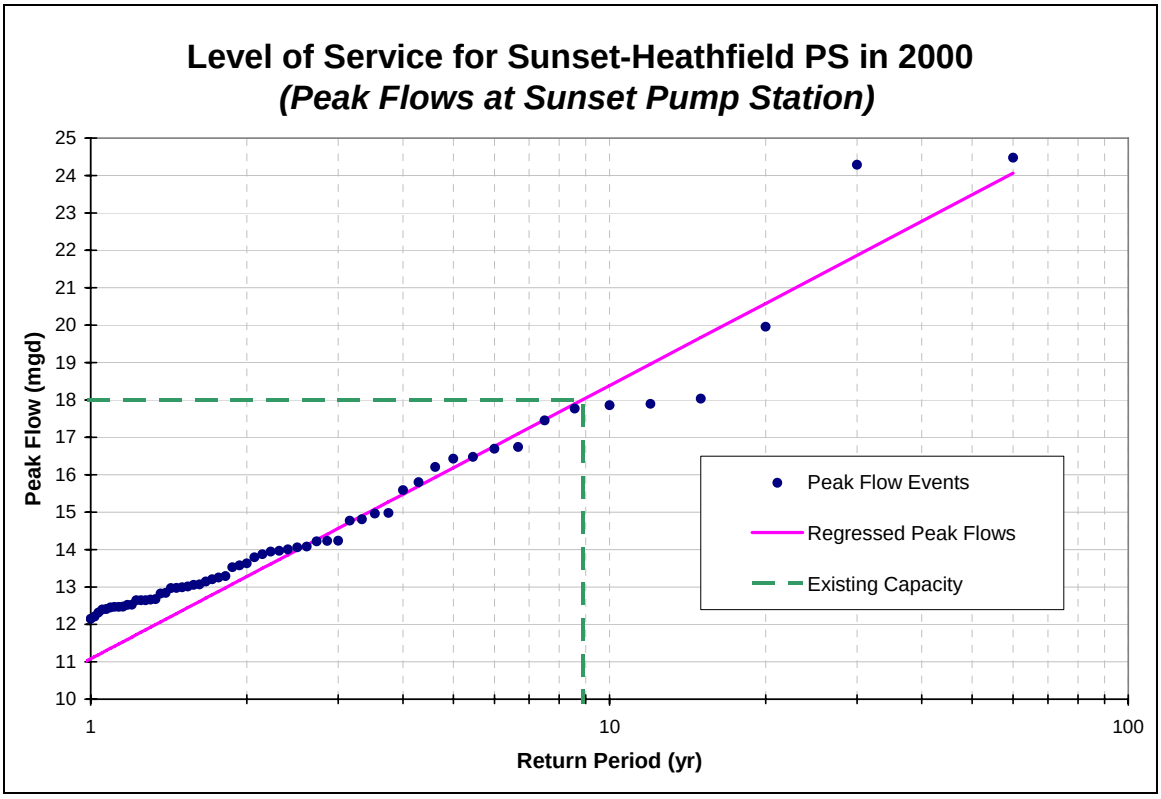

Figure 4.7: Sunset Pump Station Level of Service in 2000

Cost Calculations for Project: Heathfield/Sunset Pump Station Replacement and Force Main Upgrade

The estimated construction cost below, which includes contractor overhead and profit, is for planning purposes only. The output does NOT include contingency, sales tax, or allied costs (design, permitting, construction management, etc.).

Assumptions

Comments:

Sub Items

Name	Type	2006 Cost
RE*ISSAQ1.HEATHFIELD(1)FM	Pipe	$660,000
SE 35th Pl and SE Eastgate Way	Jack and Bore	$276,000
Vasa Creek	Microtunnel	$601,000
RE*ISSAQ1.SUNSET(1)FM	Pipe	$1,272,000
Culvert 1	Jack and Bore	$261,000
Vasa Creek	Microtunnel	$601,000
HEATHFIELD	Pump Station	$10,168,000
SUNSET	Pump Station	$10,287,000
Subtotal		$24,126,000

Year 2006 Total: **$24,126,000**

Cost Calculations for Pump Station: HEATHFIELD

The estimated construction cost below, which includes contractor overhead and profit, is for planning purposes only. The output does NOT include contingency, sales tax, or allied costs (design, permitting, construction management, etc.). Unless added as an Additional Costs item in the estimate, this cost does NOT include land acquisition costs.

Assumptions

Firm Capacity:	26.62	mgd
Total Dynamic Head:	145	ft
Excavation Depth:	30	ft

Calculated Parameters

Required Pump Power	1,328.20	Hp
Base Architectural/Structural Unit Cost	139,147.09	$/mgd
Architectural/Structural Unit Cost Adjustment	500	$/mgd
Base Mechanical Unit Cost	101,375.74	$/mgd
Mechanical Unit Cost Adjustment	12,500	$/mgd

Unit Costs (Basis 2005)

Item	Quantity	Unit	Unit Cost	Item Cost
Site/Civil	1	LS	$1,092,733	$1,092,733
Electrical/Instrumentation	1	LS	$1,842,751	$1,842,751
Architectural/Structural	26.62	mgd	$139,647	$3,716,949
Mechanical	26.62	mgd	$113,876	$3,031,000
			Year 2005 subtotal	$9,683,432

Multiplier from ENRCCI 8390 (2005) to 8780 (2006)	1.05
Effective Multiplier	1.05

Year 2006 subtotal **$10,167,603**

Cost Calculations for Pipe: RE*ISSAQ1.HEATHFIELD(1)FM

The estimated construction cost below, which includes contractor overhead and profit, is for planning purposes only. The output does NOT include contingency, sales tax, or allied costs (design, permitting, construction management, etc.).

Assumptions

Length	1667.5 ft
Conduit Type	Force Main
Depth of Cover	4 ft
Trench Backfill Type	Imported
Disposal Type	No Disposal Cost
Manhole Spacing	None
Existing Utilities	Average
Dewatering	Minimal
Pavement Restoration	Half Width - Residential Street (14 ft)
Traffic	Heavy
Land Acquisition	None
Required Easements	None
Trench Safety	Standard
Pipe Diameter	24 in.

Geometry

Outer Diameter	2.15	ft
Trench Width	5.295	ft
Excavation Depth	7.15	ft
Complete Surface Rest. Width	7.295	ft

Unit Costs (Basis 2005)

Item	Quantity	Unit	Unit Cost	Item Cost
Excavation	2,338.16	CY	$12	$28,058
Backfill	981.05	CY	$32	$31,393
Complete Pavement Restoration	1,351.60	SY	$55	$74,338
Overlay Pavement Restoration	1,242.29	SY	$25	$31,057
Trench Safety	23,845.25	SF	$1	$11,923
Spoil Load and Haul	2,338.16	CY	$12	$28,058
Pipe Unit Material Cost	1,667.50	lf	$73	$121,728
Pipe Installation	1,667.50	lf	$36	$60,030
Place Pipe Zone Fill	1,132.90	CY	$32	$36,253
Existing Utilities	1,667.50	lf	$45	$75,038
Dewatering	1,667.50	lf	$20	$33,350
Traffic Control	1,667.50	lf	$24	$40,020
			Year 2005 subtotal	$571,245

Mobilization/Demobilization at 10%	1.1
Multiplier from ENRCCI 8390 (2005) to 8780 (2006)	1.05
Effective Multiplier	1.155
Year 2006 subtotal	**$659,788**

Sub Items

Name	Type	Year	Cost
SE 35th Pl and SE Eastgate Way	Jack and Bore	2006	$276,109
Vasa Creek	Microtunnel	2006	$600,636
Subtotal			**$876,745**

Cost Calculations for Microtunnel: Vasa Creek

The estimated construction cost below, which includes contractor overhead and profit, is for planning purposes only. The output does NOT include contingency, sales tax, or allied costs (design, permitting, construction management, etc.). Unless added as an Additional Costs item in the estimate, this cost does NOT include land acquisition costs.

Assumptions

Inside Diameter	24 in.
Length	100 ft
Dewatering	Significant
Launch Shaft Existing Utilities	Average
Launch Shaft Excavation Depth	15 ft
Launch Shaft Surface Restoration	Hydroseed
Retrieval Shaft Excavation Depth	15 ft
Retrieval Shaft Surface Restoration	Hydroseed
Retrieval Shaft Existing Utilities	Average
Tunnel Easement Length	0 ft
Easement Type	None
Traffic	Light
Casing Required	false
Number of Intermediate Shafts	0
Intermediate Shaft Existing Utilities	None
Intermediate Shaft Excavation Depth	20 ft
Intermediate Shaft Surface Restoration	None

Tunnel Geometry

Outer Diameter		2.5	ft
Spoils Volume		18.181	CY
Casing Pipe Diameter	N/A		in

Launch Shaft Geometry

Width	17	ft
Length	30	ft
Footprint	510	SF
Volume	283.333	CY
Easement Footprint	2,820	SF

Retrieval Shaft Geometry

Width	21	ft
Length	21	ft
Footprint	441	SF
Volume	245	CY
Easement Footprint	2,601	SF

Miscellaneous

Spoils Loads	2	loads

Intermediate Shaft Geometry

Width	17	ft
Length	30	ft
Footprint	510	SF
Volume	283.333	CY
Easement Footprint	2,820	SF

Unit Costs (Basis 2005)

Item	**Quantity**	**Unit**	**Unit Cost**	**Item Cost**
Spoils Haul	18.18	CY	$12	$218
Launch Shaft Excavation	283.33	CY	$15	$4,250
Launch Shaft Shoring	1,410.00	SF	$38	$53,228
Launch Shaft Existing Utilities	510	SF	$7	$3,570
Launch Shaft Backfill	283.33	CY	$18	$5,100
Launch Shaft Surface Restoration	56.67	SY	$5	$283
Retrieval Shaft Excavation	245	CY	$15	$3,675
Retrieval Shaft Shoring	1,260.00	SF	$38	$47,565
Retrieval Shaft Existing Utilities	441	SF	$7	$3,087
Retrieval Shaft Backfill	245	CY	$18	$4,410
Retrieval Shaft Surface Restoration	49	SY	$5	$245
MTBM Fixed Costs	1	LS	$210,000	$210,000
Microtunnel Boring	100	ft	$744	$74,400
Tunnel Dewatering	1	LS	$70,000	$70,000
Traffic Control	2	shaft	$20,000	$40,000
			Year 2005 subtotal	$520,031

Mobilization/Demobilization at 10%	1.1
Multiplier from ENRCCI 8390 (2005) to 8780 (2006)	1.05
Effective Multiplier	1.155
Year 2006 subtotal	**$600,636**

Cost Calculations for Jack and Bore: SE 35th Pl and SE Eastgate Way

The estimated construction cost below, which includes contractor overhead and profit, is for planning purposes only. The output does NOT include contingency, sales tax, or allied costs (design, permitting, construction management, etc.). Unless added as an Additional Costs item in the estimate, this cost does NOT include land acquisition costs.

Assumptions

Inside Diameter	24 in.
Length	60 ft
Dewatering	Minimal
Launch Shaft Existing Utilities	None
Launch Shaft Excavation Depth	20 ft
Launch Shaft Surface Restoration	Hydroseed
Retrieval Shaft Excavation Depth	10 ft
Retrieval Shaft Surface Restoration	Hydroseed
Retrieval Shaft Existing Utilities	None
Tunnel Easement Length	0 ft
Easement Type	None
Traffic	Heavy
Casing Required	true

Tunnel Geometry

Outer Diameter	3.66	ft
Spoils Volume	23.38	CY
Casing Pipe Diameter	36	in

Launch Shaft Geometry

Width	15	ft
Length	26	ft
Footprint	390	SF
Volume	288.889	CY
Easement Footprint	2,520	SF

Retrieval Shaft Geometry

Width	15	ft
Length	21	ft
Footprint	315	SF
Volume	116.667	CY
Easement Footprint	1,435	SF

Miscellaneous

Spoils Loads	3	loads

Unit Costs (Basis 2005)

Item	Quantity	Unit	Unit Cost	Item Cost
Spoils Haul	23.38	CY	$12	$281
Launch Shaft Excavation/Backfill	288.89	CY	$33	$9,533
Launch Shaft Shoring	1,640.00	SF	$47	$77,080
Launch Shaft Surface Restoration	43.33	SY	$5	$217
Retrieval Shaft Excavation/Backfill	116.67	CY	$33	$3,850
Retrieval Shaft Shoring	720	SF	$29	$20,520
Retrieval Shaft Surface Restoration	35	SY	$5	$175
Cased Carrier Pipe Cost	60	ft	$95	$5,700
Boring Cost	60	ft	$720	$43,200
Tunnel Dewatering	1	LS	$8,500	$8,500
Traffic Control	2	shaft	$35,000	$70,000
			Year 2005 subtotal	$239,056

Mobilization/Demobilization at 10%	1.1
Multiplier from ENRCCI 8390 (2005) to 8780 (2006)	1.05
Effective Multiplier	1.155
Year 2006 subtotal	**$276,109**

Cost Calculations for Pump Station: SUNSET

The estimated construction cost below, which includes contractor overhead and profit, is for planning purposes only. The output does NOT include contingency, sales tax, or allied costs (design, permitting, construction management, etc.). Unless added as an Additional Costs item in the estimate, this cost does NOT include land acquisition costs.

Assumptions

Firm Capacity	26.62	mgd
Total Dynamic Head	150	ft
Excavation Depth	30	ft

Calculated Parameters

Required Pump Power	1,374.00	Hp
Base Architectural/Structural Unit Cost	139,147.09	$/mgd
Architectural/Structural Unit Cost Adjustment	600	$/mgd
Base Mechanical Unit Cost	101,375.74	$/mgd
Mechanical Unit Cost Adjustment	15,000	$/mgd

Unit Costs (Basis 2005)

Item	Quantity	Unit	Unit Cost	Item Cost
Site/Civil	1	LS	$1,092,733	$1,092,733
Electrical/Instrumentation	1	LS	$1,887,004	$1,887,004
Architectural/Structural	26.62	mgd	$139,747	$3,719,610
Mechanical	26.62	mgd	$116,376	$3,097,541
			Year 2005 subtotal	$9,796,889

Multiplier from ENRCCI 8390 (2005) to 8780 (2006)	1.05
Effective Multiplier	1.05
Year 2006 subtotal	**$10,286,733**

Cost Calculations for Pipe: RE*ISSAQ1.SUNSET(1)FM

The estimated construction cost below, which includes contractor overhead and profit, is for planning purposes only. The output does NOT include contingency, sales tax, or allied costs (design, permitting, construction management, etc.).

Assumptions

Length	3332.5 ft
Conduit Type	Force Main
Depth of Cover	4 ft
Trench Backfill Type	Imported
Disposal Type	No Disposal Cost
Manhole Spacing	None
Existing Utilities	Average
Dewatering	Minimal
Pavement Restoration	Half Width - Residential Street (14 ft)
Traffic	Light
Land Acquisition	None
Required Easements	None
Trench Safety	Standard
Pipe Diameter	24 in.

Geometry

Outer Diameter	2.15	ft
Trench Width	5.295	ft
Excavation Depth	7.15	ft
Complete Surface Rest. Width	7.295	ft

Unit Costs (Basis 2005)

Item	Quantity	Unit	Unit Cost	Item Cost
Excavation	4,672.81	CY	$12	$56,074
Backfill	1,960.62	CY	$32	$62,740
Complete Pavement Restoration	2,701.18	SY	$55	$148,565
Overlay Pavement Restoration	2,482.71	SY	$25	$62,068
Trench Safety	47,654.75	SF	$1	$23,827
Spoil Load and Haul	4,672.81	CY	$12	$56,074
Pipe Unit Material Cost	3,332.50	lf	$73	$243,273
Pipe Installation	3,332.50	lf	$36	$119,970
Place Pipe Zone Fill	2,264.09	CY	$32	$72,451
Existing Utilities	3,332.50	lf	$45	$149,963
Dewatering	3,332.50	lf	$20	$66,650
Traffic Control	3,332.50	lf	$12	$39,990
			Year 2005 subtotal	$1,101,643

Mobilization/Demobilization at 10%	1.1
Multiplier from ENRCCI 8390 (2005) to 8780 (2006)	1.05
Effective Multiplier	1.155
Year 2006 subtotal	**$1,272,398**

Sub Items

Name	Type	Year	Cost
Culvert 1	Jack and Bore	2006	$261,116
Vasa Creek	Microtunnel	2006	$600,636
Subtotal			**$861,752**

Cost Calculations for Microtunnel: Vasa Creek

The estimated construction cost below, which includes contractor overhead and profit, is for planning purposes only. The output does NOT include contingency, sales tax, or allied costs (design, permitting, construction management, etc.). Unless added as an Additional Costs item in the estimate, this cost does NOT include land acquisition costs.

Assumptions

Inside Diameter	24 in.
Length	100 ft
Dewatering	Significant
Launch Shaft Existing Utilities	Average
Launch Shaft Excavation Depth	15 ft
Launch Shaft Surface Restoration	Hydroseed
Retrieval Shaft Excavation Depth	15 ft
Retrieval Shaft Surface Restoration	Hydroseed
Retrieval Shaft Existing Utilities	Average
Tunnel Easement Length	0 ft
Easement Type	None
Traffic	Light
Casing Required	false
Number of Intermediate Shafts	0
Intermediate Shaft Existing Utilities	None
Intermediate Shaft Excavation Depth	20 ft
Intermediate Shaft Surface Restoration	None

Tunnel Geometry

Outer Diameter		2.5	ft
Spoils Volume		18.181	CY
Casing Pipe Diameter	N/A		in

Launch Shaft Geometry

Width	17	ft
Length	30	ft
Footprint	510	SF
Volume	283.333	CY
Easement Footprint	2,820	SF

Retrieval Shaft Geometry

Width	21	ft
Length	21	ft
Footprint	441	SF
Volume	245	CY
Easement Footprint	2,601	SF

Miscellaneous

Spoils Loads	2	loads

Intermediate Shaft Geometry

Width	17	ft
Length	30	ft
Footprint	510	SF
Volume	283.333	CY
Easement Footprint	2,820	SF

Unit Costs (Basis 2005)

Item	**Quantity**	**Unit**	**Unit Cost**	**Item Cost**
Spoils Haul	18.18	CY	$12	$218
Launch Shaft Excavation	283.33	CY	$15	$4,250
Launch Shaft Shoring	1,410.00	SF	$38	$53,228
Launch Shaft Existing Utilities	510	SF	$7	$3,570
Launch Shaft Backfill	283.33	CY	$18	$5,100
Launch Shaft Surface Restoration	56.67	SY	$5	$283
Retrieval Shaft Excavation	245	CY	$15	$3,675
Retrieval Shaft Shoring	1,260.00	SF	$38	$47,565
Retrieval Shaft Existing Utilities	441	SF	$7	$3,087
Retrieval Shaft Backfill	245	CY	$18	$4,410
Retrieval Shaft Surface Restoration	49	SY	$5	$245
MTBM Fixed Costs	1	LS	$210,000	$210,000
Microtunnel Boring	100	ft	$744	$74,400
Tunnel Dewatering	1	LS	$70,000	$70,000
Traffic Control	2	shaft	$20,000	$40,000
			Year 2005 subtotal	$520,031

Mobilization/Demobilization at 10%	1.1
Multiplier from ENRCCI 8390 (2005) to 8780 (2006)	1.05
Effective Multiplier	1.155
Year 2006 subtotal	**$600,636**

Cost Calculations for Jack and Bore: Culvert 1

The estimated construction cost below, which includes contractor overhead and profit, is for planning purposes only. The output does NOT include contingency, sales tax, or allied costs (design, permitting, construction management, etc.). Unless added as an Additional Costs item in the estimate, this cost does NOT include land acquisition costs.

Assumptions

Inside Diameter	24 in.
Length	25 ft
Dewatering	Minimal
Launch Shaft Existing Utilities	Average
Launch Shaft Excavation Depth	20 ft
Launch Shaft Surface Restoration	Hydroseed
Retrieval Shaft Excavation Depth	20 ft
Retrieval Shaft Surface Restoration	Hydroseed
Retrieval Shaft Existing Utilities	Average
Tunnel Easement Length	0 ft
Easement Type	None
Traffic	Light
Casing Required	false

Tunnel Geometry

Outer Diameter		2.5	ft
Spoils Volume		4.545	CY
Casing Pipe Diameter	N/A		in

Launch Shaft Geometry

Width	15	ft
Length	26	ft
Footprint	390	SF
Volume	288.889	CY
Easement Footprint	2,520	SF

Retrieval Shaft Geometry

Width	15	ft
Length	21	ft
Footprint	315	SF
Volume	233.333	CY
Easement Footprint	2,295	SF

Miscellaneous

Spoils Loads	1	loads

Unit Costs (Basis 2005)

Item	Quantity	Unit	Unit Cost	Item Cost
Spoils Haul	4.55	CY	$12	$55
Launch Shaft Excavation/Backfill	288.89	CY	$33	$9,533
Launch Shaft Shoring	1,640.00	SF	$47	$77,080
Launch Shaft Existing Utilities	390	SF	$7	$2,730
Launch Shaft Surface Restoration	43.33	SY	$5	$217
Retrieval Shaft Excavation/Backfill	233.33	CY	$33	$7,700
Retrieval Shaft Shoring	1,440.00	SF	$47	$67,680
Retrieval Shaft Existing Utilities	315	SF	$7	$2,205
Retrieval Shaft Surface Restoration	35	SY	$5	$175
Boring Cost	25	ft	$408	$10,200
Tunnel Dewatering	1	LS	$8,500	$8,500
Traffic Control	2	shaft	$20,000	$40,000
			Year 2005 subtotal	$226,075

Mobilization/Demobilization at 10%	1.1
Multiplier from ENRCCI 8390 (2005) to 8780 (2006)	1.05
Effective Multiplier	1.155
Year 2006 subtotal	**$261,116**