King County

King County Department of Natural Resources and Parks

Barton, Murray, South Magnolia, and North Beach CSO Projects

Technical Memorandum No. 202.1
CSO Control Approach and Planning Boundaries

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KING COUNTY DEPARTMENT OF NATURAL RESOURCES AND PARKS

BARTON, MURRAY, SOUTH MAGNOLIA, AND NORTH BEACH CSO PROJECTS

TECHNICAL MEMORANDUM NO. 202.1

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CSO CONTROL APPROACH AND PLANNING BOUNDARIES

ES.0 EXECUTIVE SUMMARY

ES.1 Purpose

The purpose of this Technical Memorandum (TM) is to identify potential Combined Sewer Overflow (CSO) control approaches that may be used in the Barton, Murray, South Magnolia, and North Beach CSO basins, and to define the planning boundaries for each basin. Potential control approaches have been identified by consideration of the following elements:

- The goals and policies of the King County Department of Natural Resources and Parks (KCDNRP, County) CSO Control Program;
- The local and national regulatory framework that defines requirements for CSO Control;
- Technical feasibility and relative cost of potential approaches;
- Preliminary evaluation criteria as established by the KCDNRP and Consultant team.

The preliminary screening of approaches described in this TM is used to identify the most likely alternatives that should be further refined and evaluated in subsequent planning phases. Additional detail will be developed for alternatives within each recommended approach. Alternative selection will be made with input from key stakeholders and the affected public, and summarized in TM 205.1, "Siting Report."

ES.2 Evaluation Methodology

ES.2.1 Basis of Peak Flows and Volumes

Computer modeling of wastewater flows for each of the basins was completed by KCDNRP-WTD prior to the start of this project. Model results included analyses of project elements needed to meet various levels of confidence for both storage and conveyance that would be required to meet the project requirements. In general, it was agreed (as proposed by KCDNRP-WTD) that the 90% probability of meeting the CSO regulations would become the project requirement for the minimum level of control. A summary of the pumping and storage requirements needed within each basin to meet CSO regulations is presented in Tables ES.1 and ES.2, respectively.

Table ES.1	Conveyance Capacity Requirements Assuming No Storage Upgrades CSO Control Approach and Planning Boundaries Barton, Murray, South Magnolia, and North Beach CSO Projects		
Service Basin	**Existing Conveyance Capacity[1]**	**Total Future Conveyance Capacity Required**	**Additional Conveyance Capacity Required**
Barton	28 mgd	53 mgd	25 mgd
Murray[2]	31.5 mgd	55 mgd	23.5 mgd
Murray[3]	31.5 mgd	69 mgd	37.5 mgd
South Magnolia	4.3 mgd	15 mgd	11 mgd
North Beach	3.4 mgd	10 mgd	6.5 mgd

1. Schock, K., "Description of CSO Modeling for the CSO Facilities Project," KCDNRP, 2007.
2. The required conveyance capacity presented assumes no increase in peak flow from the Barton basin (i.e., flow reduction achieved within the Barton basin).
3. The required conveyance capacity presented assumes conveyance of future peak flows from Barton Basin to Murray Basin (i.e., no flow reduction achieved within the Barton basin).

Table ES.2	Storage Volume Requirements Assuming No Conveyance Upgrades CSO Control Approach and Planning Boundaries Barton, Murray, South Magnolia, and North Beach CSO Projects	
Service Basin	**Existing Conveyance Capacity[1]**	**Additional Storage Volume Required**
Barton	28 mgd	0.5 MG
Murray[2]	31.5 mgd	1.3 MG
Murray[3]	31.5 mgd	1.7 MG
South Magnolia	4.3 mgd	2.6 MG
North Beach	3.4 mgd	3.5 MG

1. Schock, K., "Description of CSO Modeling for the CSO Facilities Project," KCDNRP, 2007.
2. The storage volume presented assumes flow reduction achieved within the Barton basin.
3. The storage volumes presented assumes no flow reduction achieved within the Barton basin.

ES.2.2 <u>Regulatory and Policy Constraints</u>

Chapter 173-245 of the Washington Administrative Code requires that dischargers with CSOs develop and implement plans to achieve the greatest reasonable reduction at each CSO site. The greatest reasonable reduction is defined as control of each CSO in such a way that an average of one untreated discharge may occur per year.

The County's West Point Service Area NPDES permit further specifies that the "permittee shall discharge no more than an average of 1 overflow event per year per CSO based on a long term average" and establishes that permit compliance will be based on a 5-year average for the permit cycle.

ES.2.3 Initial Evaluation Criteria

The following criteria were developed by the project team to evaluate the proposed CSO control approaches and the associated alternatives:

- Cost Effectiveness
- Operations and Maintenance Feasibility
- Technical Feasibility
- Public Health and Environmental Benefits
- Flexibility
- Community Issues
- Program Compatibility

Based on these evaluations, a shortlist of preferred alternatives was developed for further review and investigation as part of the Alternatives Development phase of this work.

ES.3 Summary of Findings

General findings of the scenario evaluations for all four basins are as follows:

- Storage needed to meet the project requirements is generally greater (up to 25 times larger) than predicted by the previous CSO plan.
- Pumping needed to meet the project requirements is generally greater than predicted by the previous CSO plan (up to 3 times more capacity is needed).
- Conveyance improvements could be used in lieu of storage, if downstream conveyance and treatment capacity are sufficient.
- Combinations of storage, conveyance, treatment, and demand management could be used to meet regulatory requirements.

The specific findings for the conveyance, storage, and demand management requirements of each basin were summarized in a series of graphs and tables provided by the County modeling staff, and are included in Appendix A. These findings were presented to the Project Team as part of Workshop No. 1, held on March 20, 2007. The results of Workshop 1 are included in Appendix B of this TM.

ES.3.1 Barton and Murray Basin Findings

Preliminary cost estimates and approach evaluations indicated that within the Barton and Murray Basins, peak flow storage and peak flow reduction approaches appeared more favorable than the peak flow conveyance and end of pipe treatment approaches.

The County should perform follow up flow monitoring at the Fauntleroy School Site to determine if storage at the site is feasible. In addition, the County should conduct public outreach efforts to determine if storage at Lowman Beach Park is possible. The County should continue to evaluate other storage sites within the basins in case storage at one of the preliminary sites is not feasible. In addition, the County should continue to coordinate

with SPU to determine if demand management within the Barton and Murray Basins is feasible, as this approach may need to be implemented in conjunction with storage to achieve CSO control within the basins.

ES.3.2 South Magnolia Basin Findings

Based on an evaluation of the peak flows within the basin, and results of the workshops, the preferred CSO approaches for the South Magnolia basin are end of pipe treatment (3A) and storage (1B and 1C).

End of pipe treatment appears to be the least cost alternative for the South Magnolia basin. Additional investigation should be made to determine the feasibility of obtaining a new permit for treatment at this location, as well as for SPU's Pump Station #77, which would require an upgrade as part of the end of pipe treatment CSO control alternative.

The topography of the South Magnolia basin is such that very few siting locations exist for storage facilities, due to potential challenges to construction. It is recommended that further analysis be conducted to identify and evaluate all the potential site locations to further develop the viability of this CSO approach.

Demand Management, if feasible has potential for reducing storage requirements; combined approaches may offer benefits for meeting control requirements.

ES.3.3 North Beach Basin Findings

The three most favorable alternatives for controlling overflows within the North Beach basin are end of pipe treatment (3A), storage (1C), and a combination of onsite storage and I/I reduction (5A).

The topography of the North Beach basin presents a challenge in locating a storage facility that would not require pumping from the North Beach Pump Station to the storage tank. Based on an initial review of potential site locations, the only feasible alternative to convey flow through gravity into a storage tank is at the site of the North Beach Pump Station. However, the site footprint is not large enough to construct a storage facility of sufficient size to control overflow events within the basin. Therefore, the only storage-based alternative that was determined to be a viable CSO control approach is offsite storage, which requires pumping into the storage facility. Several example sites were identified for this purpose.

Following Workshop 2, another example site was identified: the former Crown Hill Elementary School site. This site holds significant potential as a location that would not require additional pumping from the storage facility into the collection system. It is recommended that further evaluation of this site and others within the North Beach basin be conducted as part of the Alternatives Development phase of this project.

End of pipe treatment is the least cost alternative for controlling overflows in the North Beach basin. Additionally, it is considered to be the simplest approach to implement, and if

constructed below grade, would have reduced impacts on the neighboring community. It is recommended that this approach be further evaluated as part of the next phase of this project.

Demand management, including both inflow and infiltration reduction, appears to be technically feasible to control overflows within the North Beach basin. However, it would require an aggressive implementation plan to rehabilitate approximately 70%-80% of the sewer infrastructure within the basin. Implementation of demand management to any degree will reduce the corresponding size and capacity of the supplemental infrastructure needed to sufficiently reduce overflows to one event per year. It is recommended that the costs and feasibility of implementing demand management in combination with peak flow storage be more fully evaluated to determine the viability of this CSO approach.

ES.4 Next Steps

The next steps in the CSO Control project are development of the CSO Facility Selection Criteria (Task X03) and Alternatives Development (Task X05), which will lead to the selection of one preferred CSO control scenario for each of the four basins. Based on the interest in demand management exhibited in Workshop 2, further discussions with King County staff have been scheduled. These meetings may identify the need for additional analysis of demand management, including techniques, costs, and implementation constraints. Once the preferred alternative for each basin has been more fully developed, additional tasks will be conducted, including those relating to environmental services, public involvement (community relations), geotechnical evaluations and land surveys for easement or property acquisition, and development of costs for the preferred alternative.

1.0 INTRODUCTION

The purpose of this memorandum is to describe planning boundaries and technical approaches to CSO control within the Barton, Murray, South Magnolia, and North Beach CSO basins. This TM also presents the findings and results of the Planning Confirmation Workshops Nos. 1 and 2, held respectively on March 20 and May 30, 2007.

1.1 Background

The Barton, Murray, South Magnolia, and North Beach CSO basins are associated with the Regional Wastewater Services Plan and are assigned the goal of reducing uncontrolled combined sewer overflows to meet the current regulatory standard. These projects are scheduled to be complete by 2013.

The objective of the Barton, Murray, South Magnolia, and North Beach CSO Projects is to develop a comprehensive CSO Facilities Plan for each basin. These plans will be developed as part of a three-phase approach, including Planning Confirmation and Criteria Development, Alternative Evaluation, and Facilities Planning. This TM presents the findings of the first phase of this project, Planning Confirmation and Criteria Development, and

presents the alternative evaluation criteria and a short-list of the preferred CSO approaches for each basin. Subsequent phases of this effort will include development of a preferred CSO alternative for each basin, preliminary design of the CSO facilities, environmental services, public involvement, geotechnical evaluations, land surveys for easement or property acquisition, and development of the project costs for the preferred alternative. These tasks will culminate in the development of a Facilities Plan for each basin, in preparation for completion of full design of the CSO facilities, subsequent to 2009.

1.2 CSO Policy and Regulatory Framework

Combined sewer overflow management and control requirements are established by Washington rules and regulations, federal law, and the US EPA CSO Control Policy. The US EPA CSO Control Policy was issued in 1994 and establishes nine minimum controls for CSOs as well as a presumptive level of control that is protective of water quality. This presumptive level of control is no more than four uncontrolled overflow events per year or an 85% reduction in CSO volumes following implementation of control measures. For most communities with combined sewers, this 85% level of control typically results in 2-3 uncontrolled discharges per year.

The level of CSO control established by the State of Washington was adopted in 1987, prior to development of the US EPA CSO Control Policy and is more restrictive in terms of level of control. Chapter 173-245 of the Washington Administrative Code (WAC) requires dischargers with CSOs to develop and implement plans to achieve the greatest reasonable reduction at each CSO site. The greatest reasonable reduction is defined as control of each CSO in such a way that an average of one untreated discharge may occur per year.

The County's West Point Service Area NPDES permit requires that the County implement the nine minimum controls from the US EPA Control Policy and further defines the level of control established by state rules. The permit requires that the "permittee shall discharge no more than an average of 1 overflow event per year per CSO based on a long term average" and establishes that permit compliance will be based on a 5-year average for the permit cycle.

The Washington State Department of Ecology (DOE) has recently indicated that their policy is evolving on their interpretation of WAC 173-245 and that control requirements may become more restrictive than established in the County's current permit. KCDNRP staff has initiated discussions with the DOE to determine what the potential impacts are on the County's future NPDES permit requirements.

The control approaches outlined within this technical memorandum are based upon current NPDES permit requirements of one uncontrolled CSO discharge at each outfall based upon a five-year rolling average.

1.3 Prior Planning Assumptions and Conclusions

1.3.1 Barton and Murray CSO Basins

The Barton and Murray CSO basins have interdependent systems; the Barton Street Pump Station conveys flows to the Murray Avenue Pump Station, which handles flows from both the Barton and Murray basins. Therefore, the flow analysis, planning confirmation, and scenario evaluation of these two basins will be addressed together throughout this TM.

The 1997 CSO Plan Update[1] evaluated alternatives involving the different combinations of the following technical approaches to CSO controls in the Barton and Murray CSO Basins:

1. **Partial separation of the storm water drainage from the combined sewer.** This alternative included separation of approximately 150 acres of impervious area drainage from the combined sewer.

2. **Storage within the CSO Basins to offset excessive peak flows to the Barton and Murray pump stations.** This included offline storage with 0.5 million gallons (MG) storage at the Fauntleroy School within the Barton CSO Basin and 1.0 MG of storage along 48th Avenue SW within the Murray CSO Basin.

3. **Additional conveyance at the Barton pump station and storage at other affected downstream facilities to convey the excess peak flows downstream.** This alternative included a combination of conveyance and storage improvements to the collection system to control CSOs. An additional 7.5 million gallons per day (mgd) of conveyance at the Barton Street pump station, through installation of a new pump station and force main, was recommended to convey the peak flows downstream to the Murray CSO Basin. A 0.5 MG storage facility at Lowman Beach Park was recommended to reduce peak flows to the Murray Avenue pump station. Approximately 0.6 MG of storage under SW Alaska Drive was also recommended.

4. **Additional conveyance at the Barton Pump Station for treatment at the Alki CSO Treatment Plant.** The alternative included conveyance of the excess peak flows from the Barton Street pump station to the Alki CSO Treatment Plant. Improvements for this alternative included a new 7.5 mgd pump station and force main from the Fauntleroy Ferry Dock to Lowman Beach Park, a new 18 mgd pump station and force main from Lowman Beach Park to SW Alaska Drive, a new 28 mgd pump station and force main from SW Alaska Drive to the Alki CSO Treatment Plant, and upgrades to the Alki CSO Treatment Plant to handle the additional 28 mgd in peak flows.

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1 "King County CSO 5-Year Update, Task 4.0 Development of Alternatives," Brown and Caldwell, December 1997.

1.3.2 South Magnolia CSO Basin[1]

Flow monitoring was conducted within the South Magnolia basin for several years in the mid-1990s. This monitoring identified that the average annual overflow volume in the basin was 5.4 MG, and the volume of the once annual event at the South Magnolia overflow was 1.3 MG. The control alternatives evaluated to address these overflows were storage and roof drain disconnection.

The storage alternative required construction of a diversion structure that would route the overflows to a new 1.3 MG underground storage tank. Following the storm event, the storage tank would release the flow back into the system for treatment at the West Point Treatment Plant. The estimated cost for this alternative was $6 million (in 1997 dollars).

The roof drain disconnection alternative was proposed to reduce impervious area within the basin by disconnecting the roof drains of 900 residences from the combined sewer system. It was estimated that the cost for implementing this alternative was $2.9 million (in 1997 dollars), or approximately $3,200 per residence.

1.3.3 North Beach CSO Basin[1]

The North Beach Pump Station experiences overflow events several times each year. To address this issue, King County developed a pre-design study that identified several alternatives to minimize the overflow occurrences. These alternatives included construction of a storage facility, followed by additional improvements such as expansion of the pump station capacity, forcemain replacement, and minor modifications to the City of Seattle pipelines.

The recommended storage capacity was a 140,000-gallon underground storage tank at the site of the North Beach Pump Station. This was expected to reduce the number of overflows from 18 to 4 events per year, thereby reducing the overflow volume from 1.9 MG to 1.0 MG each year. The secondary improvements would further reduce the overflow frequency to once per year, and would reduce the overflow volume to 0.2 MG annually. The secondary improvements consisted primarily of upgrading the North Beach Pump Station from 3.5 mgd to 4.5 mgd and replacing 2,060 feet of the approximately 2,200 feet of forcemain within Carkeek Park. Stored flow was to be pumped to the Carkeek CSO Treatment Plant using the expanded pump station following each storm event. The estimated cost for these improvements (storage, pump station, and forcemain) was $3.5 million (in 1997 dollars), which is equivalent to a unit cost of $1.75 per gallon.

1.4 Evaluation Approach

Five CSO control approaches were evaluated as part of this planning effort:

1. Peak Flow Storage. Store peak flows that exceed conveyance capacity in the basin during each storm event, and use existing pumping and piping facilities to convey stored flow out of the basin once the rainfall event has subsided.

2. **Convey and Treat Peak Flows.** Convey peak flows out of the basin by increasing pumping and forcemain capacity, or the capacity of the gravity sewer system. This approach also requires treatment plant upgrades at the point where the peak flows are discharged, as the capacity of these facilities are not adequate to handle the additional flows and loads.

3. **End of Pipe Treatment for Peak Flows.** Treat and discharge peak flows at or near the current CSO locations. Typical processes used for remote, end of pipe treatment include primary treatment and disinfection. In this effort, high rate clarification (HRC) and ultraviolet (UV) disinfection are recommended for end of pipe treatment.

4. **Peak Flow Reduction (Demand Management).** Reduce the magnitude of the flow in the collection system through infiltration and inflow (I/I) reduction in separated systems, or by disconnecting impervious areas in combined systems.

5. **Combined Approach.** Reduce peak flows within the basin by implementing a combination of two or more of the previously mentioned CSO approaches.

This TM presents the initial list of CSO control alternatives for each CSO approach. Selected alternatives from each approach will be screened for effectiveness based on cost and non-cost evaluation criteria. A short list of alternatives will be further developed in subsequent TMs. A Facilities Plan will then be developed for the recommended alternative in each basin.

1.4.1 Alternatives and Theoretical Site Locations

For each CSO basin, the five CSO control approaches (identified above) were considered. For each CSO approach, a group of alternatives was evaluated. For example, in the case of the North Beach CSO Basin, for the Peak Flow Storage approach, three alternatives were developed. These alternatives consider the range of options available to treat the CSO events for the specified approach, and identify the necessary infrastructure improvements and theoretical site locations of the proposed improvements. The site locations were chosen based on their proximity to the pump stations, and the feasibility of using gravity to convey flow into and out of the proposed infrastructure. It should be noted that the site locations identified in this TM are examples only; further evaluation of these locations must be made as part of the Alternatives Development before recommended site locations are proposed.

1.4.2 Criteria for Alternative Screening

To evaluate the CSO control approaches and associated alternatives for the Barton, Murray, South Magnolia, and North Beach CSO basins, a list of screening criteria were developed. These criteria were presented and discussed as part of Workshop No. 1, held March 20, 2007, and were subsequently reviewed by the King County Department of Natural Resources and Parks (County) staff.

To evaluate each of the control approaches, criteria within the following categories were developed:

- Cost Effectiveness
- Operations and Maintenance Feasibility
- Technical Feasibility
- Public Health and Environmental Benefits
- Flexibility
- Community Issues
- Program Compatibility

Cost Effectiveness

The impact of each CSO control approach was evaluated based on its capital cost relative to the other approaches.

Operations and Maintenance (O&M) Feasibility

The impact of each CSO control approach was evaluated based on its O&M feasibility relative to the other approaches. The level of O&M impact was determined by King County O&M staff during the evaluation and screening process.

Technical Feasibility

CSO approaches that were deemed to be infeasible based on program compatibility, constructability, engineering criteria, permitting constraints, and land availability were eliminated during the screening process.

Public Health and Environmental Benefits

Public health and safety was evaluated for each approach. All approaches were required to meet fundamental CSO goals, and limit public exposure to CSOs. Specific impacts of the various approaches include:

Demand Management: The potential for increased stormwater runoff to decrease slope stability was considered, and will be further evaluated in selected basins where Demand Management is considered alone or in combination with other approaches.

Flexibility

Approaches with a high degree of flexibility to meet future changes in regulation or flow were favored. Specific impacts of the various approaches include:

Storage: Peak flow storage was considered to be the lease flexible approach, particularly when limited area for facility siting was available.

Community Considerations

All approaches under consideration will have some level of community impact. Specific impacts of the various approaches include:

Storage: The local impact of facility on property and construction implementation was considered.

Convey and Treat: Community impact due to shoreline and/or roadways for pipeline

construction was considered.

End of Pipe Treatment: Local impact of facility on property and construction implementation, and long-term impact due to facility operation was considered.

Demand Management: Community impact to public rights-of-way and private property was considered, along with the potential stormwater impacts associated with separation of storm flow from the combined system (such as soil stability, flooding, etc.).

Program Compatibility

CSO approaches that were deemed to be incompatible with other programs and initiatives (including the plans of Seattle Parks, Public Utilities, and Transportation departments, as well as other County-wide plans) were eliminated during the screening process.

The specific criteria identified for each of these categories is presented in Table 1. Further description regarding the specifics of these criteria can be found in Technical Memorandum 203.1, "Screening Criteria for CSO Approaches and Alternatives."

These criteria were used to evaluate the proposed CSO control scenarios presented in Workshop No. 2, held May 30, 2007. The purpose of this workshop was to present and evaluate the potential CSO control alternatives for each basin. Specific information about each alternative, including capacity, component elements, location, and relative cost, was presented and discussed. Based on this information, the workshop participants ranked the proposed scenarios with respect to the evaluation criteria, identified potential implementation issues, and identified areas of remaining uncertainty requiring further evaluation. This TM provides a summary of the outcome of this workshop, and presents a short-list of the preferred scenarios, which will be further evaluated and developed as part of the next phase of this CSO control project: Alternatives Evaluation.

1.4.3 Basis of Capital Costs

In order to use the Selection Criteria to evaluate CSO control approaches, it is necessary to develop planning level costs of the technical elements of the approaches. Planning level capital costs were developed for each approach as part of the planning confirmation phase of this project. It should be noted that all costs presented in this TM are capital costs only; total lifecycle costs were not evaluated as part of this effort. The eight major project elements identified as part of the CSO control alternatives are as follows:

- CSO storage tanks
- Gravity sewers
- Force mains
- Microtunnels
- Tunnels
- Submersible pump stations
- High head pump stations
- Treatment facilities (High Rate Clarification / Disinfection)

Three sources were used to develop the planning level costs:

- Design estimates and bid experience from recent projects (storage tanks, high head pump stations, and treatment facilities).

Table 1 Alternatives Evaluation Criteria
CSO Control Approach and Planning Boundaries
Barton, Murray, South Magnolia, and North Beach CSO Projects

Cost Effectiveness	Operations and Maintenance Feasibility	Technical Feasibility	Public Health and Environmental Benefits	Flexibility	Community	Compatibility with Other Programs and Initiatives
-Capital cost -Life cycle costs -Use of existing facilities -Grants/loan ranking	-Reliably meet CSO objectives -WTD automation -Ease of start-up/shut-down -Ease of maintenance -No adverse impacts to - County or City -Ease of regulatory reporting	-Compatible with existing system -Technically feasible -Can be permitted -Land is available -Minimize federal & state permit constraints	-Meet CSO requirements -Minimizes public exposure -Minimal environmental footprint -Minimizes environmental risks -Minimize or avoid contact with endangered species -Coordinates with Puget Sound goals	-Future regulations -Climate change -Implementation	-Neighborhood equity -Cost allocation -Minimal shoreline impacts -Minimal property disruption -Minimal implementation impacts -Minimal operations impacts -Minimal disturbance of archeological areas	-Coordinate with Seattle parks, SPU, and transportation -Sediment management plan -County-wide planning policies -Stormwater management responsibilities -Conveyance system improvement policies -WTD productivity initiative -WTD CSO Program

- Engineers' estimates based on vendor quotes (submersible pump stations and treatment facilities.)
- King County Tabula cost estimating model (pipelines and tunnels.)

The planning-level capital cost estimates for the CSO alternatives are based on cost curves developed from the current design of similar facilities and/or Tabula, the County's cost estimating tool. These costs were then escalated to develop total project costs, including general contractor overhead and profit, an estimating contingency of 30%, and allied costs of 30% (including engineering, legal, and administrative costs). The cost estimates of the discrete scenario elements and the cost curves (based on data from recent bid prices, design of similar facilities, and Tabula) are included in Appendix C.

2.0 FLOW ANALYSIS AND PROBLEM DEFINITION

This section compares existing King County facility conveyance capacities to projected peak flows obtained from the updated flow modeling results prepared by the County. Existing pumping and conveyance (gravity or force main) capacities within each basin, combined with the capacities of downstream conveyance and treatment facilities, dictate the magnitude of flow that must be controlled to limit CSOs and meet regulatory requirements. Various alternatives to control CSOs are presented in Sections 4 - 7 of this TM.

To identify the flows and volume of storage needed to limit overflows to one event per year, King County modeled the impacts of wet weather events on the sewer system of each of the four CSO basins. The Runoff/Transport model was calibrated against observed sewer flows using measured rainfall data from the City of Seattle, which maintains a system of rain gauges throughout the metropolitan area. Flow data was obtained from the King County Flow Metering Group and the online King County Sewage Data Retrieval System. Following calibration, the model simulations were developed to provide a 28-year hydrograph for each basin.

The County's NPDES permit requires that no more than an average of one overflow event occur per year, based on a 5-year moving average. To meet these requirements, the County selected the 90% level of confidence for developing flow and storage requirements.

For a specified flow capacity, the volume of additional storage needed to meet the regulatory requirements without increasing conveyance capacity was determined from the hydrographs that exceeded the existing conveyance capacity. In contrast, the conveyance capacity needed to meet the regulatory requirements without increasing storage was determined by increasing the capacity within the model until only one overflow event occurred annually. A summary of the pumping and conveyance requirements needed to meet the CSO regulations is presented in Table 2. A summary of the storage requirements (with no increase in conveyance capacity) to meet the CSO regulations is presented in Table 3.

Table 2	Conveyance Capacity Requirements Assuming No Storage Upgrades CSO Control Approach and Planning Boundaries Barton, Murray, South Magnolia, and North Beach CSO Projects		
Service Basin	**Existing Conveyance Capacity[1,2]**	**Total Future Conveyance Capacity Required**	**Additional Conveyance Capacity Required**
Barton	28 mgd	53 mgd	25 mgd
Murray[3]	31.5 mgd	55 mgd	23.5 mgd
Murray[4]	31.5 mgd	69 mgd	37.5 mgd
South Magnolia	4.3 mgd	15 mgd	11 mgd
North Beach	3.4 mgd	10 mgd	6.5 mgd

1. Schock, K., "Description of CSO Modeling for the CSO Facilities Project," KCDNRP, 2007.
2. It should be noted that the existing conveyance requirements are based on the actual conveyance capability of the individual pump stations. For example, the peak design flow of the pump station may be greater than the conveyance capacity of the downstream pipeline, therefore, the resulting overall existing capacity of the pump station is limited to the overall conveyance capacity of the system.
3. The required conveyance capacity presented assumes no increase in peak flow from the Barton basin (i.e., flow reduction achieved within the Barton basin).
4. The required conveyance capacity presented assume conveyance of future peak flows from Barton Basin to Murray Basin (i.e., no flow reduction achieved within the Barton basin).

Table 3	Storage Volume Requirements Assuming No Conveyance Upgrades CSO Control Approach and Planning Boundaries Barton, Murray, South Magnolia, and North Beach CSO Projects	
Service Basin	**Existing Conveyance Capacity[1,2]**	**Additional Storage Volume Required**
Barton	28 mgd	0.5 MG
Murray[3]	31.5 mgd	1.3 MG
Murray[4]	31.5 mgd	1.7 MG
South Magnolia	4.3 mgd	2.6 MG
North Beach	3.4 mgd	3.5 MG

1. Schock, K., "Description of CSO Modeling for the CSO Facilities Project," KCDNRP, 2007.
2. Total system conveyance capacity reported (including pump stations and pipelines). Values do not necessarily reflect total or firm pumping capacity.
3. The storage volume presented assumes flow reduction achieved within the Barton basin.
4. The storage volumes presented assume no flow reduction achieved within the Barton basin.

In addition to establishing conveyance and volume requirements needed to meet DOE regulations, the model was used to determine the impacts of inflow and infiltration (I/I) reduction on the storage requirements for each basin. Inflow and Infiltration is defined as the total quantity of water entering a sewer system. Inflow sources include runoff from impervious areas that are directly connected into the sewer system (roof drains, catch

basins, etc.). Infiltration is groundwater and stormwater which permeates through the soil into laterals, side sewers, and manholes.

Inflow has the most immediate impact on the sewer system; because inflow is due to direct connections from impervious areas, these flows are the first to enter the sewer system. If inflow is reduced, the corresponding peak flow response is reduced and delayed, thereby reducing the necessary storage volume to handle the peak flows. The impact on storage from inflow reduction was modeled at 25%, 50%, and 75% impervious area disconnection within each basin. The results are presented in Table 4.

Table 4 Storage Volume Associated with Inflow Reduction
CSO Control Approach and Planning Boundaries
Barton, Murray, South Magnolia, and North Beach CSO Projects

Service Basin	Impervious Area Reduction			
	0%	25%	50%	75%
Barton	0.5 MG	0.16 MG	0 MG	N/A
Murray	1.4 MG	0.7 MG	0.15 MG	0 MG
South Magnolia	2.6 MG	1.8 MG	1.1 MG	0.4 MG
North Beach	3.5 MG	3.2 MG	2.8 MG	2.5 MG

1. Storage volumes are based on a 10% probability of exceedance.
2. The impact of impervious disconnection in the Murray basin is based on the existing pump capacity of the Barton Pump Station.

2.1 Barton and Murray CSO Basins

2.1.1 Existing Facilities

The Barton Basin comprises 1080 acres within the Alki Basin of West Seattle (Figure 1). The basin is built out, consisting primarily of residential land use within the basin. Most of the impervious pavement areas are disconnected from the combined sewer; however, there is a small section at the east side of the basin in which approximately 27 acres of pavement area drains to the combined sewer system. In addition, most of the building roofs within the basin are connected directly to the combined sewer. An evaluation of the roof drainage system for several homes within the Barton Basin is provided in Appendix D. All flow from the combined sewer system in this basin drains to the Barton Street Pump Station, which is located next to the Fauntleroy Ferry Dock. KCDNRP-WTD field tests indicate that the Barton Street Pump Station, which pumps into parallel 24-inch force mains, has a peak capacity of approximately 28 mgd. From the Barton Pump Station, the combined sewer flows are conveyed downstream to the Murray Avenue Pump Station and then to the West Seattle Tunnel during dry weather conditions or to the Alki CSO Treatment Plant during wet weather conditions.

The Murray Basin is comprised of 966 acres within the Alki Basin of West Seattle (Figure 2). The basin is almost completely built out with mostly residential land use within the basin.

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Figure 1

Barton Basin

Barton, Murray, Magnolia and North Beach CSO Projects

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Figure 2

Murray Basin

Barton, Murray, Magnolia and North Beach CSO Projects

Most of the impervious pavement areas are disconnected from the combined sewer; however, most of the building roofs within the basin are connected directly to the combined sewer. An evaluation of the roof drainage system for several homes within the Murray Basin is provided in Appendix E. All flow from the combined sewer system in this basin drains to the Murray Avenue Pump Station, which is located within Lowman Beach Park. KCDNRP-WTD field tests indicate that the Murray Avenue Pump Station, which pumps into parallel 27-inch force mains, has a peak capacity of approximately 31.5 mgd. From the Murray Pump Station, the combined sewer flows are conveyed downstream to the West Seattle Tunnel during dry weather conditions or to the Alki CSO Treatment Plant during wet weather conditions.

KCDNRP-WTD has indicated that several facilities located downstream of the Barton and Murray basins, including the conveyance piping downstream of the Murray Avenue Pump Station, the 63rd Street Pump Station, the West Seattle Tunnel, and the Alki CSO Treatment Plant, do not have sufficient capacity to handle additional peak flows. This finding is important as it indicates that improvements to these downstream facilities would be required if conveyance improvements at the Barton and Murray basins were selected as the CSO control approach.

2.1.2 Peak Flow Analysis Summary

The updated modeling performed by KCDNRP-WTD indicates that the peak design flow to the Barton Street pump station is 53 mgd. With the increased peak design flow to the pump station, KCDNRP-WTD modeling has indicated a need for disconnection of 70 acres of impervious area within the basin, 0.5 MG of storage, or an additional 25 mgd of conveyance at the Barton Pump Station to meet the current CSO regulatory standard.

As stated previously, because the Barton Street Pump Station conveys flows directly to the Murray Avenue Pump Station, any improvements at the Barton Pump Station will have an effect on the upgrades required at the Murray Pump Station. A flow chart is provided in Figure 3 to illustrate the different combinations of approaches. An alpha-numeric coding convention was developed in order to describe the different combinations of approaches by basin. The first term in the coding convention, B1A for example, uses the leading character "B" to indicate the Barton Basin combined with a number (1 through 4) to describe the approach alternative for a given basin. In this example, approach 1 refers to storage as the CSO control approach.

If storage or flow reduction approaches are implemented at the Barton CSO basin (as indicated by the portion of Figure 3 below the blue dashed line) the updated modeling performed by KCDNRP-WTD indicates that the peak design flow to the Murray Pump Station will be 55 mgd. With the increased peak design flow to the pump station, KCDNRP-WTD modeling has indicated a need for disconnection of 40 acres of impervious area within the basin, 1.3 MG of storage, or an additional 23.5 mgd of conveyance at the Murray Avenue Pump Station to meet the current CSO regulatory standard.

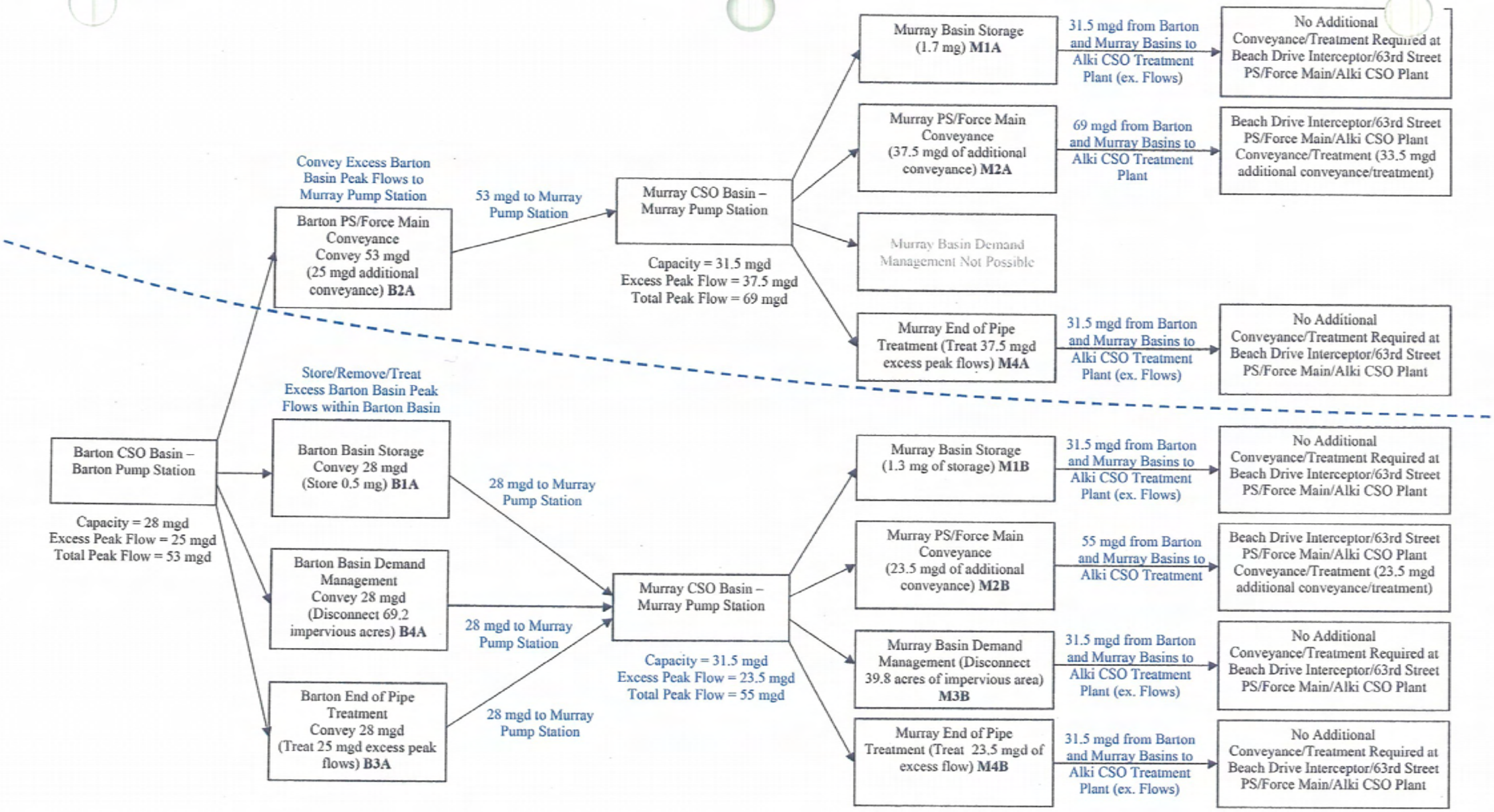

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Figure 3
CSO CONTROL ALTERNATIVES FOR BARTON AND MURRAY BASINS
BARTON, MURRAY, MAGNOLIA, AND
NORTH BEACH CSO PROJECTS
KING COUNTY DEPARTMENT OF NATURAL RESOURCES
AND PARKS

If storage or flow reduction approaches are not implemented at the Barton CSO basin and the peak flows are conveyed to the Murray Avenue Pump Station (as indicated by the portion of Figure 3 above the blue dashed line) the updated modeling performed by KCDNRP-WTD indicates that the peak design flow to the Murray Avenue Pump Station will be 69 mgd. With the increased peak design flow to the pump station, KCDNRP-WTD modeling has indicated a need for 1.7 MG of storage, or an additional 37.5 mgd of conveyance at the Murray Avenue Pump Station to meet the current CSO regulatory standard.

2.2 South Magnolia CSO Basin

2.2.1 Existing Facilities

The South Magnolia Basin comprises 751 acres in the Magnolia neighborhood of Seattle. The basin is largely built out as a residential area (approximately 3,000 residential properties) with one small commercial area. The majority of the sewerage in the basin is combined sewers, and there are about ten blocks of separated sewers, according to GIS sewer map coding provided by King County. There are storm sewers in a large portion of the basin, that according to County GIS information, have catch basins at street corners; whether or not there are connections from individual parcels is unknown. Of the total basin area, KCDNRP-WTD modeling indicates that 12% of the area is impervious surfaces that contribute flow to the combined sewer system.

A GIS-based analysis of the basin indicates that about 2,400 houses are within 100-feet of a storm sewer inlet; rooftops are estimated to comprise about 65-acres of impervious surface. This area is larger than the total impervious area estimated by current modeling (see section 3.2.2 below.)

The sewer system owned by the City of Seattle is tributary by gravity and one SPU pump station (Pump Station #77, firm capacity of 1.4 mgd [personal communication Andrew Lee, 5/29/07]) to a single control manhole (Metro number D026-153) located at the foot of 32nd Avenue, as shown in Figure 4. Flow up to 4.3 mgd is conveyed via the South Magnolia Interceptor (also referred to as the South Magnolia Trunk) to the Interbay Pump Station, where it is pumped to the West Point Treatment Plant through the Elliott Bay Interceptor. The capacity of the South Magnolia Interceptor just downstream of the control manhole is approximately 4.3 mgd, according to an analysis by KCDNRP-WTD, completed in 2004. There are minimal connections to the interceptor downstream of the control manhole, most notably the Elliott Bay Marina. Capacity downstream of the marina has not been calculated, but is estimated to be 6.8 mgd based on review of County record drawings.

2.2.2 Peak Flow Analysis Summary

Flows exceeding 4.3 mgd overflow at the control manhole are discharged through a County outfall that extends about 750 feet offshore at the foot of 32nd Avenue to a depth of approximately 75.50 feet (per County staff) or about 18-feet below the Mean Low-Low

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Figure 4

Magnolia Basin

Barton, Murray, Magnolia and North Beach CSO Projects

Water level. The outfall was replaced in 1988. The South Magnolia Interceptor consists of about 7,300 feet of 18-inch and 27-inch diameter pipe. The 18-inch pipe which is primarily in the beach area along the south side of Magnolia bluff, and about 4,600 feet long, is pressure pipe with a maximum operating head of about 27 feet. At full pressure, computed capacity is just over 5 mgd. Originally cast iron (1966), much of the pipe was replaced in 1988 with ductile iron prior to construction of the Elliott Bay Marina. The remaining pipe is a conventional reinforced concrete (RCP) gravity sewer with manholes at irregular intervals. The capacity of the gravity portion of the sewer is just over 6 mgd.

As previously discussed, the 1997 CSO planning study proposed two alternatives to limit overflows to one event per year: a 1.3 MG storage tank or disconnection of roof drains from 900 houses within the basin. To update these findings, King County staff conducted additional modeling of the basin under existing conditions. This modeling indicates a need for either twice the amount of storage (2.6 MG) without reduction in impervious area contribution, or a combination 1.3 MG storage and disconnection of about 40% of the rooftop drains. Even if 100% of impervious area is disconnected, 0.2 MG of storage will be required.

2.3 North Beach CSO Basin

2.3.1 Existing Facilities

The North Beach basin comprises 691 acres in the northwest Seattle, immediately adjacent to Golden Gardens Park. This basin is mostly residential (approximately 2,600 residential properties are within the basin), and is primarily a separated sewer system; only a small portion of the basin has combined storm and sewer infrastructure. Figure 5 shows the sewer conveyance systems within the North Beach basin.

The SPU sewer system currently conveys flow to the North Beach Pump Station, which has a maximum capacity of 9 mgd, and a firm capacity of 5.5 mgd. However, it should be noted that the current capacity of the North Beach Pump Station is limited by the capacity of the downstream forcemain, which is 3.5 mgd. The flow is conveyed through this 14-inch forcemain to the Carkeek Pump Station and CSO Treatment Plant located in Carkeek Park. The capacity of the Carkeek Pump Station and the Treatment Plant are 20 mgd each. During dry weather, the flow from North Beach Pump Station is pumped through the Carkeek Pump Station to the 8th Avenue Interceptor for treatment at the West Point Wastewater Treatment Plant. During wet weather, when the 8th Avenue Interceptor is full, the flow is pumped from the North Beach Pump Station to the Carkeek Treatment Plant where it is treated and discharged through a 33-inch outfall into Puget Sound. When wet weather flows exceed the capacity of the Carkeek Treatment Plant, overflows occur at the North Beach Pump Station.

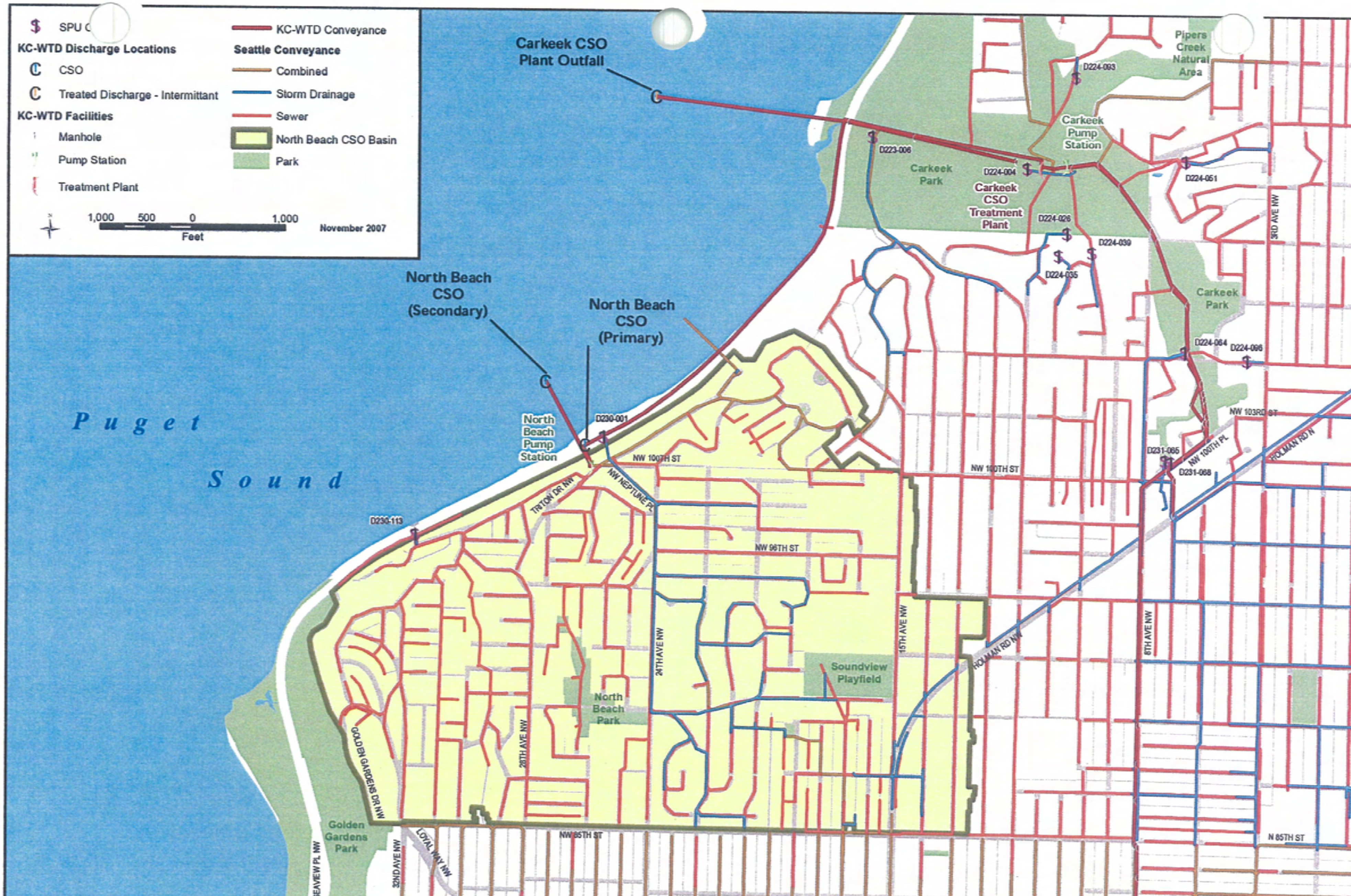

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Figure 5

North Beach Basin

BARTON, MURRAY, MAGNOLIA AND NORTH BEACH CSO PROJECTS

2.3.2 Peak Flow Analysis Summary

Peak flows and resulting storage volumes in the North Beach basin were updated by King County in February of 2007. The data are based on continuous flow simulation modeling using more recent flow monitoring data in the basin, and criteria that account for the range of expected model accuracy. This effort has identified that the storage needed to reduce overflows to one event per year in the North Beach basin is 3.5 MG. In lieu of storage, the pumping capacity of the North Beach Pump Station would need to be increased to 10-12 mgd. Because the North Beach basin is largely a separated system, a significant portion of wet weather flow is due to infiltration through laterals, side sewers, sewer mains, and manholes. A previous inflow and infiltration (I/I) study[2], conducted in 1988, established that the North Beach basin I/I flows are roughly 49% inflow (through direct connections into the sewer) and 51% infiltration. The recent flow modeling is in agreement with this conclusion.

3.0 BARTON AND MURRAY BASIN EVALUATION

As previously mentioned, the Barton and Murray basins are interdependent. Therefore, the scenarios described in this section incorporate the combined CSO approach for both basins.

The flow analysis modeling results for the Barton basin indicate that the peak flow conveyance requirements to control CSOs (53 mgd) were significantly greater than the storage requirements (0.5 MG). Additionally, conveyance improvement options within the Barton basin require additional upgrades at all of the facilities downstream of the Barton Street Pump Station. Because of these factors, the conveyance and end of pipe treatment approaches for the Barton basin were estimated to be 3 to 4 times more expensive than storage options. These approaches have been evaluated on a preliminary basis (and are provided in Appendices D and E, respectively), but are not considered to be viable compared to the storage and demand management CSO approaches for the Barton basin. Therefore, the scenarios associated with these control approaches are not presented in the following sections.

3.1 Barton Peak Flow Storage Alternatives

Four alternatives were evaluated that incorporated storage within the Barton basin in conjunction with other CSO approaches in the Murray basin:

- B1A-M1B: Peak Flow Storage at Barton and Murray Basins
- B1A-M2B: Peak Flow Storage at Barton and Peak Flow Conveyance at Murray
- B1A-M3B: Peak Flow Storage at Barton and Demand Management at Murray

2 "Inflow/Infiltration Analysis", Brown and Caldwell, 1988.

- B1A-M4B: Peak Flow Storage at Barton and End of Pipe Treatment at Murray

It should be noted that the site location of facilities described in this section are provided only to illustrate the different approaches to CSO control by basin. Additional siting options for facilities within the basins are to be explored during the Alternative Development and Siting Evaluation phase of the project.

Alternative B1A–M1B: Peak Flow Storage at Barton and Murray Basins

This alternative requires construction of two storage tanks (one per basin), to store peak flows during wet weather events and then release these flows back into the collection system following the storm event. The example locations provided for this alternative are a 0.5 MG rectangular storage tank located at the Fauntleroy School within the Barton basin and a 1.3 MG storage tank located at the Lowman Beach Park within the Murray basin.

As an example, a 0.5 MG storage tank for the Barton basin could be located at the Fauntleroy School parking lot. The tank dimensions would be approximately 80 feet long, 40 feet wide, with an assumed storage depth of 25 feet. The storage tank would include a flow control structure that would divert flows from the 24-inch interceptor along SW Director Street during rain events that cause flows in excess of the capacity of the Barton Pump Station. Following the storm event, the tank will re-introduce the stored volume back into the 24-inch interceptor along SW Director Street with a 0.5 mgd pump system designed to dewater the tank within 24 hours. All the "Barton Storage"-based alternatives require the construction of this storage tank at this location, and therefore include the assumptions, benefits, and limitations of the "Barton Storage" component of the proposed scenario (see description below).

A 1.3 MG storage tank for the Murray CSO Basin could be located at the Lowman Beach Park. The tank dimensions would be approximately 120 feet long, 60 feet wide, with an assumed storage depth of 25 feet. The tank will re-introduce the stored volume back into the Murray Pump Station with a 1.3 mgd pump system designed to dewater the tank within 24 hours.

The benefits and limitations of this alternative include the following:

- The benefits of this alternative are 1) relatively low cost, 2) minimal impact related to operations and maintenance, and 3) technical feasibility.
- The main challenge associated with this alternative is the limited options for storage siting within the two basins.

  In the Barton basin, the Fauntleroy School site appears to be the most viable alternative, but because it is located in the uplands portion of the basin, this site would present flow regulator challenges because the peak flow may pass through the system and inundate the Barton Street Pump Station before the controls system could react. In the Murray basin, there may be significant challenges associated with

public acceptance of siting the 1.3 MG storage tank in the Lowman Beach Park, as it would cause significant disruption during construction.

This scenario is based on the assumption that sufficient flows can be intercepted at the Fauntleroy School to adequately attenuate the peak flows at the Barton Street Pump Station. This assumption is based on a geographic information system (GIS) analysis which indicates that approximately 50% of the basin area drains to the interceptor pipe located adjacent to the Fauntleroy School. Therefore, it appears to be possible to intercept sufficient flow at the Fauntleroy School site to control CSOs within the Barton basin. However, additional flow monitoring and modeling is needed to verify this assumption.

Alternative B1A–M2B: Peak Flow Storage at Barton and Peak Flow Conveyance at Murray

In this alternative, peak flows from the Barton basin would be stored and pumped back into the collection system following the storm event, while the incremental peak flows from the Murray basin would be conveyed downstream through the construction of a new wet weather pump station and force main. A 0.5 MG rectangular storage tank could be located at the Fauntleroy School within the Barton basin and a new 23.5 mgd wet weather pump station could be constructed at the Lowman Beach Park in the Murray basin.

The 0.5 MG storage tank for the Barton CSO basin was evaluated at the Fauntleroy School parking lot location and would have the same configuration and operation as described in Alternative B1A – M1B. The new 23.5 mgd wet weather pump station in the Murray basin would convey flows approximately 13,500 feet through a new 42-inch force main routed along Beach Drive SW and would discharge to the existing 63rd Street Pump Station. This alternative would also require upgrades to the 63rd Street Pump Station and Alki CSO Treatment Plant to handle the additional peak flows from the Murray basin. Alternatively, it may be possible to convey the flows through the new wet weather pump station/force main to the 63rd Street Pump Station and then to the West Seattle Tunnel; however, KCDNRP-WTD modeling results indicate that there is not excess capacity in the West Seattle Tunnel so this alternative does not appear feasible.

The challenges associated with this alternative are 1) the significant costs to upgrade the existing 63rd Street Pump Station and the outfall at the Alki CSO Treatment Plant, 2) the proposed location of the storage tank within the Barton basin (see Alternative B1A-M1B), and 3) public acceptance and the community impacts of constructing an additional facility at Lowman Beach Park.

Alternative B1A–M3B: Peak Flow Storage at Barton and Demand Management at Murray

Peak flows from the Barton basin would be stored and pumped back into the collection system after the storm event subsides, while the incremental peak flows from the Murray basin would be eliminated through roof drain disconnections within the Murray basin. It is

proposed that a 0.5 MG rectangular storage tank be located at the Fauntleroy School in the Barton basin and that 40 acres of roof drains are disconnected within the Murray basin.

The 0.50 MG storage tank at the Fauntleroy School parking lot would have the same configuration and operation as described in Alternative B1A–M1B. The demand management efforts in the Murray basin would consist of disconnecting 40 acres of roof drains from the sewer system. A GIS analysis has confirmed that all of the roof drain disconnections would be within 100 feet of an existing storm inlet or catch basin.

The benefit of using demand management to reduce peak flows is that no additional infrastructure needs to be constructed within the Murray basin. The challenges of this alternative include 1) the proposed location of the storage tank within the Barton basin (see Alternative B1A-M1B) and 2) implementation of the roof drain disconnection program, including re-routing of drainage flows.

Although there appears to be a sufficient number of homes that can be disconnected to achieve CSO control within the Murray basin, challenges do exist with implementing this alternative. Implementation costs, siting challenges, and maintenance issues to implement the disconnections are the primary challenges to the peak flow reduction approach. KCDNRP-WTD is facilitating ongoing discussions with SPU regarding design, construction, and maintenance of the roof drain disconnections to determine the feasibility of implementing demand management within the project basins.

Alternative B1A–M4B: Peak Flow Storage at Barton and End of Pipe Treatment at Murray

This scenario requires the construction of a 0.5 MG storage tank at the Fauntleroy School to store peak flows from within the Barton basin, in combination with a new 23.5 mgd treatment facility located in Lowman Beach Park to treat peak flows from the Murray basin.

The Barton basin storage tank is located at the same site and has the same configuration and operation as described in Alternative B1A–M1B. The new 23.5 mgd treatment facility would include high rate clarification (HRC) followed by UV disinfection. The treatment facility would be located in the Lowman Beach Park and would discharge 23.5 mgd of treated flow into Puget Sound.

The challenges with this scenario are 1) the siting issues (as previously discussed for Alternative B1A-M1B), 2) public acceptance of an additional facility located at Lowman Beach Park, and 3) the acquisition of a permit for additional treatment and discharge into Puget Sound.

3.2 Barton Pump and Treatment Alternatives

As previously discussed, the cost to convey and treat the peak flows from the Barton CSO basin was significantly more expensive (3 to 4 times greater) than the estimated cost of the storage-based alternative. Therefore, these alternatives are not presented in detail in this

section. A preliminary evaluation of these alternatives is provided in Appendix F. It should be noted that the flow analysis was updated following Workshop 2; the pump and treatment capacity (and associated costs) was increased from 8.5 mgd to 23.5 mgd. The documents presented in Appendix F do not reflect the updated flow analysis results.

3.3 Barton End of Pipe Treatment Alternatives

The estimated cost for end of pipe treatment of the peak flows from the Barton basin is 3 to 4 times greater than the cost of the storage option. Therefore, these alternatives are not presented in detail in this section. A preliminary evaluation of these alternatives is provided in Appendix G. It should be noted that the flow analysis was updated following Workshop 2; the end of pipe treatment capacity (and associated costs) was increased from 8.5 mgd to 23.5 mgd. The documents presented in Appendix G do not reflect the updated flow analysis results.

3.4 Barton Peak Flow Reduction Alternatives

Four alternatives were evaluated that used a peak flow reduction approach within the Barton CSO basin in conjunction with different CSO approaches in the Murray CSO basin:

- B4A–M1B: Demand Management at Barton and Peak Flow Storage at Murray
- B4A–M2B: Demand Management at Barton and Peak Flow Conveyance at Murray
- B4A–M3B: Demand Management at Barton and Murray
- B4A–M4B: Demand Management at Barton and End of Pipe Treatment at Murray

It should be noted that the site location of facilities described in this section are provided only to illustrate the different approaches to CSO control by basin. Additional siting options for facilities within the basins are to be explored during the Alternative Development and Siting Evaluation phase of the project.

Alternative B4A–M1B: Demand Management at Barton and Storage at Murray

In this alternative, peak flows from the Barton basin would be eliminated from the system through roof drain disconnections and other impervious area disconnections, while the peak flows from the Murray basin would be stored and pumped back into the collection system following the storm event. This scenario requires disconnection of 70 acres of impervious area within the Barton basin and construction of a 1.3 MG rectangular storage tank at the Lowman Beach Park within the Murray basin.

A GIS analysis of the roof drain connections in the Barton basin has identified approximately 45 acres of rooftops with direct connections into the sewer system which are within 150 feet of an existing storm inlet or catch basin. Additionally, a 25-acre section of impervious area has been identified which is still connected into the combined sewer. The

combined total of 70 acres of impervious area would satisfy the demand management requirements to eliminate the excess Barton peak flows. All the "Barton Demand Management"-based alternatives require the disconnection of 70 acres of impervious area within the basin, and include the assumptions, benefits, and challenges of the "Barton Demand Management" component of the proposed scenario (see description below).

The 1.3 MG storage tank for the Murray CSO basin would be approximately 120 feet long, 60 feet wide, with an assumed storage depth of 25 feet. The storage tank would be connected to the existing Murray Pump Station wet well and would be filled by gravity. Once the wet well level has returned to the level set-point, the tank will re-introduce the flows back into the Murray Pump Station Wet Well with a 1.3 MGD pump system designed to dewater the tank within 24 hours.

The benefit of this alternative is that less infrastructure (as compared to the non-demand management-based scenarios) would be needed to manage CSOs. The challenge of this alternative is that although there appears to be a sufficient number of homes that can be disconnected to achieve the CSO control within the Barton basin, implementation costs, siting challenges, and maintenance issues to implement disconnections may impede the implementation of this peak flow reduction approach. Additionally, there may be significant challenges to public acceptance of siting the 1.3 MG storage tank in the Lowman Beach Park, due to the impacts of construction to the community.

Alternative B4A–M2B: Demand Management at Barton and Peak Flow Conveyance at Murray

This alternative requires that peak flows from the Barton basin be eliminated from the system through impervious area disconnections, while the incremental peak flows from the Murray basin would be conveyed downstream through the construction of a new pump station and force main. It is proposed that 70 acres of impervious area be disconnected within the Barton basin and a new 23.5 mgd wet weather pump station be constructed at the Lowman Beach Park to manage peak flows from the Murray basin.

Approximately 70 acres of roof drain disconnection within the Barton CSO basin was evaluated as described in Alternative B4A –M1B. The new 23.5 mgd pump station would convey flow through 13,500 feet of 42-inch force main routed along Beach Drive SW and would discharge to the existing 63rd Street Pump Station. This alternative would also require upgrades at the 63rd Street Pump Station and Alki CSO Treatment Plant to handle the additional peak flows from the Murray CSO basin.

The benefits and challenges of this alternative include the following:

- Benefit: Less infrastructure (as compared to the non-demand management-based scenarios) would need to be constructed to manage CSOs within the two basins.

- Challenges: 1) Implementation costs, siting challenges, and maintenance issues to implement disconnections may impede the implementation of the demand management CSO approach, 2) significant costs are associated with the upgrade of the existing 63rd Street Pump Station and the Alki CSO Treatment Plant, and 3) obtaining public acceptance may be difficult due to the community impacts of constructing an additional facility at Lowman Beach Park.

Alternative B4A–M3B: Peak Flow Reduction at Barton and Murray

For this alternative, peak flows from both the Barton and Murray basins would be eliminated from the system through roof drain disconnections. This alternative requires disconnection of 70 acres of impervious area in the Barton basin and disconnection of 40 acres of roof drains within the Murray basin.

As previously discussed (Alternative B4A–M1B), a GIS analysis of the Barton basin has identified approximately 70 acres of impervious area that is connected into the Barton sewer system. Disconnection of this area would satisfy the demand management requirements (as identified by the County) to eliminate the excess Barton peak flows. The roof drain disconnection analysis for the Murray basin indicates that 40 acres of roof drainage is within 100 feet of an existing storm sewer inlet or catch basin. Disconnection of these roof drains would effectively limit overflows to one event per year in the Murray basin.

The benefits and limitations of this alternative are as follows:

- Benefits: 1) Peak flows can be handled by the existing infrastructure (significantly reducing capital costs), and 2) demand management is a sustainable method to reduce peak flows in the basin.
- Challenges: 1) Implementation costs, siting challenges, and maintenance issues to implement disconnections may impede the implementation of the demand management CSO approach, 2) flow monitoring is required to evaluate the impacts of the reduction efforts, and 3) coordination with SPU is needed to repair the existing infrastructure system.

Alternative B4A–M4B: Peak Flow Reduction at Barton and End of Pipe Treatment at Murray

In this alternative, peak flows from the Barton basin would be eliminated from the system through roof drain disconnections, while the incremental peak flows from the Murray basin would be treated within the Murray basin. Approximately 70 acres of impervious area would be disconnected within the Barton basin and a 23.5 mgd treatment facility would be constructed for the excess peak flows in the Murray basin.

Approximately 70 acres of roof drain disconnection within the Barton CSO basin was evaluated as described in Alternative B4A–M1B. A new 23.5 mgd HRC/UV treatment facility

located in Lowman Beach Park would be constructed to provide end of pipe treatment for the excess peak flows from the Murray CSO basin.

The benefits and challenges of this alternative are as follows:

- Benefits: Less infrastructure (as compared to the non-demand management-based scenarios) would need to be constructed to manage CSOs within the two basins.
- Challenges: 1) Implementation costs, siting challenges, and maintenance issues to implement disconnections may impede the implementation of the demand management CSO approach, 2) siting issues associated with public acceptance of new construction at Lowman Beach Park (as previously discussed for Alternative B1A-M1B), and 3) acquisition of a permit is required for additional treatment and discharge into Puget Sound.

3.5 Combined Approach Alternatives

It may be necessary to implement more than one approach in each of the basins because of the significant challenges of siting facilities in these highly urbanized areas. Because the end of pipe treatment and conveyance approaches were estimated to be 3 to 4 times more expensive than the peak flow reduction and storage options, only combinations of peak flow reduction (demand management) and storage were considered.

3.6 Barton and Murray Conclusions and Recommendations

General Recommendations

The peak flow storage and reduction approaches are the preferred CSO approaches because preliminary cost estimates indicate that peak flow conveyance and end of pipe treatment were 3 to 4 times more expensive. Findings and recommendations for the preferred peak flow storage and reduction alternatives within the approaches are summarized below.

Barton CSO Basin Recommendations

There are very few options for storage siting within the Barton and Murray basins. Many of the available sites, such as the Fauntleroy School parking lot site in the Barton basin, have significant technical feasibility issues. The KCDNRP-WTD should perform follow up flow monitoring at this location to determine the technical feasibility of storage at this site. Other options, such as a combined Barton/Murray storage facility under Lincoln Park should also be evaluated.

It appears that there may be enough impervious area which could be disconnected within the Barton basin such that no other CSO controls would be required. However, this would require a highly aggressive roof drain disconnection program with almost 100 percent resident participation to disconnect the required 70 acres of impervious area. Even with a

highly aggressive program, the cost to perform disconnections and maintain the stormwater facilities could be significantly more expensive than other approaches, depending on the level of water quality treatment measures that would need to be implemented. KCDNRP-WTD is continuing to evaluate and negotiate the design and maintenance criteria with SPU for roof drain disconnections to determine if it is feasible to perform the disconnections. Another option that should be further evaluated is disconnection of pavement areas at the east side of the Barton basin in conjunction with storage along the east side of Fauntleroy Avenue SW, near the ferry docks.

Murray CSO Basin Recommendations

Although it appears to be technically feasible to locate a storage facility at Lowman Beach Park in the Murray CSO basin, the siting of storage at this location is likely to incur issues with public acceptance. The implications of utilizing this site should be further evaluated. Additionally, other sites within the Murray basin, such as the site located east of 48th Avenue SW, about one quarter mile uphill from the Lowman Beach Park, should also be evaluated. This site may be classified as environmentally sensitive, so an environmental assessment of the site should be conducted to determine the permit requirements and suitability for locating a storage facility at this site.

Peak flows within the Murray basin can be sufficiently reduced by roof drain disconnection to meet the CSO regulations of one overflow event per year. However, these disconnections face the same technical and cost challenges as those in the Barton basin. KCDNRP-WTD is continuing to evaluate and negotiate the design and maintenance criteria with SPU for roof drain disconnections to determine if it is feasible to perform the disconnections.

3.6.1 Alternative Screening

The feasible CSO alternatives and related scenarios for storage, conveyance and treatment, end of pipe treatment, demand management, or a combination thereof, were presented and discussed in Workshop No. 2. The results of this workshop have identified preferred scenarios which will be further developed as part of the Alternatives Development phase of this CSO Control project. The preferred scenarios are presented below.

The most favorable alternatives for controlling overflows within the Barton and Murray basins are storage (B1A-M1B) ,end of pipe treatment (B1A-M4B, B4A-M4B), and demand management (B1A-M3B, B4A-M3B), should this alternative be determined to be viable.

- Storage in both the Barton and Murray basins was identified as the most favorable alternative. However, concerns were expressed regarding the siting limitations associated with the proposed storage locations. This alternative was rated favorably with respect to Cost Effectiveness, Operations and Maintenance impacts, Technical Feasibility, Pubic Health and Environmental Benefits, and Flexibility.

- Storage in the Barton basin, combined with demand management in the Murray basin, was rated favorably with respect to Public Health and Environmental Benefits, as well as Technical Feasibility, and Operations and Maintenance impacts.

- Demand management in both the Barton and Murray basins was not rated by all four stakeholder groups during the workshop. However, the ratings that were provided indicate that this alternative would likely be among the preferred scenarios. Further investigation of the feasibility of reducing peak flows to control the overflows in the two basins should be conducted as part of the Alternatives Development phase of this project.

- Peak flow end of pipe treatment for the Barton Basin does not appear feasible, as there is not sufficient space for treatment facilities near the outlet of the Basin. For the Murray Basin, peak flow end of pipe treatment was determined to have siting limitations similar to those cited for the storage approach; however, this alternative was rated favorably with respect to Public Health and Environmental Benefits. Based on the feedback in Workshop 2, this approach should continue to be considered as a method for controlling CSOs within the Murray Basin.

The concerns and challenges cited by the stakeholders at the workshop were similar to those listed in the alternative descriptions above and include the following:

1. Peak flow conveyance was identified as an unfavorable CSO approach because it requires upgrades to the downstream facilities and requires continued maintenance for the life cycle of the proposed facility.

2. Peak flow storage appeared to be a favored approach; however, the representative site alternatives of the Fauntleroy School and the Lowman Beach Park were considered somewhat unfavorable due to technical feasibility and public acceptance issues.

3. Peak flow reductions (demand management) appeared to be a favorable alternative worthy of further consideration, although at the time of the workshop, the design and maintenance criteria for flow reduction put forth by SPU was not yet known.

3.6.2 <u>Planning Area Boundary Delineation</u>

With the technical and stakeholder evaluations effectively ruling out the peak flow conveyance and end of pipe treatment approaches, the peak flow storage and reduction alternatives lead to a planning area boundary that extends into the uplands of the basin and is bounded at the downstream end of the CSO basins by the respective pump stations.

4.0 SOUTH MAGNOLIA BASIN EVALUATION

Seven alternatives were initially investigated during Planning Confirmation. Three storage alternatives, two convey and treat alternatives, one end of pipe treatment alternative, and one combination alternative were evaluated.

4.1 Peak Flow Storage Alternatives

Three alternatives for peak flow storage in the South Magnolia basin were evaluated during the Planning Confirmation phase:

- 1A: Store peak flows up basin from the CSO control point
- 1B: Store peak flows near the CSO control point
- 1C: Store peak flows east of the marina

A description of each storage alternative is presented below.

Alternative 1A: Peak Flow Storage Up Basin

This scenario follows the recommendations of the 1997 CSO Plan to construct a storage tank in the vicinity of West Lynn Street and 32nd Avenue, approximately 2,200 feet north of the South Magnolia basin CSO control point. The storage facility would be 2.6 MG rectangular tank, and could be located on a parcel of land comprising approximately 0.5 acres. The tank would be connected to extant combined sewers for approximately 31% of the basin tributary to that area (approximately 235 acres). The storage facility would include submersible pumps to drain the basin.

The existing gravity system would continue to collect sewage from the remaining 69% of the basin. A new pump station would be required at the CSO control point to transfer those flows to the storage tank. A new gravity discharge pipeline would also be required to convey flow from the tank to the existing South Magnolia Interceptor.

The challenges of this alternative include the following: 1) Relatively high construction cost, 2) limited site locations available, and 3) the proposed land use for the potential site location may preclude construction of the storage facility.

Alternative 1B: Peak Flow Storage Near CSO Control Point

In this scenario, a 2.6 MG rectangular storage tank would be constructed on 32nd Avenue near the CSO control point. Adjacent property would be acquired for the tank. The SPU pump station #77 would likely have to be modified (to be determined by further investigation) to increase pumping head sufficiently to lift flow into the tank. The discharge line for the pump station would be extended to the tank. Capacity of the SPU station is currently unknown.

Depending on location and footprint, a pump station may be needed to empty the tank into the South Magnolia Interceptor upstream of the CSO control point.

The advantages and limitations of this alternative include the following:

- Advantages: 1) the capital costs are the lowest of all the storage-based scenarios for the South Magnolia basin, and 2) less pumping is required; it is possible that the storage tank could be drawn down through gravity alone.

- Challenges: 1) siting limitations (the storage facility would be located in a ravine near the control point), 2) impacts to the community, 3) obtaining easements / approval from the City, and 4) obtaining the necessary permits to upgrade to the SPU pump station.

Alternative 1C: Peak Flow Storage East of Elliott Bay Marina

A storage tank would be constructed north and east of the Marina on 23rd Avenue on a site currently owned by the City of Seattle, which is currently used as a sports field. A pump station would be required to empty the tank.

A new gravity sewer would be constructed from the CSO control point to the tank, approximately 3,000 feet long, to convey flow from the basin. The SPU pump station and discharge line would likely be upgraded for higher head and distance needed to convey flows from approximately 20% of the basin to the new sewer. The existing South Magnolia Interceptor would remain in service for local connections between 32nd Avenue and the storage tank, which would then be re-routed into the storage tank.

This alternative is based on the assumptions that microtunneling can be conducted in this area of the basin. A geotechnical study will need to be conducted to confirm this assumption. An alternative to the construction of a new sewer line to the storage tank is conversion of the existing pressure sewer to a force main, with a pump station located at the foot of 32nd Avenue. This requires further investigation of the pressure rating, and other details of the existing pipeline.

The challenges of this alternative include: 1) obtaining easements and/or right-of-ways from the City for construction of the new sewer main, 2) constructability due to geotechnical/ slope stability issues, and 3) obtaining the necessary permits for storage and to upgrade the SPU pump station.

4.2 Pump and Treatment Alternatives

Options 2A and 2B comprised two conveyance upgrades (complete replacement or partial parallel) of the existing interceptor to convey flow to the Interbay Pump Station. Based on discussions with KCDNRP-WTD staff, it was determined that due to operational constraints, there is not sufficient capacity within the Interbay Pump Station to convey peak flows to the

West Point Treatment Plant during a wet weather event. Therefore, this CSO control approach has not been included for analysis within the South Magnolia basin.

4.3 End of Pipe Treatment Alternatives

End of pipe treatment was also considered to reduce overflow events within the South Magnolia Basin. A description of the alternative is presented below:

Alternative 3A: Treatment at South Magnolia CSO Control Point

A new 15 mgd HRC/UV wet weather treatment plant would be constructed near the CSO control point. New control structures would divert flows above 4.3 mgd to the treatment plant. Plant footprint is approximately 90 x 105 feet (including odor control, electrical buildings and an allowance for setbacks and access. A pump station would be needed to empty the plant after use. It should be noted that SPU pump station #77 would require an upgrade to pump flow to the proposed plant.

The primary benefit of this alternative is its low relative cost as compared to the other CSO control approaches in the South Magnolia basin. The limitations associated with this alternative are 1) confirming the soils condition at the proposed site location for construction of a new treatment facility, and 2) obtaining the necessary permits to upgrade to the SPU pump station and construct a new treatment facility at the South Magnolia CSO control point.

4.4 Peak Flow Reduction Alternatives

As an alternative to the facility improvements described above (storage, pumping, end of pipe treatment), other methods were evaluated to reduce overflow events in the basin. Following the flow analysis conducted by King County, it was determined that impervious area disconnection could significantly reduce peak flows within the South Magnolia Basin. A description of the alternative is discussed below:

Alternative 4A: Impervious Area Disconnection

During the planning confirmation phase of this project, an assessment was made of the impervious area that could be feasibly disconnected to reduce the peak flows during a storm event. Based on conservations with SPU, which has recently been implementing a flow reduction program, it was determined that a maximum distance of 100 feet would be used to identify potential sites for roof drain disconnection. The 100-foot standard is based on two main objectives: 1) reducing the impacts of sheet flow on the system and 2) preventing construction of additional storm sewer infrastructure.

A GIS-based analysis of sewerage maps of the basin identified that 65 acres of impervious roof tops are located within 100 feet of the catch basins connected to the storm sewers. These roof drains could feasibly be disconnected from the storm sewer to reduce peak flows into the combined system. However, the flow analysis model, which was used to

determine the storage volume needed to meet CSO regulations, was based on an assumed area of impervious rooftops of 58 acres. Based on this assumption, it was found that disconnection of the impervious area would not be sufficient to completely manage the excess flows; approximately 0.2 MG of storage would still be required. Further field investigation is necessary to confirm the extent of rooftop drains that could be disconnected to achieve reductions in required storage volumes. Field investigations would include windshield surveys to validate GIS-based estimates of connected roofs, and topography and other site influences such as topographic differences between house and street that might limit disconnection opportunities. Following validation, conceptual engineering estimates would be required to estimate costs based on SPU requirements and neighborhood constraints such as landscaping.

By implementing demand management within the basin, CSO flows could be reduced because the initial peak flows from a storm event would be delayed. The storm flows would not be routed directly into the combined sewer system, but would rather percolate through the soil into the groundwater table or could eventually enter into the combined sewer system through leaks in the infrastructure from tree roots and other sources. In either case, the system would be able to more effectively handle the storm event, leading to a reduction in combined sewer overflows. However, it should be noted that demand management would require significant cooperation between the County and SPU. SPU is the owner/operator of the direct connections (roof drains, catch basins, others) and side sewers into the combined sewer, while the County is the owner/operator of the sewer mains and manholes.

The challenges associated with this alternative include 1) roof drain disconnection is not sufficient to control CSOs completely, 2) interjurisdictional cooperation between the County and SPU, 3) the need to obtain approval from residential home owners to work on their private property, and 4) the cost of implementing the demand management strategy in comparison to other CSO control approaches.

4.5 Combined Approach Alternatives

As previously stated, the impacts of roof drain disconnection within the South Magnolia Basin are not sufficient to reduce overflow events to once per year. Therefore, additional overflow abatement measures would have to be implemented, such as construction of a new storage facility. The storage requirements of such a combined scenario are as little as 0.2 MG with 100% rooftop disconnection, or up to 1.1 MG with 50% rooftop disconnection.

Alternative 4A includes a storage tunnel constructed to store additional flows; this tunnel would be located along the Galer Street right of way, and would be used to store approximately 1.1 mgd of peak flow (with 50% roof drain disconnection). The tunnel would end in the vicinity of 23rd Avenue. Interconnecting sewers would connect the upstream and downstream ends of the tunnel to the existing South Magnolia Interceptor.

4.6 South Magnolia Conclusions and Recommendations

The topography of the South Magnolia basin is such that very few siting locations exist for storage facilities, with the exception of sites east and north of the Elliott Bay Marina. The potential sites pose challenges to construction (namely, geotechnical concerns) and require an upgrade of SPU Pump Station #77 to convey peak flows to the storage facility. It is recommended that further consideration be made for locating the storage facility at either the CSO control point or near the Marina. Geotechnical analysis of the two proposed site locations should also be conducted to further develop the viability of this CSO approach.

The convey and treat control approach was determined to be technically infeasible because of capacity limitations within the South Magnolia Trunk and the Interbay Pump Station, and the impacts of operations at the West Point Treatment Plant during a wet weather event. Therefore, these scenarios have been removed from further consideration.

End of pipe treatment appears to be the least cost alternative for the South Magnolia basin. Therefore, it is recommended that a geotechnical analysis of the soil conditions be conducted to determine the feasibility of locating a 10 mgd facility at this site. Additional investigation should be made to determine the feasibility of obtaining a new permit for treatment and discharge at this location, as well as for SPU's Pump Station #77.

Demand management, based on impervious area disconnection, may not be sufficient to fully reduce CSOs to one event per year within the South Magnolia basin. Therefore, demand management must be used in combination with storage to meet the CSO regulations. It is recommended that the costs and feasibility (technical, interjurisdictional, others) associated with implementing demand management within the South Magnolia basin be more fully evaluated to determine the viability of this combined approach.

4.6.1 <u>Alternative Screening</u>

The five CSO approaches and related scenarios for storage, conveyance and treatment, end of pipe treatment, demand management, or a combination thereof, were presented and discussed in Workshop No. 2, held on May 30, 2007. A summary of the workshop findings is provided in Appendix H of this TM.

The project team, consisting of staff from King County, SPU, and consultants, evaluated the proposed scenarios with respect to the evaluation criteria presented in Section 2.4 of this TM. The results of this workshop have identified preferred scenarios which will be further developed as part of the Alternatives Development phase of this CSO Control project. The preferred scenarios are presented below.

Both end of pipe treatment (3A) and storage (1B and 1C) have been identified as preferred control approaches to meet overflow requirements within the South Magnolia Basin.

- End of pipe treatment was ranked most favorably with respect to Cost Effectiveness, and was also evaluated favorably for Public Health and Environmental Benefits, Flexibility, and Program Compatibility.
- Onsite storage near the South Magnolia CSO control point was ranked favorably for Public Health and Environmental Benefits, Cost Effectiveness, and Operations and Maintenance Impacts.
- Offsite storage at the Marina, with treatment at West Point (1C), was ranked favorably with respect to Public Health and Environmental Benefits, Operations and Maintenance Impacts, and (to a lesser degree) Program Compatibility, Community, and Flexibility.

The least favorable scenario was identified as offsite storage at West Lynn Street due to concerns regarding Community Impacts, Technical Feasibility, Operations and Maintenance Impacts, and Cost Effectiveness.

4.6.2 Planning Area Boundary Delineation

Based on the outcome of Workshop No. 2, which identified that the Convey and Treat control approach was not feasible for the South Magnolia Basin, the planning boundary for this basin has been established as the basin boundary (see Figure 4).

5.0 NORTH BEACH BASIN EVALUATION

As discussed in Section 3.3, the North Beach Pump Station has a firm capacity of 5.5 mgd, but is limited by the capacity of the downstream forcemain (3.5 mgd) to the Carkeek Pump Station and CSO Treatment Plant. Therefore, to meet the CSO regulations of one overflow event per year, the North Beach Pump Station and forcemain need to be upgraded for all of the proposed CSO approaches, with the exception of Peak Flow Storage. Peak Flow Storage would not require an upgrade to the North Beach Pump Station and forcemain, because the peak flows would be stored and released following the storm event, so that the existing capacity of the pump station and forcemain would be sufficient to meet the CSO regulations. However, it should be noted that the existing condition of the forcemain is suspected to be poor due to its age and leak history. Therefore, all the CSO approaches and corresponding alternatives that utilize the existing forcemain will also require repair or other upgrades to the forcemain to improve the condition of the pipeline.

5.1 Peak Flow Storage Alternatives

Three alternatives for peak flow storage in the North Beach basin were evaluated during the Planning Confirmation phase:

- 1A: Store peak flows at the NBPS site, then pump to Carkeek PS (via NBPS) following the storm event.

- 1B: Pump peak flows to an alternate storage location in the North Beach basin, then use the NBPS to pump to Carkeek PS following the storm event.

- 1C: Pump peak flows to an alternate storage location in the North Beach basin, then pump or gravity feed to the 8th Avenue interceptor for transfer to the West Point WWTP following the storm event.

Alternative 1A: Peak Flow Storage at the North Beach Pump Station

Alternative 1A assumes no increase in the pumping capacity at the NBPS, but would require a storage tank volume of 3.5 MG. This alternative also requires that the storage be located at an elevation low enough in the basin to intercept the peak flows generated during a wet weather event. The topography of the North Beach basin varies from elevation ± 350 feet at the top of the basin to sea level at the CSO outfall. Figure 6 shows that there are essentially no alternative open spaces below elevation 225 feet, therefore the storage would need to be located directly adjacent to the North Beach Pump Station and CSO outfall.

The storage facility would include submersible pumps to drain the basin, as well as washdown facilities. Following the storm event, the stored water would be pumped by the NBPS to the Carkeek PS through the existing 14-inch forcemain. The flow would then be pumped up to the 8th Avenue Interceptor and conveyed to the West Point WWTP for secondary treatment.

The benefits and challenges of Alternative 1A include the following:

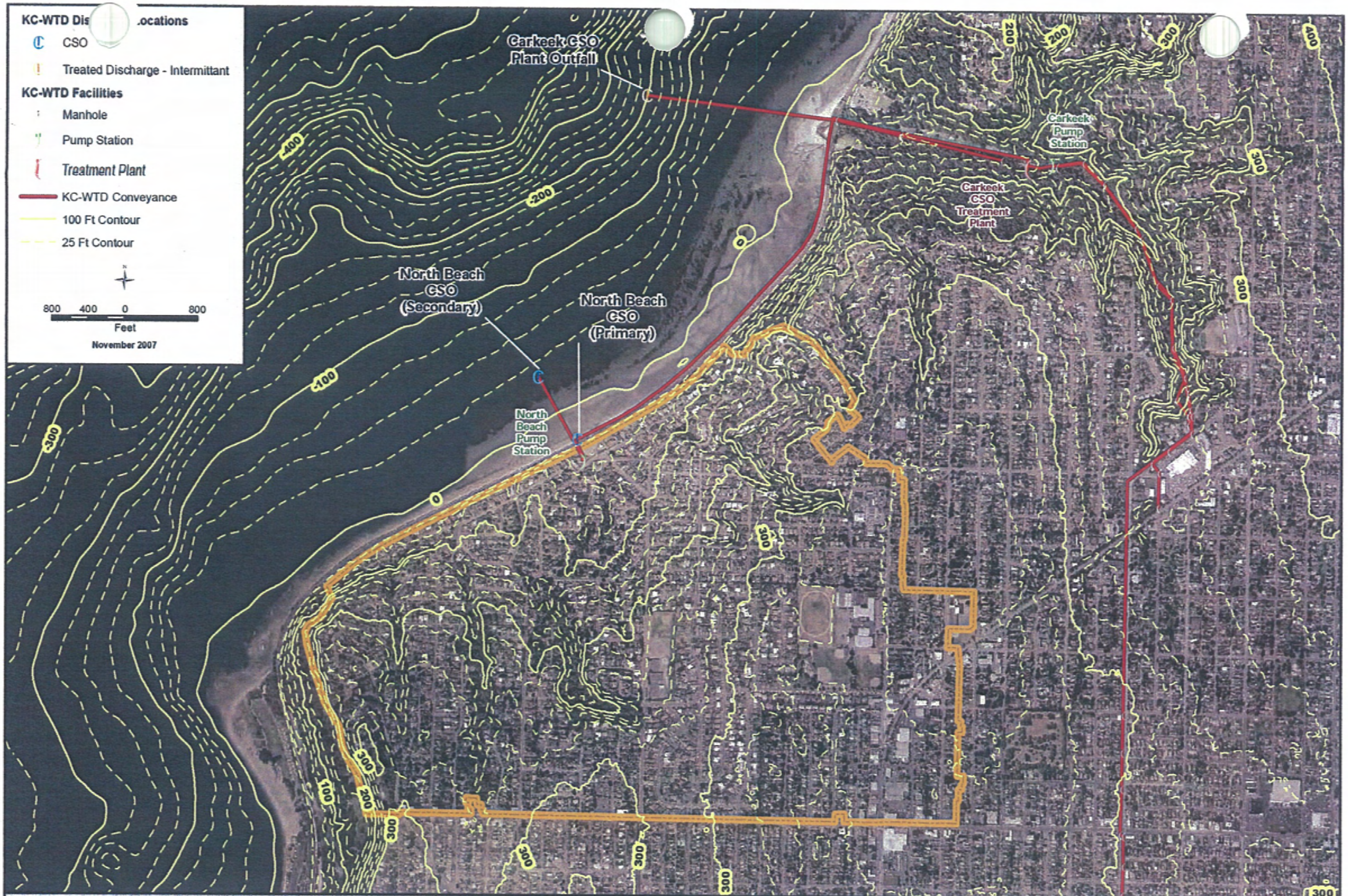
- Benefits: 1) Relatively low-cost option for CSO control, 2) Low impact on operations and maintenance efforts.

- Challenges: 1) Storage is unlikely to fit on NBPS site, 2) May require increased pump station capacity to drain tank following peak flow event, 3) Does not improve the existing condition of the North Beach forcemain, 4) Will require double pumping of peak flows.

Alternative 1B: Peak Flow Storage at Alternate Site within the North Beach Basin, Pump to Carkeek Pump Station

In this alternative, peak flows would be pumped from the existing North Beach Pump Station (NBPS) to an offsite storage tank, and following the high flow event, would then be pumped back to the NBPS for conveyance to the Carkeek Pump Station.

A new 10 mgd high head pump station would be constructed at the NBPS site. From this pump station, a 24-inch forcemain would convey the peak flows (10 mgd) to a new 3.5 MG rectangular storage facility located within the North Beach basin. The storage facility would include a submersible pump and washdown facilities. Following the storm event, the peak flows would be pumped from a new 3.5 mgd submersible pump station at the storage tank



King County
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Figure 6

North Beach Basin Topography

BARTON, MURRAY, MAGNOLIA AND NORTH BEACH CSO PROJECTS

to the existing NBPS through a new 14-inch, 3.5 mgd forcemain. The flows would then be pumped to the Carkeek PS through the existing 14-inch forcemain alignment along the beach.

The benefit of Alternative 1B is the ability to more easily site the storage tank at a different location. The challenges associated with this alternative are the same as those associated with Alternative 1A.

Alternative 1C: Peak Flow Storage at Alternate Site within the North Beach Basin, Pump to West Point Wastewater Treatment Plant

In Alternative 1C, peak flows would be pumped from a new high head pump station located at the North Beach Pump Station (NBPS) site to an offsite storage tank, and following the high flow event, would be gravity fed (or pumped, if necessary) to the existing 8th Avenue Interceptor for conveyance to the West Point Wastewater Treatment Plant (West Point WWTP).

A new 10 mgd high head pump station would be constructed at the NBPS site. From this pump station, a new 24-inch forcemain would convey 10 mgd from the NBPS to a new 3.5 MG rectangular storage facility located within the North Beach Basin. The storage facility would include a submersible pump and washdown facilities. Following the storm event, the peak flows would be gravity fed (or pumped through a new 14-inch forcemain) into the existing 8th Avenue Interceptor. The flows would then be conveyed to the West Point WWTP through the 11th Avenue Interceptor and Ballard siphons.

The benefits of Alternative 1C include 1) the ability to more easily site the storage tank, and 2) will likely eliminate the need for double pumping of the peak flows. The main limitation of this alternative is the fact that the condition of the North Beach forcemain would not be improved.

5.2 Pump and Treatment Alternatives

Two alternatives for conveying and treating peak flows in the North Beach basin were evaluated during the Planning Confirmation phase:

- 2A: Convey peak flows from North Beach Pump Station to Carkeek CSO TP through a beachfront alignment.
- 2B: Convey peak flows from North Beach Pump Station site to the Carkeek CSO TP through a neighborhood alignment.

Alternative 2A: Convey and Treat at Carkeek TP (Beachfront Alignment)

Alternative 2A would require peak flows to be pumped from the existing North Beach Pump Station site (parallel to the existing North Beach forcemain) to the Carkeek CSO Treatment Plant for treatment and discharge to Puget Sound.

A new submersible pump station would be constructed at the NBPS site, which would convey peak flows up to approximately 10 mgd through a 24-inch forcemain to a new treatment facility at the Carkeek TP. One potential forcemain alignment would travel parallel to the existing 14-inch forcemain along the beach to the Carkeek TP. The treatment facility at Carkeek TP would be expanded to include high rate clarification (HRC) and additional disinfection capacity for the peak flow from North Beach. Treated flow from the HRC train would be discharged to Puget Sound via a new 24-inch outfall.

The benefits and challenges of Alternative 2A include the following:

- Benefits: 1) New submersible pump station at NBPS is less costly than construction of a high-head pump station, 2) Potential exists to improve the condition of the existing North Beach forcemain.

- Challenges: 1) Expansion of Carkeek TP may be difficult to construct due to space limitations, 2) Construction of a beachfront forcemain may be difficult due to permitting and constructability issues, and 3) Cost of constructing a new forcemain from NBPS to Carkeek, as well as expanding the Carkeek TP and outfall, will be significant.

Alternative 2B: Convey and Treat at Carkeek TP (Neighborhood Alignment)

Under Alternative 2B, peak flows would be pumped from the existing North Beach Pump Station site via a neighborhood alignment (through the basin rather than along the shoreline) to the Carkeek CSO Treatment Plant for treatment and discharge to Puget Sound.

A high head pump station would be constructed at the NBPS site, which would convey peak flows up to approximately 10 mgd through a 24-inch forcemain to a gravity pipeline, which would then connect into a new treatment facility at the Carkeek TP. One potential forcemain alignment (approximately 1.1 miles) would travel east from the new high head pump station, along NW 100th Street to the intersection of NW 100th Street and 8th Avenue NW. The forcemain would then tie in to a new gravity pipeline, which would head north along 8th Avenue NW and into Carkeek Park, before connecting into the existing gravity pipeline which conveys flow to the Carkeek TP. The treatment facility at Carkeek TP would be expanded to include high rate clarification (HRC) and additional disinfection capacity for the peak flow from North Beach. Treated flow from the HRC train would be discharged to Puget Sound via a new 24-inch outfall.

The challenges of this alternative include 1) Significant cost for construction (high head pump station, new forcemain, expansion of Carkeek TP and outfall), 2) Impact to the community resulting from the neighborhood alignment of the new forcemain and expansion of the Carkeek TP, 3) Condition of the existing North Beach forcemain would not be improved.

5.3 End of Pipe Treatment Alternatives

Alternative 3A: End of Pipe Treatment

This approach requires the construction of a new treatment facility at the North Beach Pump Station site, which would treat and discharge peak flows directly to Puget Sound. The new, approximately 10 mgd treatment facility would include high rate clarification (HRC) and disinfection, such as UV or Sodium Hypochlorite. Treated flow from the new treatment facility would then be discharged to Puget Sound via the existing 24-inch North Beach outfall. It should be noted that for this alternative, no upgrades or modification would be made to improve the condition of the existing forcemain from the North Beach Pump Station to the Carkeek TP.

The benefits and limitations of this alternative include the following:

- Benefits: 1) Lowest cost alternative to meet CSO requirements, 2) Will likely have the least impact on the community during construction, 3) Fits easily onto the NBPS site.
- Challenges: 1) Public perception of a new treatment facility near parks and homes, 2) May be difficult to acquire a permit for a new treatment and discharge.

5.4 Peak Flow Reduction Alternatives

Alternative 4A: I/I Reduction

As previously mentioned, the 1988 I/I Analysis conducted for SPU has identified that the inflow and infiltration components resulting from a wet weather event within the North Beach basin are 49% and 51%, respectively. Additionally, the impacts of reducing I/I within King County were evaluated as part of a series of case studies conducted in 2005[3]. The case studies identified that the individual components of I/I could be reduced by repairing or replacing select portions of the sewer infrastructure. Table 5 presents the I/I flow components, associated infrastructure components, and the expected percent flow reduction resulting from repair of the infrastructure.

3 "King County I/I Control Program Pilot Project Report," Earth Tech, 2004.

Table 5	Impacts of I/I Reduction within the North Beach Basin CSO Control Approach and Planning Boundaries Barton, Murray, South Magnolia, and North Beach CSO Projects				
I/I Component	System Component	Percent of I/I Flow	Flow (mgd)	Expected Percent Reduction	Predicted I/I Flow (mgd)
Fast Response (Inflow)	Catch basins, roof drains, other direct connections	49%	6.4	10%-15%	5.4-5.7
Rapid Infiltration	Laterals, side sewers, foundation drains	40%	5.2	50%-60%	2.1-2.6
Slow and Base Infiltration	Manholes, sewer drains	11%	1.4	30%	1.0
All	All of the above	100%	13.0	70%-80%	2.6 - 3.9

The case studies also identified that the percent flow reduction could be dramatically increased to 70% - 80%, if the entire infrastructure system leading into the sewer main was repaired. Therefore, it is feasible that through I/I reduction alone, the peak flows in the North Beach basin could be sufficiently reduced so as to not require any additional infrastructure in the management of peak flows.

The benefits of this approach are that 1) Peak flows can be handled by existing infrastructure, and 2) Demand management is a sustainable method to reduce peak flows in the basin. The challenges associated with this approach include 1) An aggressive reduction target of 70%-80%, 2) Requires flow monitoring to evaluate the impacts of the reduction efforts, 3) Requires coordination with SPU to repair the existing infrastructure system, and 4) Requires approval from private property owners regarding the impacts of construction on their land and in the right-of-way. It should be noted that the impacts of I/I reduction could potentially impact slope stability and residential owners; further evaluation of the impacts of I/I should be conducted as part of the Alternatives Development phase of this evaluation.

5.5 Combined Approach Alternatives

Combined approach alternatives were also considered to reduce peak flows for CSO control in the North Beach basin. These alternatives included I/I reduction with storage, I/I reduction with conveyance and treatment, and I/I reduction with end of pipe treatment.

Alternative 5A: Storage and I/I Reduction

Because offsite storage is more costly than storage located at the NBPS site, these combinations were not initially considered. Additionally, due to sizing constraints, storage located at the NBPS site would be limited in capacity to less than 200,000 gallons. To utilize the NBPS site for storage, demand management efforts would need to be sufficient to reduce I/I flows by about 70%; making no significant impact on the costs of implementing I/I reduction (as compared to Alternative 4A).

Because onsite storage is significantly limited in capacity due to site constraints, and the resulting reduction in demand management efforts is therefore minimal, offsite storage locations (in combination with demand management) were again considered as a feasible option. It is possible that the increased cost associated with off-site storage would be offset by a potentially significant reduction in demand management efforts (thereby reducing the overall costs of this alternative as compared to 4A). This possibility will need to be further evaluated as part of the Alternatives Evaluation phase of this effort.

Alternative 5B: Convey and Treat with I/I Reduction

The combined I/I reduction and convey and treat scenarios are possibilities for CSO control within the North Beach basin; however, the relative cost of constructing the new infrastructure to convey and treat the excess flows (even if significantly reduced through I/I reduction) is still significantly higher than the other CSO control approaches.

Alternative 5C: End of Pipe Treatment and I/I Reduction

Implementing a combined end of pipe treatment scenario with I/I reduction would be more costly than end of pipe treatment alone, and would require flow monitoring and coordination with SPU. However, the benefits of this alternative are that the costs are likely to be lower than those associated with conveying and treating peak flows, as well as incorporating the sustainability measures associated with I/I reduction.

5.6 North Beach Conclusions and Recommendations

The five alternatives and related scenarios for storage, conveyance and treatment, end of pipe treatment, demand management, or a combination thereof, were presented and discussed in Workshop No. 2. The results of this workshop have identified preferred scenarios which will be further developed as part of the Alternatives Development phase of this CSO Control project. The preferred scenarios are presented in Section 6.6.1.

The topography of the North Beach basin presents a challenge in locating a storage facility that would not require pumping from the North Beach Pump Station to the storage tank. Based on an initial review of potential site locations, the only feasible alternative to convey flow through gravity into a storage tank is at the site of the North Beach Pump Station. However, the site footprint is not large enough to construct a storage facility of sufficient size to control overflow events within the basin. Therefore, the only storage-based alternative that was determined to be a viable CSO control approach is offsite storage, which requires pumping into the storage facility.

However, following Workshop 2, it was identified that the former Crown Hill Elementary School site is being sold by Seattle Public Schools. This site holds significant potential as a location that would not require additional pumping from the storage facility into the collection system. Therefore, it is recommended that further evaluation of this site and others (including North Beach Elementary and the Soundview Playfield) be conducted as part of the Alternatives Development phase of this project.

The convey and treat control approach was determined to be technically feasible, but is by far the most costly alternative of the proposed CSO approaches. Therefore, these scenarios are not included in the shortlist of preferred alternatives for the North Beach basin.

End of pipe treatment is the least cost alternative for controlling overflows in the North Beach basin. Additionally, it is considered to be the simplest approach to implement, and if constructed primarily below grade, would have minimal impact on the community. It is recommended that this approach be further evaluated as part of the next phase of this project.

Demand management, including both inflow and infiltration reduction, appears to be technically feasible to control overflows within the North Beach basin. However, it would require an aggressive implementation plan to rehabilitate approximately 70%-80% of the sewer infrastructure within the basin. It is recommended that the costs and feasibility of implementing demand management within the North Beach basin be more fully evaluated to determine the viability of this CSO approach.

5.6.1 Alternative Screening and Recommendations

The three most favorable alternatives for controlling overflows within the North Beach basin (as evaluated by the project team during Workshop 2) are end of pipe treatment (3A), storage (1C), and a combination of storage and I/I reduction (5A).

- End of pipe treatment was ranked most favorably for Cost Effectiveness, Technical Feasibility, Public Health and Environmental Benefits, and Program Compatibility, and (to a lesser degree), Operations and Maintenance Impacts.
- Offsite storage, with treatment at West Point Wastewater Treatment Plant, was ranked most favorably with respect to Technical Feasibility and Flexibility, followed by Public Health and Environmental Benefits.
- The combined scenario of onsite storage and I/I reduction was also ranked highly with respect to Public Health and Environmental Benefits, Program Compatibility, and Technical Feasibility.

The least favorable alternatives are conveyance and treatment (2A, 2B) and offsite storage (1B). Conveyance and treatment was ranked as least favorable due primarily to capital

costs and community impacts. Offsite storage with treatment at Carkeek was ranked poorly due primarily to Operations and Maintenance impacts.

A summary of the rankings for each alternative with respect to the evaluation criteria is provided in Appendix H.

5.6.2 Planning Area Boundary Delineation

Based on the outcome of Workshop No. 2, which identified that the convey and treat control approach was among the least favorable scenarios for the North Beach Basin, the planning boundary for this basin has been established as the actual basin boundary (see Figure 5).

6.0 SUMMARY AND NEXT STEPS

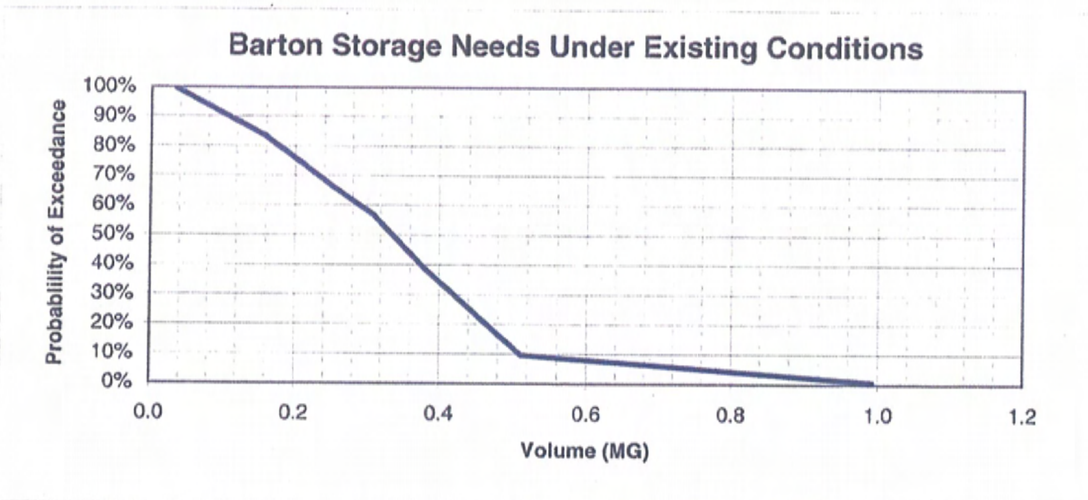
As part of the flow analysis and planning confirmation phases of this project, a short-list of the preferred CSO control alternatives for each basin has been developed. These alternatives are summarized in Table 6.

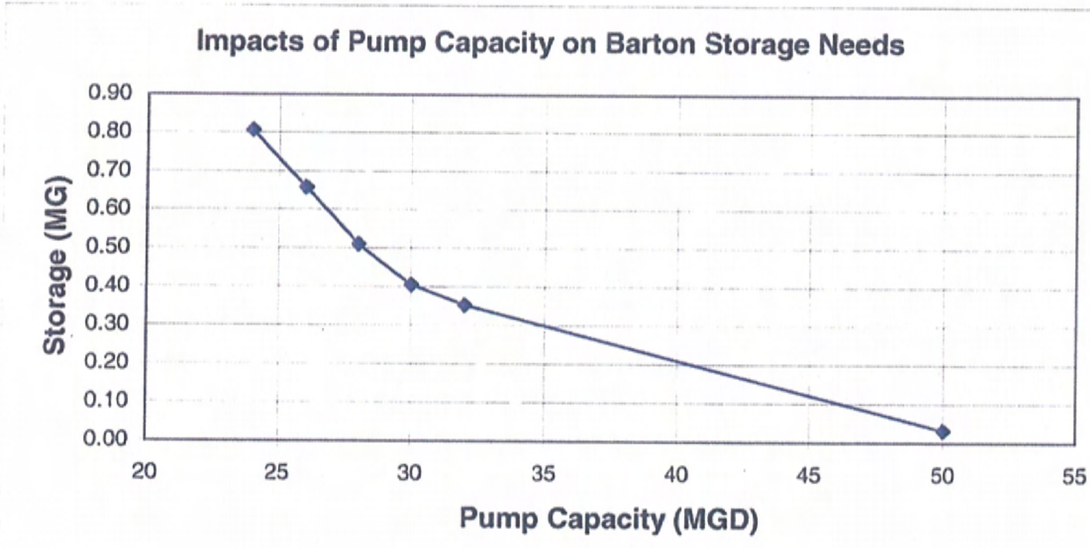
The next steps in the CSO Control project are development of the CSO Facility Selection Criteria (Task X03) and Alternatives Development (Task X05), which will lead to the selection of one preferred CSO control scenario for each of the four basins. Based on the interest in demand management exhibited in Workshop 2, further discussions with King County staff have been scheduled. These meetings may identify the need for additional analysis of demand management, including techniques, costs, and implementation constraints. Once the preferred alternative for each basin has been more fully developed, additional tasks will be conducted, including those relating to environmental services, public involvement (community relations), geotechnical evaluations and land surveys for easement or property acquisition, and development of costs for the preferred alternative.

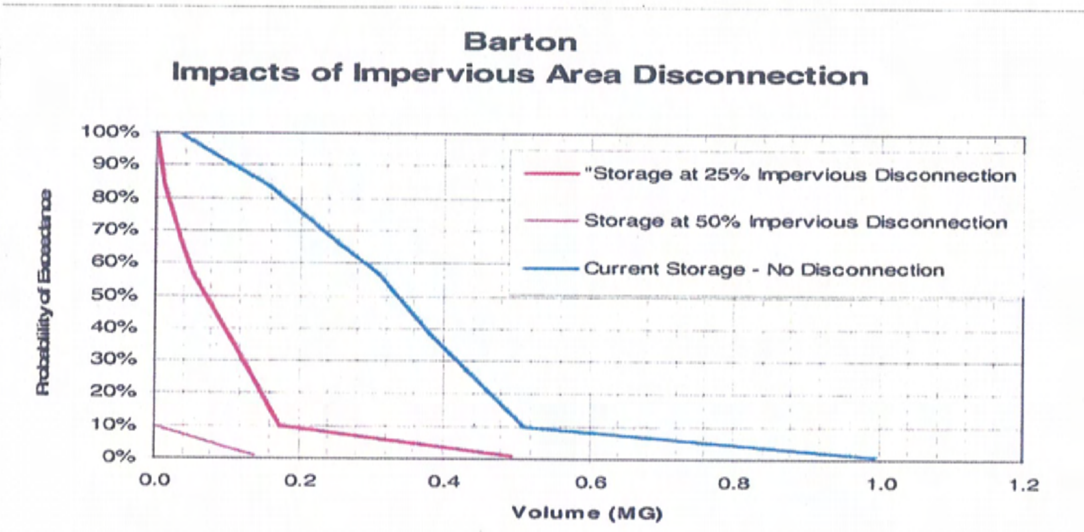
Table 6	Short-List of Preferred Alternatives by Basin CSO Control Approach and Planning Boundaries Barton, Murray, South Magnolia, and North Beach CSO Projects
CSO Control Approach	**Preferred Scenarios**
	Barton and Murray
Storage	B1A-M1B: 0.5 MG storage tank in Barton basin and 1.3 MG storage in Murray basin
Storage / End of Pipe Treatment	B1A-M4B: 0.5 MG storage tank in Barton Basin and 23.5 mgd of end of pipe treatment in Murray Basin
Demand Management / End of Pipe Treatment	B4A-M4B: Disconnection of 70 acres of impervious area in Barton Basin and 23.5 mgd of end of pipe treatment in Murray Basin
Storage / Demand Management	B1A-M3B: 0.5 MG storage tank in Barton basin and disconnection of 40 impervious acres in Murray basin
Demand Management	B4A-M3B: Disconnection of 70 acres of impervious area in Barton basin and 40 acres of impervious area in Murray basin
	South Magnolia
Storage	1C: Offsite storage with treatment at West Point WWTP
	1B: Storage near Control Point
End of Pipe Treatment	3A: HRC/UV at Control Point
	North Beach
Storage	1C: Offsite storage with treatment at West Point WWTP
End of Pipe Treatment	3A: HRC/UV at NBPS site
Combination	5A: Storage and demand management
	5C: End of pipe treatment and demand management

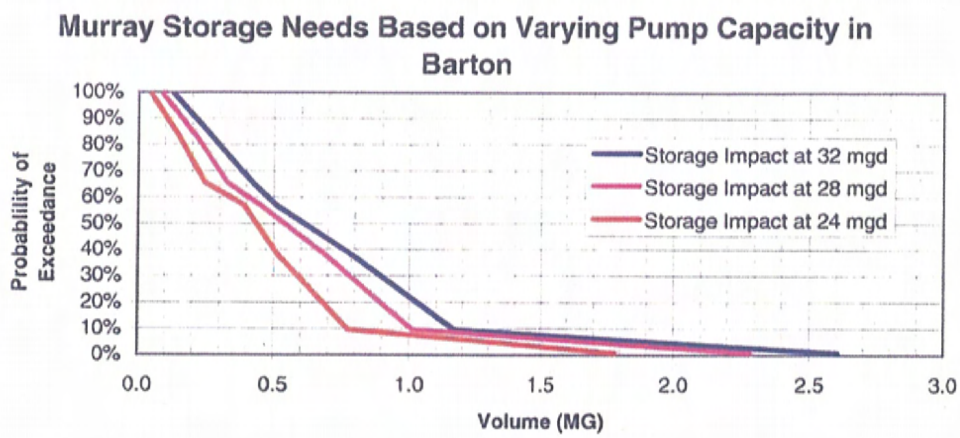
Note: The viability of demand management within the four basins has not yet been fully evaluated. The demand management alternatives included in this short-list are based on the assumption that demand management is determined to be cost effective and is not maintenance intensive. These issues will be more fully developed as part of the Alternatives Development phase of this project.

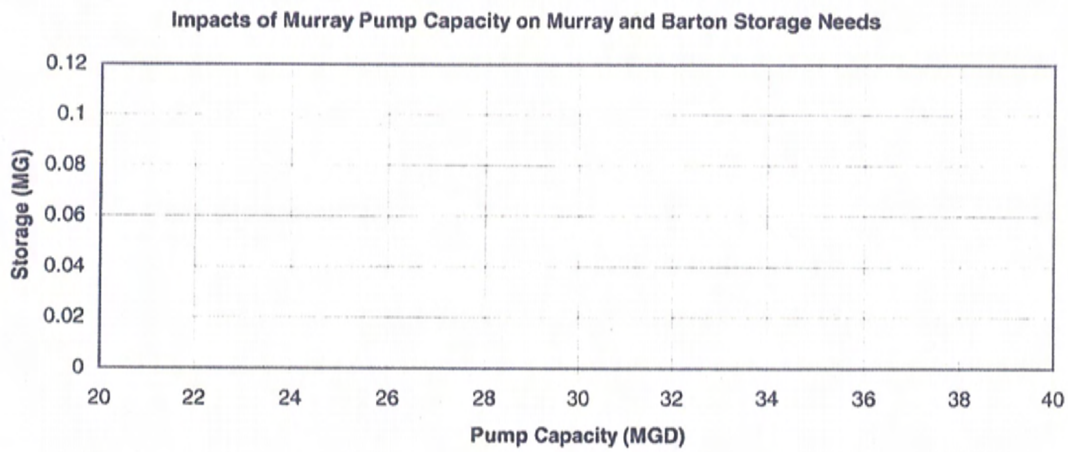
MODELING RESULTS: STORAGE, PUMPING, AND I/I REDUCTION REQUIREMENTS

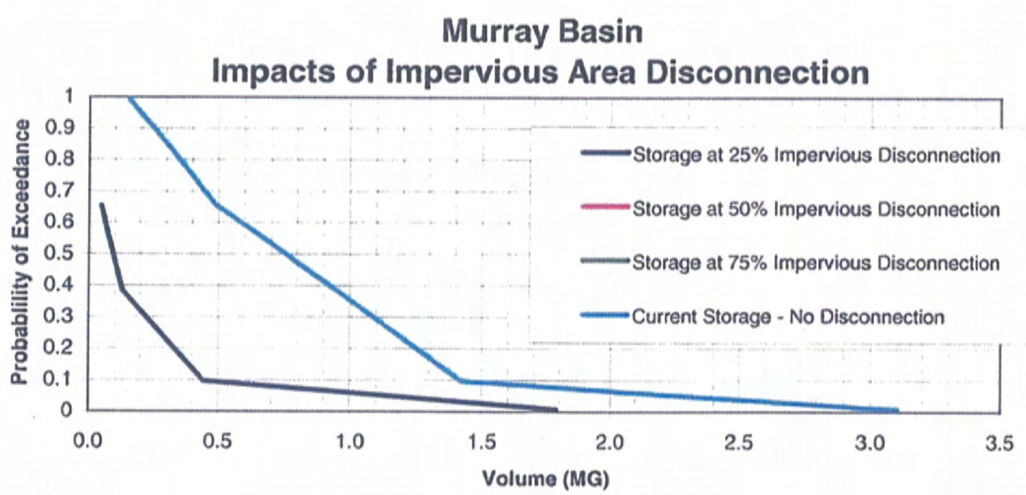

Barton Storage Needs Under Existing Conditions
Probability of Exceedance
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
0.0
0.2
0.4
0.6
0.8
1.0
1.2
Volume (MG)


Impacts of Pump Capacity on Barton Storage Needs
Storage (MG)
0.90
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00
20
25
30
35
40
45
50
55
Pump Capacity (MGD)

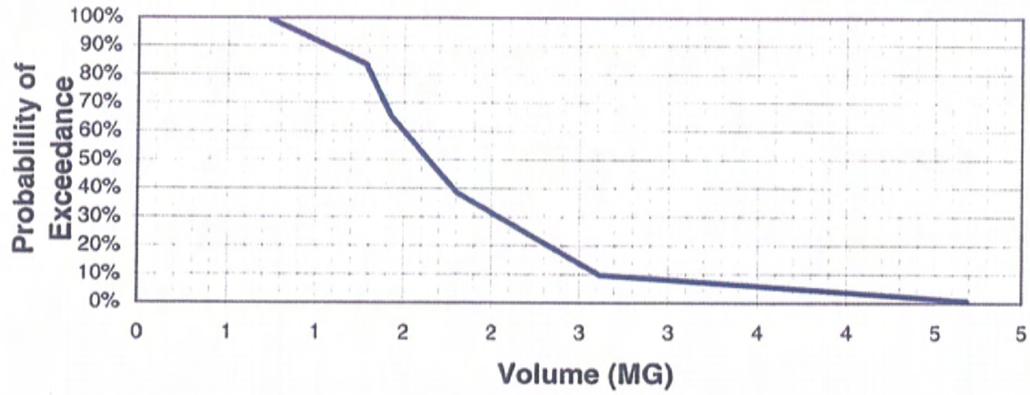

Barton
Impacts of Impervious Area Disconnection
Probability of Exceedance
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
"Storage at 25% Impervious Disconnection
Storage at 50% Impervious Disconnection
Current Storage - No Disconnection
0.0
0.2
0.4
0.6
0.8
1.0
1.2
Volume (MG)


Murray Storage Needs Based on Varying Pump Capacity in Barton
Probabililty of Exceedance
Volume (MG)
Storage Impact at 32 mgd
Storage Impact at 28 mgd
Storage Impact at 24 mgd

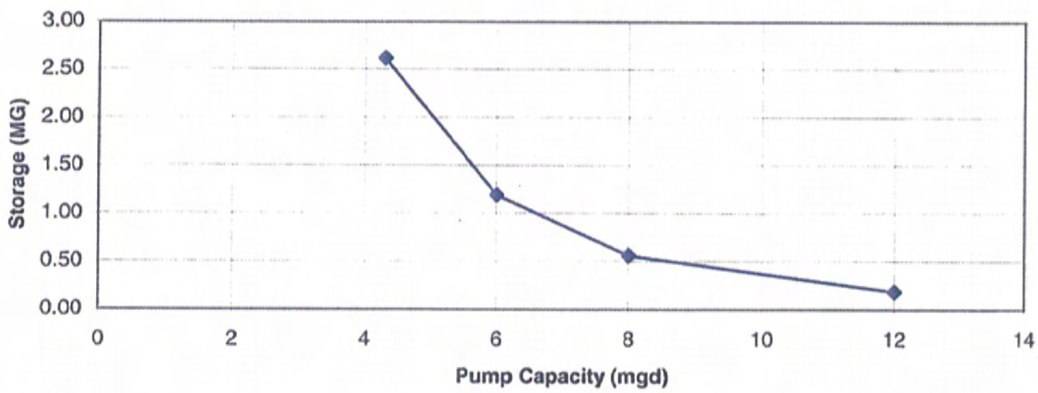

Impacts of Murray Pump Capacity on Murray and Barton Storage Needs
Storage (MG)
Pump Capacity (MGD)


Murray Basin
Impacts of Impervious Area Disconnection
Probabililty of Exceedance
Volume (MG)
Storage at 25% Impervious Disconnection
Storage at 50% Impervious Disconnection
Storage at 75% Impervious Disconnection
Current Storage - No Disconnection

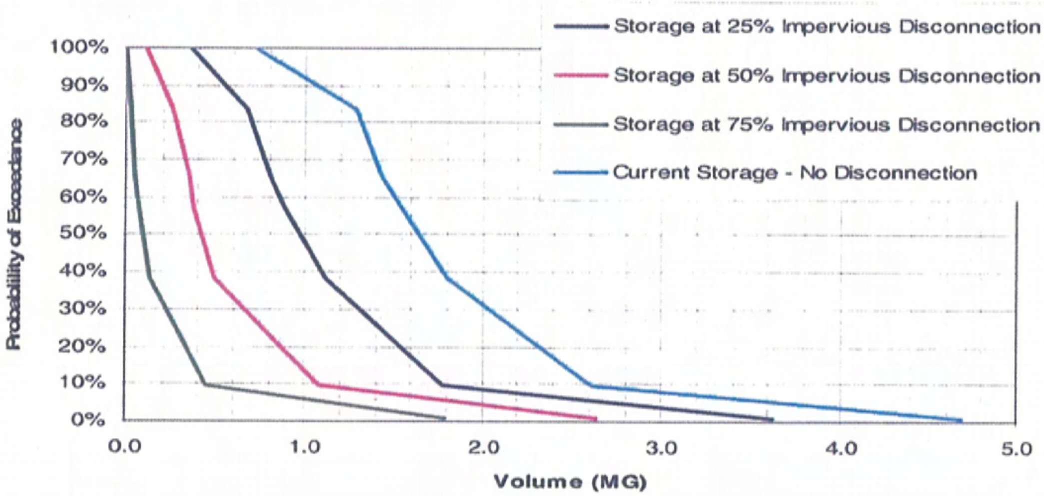
Magnolia Storage Needs Under Existing Conditions

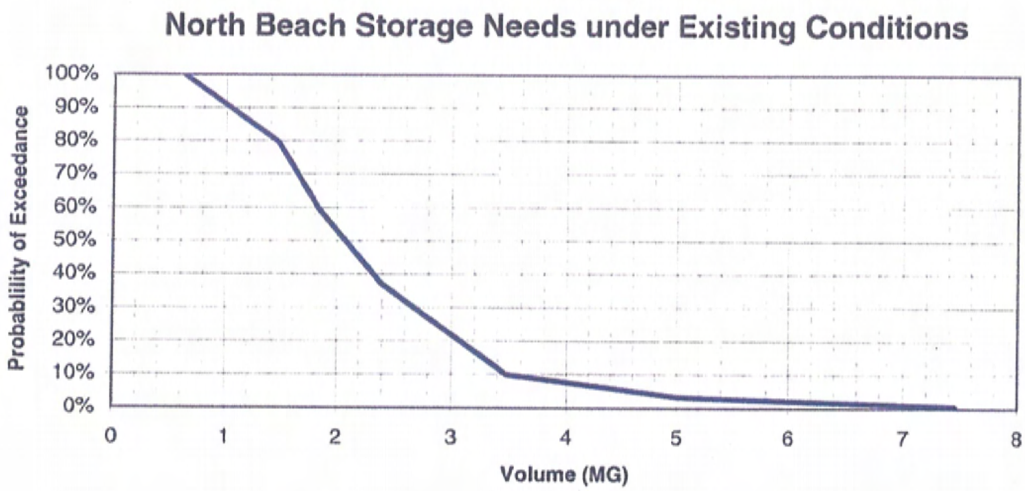


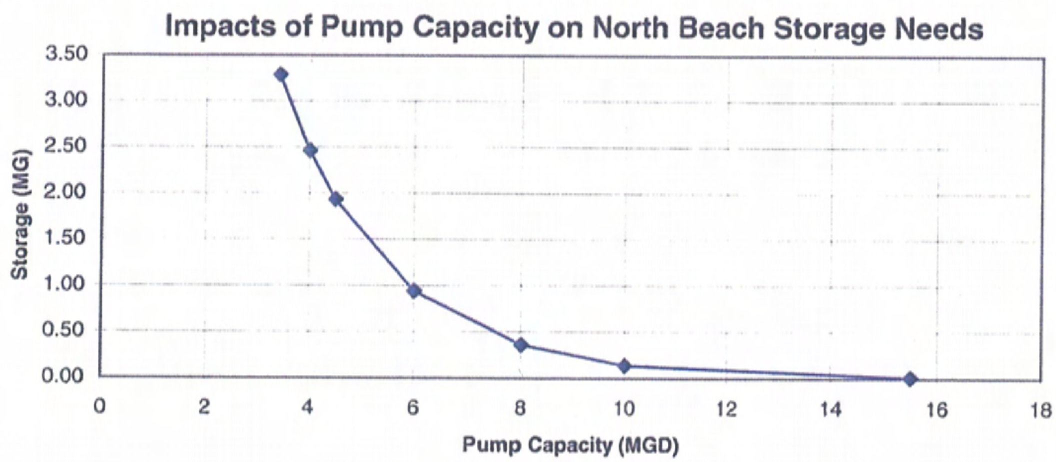
Impact of Pumping on Magnolia Storage Needs

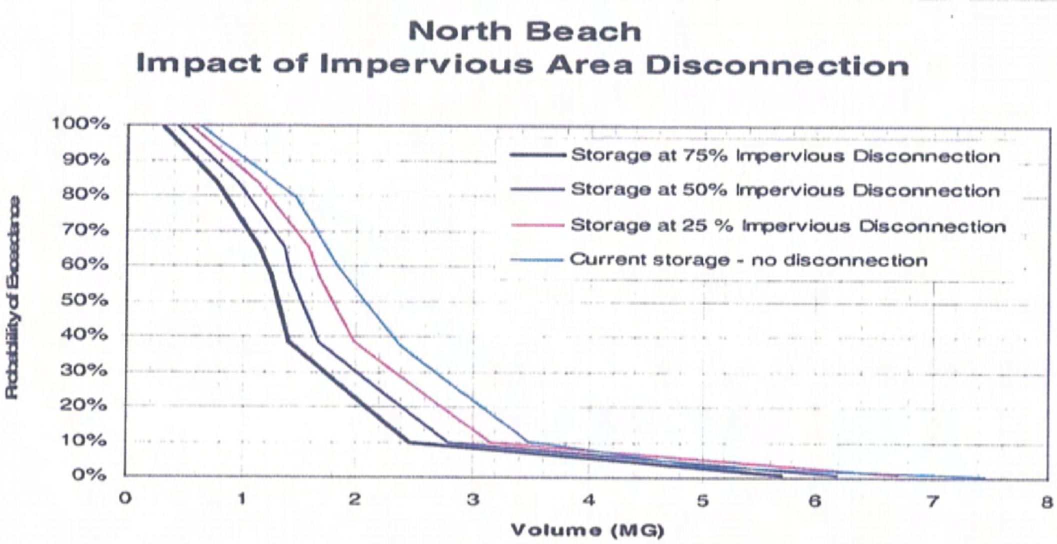


Impact of Impervious Area Disconnection




North Beach Storage Needs under Existing Conditions
Probability of Exceedance
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
0
1
2
3
4
5
6
7
8
Volume (MG)


Impacts of Pump Capacity on North Beach Storage Needs
Storage (MG)
3.50
3.00
2.50
2.00
1.50
1.00
0.50
0.00
0
2
4
6
8
10
12
14
16
18
Pump Capacity (MGD)


North Beach
Impact of Impervious Area Disconnection
Probability of Exceedance
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
0
1
2
3
4
5
6
7
8
Volume (MG)
Storage at 75% Impervious Disconnection
Storage at 50% Impervious Disconnection
Storage at 25 % Impervious Disconnection
Current storage - no disconnection