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PROJECT MEMORANDUM

Project Name:	BMMNB CSO Beaches Project	**Date:**	May18, 2010
Client:	King County DNRP, Wastewater Treatment Division	**Project Number:**	7562A.10
Prepared By:	Karl Hadler		
Reviewed By:	Erica Jacobs (King County)		
Subject:	North Beach Inflow and Infiltration Alternative Analysis		
Distribution:	King County, Project Team		

1.0 INTRODUCTION AND BACKGROUND

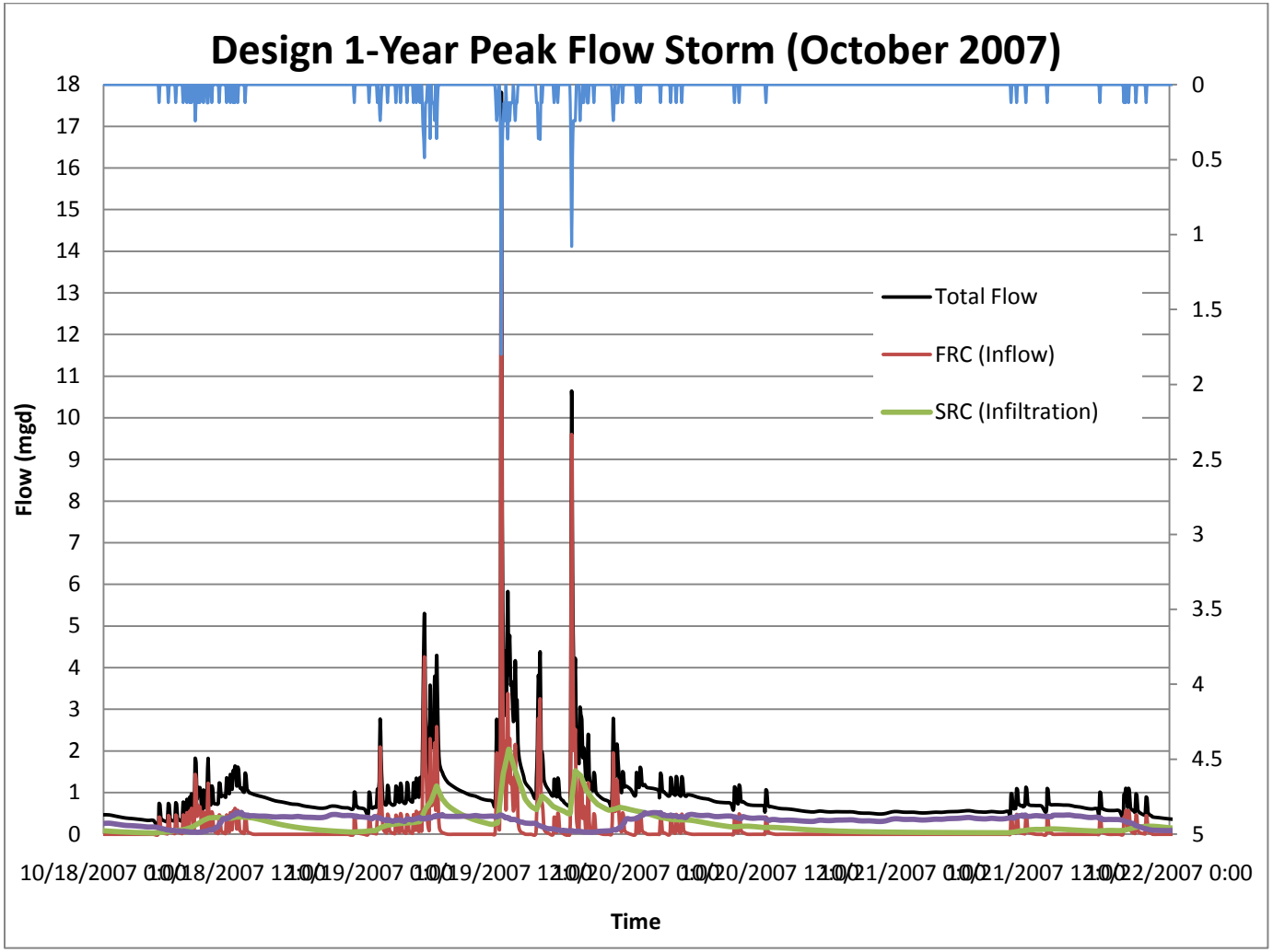
This project memorandum (PM) summarizes the results of a preliminary analysis performed on disconnecting roof connections (inflow) and repairing side sewers/laterals (infiltration) in the North Beach Basin.

2.0 BASIS OF ESTIMATE AND METHODS

The North Beach hydraulic model was used to determine the amount of infiltration and inflow in each basin. A 1-year storm from October 2007, identified by King County as a design storm, was used to generate the storm flow volumes. Figure 1 shows the total flow, inflow (FRC), infiltration (SRC), and sanitary flow to the North Beach Pump Station during this storm.

Table 1 summarizes the assumptions used in the cost analysis. If I/I improvements are recommended as the proposed alternative for environmental review, more detailed investigations (sewer system evaluation survey (SSES)) will be conducted to refine these assumptions and gain pre-design level information.

The North Beach I/I Reduction Benefit-Cost Analysis (July 2007) report estimated 4% of the homes had roof drains connected to the sewer system. The CSO Beach Project GIS Analysis (September 2008) indicated 13% of the homes had roof drains connected. This analysis assumed 13% of houses are connected. Disconnecting a maximum of 75% of those connected homes is assumed to account for potential issues associated with disconnection such as technical feasibility, homeowner willingness, etc.



DESIGN 1 YEAR STORM FLOWS (OCTOBER 2007)

FIGURE 1

KING COUNTY DNRP, WASTEWATER TREATMENT DIVISION
BMMNB CSO BEACHES PROJECT

carollo

PATH AND FILE NAME

Table 1	**Cost Analysis Assumptions BMMNB CSO Beaches Project King County DNRP, Wastewater Treatment Division**	
Number of Homes in Sub-basin	NB01-274; NB02-676; NB03-310; NB04-667; NB05-461	
	Inflow	**Infiltration**
Percent of Homes Repaired	13% (2)	63% (1)
Repair Effectiveness (1)	100%	75%
I/I Reduction Cost	$3,300/home (3)	Easy - $10,000/home (4) Medium - $12,000/home (4) Hard - $17,000/home (4)
Percent of Homes per Repair Category	N/A	Easy - 33% Medium - 33% Hard - 33%

Notes:

(1) Based on 95% of "easy" and "medium" homes consistent with the Initial Infiltration and Inflow Reduction Project Alternative Analysis Report (April 2009).

(2) Based on the CSO Beach Project GIS Analysis (September 2008).

(3) Based on North Beach I/I Reduction Benefit/Cost Analysis (July 2007).

(4) From Initial Infiltration and Inflow Reduction Project Alternatives Analysis Report (April 2009).

It is assumed that 63% of side sewers are repaired for infiltration. In the Initial Infiltration and Inflow Reduction Project Alternative Analysis Report (April 2009) the County estimated they could repair side sewers on the "easy" and "medium" homes (67%). The "hard" homes would have significant landscaping, topography, or other issues making side sewer repair infeasible or cost prohibitive. Of the "easy" and "medium" homes, the Initial Infiltration and Inflow Reduction Project Alternative Analysis Report (April 2009) assumes the county could obtain right of entry agreements with 95% of the homeowners.

Any repairs made to the side sewers/laterals will not completely eliminate infiltration in that location. The I/I Reduction Feasibility Evaluation for Alternatives Analysis (November 2009) estimated a range for side sewer/lateral repair effectiveness. The range assumes that between 60% and 75% of the infiltration will be eliminated in that particular location by the repair efforts. This analysis assumes 75% repair effectiveness.

The cost to disconnect roof drains was given in the North Beach I/I Reduction Benefit-Cost Analysis (July 2007) as $3,000 per roof in 2003 dollars. Using the Engineering New Record Construction Cost Indices (ENR CCI) the cost has been escalated to 2010 dollars for a cost of $3,300 per roof. These costs do not include contingency, project costs, or other miscellaneous costs associated with construction. This estimate does not include conveyance or treatment of roof runoff, which would increase the costs substantially.

The cost to repair a side sewer/lateral varies depending upon how easy or difficult it is to access the pipe. The Initial Infiltration and Inflow Reduction Project Alternatives Analysis Report (April 2009) for Eastgate, Issaquah, and Skyway divided the ease of access and construction between three categories: “Easy”, “Medium”, and “Hard”. The report also estimated the costs for each category as follows:

- Easy - $10,000/home
- Medium - $12,000/home
- Hard - $17,000/home

These costs are construction costs only in February 2010 dollars. These costs do not include contingency, project costs, or other miscellaneous costs associated with construction. It is assumed that the homes in the North Beach Basin will be evenly split between the three categories.

Table 2 summarizes the estimated construction costs for a storage tank in the North Beach basin.

Table 2 Proposed Storage Tank Estimated Construction Costs
BMMNB CSO Beaches Project
King County DNRP, Wastewater Treatment Division

Storage Tank Volume (Gallons)	230,000
Storage Tank Construction Cost ($/gallon)	$10.00 (1)
Storage Tank Construction Cost	$2,300,000
Storage Tank Project Cost(2)	~$7,000,000

Notes:

(1) From Cost Curves developed for Barton, Murray, Magnolia, and North Beach CSO Project Alternatives Development Documentation Alternatives Basis of Cost and Cost Estimates (December 2009).

(2) Project cost includes dewatering, street restoration, shoring, site access (20%), allied costs (30%) and contingency (50%).

The required storage volume has been estimated at 230,000 gallons. In Barton, Murray, South Magnolia and North Beach CSO Project Alternatives Development Documentation Alternatives Basis of Cost and Cost Estimates (December 2009), cost curves were developed using King County’s TABULA cost estimating tool. These curves give storage tank construction costs ($/gallon) based on the size of the storage facility. For the size of facility proposed here, the construction cost has been estimated at $10 per gallon. In comparison, construction costs for a 50,000 gallon storage tank has been estimated at $20 per gallon. These costs do not include contingency, project costs, or other miscellaneous costs associated with construction of the storage tank.

3.0 INFLOW AND INFILTRATION REDUCTION CALCULATIONS

Potential inflow reduction calculations are shown in Table 3.

Table 3 Estimated Reduction in Inflow Based on Flow Rate Design Criteria
BMMNB CSO Beaches Project
King County DNRP, Wastewater Treatment Division

	Units	SUB-BASIN					Total
		NB01	NB02	NB03	NB04	NB05	
Peak Storm Inflow Rate(1)	mgd	1.23	1.04	1.48	1.65	0.50	5.90
Number of Homes in Sub-Basin	No.	274	676	310	667	461	2388
Percentage of Homes Connected(2)	%	24	8	25	13	6	13
Number of Homes Connected(3)	No.	64	55	78	87	26	310
Inflow Rate per Connected Home	gal/day	19,000	19,000	19,000	19,000	19,000	19,000 (avg.)
Percentage of Homes Disconnected	%	75	75	75	75	75	75
Number of Homes Disconnected	No.	48	41	59	65	20	233
Repair Effectiveness Factor(4)	%	100	100	100	100	100	100
Inflow Reduction with Repair Effectiveness Factor	mgd	0.92	0.78	1.11	1.23	0.38	4.42

Notes:
(1) From Carollo Hydraulic model for November 2001 storm.
(2) Total based on GIS analysis. Percent connected in sub-basin based on estimate of number of homes connected.
(3) Homes connected in sub-basin calculated based on peak storm inflow rate divided by average inflow rate per connected home.
(4) From I/I Reduction Feasibility Evaluation for Alternatives Analysis (November 2009).

Table 3 provides the estimated reduction in inflow based on flow rate. To eliminate storage, on-site treatment or convey and treat requirements for North Beach CSOs, inflow and infiltration need to be reduced by 5.5 mgd. This is the flow rate over and above the capacity of the North Beach Pump Station (3.0 mgd). The calculations assume 13% of homes are connected and averages the inflow rate per connected home over the sub-basins to estimate the number of homes connected in each sub-basin. The calculations also assume disconnection of 75% of those homes and effectively eliminating 100% of the inflow from the disconnected homes. The inflow reduction for the entire basin is estimated to be 4.42 mgd or approximately 80% of the required flow rate reduction.

Potential infiltration reduction calculations are shown in Table 4.

Table 4 provides the estimated reduction in infiltration based on flow rate. To eliminate storage, on-site treatment or convey and treat requirements for North Beach CSOs, inflow and infiltration need to be reduced by 5.5 mgd. This is the flow rate over and above the capacity of the North Beach Pump Station (3.0 mgd). The calculations assume 63% of homes in the basin/sub-basin are repaired and 75% of the infiltration from those homes is eliminated. The infiltration reduction for the entire basin is estimated to be 1.51 mgd or approximately 27% of the required flow rate reduction. Since inflow would be the first priority, only 1.1 mgd of the total potential infiltration reduction would be required to eliminate storage.

4.0 INFLOW AND INFILTRATION REDUCTION UNIT COSTS

Potential inflow and infiltration reduction volumes and unit costs are summarized in Table 5 and 6.

Table 5 shows the potential inflow reduction rates from Table 3. Inflow reduction project costs are based on the unit cost of $3,300 per home disconnected. The approximate volume reduction from complete inflow reduction is 185,000 gallons. Therefore, approximately 45,000 gallons of storage or infiltration improvements would be required even with inflow reduction throughout the North Beach Basin. The unit costs for inflow reduction range from $2.17 per gallon to $9.25 per gallon. The average unit cost is $4.16 per gallon. This is lower than the unit cost of $10.00 per gallon of storage shown in Table 2, however, the unit costs for inflow reduction do not include potential requirements for stormwater collection and treatment, project costs, or contingency.

Table 4 Estimated Reduction in Infiltration Based on Flow Rate Design Criteria
BMMNB CSO Beaches Project
King County DNRP, Wastewater Treatment Division

	Units	SUB-BASIN					Total
		NB01	NB02	NB03	NB04	NB05	
Peak Storm Infiltration Rate(1)	mgd	0.40	0.82	0.87	0.67	0.42	3.19
Number of Homes in Sub-Basin	No.	274	676	310	667	461	2388
Infiltration Rate per Home	gal/day	1472	1218	2818	1007	911	1335 (avg.)
Percentage of Homes Repaired(2)	%	63	63	63	63	63	63
Number of Homes Repaired	No.	173	426	195	420	290	1504
Repair Effectiveness Factor(2)	%	75	75	75	75	75	75
Infiltration Reduction with Repair Effectiveness Factor	mgd	0.19	0.39	0.41	0.32	0.20	1.51

Notes:
(1) From Carollo Hydraulic model for November 2001 storm.
(2) From I/I Reduction Feasibility Evaluation for Alternatives Analysis (November 2009).

Table 5 Inflow Reduction Volumes and Costs
BMMNB CSO Beaches Project
King County DNRP, Wastewater Treatment Division

	Units	SUB-BASIN					Total
		NB01	NB02	NB03	NB04	NB05	
Inflow Reduction with Repair Effectiveness Factor	mgd	0.92	0.78	1.11	1.23	0.38	4.42
Inflow Construction Cost(1)	$	158,000	135,000	195,000	215,000	66,000	769,000
Percent Reduction in Storage Volume Based on Complete Inflow Reduction in Sub-basin(2)	%	17	14	20	22	7	80
Approximate Volume Reduction Based on Complete Inflow Reduction in Sub-basin	gal	38,000	33,000	46,000	52,000	16,000	185,000
Inflow Reduction Unit Cost	$/gal	2.32	6.61	2.17	4.13	9.25	4.16

Notes:
(1) Based on an average of $3,300 per home repair.
(2) Based on design requirement to eliminate 5.5 mgd of flow for elimination of storage.

Table 6 Infiltration Reduction Volumes and Costs
BMMNB CSO Beaches Project
King County DNRP, Wastewater Treatment Division

	Units	SUB-BASIN					Total
		NB01	NB02	NB03	NB04	NB05	
Infiltration Reduction with Repair Effectiveness Factor	mgd	0.19	0.39	0.41	0.32	0.20	1.51
Infiltration Construction Cost(1)	$	2,250,000	5,540,000	2,540,000	5,460,000	3,770,000	19,550,000
Percent Reduction in Storage Volume Based on Complete Infiltration Reduction in Sub-basin(2)	%	3	7	7	6	4	27
Approximate Volume Reduction Based on Complete Infiltration Reduction in Sub-basin	gal	7,000	16,000	16,000	14,000	9,000	62,000
Infiltration Reduction Unit Cost	$/gal	321	346	159	390	419	315

Notes:
(1) Based on $13,000 per home disconnected.
(2) Based on design requirement to eliminate 5.5 mgd of flow for elimination of storage.

Table 6 shows the potential infiltration reduction rates from Table 4. Infiltration reduction project costs are based on the unit costs in Table 1 with an average cost of $13,000 per home repaired. The approximate volume reduction from complete infiltration reduction is 62,000 gallons. Therefore, approximately 168,000 gallons of storage or inflow improvements would be required even with infiltration reduction throughout the North Beach Basin. The unit costs for infiltration reduction range from $159 per gallon to $419 per gallon. The average unit cost is $315 per gallon. This is significantly higher than the unit cost of $10.00 per gallon of storage shown in Table 2. In addition, the unit costs for infiltration reduction do not include potential requirements for stormwater collection and treatment, project costs, or contingency.

5.0 CONCLUSIONS

Since inflow reduction unit costs are significantly lower than infiltration reduction, full inflow reduction would be the primary focus. Even with inflow reduction throughout the basin, approximately 45,000 gallons of storage, green stormwater infrastructure or infiltration improvements would be required.

Requirements for stormwater collection and treatment should be considered if this alternative moves forward. Additional water percolating into the ground may exacerbate landslide issues within the basin considering the steep slopes and high groundwater table within certain areas of the North Beach Basin. Stormwater collection and treatment would impact the costs significantly and add to the risk and cost variability of inflow and infiltration improvements within the North Beach Basin.

5.1 Inflow Improvements with Bottom of the Basin Storage

A 45,000 gallon storage tank would be required to supplement inflow improvements. The cost for the project elements would be approximately $19 million (Inflow - $769,000; Storage - $1,130,000). Including miscellaneous items, allied costs and contingency, the total construction cost is approximately $5.7 million (not including stormwater collection infrastructure). If stormwater collection were required, the total construction costs could be as high as $46.6 million to include storm sewers, and street upgrades. Refer to the Alternative Development Documentation Basis of Cost/Cost Estimates for more information on how these costs were developed.

The need for a complete stormwater system should be evaluated if this option moves forward. While the scope of requirements may be reduced, the range of costs indicate the high degree of variability and risk associated with this option.

5.2 Inflow Improvements with Green Stormwater Infrastructure (GSI)

Green Stormwater Infrastructure (GSI) was evaluated separately and not recommended in the North Beach Basin for a number of reasons. Refer to TM 600.5 – Demand Management Analysis (May 2010).

5.3 Inflow Improvements with Infiltration Improvements

Sub-basin NB03 (Blue Ridge) has the lowest unit cost for infiltration reduction but may require additional stormwater collection and treatment improvements. Sub-basin NB02 (Olympic Manor) has a higher unit cost for infiltration reduction. However, this sub-basin has an existing stormwater collection system and would be the next area of priority for infiltration reduction following Sub-basin NB03. NB01 and NB04 would be the next areas of priority based on unit costs.

Approximately 75% of the potential infiltration improvements would be required to supplement inflow improvements. The cost for the project elements would be approximately $15 million (Inflow - $769,000; Infiltration - $14,200,000). Including miscellaneous items, allied costs and contingency, the total construction cost is approximately $32.4 million (not including stormwater collection infrastructure). If stormwater collection were required, the total construction costs could be as high as $73.3 million to include storm sewers, and street upgrades. Refer to the Alternative Development Documentation Basis of Cost/Cost Estimates for more information on how these costs were developed.

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