# BASIS OF PLANNING

This chapter details modeling performed, control approaches considered, and basis of planning criteria established for developing the improvements to control CSOs from the Barton and Murray CSO basins.

Planning criteria were developed based on regulatory requirements for control of CSOs, system modeling, and viable control approaches. This project was initiated to address the following:

- **Revised Code of Washington (RCW) 90.48.480:** This law requires "the greatest reasonable reduction of combined sewer overflows."
- **Washington Administrative Code (WAC) 173-245-020 (22):** This law defines "the greatest reasonable reduction" as control of each CSO so that no more than an average of one untreated discharge may occur per year.

According to these regulatory requirements, CSOs must be controlled to an average of no more than one untreated discharge per year per outfall based on a long-term average.

## 4.1 SYSTEM MODELING

Computer modeling was performed to estimate wastewater flows in the CSO basins and their sub-basins. The software selected, the input data used, and the model calibration and verification processes are described in the following sections.

### 4.1.1 Model Description

King County Wastewater Treatment Division's computer modeling program Runoff/Transport was selected for evaluating flows in the Barton and Murray CSO basins. A second model, the Mike Urban model, was also developed to a preliminary level, but the Runoff/Transport model was then identified as a better model for this project, as described later in this chapter.

The Runoff/Transport model incorporates both a hydrologic and hydraulic model, and simulates base sewer flow and the rainfall/runoff response during rain events. It is customized to the existing physical parameters of the basin and the conveyance system, such as basin area, slope, impervious area, pervious area, and pipe sizes. Actual historical rainfall data is run through the model to compare the output hydrographs with the observed flow data hydrograph. The model is then calibrated (adjusted) until the two hydrographs match. At that point, the model is ready to perform simulations to help determine the volume of wastewater flow that needs to be controlled to achieve CSO limits, either by storage or by diverting flow to prevent it from entering the conveyance system (such as with "green stormwater infrastructure," or GSI, approaches that divert the flow to groundwater).

Three technical reports describing the model development and calibration process for the Barton and Murray Basins are included in Appendix A:

- *Barton Pump Station Service Basin Calibration, King County, January 2009*
- *Murray Pump Station Service Basin Calibration, King County, January 2009*
- *Comparing Modeled Flow Events Against Observed Events: Determining Preferred Model for Estimating CSO Storage Volumes, King County, June 2010*

### 4.1.2 Data

#### 4.1.2.1 Flow Data

Flow data for model setup and calibration came from King County and ADS Environmental Services. King County monitors pump station flows in the basins, and also monitors sewer flows, levels and overflows at select points within the system.

The majority of the county flow data came from meters at the pump stations at the bottom of the basins. For the Murray CSO basin, total basin flow was calculated by subtracting the measured Barton Pump Station discharge flow from the measured Murray Pump Station discharge flow, since flows from both basins enter the Murray Pump Station. The pump stations operate in a fill/draw mode during dry weather.

ADS Environmental Services conducted a flow monitoring survey in 2007/2008 to supplement county data. ADS monitored nine flow meters in the Barton CSO basin and six flow meters in the Murray CSO basin (see Figures 4.1 and 4.2). The meters were deployed from December 2007 through June 2008. The details of the ADS flow-monitoring program are summarized in a report by ADS (ADS, 2008).

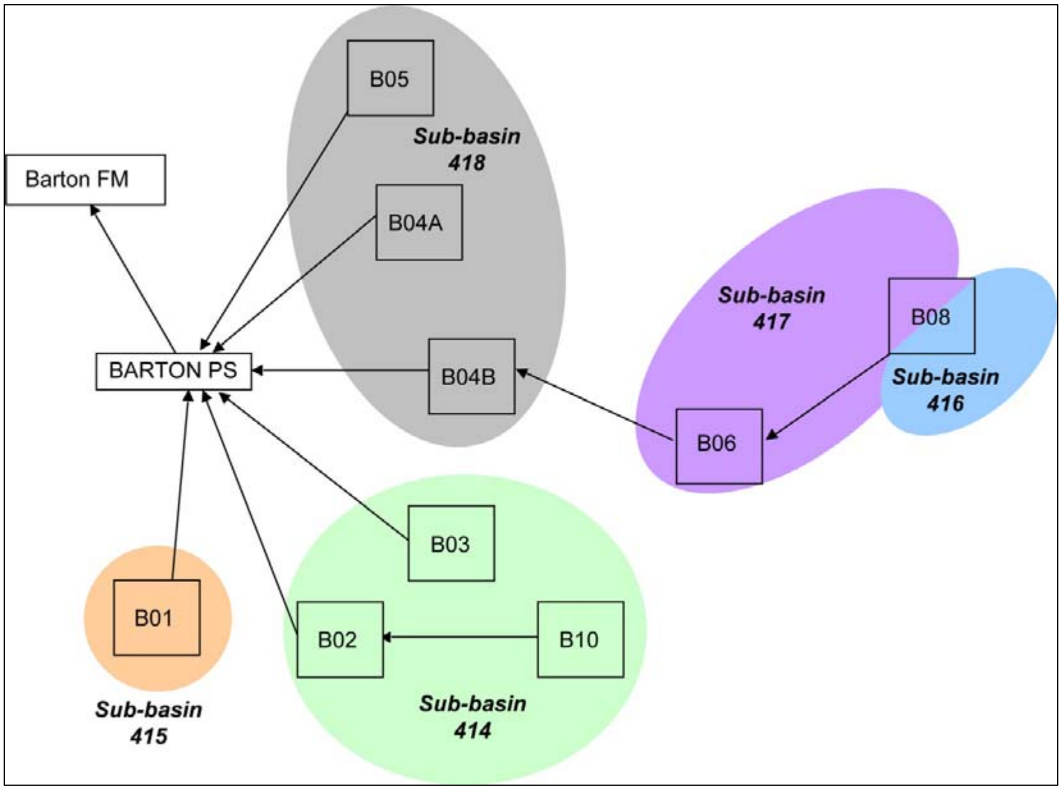



*Figure 4.1 Barton CSO Basin Flow Meter Schematic*

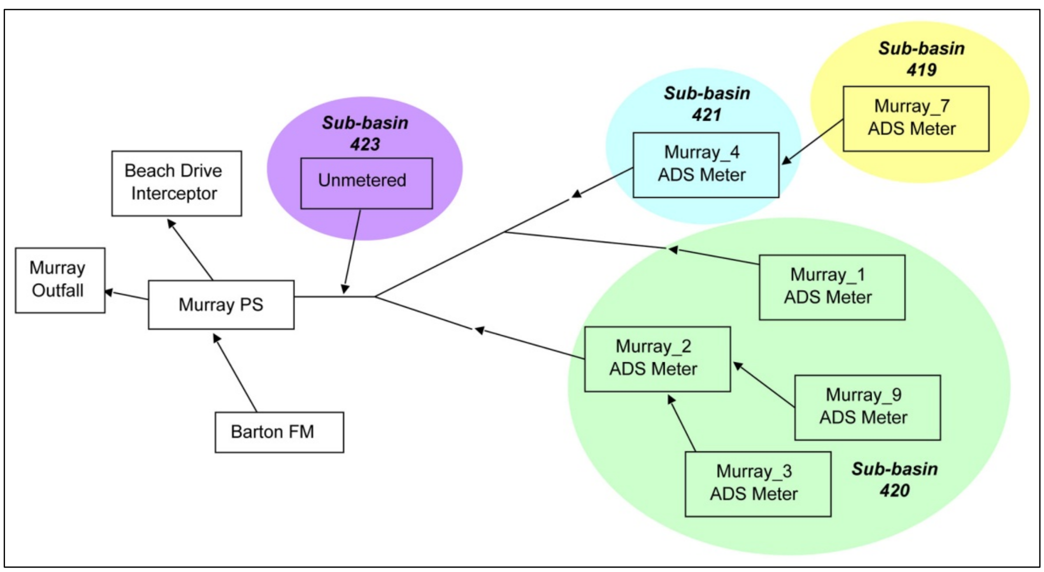



*Figure 4.2 Murray CSO Basin Flow Meter Schematic*

### 4.1.2.2 Rainfall Records

The City of Seattle maintains rain gauges throughout the city. The rain data for the Barton CSO basin was provided from Rain Gauge #5. The model for the Murray CSO basin used rain data from Rain Gauges #5 and #14.

### 4.1.3 Long-Term Simulations

A 30-year time series of precipitation and evaporation data was input to the calibrated hydrologic models to simulate response to 30 years of historical data, which was taken from City of Seattle Rain Gauge #5 and #14. The 30-year simulation produces a time series of flows at the basin outlet, representing base wastewater flow plus rainfall-dependent inflow and infiltration conveyed to the pump stations.

This step was performed with calibrate versions of the Runoff/Transport model and the Mike Urban model. Both models' results for overflow events and overflow durations were compared to historical data. As described in the King County modeling reports in Appendix A, a judgment was made that the Runoff/Transport model had a closer match to the historically recorded number and duration of overflow events. Therefore, it was used for sizing the Barton and Murray CSO facilities.

An upgraded capacity of 33 mgd was assumed for the Barton Pump Station. All peak flows above 33 mgd during the 30-year simulation were marked for analysis. Volumes of the events that exceeded the 33 mgd were ranked by storm event. A list of the resulting overflow volumes and peak flow rates are shown in Tables A-1 and A-2 in Appendix A. For the 30-year simulation, the 30th largest CSO volume was selected as the control volume (i.e., the volume of wastewater flow for which storage, conveyance or diversion capacity must be provided in order to achieve CSO goals).

For the Barton Basin, several storms around the 1-year storm (by volume) were investigated to see which would be the most challenging to control with storage at a mid-basin location rather than at the basin outlet. The November 2, 1984 storm was identified as the most appropriate storm and was used for developing a control strategy for sizing mid-basin storage.

For a green stormwater infrastructure approach that diverts flows to rain gardens in the upper Barton basin, the November 2, 1984 storm also presented the most challenging storm (near a 1-year storm) to control. This is because there was a significant amount of rain on the previous day that would use some of the available rain garden storage. This storm was selected to ensure that a GSI alternative would have a high likelihood of controlling a 1-year CSO event, even if it follows very wet antecedent conditions.

## 4.2 CSO CONTROL APPROACHES

Four broad approaches to controlling overflows were considered during the planning process. A combination of the four broad approaches was assessed as a fifth approach. Development and evaluation of these approaches is described in detail in Chapter 5. The five approaches are summarized below.

### 4.2.1 Control Approach 1—Peak-Flow Storage

The peak-flow storage control approach involves capturing and storing flows that exceed the system's conveyance capacity during precipitation events. Stored flow is pumped back to the combined system for conveyance and treatment at existing facilities following the event. This approach requires new storage tanks, tunnels, or pipes with enough storage volume to achieve the control objective. Tank storage on private property and pipeline storage in the public right of way were considered. Alternatives with a single facility are referred to as centralized storage; alternatives with more than one storage facility are referred to as distributed storage.

Storage could be located anywhere in the basin or out of the basin. It could be at the CSO control location where the flows already are conveyed ("bottom-of-basin"), or it could include a pump station to pump wastewater from the collection system to a storage site elsewhere. The required storage volume varies depending on whether or not the storage facility is located at the bottom of the basin. The sections below describe the effects of locating storage in the mid- or upper basin.

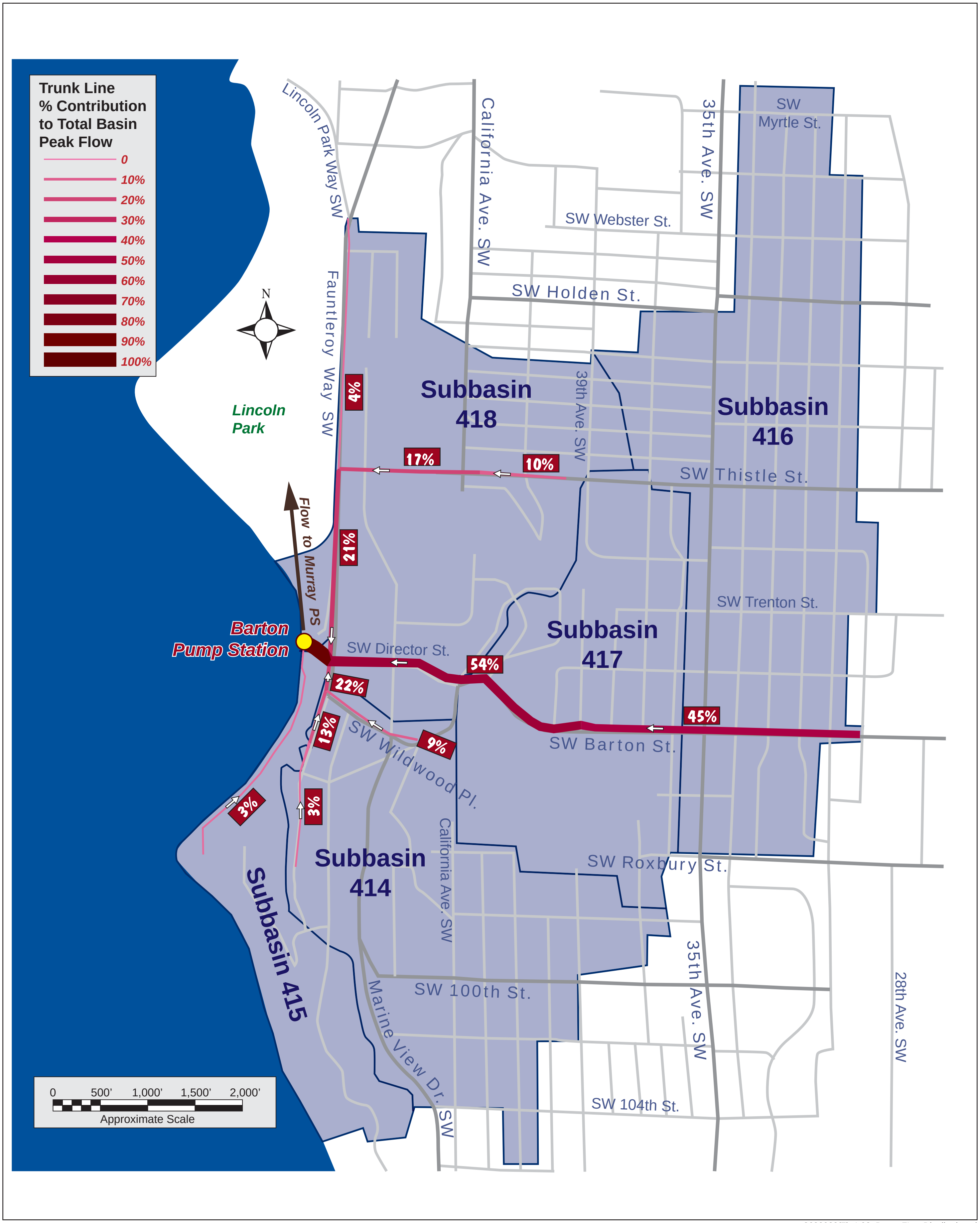
#### 4.2.1.1 Mid- or Upper Basin Storage for Barton CSO Basin

In the Barton CSO basin, flow monitoring showed that individual sub-basin flow contributions account for 3 to 45 percent of the total basin flow and that 54 percent of peak flows come from Sub-basins 416 and 417 (see Figure 4.3). Flows from these sub-basins are routed downstream along SW Barton Street and SW Director Street to the Barton Pump Station. The contribution of flow from these upper sub-basins is sufficient to allow centralized storage in the middle or upper basin to be effective in controlling CSOs.

To determine the storage requirement for a mid-basin storage facility, the November 2, 1984 hydrograph for the Barton CSO basin was disaggregated and scaled by 54 percent to represent the peak flow along Director Street from Sub-basins 416 and 417 (see Figure 4.4). The peak flow along Director Street to control CSOs was then calculated as follows:

- Peak flow during design storm = 47.7 mgd
- Peak flow contribution along Director Street = 54 percent of 47.7 mgd = 25.8 mgd
- Peak flow contribution from all other basins = 47.7 mgd – 25.8 mgd = 21.9 mgd
- Barton Pump Station peak flow capacity = 33 mgd (with planned upgrade)
- Peak flow along Director Street to Control Basin = 33 mgd – 21.9 mgd = 11.1 mgd.

In order to provide control during the peak of the design storm, flow rates along Director Street to the bottom of the basin cannot exceed 11.1 mgd. Thus, all flow along the Director Street sewer above 11.1 mgd must be routed to storage. As shown in Figure 4.4, a line was drawn across the Director Street hydrograph representing 11.1 mgd. The area between this line and the peak-flow hydrograph, representing the required storage volume, was determined to be 0.22 MG. By comparison, a bottom-of-basin storage facility would require a volume equal to the area between the 33-mgd pumping capacity shown on the figure and the uncontrolled basin peak flow, which is roughly half that required mid-basin.




**BARTON AND MURRAY COMBINED SEWER OVERFLOW CONTROL FACILITIES PLAN**

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**Figure 4.3.**
SUB-BASIN FLOW DISTRIBUTION IN BARTON CSO BASIN

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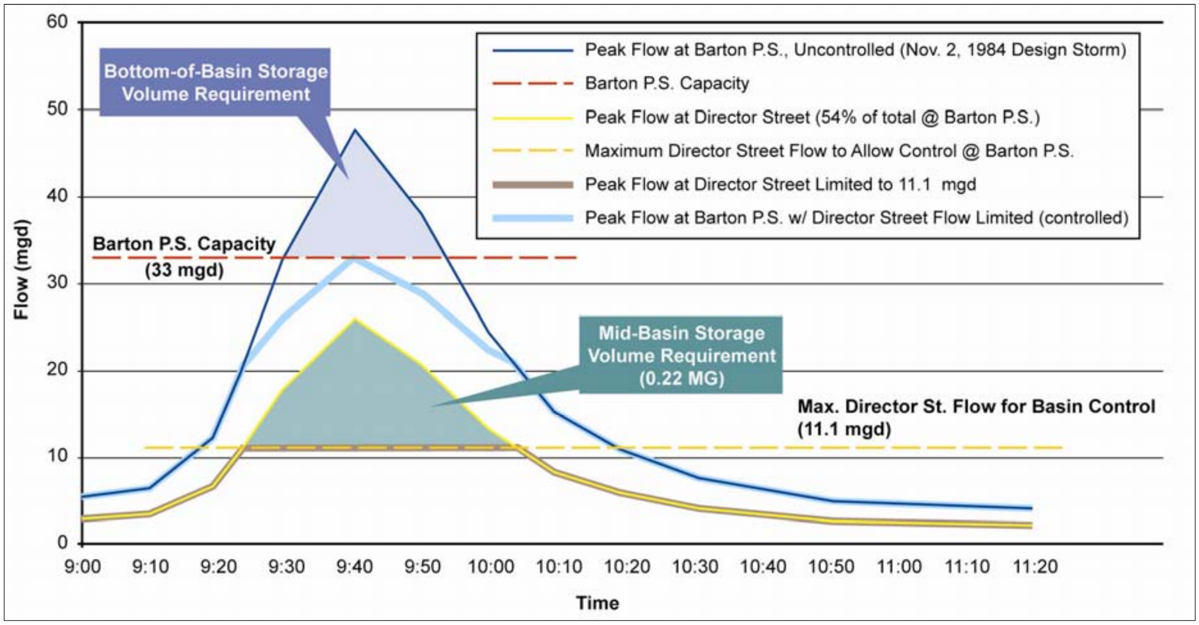



***Figure 4.4 Barton Mid-Basin Storage Calculation for Barton CSO Basin***

#### 4.2.1.2 Mid- or Upper Basin Storage for Murray CSO Basin

In the Murray CSO basin, flow monitoring showed that flow contributions from individual trunk lines account for 4 to 26 percent of the total basin flow (not accounting for the 33 mgd of flow coming into the Murray Pump Station from the Barton Pump Station) (see Figure 4.5). Sub-basin flows converge immediately upstream of the Murray Pump Station.

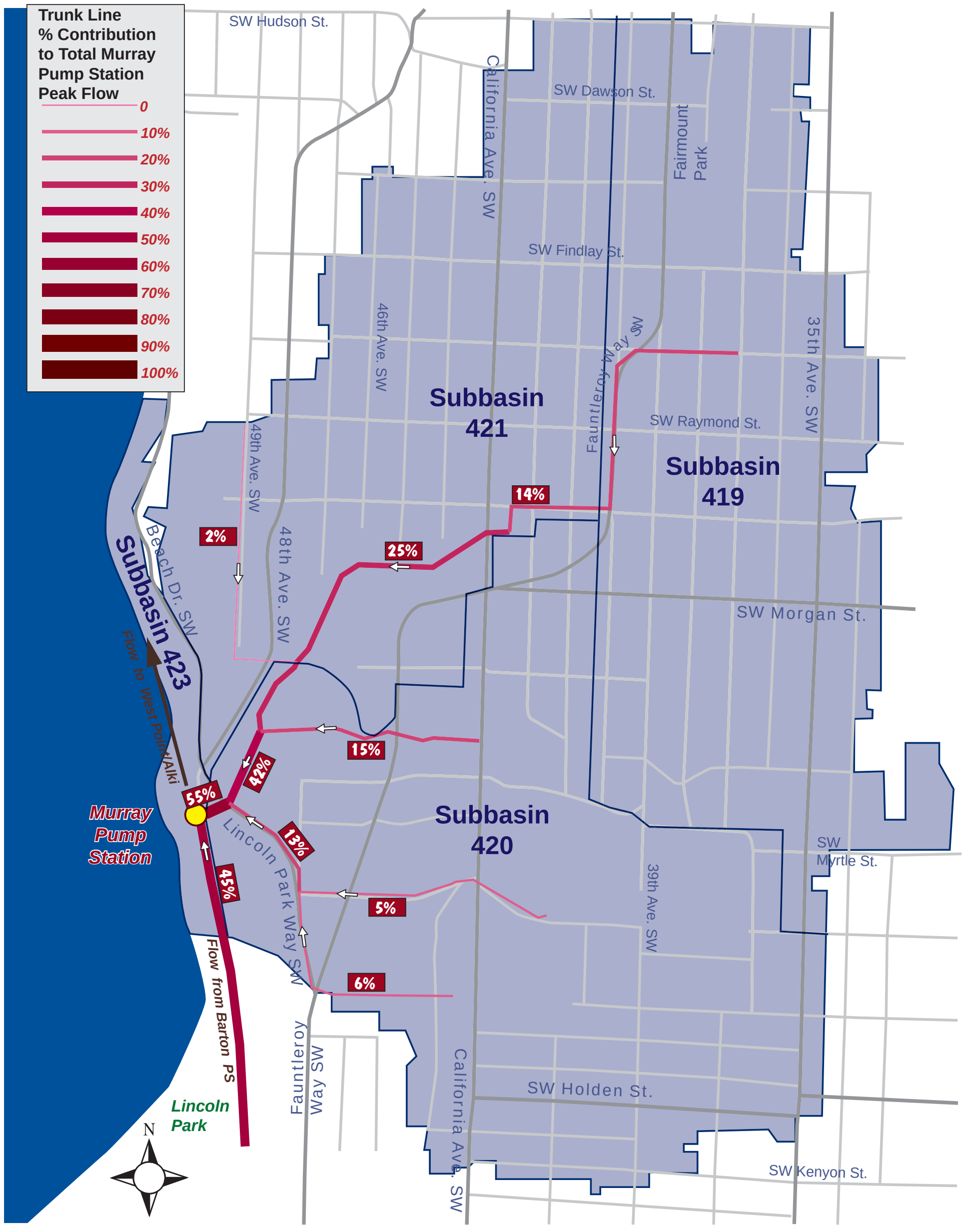
Furthermore, the peak capacity of the Murray Pump Station is 31.5 mgd and the peak flow of the Barton Pump Station will be 33 mgd after a planned capacity upgrade; so some storage volume will be required at the bottom of the basin to accommodate the excess 1.5 mgd of peak flow from the Barton Pump Station.

For all these reasons, centralized mid-basin storage was determined to be infeasible for the Murray CSO basin. For distributed storage, at least one storage facility would have to be located at the bottom of the basin to address the Barton CSO basin flows.

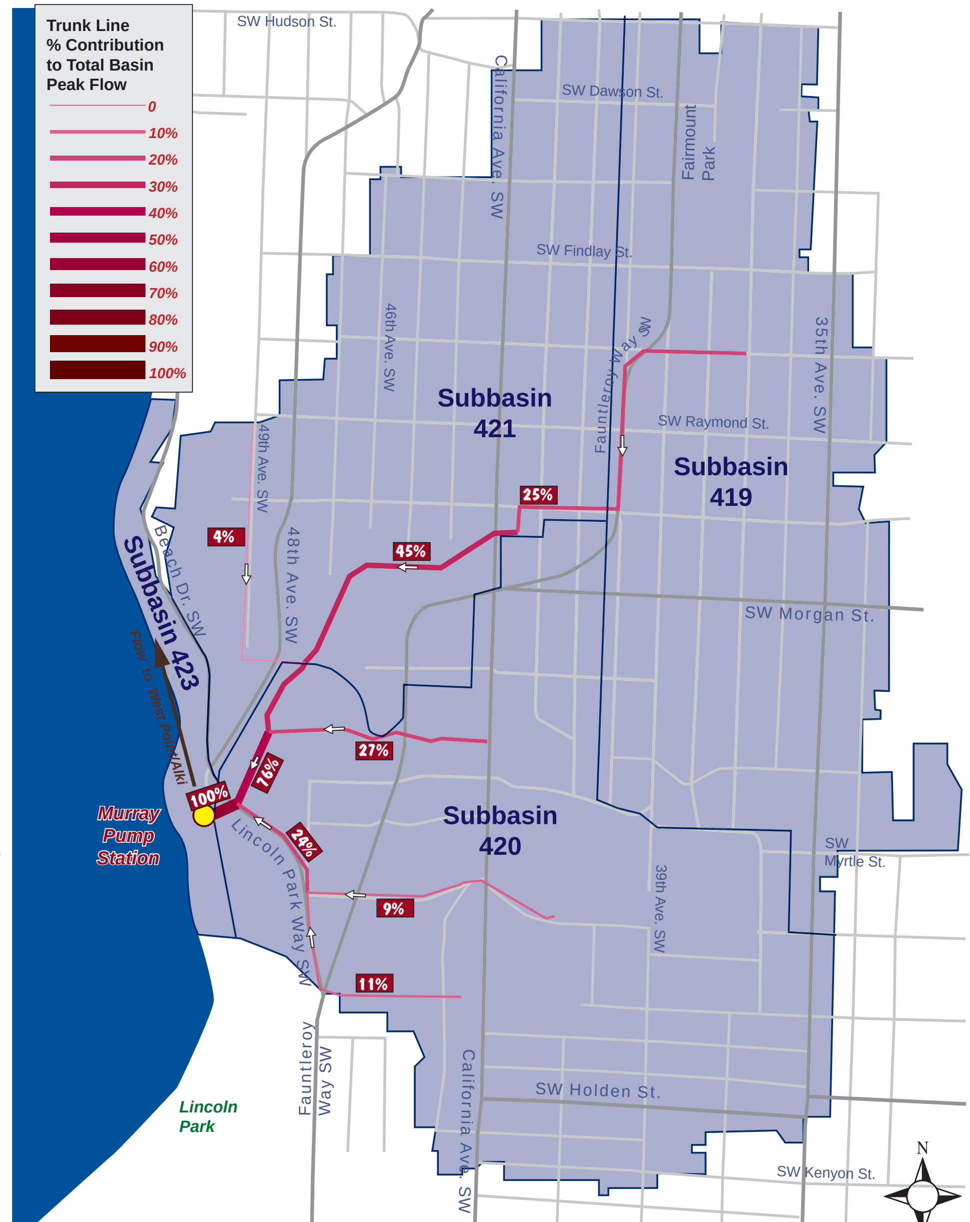
### 4.2.2 Control Approach 2—Convey and Treat

The convey-and-treat control approach involves conveyance of peak flows out of the basins to existing facilities for treatment prior to discharge. This approach may require increasing the capacity of existing facilities for pumping, conveyance or treatment.

For the Barton CSO basin, the convey-and-treat approach involves increasing the capacity of the Barton Pump Station and force main by supplementing or replacing the existing infrastructure. The Murray Pump Station's capacity also would need to be increased by supplementing its capacity or replacing the existing infrastructure.




**Flow as % of Total Flow to Pump Station**




**Flow as % of Total Flow from Basin**

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| BARTON AND MURRAY COMBINED SEWER OVERFLOW CONTROL FACILITIES PLAN<br>DRAFT – February 2011 | **Figure 4.5.**<br>SUB-BASIN FLOW DISTRIBUTION IN MURRAY CSO BASIN |
|---|---|

King County
Department of Natural Resources and Parks
**Wastewater Treatment Division**

The conveyance pipeline downstream from the Murray Pump Station also would need to upgraded, and the Alki Wet-Weather Treatment Facility would need to be expanded to accommodate higher peak flows from these upstream basins.

### 4.2.3 Control Approach 3—End-of-Pipe Treatment

The end-of-pipe treatment control approach involves capturing peak flows in excess of the existing conveyance capacity during precipitation events and treating the flows prior to discharge. This approach requires new treatment facilities, including solids capture and disinfection, at or near the existing CSO location.

End-of-pipe treatment would involve construction of a high-rate clarification and disinfection treatment facility within the basin. Discharge would be through the existing CSO outfall, as the peak rate of discharge would be identical to the existing system.

### 4.2.4 Control Approach 4—Peak Flow Reduction

Peak flow reduction entails reducing basin-wide flow to the combined system during precipitation events to a level that the system is able to convey without exceeding CSO control limits. This is achieved through one or both of the following techniques:

- Green Stormwater Infrastructure—Stormwater is separated from the combined sewer system and routed to facilities such as rain gardens, bio-swales, etc.; or stormwater is infiltrated into the ground through GSI techniques such as permeable pavement. Technical memorandums establishing criteria for GSI are provided in Appendix A.
- Inflow and Infiltration (I/I) Improvements—Inflow improvements involve taking stormwater from impervious areas (e.g., rooftops, roadways, etc.) that currently goes to the combined sewer system and re-routing it to new or existing storm sewer pipes and outfalls. Infiltration improvements involve rehabilitating sewer laterals and mains to eliminate stormwater/groundwater infiltration into the sewer system.

### 4.2.5 Control Approach 5—Combined Approach

A combined approach involves using any of the above CSO control approaches together to minimize impacts and costs (e.g., I/I improvements to reduce the required volume of storage at the bottom of the basin).

## 4.3 BASIS OF PLANNING CRITERIA

Table 4.1 summarizes the basis of planning criteria for the Barton and Murray CSO basins resulting from the long-term simulation to meet these regulatory requirements.

**Table 4.1 Basis of Planning Criteria for Barton and Murray CSO Basins**

| | Barton | Murray |
|---|---|---|
| Required Capacity at Peak Flow | 45 mgd(4) | 60 mgd(4) |
| Existing Capacity | 33 mgd(1) | 31.5 mgd |
| | ***Required Volume or Capacity*** (4) | |
| Storage Control Approach at Bottom of Basin | 0.11 MG(4) | 1.0 MG(4) |
| Storage Control Approach at Mid-Basin | 0.22 MG(4) | N/A |
| Convey and Treat Control Approach | 12 mgd(2) | 28.5 mgd(2) |
| End of Pipe Treatment Control Approach | 12 mgd(2) | 28.5 mgd(2) |
| Peak Flow Reduction Control Approach – Impervious Disconnection | 20%(3) | >75%(3) |
| Peak Flow Reduction Control Approach – Green Stormwater Infrastructure | Peak flow reduction of 14.6 mgd(4) | N/A |

Notes:
1. Based on planned upgrade to Barton Pump Station
2. Required capacity is the difference between "required capacity at peak flow" and "existing capacity."
3. Represents the percentage of impervious surface currently connected to the combined sewer system in the basin that must be disconnected to eliminate the need for storage.
4. Capacity and storage requirement based on November 2, 1984 storm and will meet state criteria of one overflow per year.

**REFERENCES:**

ADS. 2008. ADS Environmental Services, Temporary Flow Monitoring Report.
SvR, 2010. SvR Design Company, Summary of Technical Memorandums and SvR Recommendations, GSI Planning and Analysis Confirmation, June 30, 2010.