CSS Long Term Control Plan Update

Infrastructure Sizing Analysis

City of Alexandria
Department of Transportation and Environmental Services

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GREELEY AND HANSEN

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Executive Summary

The City of Alexandria is currently conducting a Long Term Control Plan Update (LTCPU) to address new *E. coli* reductions required under the Hunting Creek Total Maximum Daily Load (TMDL) published by the Virginia Department of Environmental Quality (VDEQ) on November 2, 2010. Based on previous evaluations performed as part of the LTCPU, a combination of deep storage tunnels and underground tanks for CSO-002, CSO-003, and CSO-004 were selected as primary strategies to meet the goals of the LTCPU. The purpose of this technical memorandum is to evaluate increases storage volume relative to potential benefits, costs, and other impacts. The following technical memorandum explains the regulatory drivers for the water quality benefits as well as the potential impacts on the receiving waters of different storage sizes. Tunnel sizes evaluated for CSO-002, CSO-003 and CSO-004 include:

- 8-foot diameter
- 10-foot diameter
- 12-foot diameter

Storage tank sizes evaluated for CSO-002 include:

- 2.0 million gallons
- 3.0 million gallons
- 4.0 million gallons

All of the alternatives meet regulatory requirements related to the United States Environmental Protection Agency (USEPA) Combined Sewer Overflow (CSO) Control Policy discussed in Section 2. To assess the additional potential benefit by providing larger tunnels and tanks the following are assessed:

- Number of Overflows per year
- Percent CSO Capture
- Potential Recreational Benefit

Overflow Evaluation

Table ES-1 summarizes the physical characteristics for the tunnel diameters of the CSO-003/004 tunnel alignment as well as the impacts on the overflows. Table ES-2 summarizes the characteristics and impacts on the CSO-002 tunnel alignment assessed during the typical year.

Table ES-1
CSO-003/004 Tunnel Diameter Summary

Tunnel Diameter	Tunnel Volume (MG)	Number of Overflows[1]	Volume of Overflows (MG)	Overflow Reduction[2] (%)	Flow Capture[3] (%)	NPW[4] ($M)
Current Conditions (no tunnel)	-	67	29.1	-	75%	-
8-foot	1.0	5	2.9	90%	98%	$63.0
10-foot	1.6	3	1.1	96%	99%	$68.9
12-foot	2.25	0	0	100%	100%	$77.3

Table ES-2
CSO-002 Tunnel Diameter Summary

Tunnel Diameter	Tunnel Volume (MG)	Number of Overflows	Volume of Overflows (MG)	Overflow Reduction (%)	Flow Capture (%)	NPW ($M)
Current Conditions (no tunnel)	-	48	35.8	-	58%	-
8-foot	1.9	6	6.4	92%	92%	$58.5
10-foot	2.9	2	3.2	91%	96%	$67.1
12-foot	4.2	1	1.7	95%	98%	$78.7

Table ES-3 summarizes the physical characteristics as well as the impacts on the overflows at CSO-002 for three (3) tank sizes during the typical year.

Table ES-3
CSO-002 Tank Volume Summary

Tank Volume (MG)	Number of Overflows	Volume of Overflows (MG)	Overflow Reduction (%)	Flow Capture (%)	NPW ($M)
Current Conditions (no tank)	48	35.8	-	58%	-
2.0	6	5.7	84%	93%	$32.9
3.0	2	3.1	91%	96%	$44.8
4.0	1	1.9	95%	98%	$56.0

[1] Acceptable range 4-6 or less under the National CSO Policy
[2] No Criteria under the National CSO Policy
[3] Minimum 85% capture under the National CSO Policy
[4] The Net Present Worth is estimated based on a 20 year period and a 3.0% discount rate. The NPW includes the capital costs and annual O&M. These are planning level costs and could be as much as 50% more.

Water Quality Evaluation

In addition to evaluating the impact on the volume and number of overflows, an evaluation of the potential impact on water quality was performed. This was done by comparing the *E. coli* bacteria concentrations modeled in the receiving waters against the Virginia Beach Advisory Criterion. The evaluation showed that there are twelve (12) events in the TMDL period (2004-2005) in which the beach closure criterion is exceeded when stormwater, human, and wildlife controls are implemented in addition to the proposed CSO controls. Based on the evaluation performed of the twelve (12) events, only two (the event on June 29, 2005 and the event on July 8, 2005) could potentially be eliminated by implementing additional CSO controls. The current CSO controls of an 8-foot diameter tunnel for CSO-003/004 and 2.0 million gallons of storage for CSO-002 would need to be increased by 15% in order to potentially remove the two events above. Regardless of implementing even more CSO controls ten events that exceed the beach closure criterion would still remain. It should be noted that the potential recreational benefits attributable to CSO controls will not be realized until stormwater and other controls are also in place. In addition, while larger controls will remove more CSO in terms of percent capture and number of events, the additional recreational benefit will be difficult to observe.

As stated above, it is important to note that this evaluation assumes that all other controls have already been implemented, including stormwater, human, and wildlife. Even if the CSO storage facilities are constructed, there will not be any significant attainment of water quality standards or discernable recreational benefit as measured by the advisory criterion until all the other controls are implemented as well.

Recommendation

Based on the evaluations performed as part of this technical memorandum a 10-foot diameter tunnel for CSO-003/004, a 10-foot diameter tunnel for CSO-002, and a 3.0 million gallon storage tank are recommended to be carried forward for further evaluation in the Long Term Control Plan Update. The storage tank options can be designed for easy expansion should the City wish to construct additional storage in the future.

Section 1 Introduction

The City of Alexandria is currently conducting a Long Term Control Plan Update (LTCPU) to address new *E. coli* reductions required under the Hunting Creek Total Maximum Daily Load (TMDL) published by the Virginia Department of Environmental Quality (VDEQ) on November 2, 2010. Based on previous evaluations performed as part of the LTCPU, a combination of deep storage tunnels and underground tanks for CSO-002, CSO-003, and CSO-004 were selected as primary strategies to meet the goals of the LTCPU. The purpose of this technical memorandum is to evaluate increases storage volume relative to potential benefits, costs, and other impacts. The following technical memorandum explains the regulatory drivers for the water quality benefits as well as the potential impacts on the receiving waters of different storage sizes. Tunnel sizes evaluated for CSO-002, CSO-003 and CSO-004 include:

- 8-foot diameter
- 10-foot diameter
- 12-foot diameter

Storage tank sizes evaluated for CSO-002 include:

- 2.0 million gallons
- 3.0 million gallons
- 4.0 million gallons

All of the alternatives meet regulatory requirements related to the United States Environmental Protection Agency (USEPA) Combined Sewer Overflow (CSO) Control Policy discussed in Section 2. To assess the additional potential benefit by providing larger tunnels and tanks the following are assessed:

- Number of Overflows per year
- Percent CSO Capture
- Potential Recreational Benefit

Section 2 Regulatory Requirements

The regulations that the City is required to meet with the Long Term Control Plan Update (LTCPU) is broken up in to two categories: USEPA CSO Control Policy and the Hunting Creek TMDL. Detailed information regarding the regulatory requirements of the LTCPU can be found in the *Regulatory Requirements Technical Memorandum* dated October 2014. The following is a summary of the information presented in that document.

2.1 USEPA Combined Sewer Overflow (CSO) Control Policy

The stated purpose of the CSO Control Policy is to "*…provides guidance to permittees with CSOs, NPDES* [National Pollutant Discharge Elimination System] *authorities and State water quality standards authorities on coordinating the planning, selection, and implementation of CSO controls that meet the requirements of the* [Clean Water Act (CWA)] *and allow for public involvement during the decision-making process….the Policy lays out two alternative approaches – the "demonstration" and the "presumption" approaches – that provide communities with targets for CSO controls that achieve compliance with the Act, particularly protection of water quality and designated uses.*"

A program that meets any of the criteria listed below would be presumed to provide an adequate level of control to meet the water quality-based requirements of the CWA, provided the permitting authority determines that such presumption is reasonable in light of the data and analysis conducted in the characterization, monitoring, and modeling of the system it is an acceptable level of control if the permit writer can reasonably presumed that it meets water quality standards:

i. *"No more than an average of four overflow events per year, provided that the permitting authority may allow up to two additional overflow events per year…; or*
ii. *The elimination or capture for treatment of no less than 85% by volume of the combined sewage collected in the CSS during precipitation events on a system-wide annual average basis; or*
iii. *The elimination or removal of no less than the mass of the pollutants identified as causing water quality impairment through the sewer system characterization, monitoring, and modeling effort for the volumes that would be eliminated or captures for treatment under paragraph ii above."*

All of the alternative sizes being evaluated meet the 4-6 overflows per year criterion and obtain 90% capture (exceeding the 85% capture criterion) during the Typical Year. The Typical Year is defined in the *Typical Year Selection Technical Memorandum* dated September 2014 and was developed in response to the CSO Control Policy guidance that the performance standards for the selected CSO controls should be "*…based on average design conditions*." All alternatives exceed the presumption approach criteria.

2.2 Hunting Creek TMDL

As discussed above, the presumption approach is acceptable if such presumption is reasonable in light of the data and analysis conducted in the characterization, monitoring, and modeling of the system.

In November 2010, the Virginia Department of Environmental Quality (VDEQ) published the Hunting Creek TMDL which includes characterization, monitoring and modeling of the system. In the *Water Quality Assessment and Modeling Technical Memorandum* dated October 2015, the Hunting Creek monitoring and modeling was evaluated against the CSO controls being considered. The memorandum shows that, based on the City's updated modeling approach that incorporates several parameter adjustments to abnormal assumptions to the Hunting Creek TMDL, the level of control being considered can be shown to meet the requirements of the clean water act and as a result the presumption approach levels of control can reasonably be concluded to meet the water quality requirements of the clean water act. Adjustments to the modeling assumptions consist of the following:

- AlexRenew WRRF Load – from the Hunting Creek TMDL "*In tidal Hunting Creek, two additional conservative assumptions were made. First, the concentration of the source responsible for the largest volume of water entering tidal Hunting Creek, ASA's WWTP [AlexRenew WRRF], was set at the fecal coliform equivalent of its monthly E. coli permit limit, 126 cfu/100 ml, which is also the geometric mean water quality criterion.*" By setting the largest contribution at the water quality standard limit, it leaves no room for loads from other sources. Therefore rather than set the WRRF at the limit a wet average and a dry average concentration were used based on plant data from the TMDL period.
- Potomac Boundary – Similar to the AlexRenew load, the Potomac boundary was set at the water quality criteria limit of 126 cfu/100 mL. Again, this leaves no tolerance to assimilate loads from other sources. Therefore the Potomac boundary conditions were based on the EPA-approved DC CSO LTCP Potomac River boundary conditions.
- Proportional v. Discrete Controls – The Hunting Creek TMDL assumes a constant percent reduction to each CSO event. This means that large events are assumed to be reduced by a certain percentage and small events by the same percentage; no events are eliminated. The CSO controls being evaluated are discrete controls meaning that some events will be eliminated while others will remain at a reduced volume. The discrete control of overflows was utilized when running the water quality model.
- Bacteria Decay Rate – the decay rate used in the Hunting Creek TMDL was set at 0.1/day. This decay rate is extremely low and is not representative of real-world conditions. Rather than simply employing a literature-based bacteria decay rate, the EPA-approved DC CSO LTCP decay rate of 1.5/day was used.
- Exclusion of Extreme Events – the 2004-2005 TMDL period includes a 67-year wet weather event in October 2005. This event is abnormal and contributes to a significant portion of the load driving the CSOs to very high levels of control. This event was excluded from the model run.

For more information of the water quality modeling and the assumptions that were made, see the *Water Quality Assessment and Modeling Technical Memorandum* dated October 2015.

2.3 What Does This Mean for the LTCPU?

So long as the storage sizes evaluated in this technical memorandum meet the Presumption Approach levels of control of 4-6 overflows per year or 85% capture then the LTCPU will fulfill the regulatory requirements. The intent of this document it to show that the minimum size meets the regulatory requirements and to recommend sizing for the proposed storage infrastructure.

2.4 Demonstration Approach

As discussed above, the National CSO Policy also provides for a demonstration approach. Under the demonstration approach, controls less than the presumption levels of control (e.g., 4-6 and 85%) are acceptable if a number of conditions are met. From evaluations shown in the *Water Quality Assessment and Modeling Technical Memorandum*, it appears that there is a potential to make such a demonstration. However, the City has elected to not pursue controls less than the presumption levels of control at this time.

Section 3 Potential Storage Sizes

For the purposes of this evaluation the following sizes for storage tunnels and storage tanks are considered:

- Storage Tunnels (CSO-002, CSO-003 and CSO-004)
  - 8-foot diameter
  - 10-foot diameter
  - 12-foot diameter
- Storage Tanks (CSO-002 only)
  - 2.0 million gallons
  - 3.0 million gallons
  - 4.0 million gallons

3.1 Storage Tunnels

Initial tunnel sizing was performed as part of the LTCPU in the memorandum titled *Alternatives Evaluation: Tunnels* which resulted in an 8-foot diameter tunnel. The 8-foot diameter meets the presumptive approach for CSO control as defined by the CSO Control Policy. At this diameter, the CSO-003/004 tunnel alignment can store approximately 1.0 million gallons and the CSO-002 tunnel alignment can store approximately 2.0 million gallons. The following sections describe the impacts of different tunnel diameters on the CSO-003/004 tunnel alignments. A similar analysis was performed for different tunnel diameters on the CSO-002 alignments, but those impacts are not described in detail, rather they are summarized in Table 3-2. Additionally, cost estimates were developed for each tunnel size and are presented in Attachment A for the CSO-003/004 tunnel sizes and Attachment B for the CSO-002 tunnel sizes.

3.1.1 8-foot Diameter

With the storage sizes created with an 8-foot diameter tunnel for CSO-003/004, the City will meet the regulatory requirements and the number of overflows from will be reduced from sixty-seven (67) to five (5) overflows per year during the typical year (1984). This is the minimum tunnel size that can be implemented and still meet the regulatory requirements. The estimated volume of overflows will be reduced from 29.1 million gallons to 2.9 million gallons, a 90% reduction. Nearly 98% of the flow from the combined sewer system will be captured and treated at the Alexandria Renew Enterprises Water Resource Recovery Facility (AlexRenew) during wet weather events. While this size meets the regulatory requirements, the City strives to help improve water quality as much as practicable by evaluating the larger tunnel sizes below.

3.1.2 10-foot Diameter

A 10-foot diameter tunnel for CSO-003/4 has approximately 1.6 times more storage volume than an 8-foot diameter tunnel. A nominal 2-foot incremental increase is used for the tunnel diameter. While it is possible to build a tunnel boring machine for a custom diameter, this typically only occurs for larger

tunnel diameters (in the 20 to 30-foot range) where the machines may only be used once, whereas smaller tunnel boring machines will be used several times so it is more cost effective to evaluate these nominal tunnel diameters.

A 10-foot diameter tunnel for CSO-003/004 will reduce the number of overflow from sixty-seven (67) to three (3) during the typical year. The volume will be reduced from 29.1 million gallons to 1.1 million gallons, a 96% reduction. At this size, just over 99% of the flow from the combined sewer system will be captured and treated at the plant during wet weather. The quantity of overflows and total volume of overflow will increase or decrease based on actual rainfall events during any specific year.

3.1.3 12-foot Diameter

A 12-foot diameter tunnel for CSO-003/004 can store 2.25 times more volume than an 8-foot diameter tunnel. With a 12-foot diameter tunnel the number of overflows from CSO-003/004 will be reduced from sixty-seven (67) to zero (0) during the typical year. The volume will be reduced from 29.1 million gallons to 0, a 100% reduction. Likewise 100% of the flow from the combined sewer system will be captured. The quantity of overflows and total volume of overflow will increase or decrease based on actual rainfall events during any specific year.

3.1.4 Summary

Table 3-1 summarizes the physical characteristics for the tunnel diameters of the CSO-003/004 tunnel alignment as well as the impacts on the overflows. Table 3-2 summarizes the characteristics and impacts on the CSO-002 tunnel alignment assessed during the typical year.

Table 3-1
CSO-003/004 Tunnel Diameter Summary

Tunnel Diameter	Tunnel Volume (MG)	Number of Overflows[5]	Volume of Overflows (MG)	Overflow Reduction[6] (%)	Flow Capture[7] (%)	NPW[8] ($M)
Current Conditions (no tunnel)	-	67	29.1	-	75%	-
8-foot	1.0	5	2.9	90%	98%	$63.0
10-foot	1.6	3	1.1	96%	99%	$68.9
12-foot	2.25	0	0	100%	100%	$77.3

[5] Acceptable range 4-6 or less under the National CSO Policy
[6] No Criteria under the National CSO Policy
[7] Minimum 85% capture under the National CSO Policy
[8] The Net Present Worth is estimated based on a 20 year period and a 3.0% discount rate. The NPW includes the capital costs and annual O&M. These are planning level costs and could be as much as 50% more.

Table 3-2
CSO-002 Tunnel Diameter Summary

Tunnel Diameter	Tunnel Volume (MG)	Number of Overflows	Volume of Overflows (MG)	Overflow Reduction (%)	Flow Capture (%)	NPW ($M)
Current Conditions (no tunnel)	-	48	35.8	-	58%	-
8-foot	1.9	6	6.4	92%	92%	$58.5
10-foot	2.9	2	3.2	91%	96%	$67.1
12-foot	4.2	1	1.7	95%	98%	$78.7

3.2 Storage Tanks

In lieu of constructing a deep storage tunnel to address CSO-002, the City has the opportunity to construct a below ground storage tank. For more information on the potential locations of a tank for CSO-002, see the *Alignments and Site Evaluation Technical Memorandum*. This is not possible for CSO-003/004 because of the space limitations in Old Town. The following sections explain the physical characteristics of each tank volume and the impacts on the overflows at CSO-002.

3.2.1 2.0 Million Gallons

A 2.0 million gallon storage tank would be located in the vicinity of the CSO-002 outfall. With a 2.0 million gallon tank the number of overflows will be reduced from forty-eight (48) to six (6) during the typical year. The resulting overflow volume will be reduced from 35.8 million gallons to 5.7 million gallons, a reduction of 84%. This tank would capture nearly 93% of the flow from the combined sewer system and send it to AlexRenew for a high level of treatment.

3.2.2 3.0 Million Gallons

A 3.0 million gallon storage tank would be located in the vicinity of the CSO-002 outfall. With a 3.0 million gallon tank the number of overflows will be reduced from forty-eight (48) to two (2) during the typical year. The resulting overflow volume will be reduced from 35.8 million gallons to 3.1 million gallons, a reduction of 91%. This tank would capture nearly 96% of the flow from the combined sewer system and send it to AlexRenew for a high level of treatment. The quantity of overflows and total volume of overflow can increase or decrease based on actual rainfall events during any specific year.

3.2.3 4.0 Million Gallons

A 4.0 million gallon storage tank would be located in the vicinity of the CSO-002 outfall. With a 4.0 million gallon tank the number of overflows will be reduced from forty-eight (48) to one (1) during the typical year. The resulting overflow volume will be reduced from 35.8 million gallons to 1.9 million gallons, a reduction of 95%. This tank would capture nearly 98% of the flow from the combined sewer system and send it to AlexRenew for a high level of treatment. The quantity of overflows and total volume of overflow can increase and decrease based on actual rainfall events during any specific year.

3.2.4 Summary

Table 3-3 summarizes the physical characteristics as well as the impacts on the overflows at CSO-002.

Table 3-3
CSO-002 Tank Volume Summary

Tank Volume (MG)	Number of Overflows	Volume of Overflows (MG)	Overflow Reduction (%)	Flow Capture (%)	NPW ($M)
Current Conditions (no tank)	48	35.8	-	58%	-
2.0	6	5.7	84%	93%	$32.9
3.0	2	3.1	91%	96%	$44.8
4.0	1	1.9	95%	98%	$56.0

Section 4 Potential Recreational Benefit

This section characterizes the potential recreational benefit from providing controls larger than required.

Attainment of VDEQ water quality standards (WQS) are based on the 30 day geometric mean of *E. coli* not exceeding 126 cfu/100mL. As discussed above, all of the alternatives are designed to meet or exceed this VDEQ criterion by showing that the VDEQ Hunting Creek TMDL goals are met as discussed in Section 2. Beyond meeting the Hunting Creek TMDL, there are two additional considerations when assessing recreational benefit as follows:

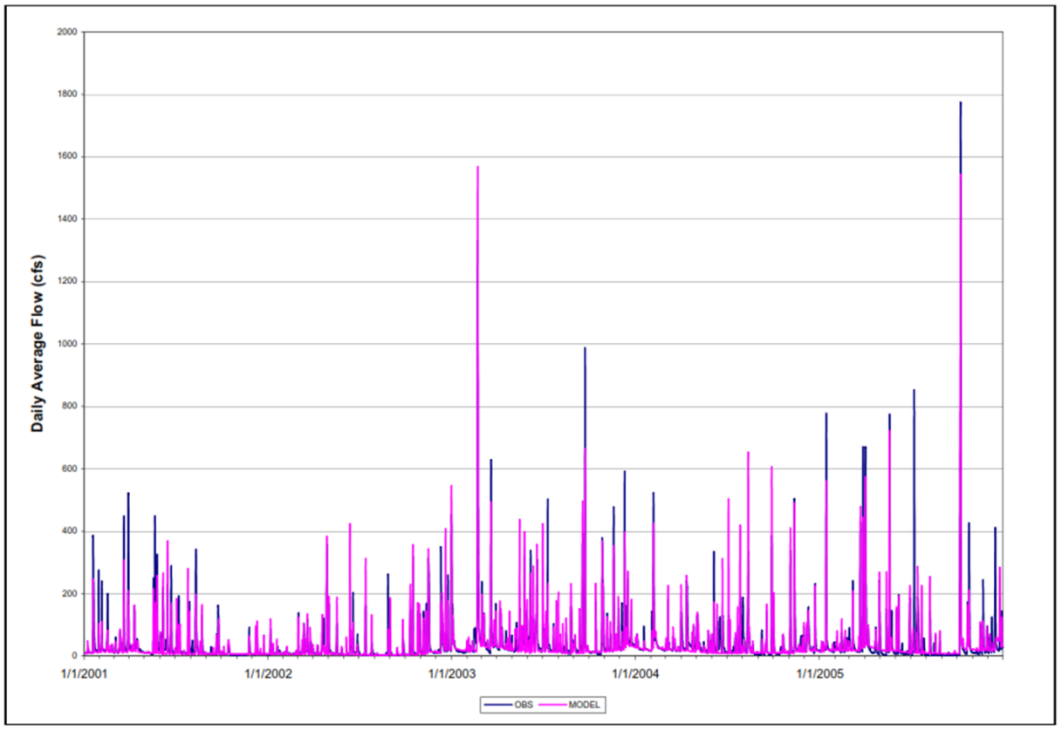
- The recreational benefits are limited until the full requirements of TMDL are implemented, including reductions of other sources of bacteria
- Even with the attainment of the standards for recreation, there will be times when heavy rain raises in-stream *E. coli* concentrations that would trigger a beach advisory. When beach advisory levels are exceeded typically a beach would be closed for swimming.

In addition to high levels of CSO control, the Hunting Creek TMDL calls for 80-98% control of stormwater, 50% reduction of wildlife, and elimination of septic systems, and all sanitary sewer overflows. Technology to obtain the level of controls called for in the TMDL for all these sources is not currently available or accepted. Without these additional controls, the actual additional recreational benefit of CSO control will be small.

If all the Hunting Creek TMDL requirements are ultimately achieved, there will still be days when recreation in the water is not advisable. To assess this condition, the State has a beach advisory criterion of 235 cfu/100mL. It is important to note that occasional exceedance of this criterion does not mean the WQS is not obtained. Also, the analysis discussed below relies on VDEQ's model with updates to the modeling made by the City as part of the LTCPU and as described in Section 2. These results should be considered semi-quantitative.

Before the impact of CSO controls is evaluated, it is important to examine the impact of the non-CSO sources. Figure 4-1 is a chart of the VDEQ Hunting Creek TMDL estimated *E. coli* level 2001-2005 above all CSO discharges. The Figure 4-1 condition upstream of the CSOs is driven by stormwater, wildlife, SSO, pets and failing septic systems. The TMDL focuses on the 2004-2005 period. During that period there were approximately 58 events upstream of the CSOs when a beach closure would have been appropriate based on the 235 cfu/100mL criterion. These 58 events are not impacted by the Alexandria CSOs and are expected to remain after CSO controls are in place until the very high levels of additional source control described above are completed.

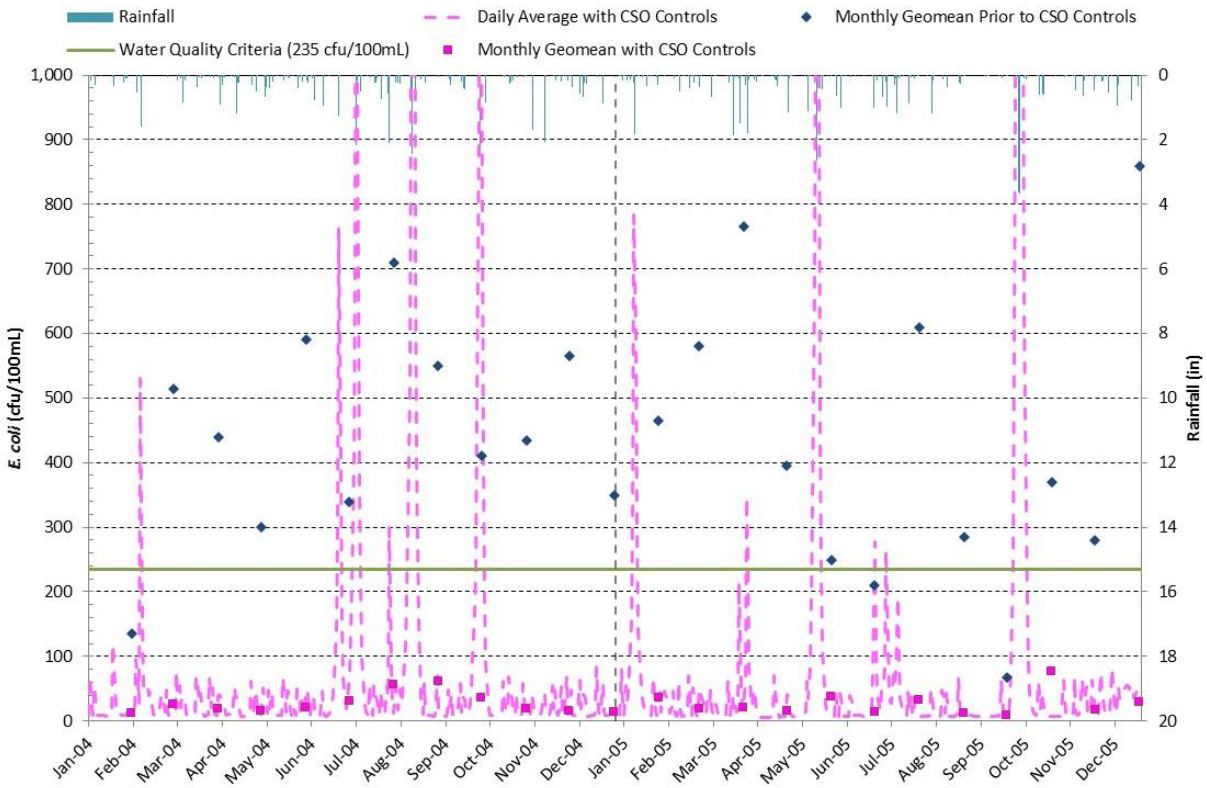
Figure 4-1
Time Series of Simulated and Observed Daily Average Flow, Cameron Run Calibration Period, 2001-2005



If the CSO controls and the other load controls are put in place, the number of events where the beach advisory criterion is exceeded drops to 12. One method to evaluate the additional recreational benefit of larger tunnels and storage is to examine the number of events exceeding the beach advisory criterion in the receiving water and to determine if reducing the volume of CSOs will result in a reduction in the number of exceedances of the beach advisory criterion. This technical memorandum explains how the events exceeding the beach advisory criterion are calculated and the water quality benefits associated with larger storage sizes.

Initial sizing of infrastructure was performed as part of the Long Term Control Plan Update (LTCPU) in two technical memoranda titled *Alternatives Evaluation: Storage Tanks* and *Alternatives Evaluation: Tunnels* resulting in 1 million gallons of storage for CSO-003/004 and 2 million gallons for CSO-002. This storage was simulated in the City's hydraulic model and the TMDL Years (2004-2005) were modeled to produce the resulting overflows into the receiving waters. The resulting flows were then modeled in the water quality model used to create the Hunting Creek TMDL to determine the *E. coli* concentrations in Hunting Creek and the Hunting Creek Embayment. The results of that water quality model are shown in Figure 4-2.

Figure 4-2
Upstream Hunting Creek – Predicted Daily and Monthly *E. coli* Concentrations



This plot shows several different things:

- The blue dots represent the 30-day geometric mean of the *E. coli* concentration in upstream Hunting Creek prior to any controls (CSO, stormwater, human, wildlife) being implemented.
- The pink dots represent the 30-day geometric mean of the *E. coli* concentration in upstream Hunting Creek after all controls have been implemented (this includes stormwater controls, human and wildlife controls, 1 million gallons of storage for CSO-003/004 equal to an 8-foot diameter tunnel, and 2 million gallons of storage for CSO-002 being either a tunnel or tank).
- The pink lines represent the daily average *E. coli* concentration in upstream Hunting Creek after all controls have been implemented.
- The green line represents the swimmable *E. coli* beach advisory criterion (235 cfu/100 mL) as defined the Virginia Administrative Code (9VAC25-260-170.A.5).
- The blue lines at the top represent rainfall.

Since all the pink dots (*E. coli* concentration after all controls have been implemented) fall below the water quality standard of 126 cfu/100 mL 30 day geometric mean threshold, the model has shown that the initial proposed controls meet water quality standards with all the Hunting Creek TMDL loads controlled (stormwater, CSO, wildlife, etc.). As stated above, the number of events where the beach advisory level

is exceeded during the 2004-2005 TMDL period, with all bacteria reductions from the TMDL implemented, is equal to 12.

Below is an evaluation to see if additional CSO controls (larger storage facilities) can yield additional improvements to water quality assuming all other Hunting Creek TMDL controls are in-place. To perform this evaluation it is important to look at the daily *E. coli* concentrations (pink lines), in particular the days on which the *E. coli* concentration is above 235 cfu/100 mL. Each of these peaks correspond to rainfall events in which the beach advisory criterion was exceeded by a combination of *E. coli* loads from CSO, stormwater, humans, and wildlife.

4.1 Event Analysis

This event analysis considers modeled instream conditions below the CSO discharges with an 8-foot tunnel for CSO-003/004 and a 2 million gallon storage basin for CSO-002. In addition, it is assumed that all the controls on stormwater, wildlife and other loads called for in the Hunting Creek TMDL are in place. The area most impacted by the CSOs is just upstream of the George Washington Bridge is used in the analysis. Under these modeled conditions, there are twelve (12) peaks that exceed the beach closure criterion corresponding to twelve (12) events. Note that this is less than a quarter the events upstream of the CSO area before the TMDL controls are in place. To better understand the impact of the CSO loads assuming all upstream loads are controlled on these events we must look at each of the events individually. For the sake of brevity, this memorandum will only perform an in-depth evaluation on three of the events while the rest of the events are summarized in Table 4-1.

4.1.1 February 6, 2004

The first event to be evaluated is the event that occurred on February 6, 2004. The beach advisory criterion was only exceeded on one day (2/6/2004) during the rainfall event that resulted in 1.60 inches of rain. The most important aspect of this event is the fact that proposed CSO controls (8-foot tunnel/2MG storage) captured all the CSS flow. Thus, there was no CSO during the event, which means that the *E. coli* concentration exceeded the beach closure criterion entirely due to the stormwater load entering the stream. Two conclusions can be drawn from this event: 1) since there was no CSO during this event, this beach closure criterion exceedance would occur regardless of if additional CSO storage was implemented; and 2) since 1.60 inches of rainfall caused an exceedance due to the stormwater load only, any rainfall event larger than 1.60 inches would typically be expected to cause an exceedance regardless of additional CSO controls.

4.1.2 July 3 – 7, 2004

The second event evaluated occurred from July 3, 2004 to July 7, 2004 with a total rainfall of 2.82 inches. During this time period, the beach closure criterion was exceeded every day (from 7/3/2004 – 7/7/2004). On the first day (7/3), the beach closure criterion was exceeded, but there was no CSO. On the second day (7/4), the beach closure criterion was exceeded and there was a CSO. On the last three days (7/5, 7/6, and 7/7) the beach closure criterion was exceeded, but there was no CSO. The conclusions drawn from this event are: 1) the rainfall was larger than 1.60 inches and the beach closure criterion was exceeded without a CSO as shown on the first day (7/3). This confirms the conclusion made from the first event.

2) Even if the CSO were eliminated during this event, the beach closure criterion exceedance would have still occurred although it may not have lasted all five (5) days.

4.1.3 June 29 – 30, 2005

The third event evaluated occurred from June 29, 2005 to June 30, 2005 with a total rainfall of 1.03inches. During this time period the beach closure criterion was exceed only on June 30 during which a CSO occurred but there was no rainfall. This means that the beach closure criterion exceedance was primarily caused by the CSO. The *E. coli* peak load during this day is 277 cfu/100mL which is approximately 15% above the beach closure criterion of 235 cfu/100mL. It can be reasonably assumed that if the CSO load is reduced by 15%, by implementing increased CSO controls (i.e. larger storage), then the beach closure criterion would be met and that event would be eliminated. There is only one other event that this scenario occurs as listed in Table 4-1.

A summary of all the events and the impact of the CSO's is presented in Table 4-1:

Table 4-1
Beach Closure Criterion Exceedance Events

Event	Summary
February 6, 2004	No CSO during this event caused by 1.60 inches of rainfall. The event would have occurred regardless of additional CSO control.
June 22 – 24, 2004	A CSO occurred on the first day triggering the exceedance. However, the exceedance occurred two (2) days after the CSO ended. It is reasonable to conclude that this event would have occurred regardless of additional CSO control.
July 3 – 7, 2004	The criterion was exceeded a full day before the CSO occurred. This event would have occurred regardless of additional CSO control.
July 27 - 28, 2004	A CSO occurred on the first day triggering the exceedance. However, the rainfall for this event totaled 2.71 inches. It is reasonable to conclude that this event would have occurred regardless of additional CSO control.
August 10 – 16, 2004	The criterion was exceeded two (2) days before the CSO occurred. This event would have occurred regardless of additional CSO control.
September 26 – October 1, 2004	The criterion was exceeded two (2) days before the CSO occurred. This event would have occurred regardless of additional CSO control.
January 13 – 16, 2005	The criterion was exceeded a full day before the CSO occurred. This event would have occurred regardless of additional CSO control.
April 2 – 3, 2005	A CSO occurred on the first day triggering the exceedance. However, the rainfall for this event totaled 1.92 inches. It is reasonable to conclude that this event would have occurred regardless of additional CSO control.
May 18 – 23, 2005	The criterion was exceeded two (2) days before the CSO occurred. This event would have occurred regardless of additional CSO control.
June 29 - 30, 2005	This exceedance was entirely driven by the CSO that occurred. A 15% reduction in the remaining CSO volume by increased storage could likely eliminate this exceedance.
July 8, 2005	This exceedance was entirely driven by the CSO that occurred. An 11% reduction in the remaining CSO volume by increased storage could likely eliminate this exceedance.
October 4 – 13, 2005	The criterion was exceeded three (3) days before the CSO occurred. This event would have occurred regardless of additional CSO control.

4.2 Summary

The plot in Figure 4-2 and the events listed in Table 4-1 show that there are twelve (12) events in the TMDL period (2004-2005) in which the beach closure criterion is exceeded when stormwater, human, and wildlife controls are implemented in addition to the proposed CSO controls. Based on the evaluation performed of the twelve events listed above, only two (the event on June 29, 2005 and the event on July 8, 2005) could potentially be eliminated by implementing additional CSO controls. The current CSO controls of an 8-foot diameter tunnel for CSO-003/004 and 2.0 million gallons of storage for CSO-002 would need to be increased by 15% in order to potentially remove the two events above. Regardless of implementing even more CSO controls ten events that exceed the beach closure criterion would still

remain. It should be noted that the potential recreational benefits attributable to CSO controls will not be realized until stormwater and other controls are also in place. In addition, while larger controls will remove more CSO in terms of percent capture and number of events, the additional recreational benefit will be difficult to observe.

As stated above, it is important to note that this evaluation assumes that all other controls have already been implemented, including stormwater, human, and wildlife. Even if the CSO storage facilities are constructed, there will not be any significant attainment of water quality standards or discernable recreational benefit as measured by the advisory criterion until all the other controls are implemented as well.

Section 5 Recommendation

When evaluating the tunnel and tank sizes it is important to evaluate them against the regulatory requirements described in Section 2.

5.1 CSO-003/004 Tunnel

As summarized in Section 3.1.4, an 8-foot diameter tunnel for the CSO-003/004 tunnel alignment will meet the CSO Control Policy requirement of 4-6 overflows per year and the 85% capture requirement and can be shown to meet the requirements of the Hunting Creek TMDL (see the *Regulatory Requirements Technical Memorandum*). As shown in Section 4, an 8-foot diameter tunnel would result in the exceedance of the beach closure criterion 12 times during the 2004-2005 TMDL periods. By making the tunnel 15% larger, two of those events could potentially be eliminated. Since the diameter cannot simply be increased by 15%, the next nominal tunnel diameter is evaluated.

A 10-foot diameter tunnel meets the CSO Control Policy requirement 4-6 overflows per year with 3 and it meets the 85% capture criterion, although both are not required at the same time. Additionally, a 10-foot tunnel is 160% larger than an 8-foot diameter tunnel so it has the potential to eliminate two events that exceeded the beach closure criterion if all other controls are in-place. The increased storage volume also provides an appropriate level of conservative to account for the inherent uncertainty in the various models and variations in rainfall from event to event and year to year.

The conceptual level project cost estimate is $63.0 million to build an 8-foot diameter tunnel for CSO-003/004. By moving up to a 10-foot tunnel it will cost an additional $5.9 million to potentially eliminate two events that exceed the beach closure criterion. A 12-foot diameter tunnel will eliminate all overflows from CSO-003/004 during the typical year and therefore meet all the criteria defined above, but will add $14.3 million to the total project cost.

It is recommended that a 10-foot diameter tunnel size for CSO-003/004 be carried forward for further evaluation in the Long Term Control Plan Update.

5.2 CSO-002 Tunnel

As summarized in Section 3.1.4, an 8-foot diameter tunnel for the CSO-002 tunnel alignment will meet the CSO Control Policy requirement of 4-6 overflows per year and the 85% capture requirement during the typical year. As shown in Section 4, an 8-foot diameter tunnel would result in the exceedance of the beach closure criterion 12 times during the 2004-2005 TMDL period. By making the tunnel 15% larger, two of those events could potentially be eliminated. Since the diameter cannot simply be increased by 15%, the next nominal tunnel diameter is evaluated.

A 10-foot diameter tunnel meets the CSO Control Policy requirement 4-6 overflows per year with 2 and it meets the 85% capture criterion, although both are not required at the same time. Finally, a 10-foot tunnel is 160% larger than an 8-foot diameter tunnel so it has the potential to eliminate two events that exceeded the beach closure criterion.

At a minimum it will cost $58.5 million to build an 8-foot diameter tunnel for CSO-002. By moving up to a 10-foot tunnel it will cost an additional $8.6 million to potentially eliminate two events that exceed the beach closure criterion. A 12-foot diameter tunnel will eliminate all but one (1) overflow from CSO-002 during the typical year and will also meet all the criteria defined above, but will add $20.2 million to the estimated total project cost.

It is recommended that a 10-foot diameter tunnel size for CSO-002 be carried forward for further evaluation in the Long Term Control Plan Update.

5.3 CSO-002 Storage Tank

As summarized in Section 3.2.4, a 2.0 million gallon storage tank for CSO-002 will meet the CSO Control Policy requirement of 4-6 overflows per year and the 85% capture requirement. As shown in Section 4, a 2.0 million gallon storage tank would result in the exceedance of the beach closure criterion 12 times during the 2004-2005 TMDL period. By making the tank 15% larger, two of those events could potentially be eliminated.

A 3.0 million gallon storage tank meets the CSO Control Policy requirement 4-6 overflows per year with 2 and it meets the 85% capture criterion, although both are not required at the same time. Finally, a 3.0 million gallon storage tank is 150% larger than a 2.0 million gallon storage tank so it has the potential to eliminate two events that exceeded the beach closure criterion. The increased storage volume also provides an appropriate level of conservative to account for the inherent uncertainty in the various models and variations in rainfall from event to event and year to year.

At a minimum it will cost $32.9 million to build a 2.0 million gallon storage tank for CSO-002. By moving up to a 3.0 million gallon tank it will cost an additional $11.9 million to potentially eliminate two events that exceed the beach closure. A 4.0 million gallon storage tank will eliminate all but one (1) overflow from CSO-002 during the typical year and will also meet all the criteria defined above, but will add an additional $23.1 million to the total project cost.

It is recommended that a 3.0 million gallon storage tank for CSO-002 be carried forward for further evaluation in the Long Term Control Plan Update. The storage tank options can be designed for easy expansion should the City wish to construct additional storage in the future.

Attachment A

CSO-003/004 Cost Estimates

COA LTCPU
T3-8-ft

Alternative T3-8-ft Diameter Tunnel
Date: 15-Oct-15
Prepared By: D. Dvorak
Checked By: J. McGettigan

Item	QTY	Units	Unit Cost	Total	Comments
003/004 Tunnel					
8' Tunnel from Dangerfield Road to NMF	**2,700**	LF	$3,600	$9,720,000	Guidance From Jacobs
Shaft 1 (15' diameter)	**75**	VLF	$26,000	$1,950,000	Guidance From Jacobs
Shaft 2 (20' diameter)	**90**	VLF	$32,000	$2,880,000	Guidance From Jacobs
Shaft 3 (15' diameter)	**100**	VLF	$26,000	$2,600,000	Guidance From Jacobs
8' Tunnel from CI to NMF	**400**	LF	$3,600	$1,440,000	Guidance From Jacobs
Diversion Structures	**2**	EA	$600,000	$1,200,000	Local Project Data (K&W)
48" Sewer	**300**	LF	$1,200	$360,000	DC LTCP
				$20,150,000	
Facilities					
Odor Control	**1**	EA	$500,000	$500,000	Allowance
Dewatering PS	1.0	MGD	Equation	$650,000	Cost Curve
Wet Weather PS	**1**	LS	$7,100,000	$7,100,000	TO-16 Estimate
Climber Screens	**1**	LS	$2,000,000	$2,000,000	Allowace
				$10,250,000	
Subtotal				*$30,400,000*	
Construction Contingency	35%			$10,640,000	
Construction Subtotal				$41,040,000	
Planning, Design, Construction Management, Administration, Permitting and Easements	35%			$14,364,000	
Land Acquisition	14,520	SF	$125	$1,815,000	
Easements			$38	$0	
Total Project				**$57,219,000**	

Table 2: Operational and Maintenance Cost Estimate

Item	QTY	Units	Unit Cost	Total	Comments
Operational Cost					
Treatment Cost at AlexRenew	15.3	MGY	$ 6.44	$ 98,468	$6.44/1,000 Gallons
Pumping Costs	8,102	kw-hrs	$ 0.08	$ 648.2	
Annual Volume	**15.3**	MGY			
Total Dynamic Head	**90**	ft			
Pump Efficiency	0.6				
Motor Efficiency	0.9				
Washdown Water (10% Tunnel Volume x 4)	400	TG	$ 4.00	$ 1,600	
Labor Costs	576	Hrs	$ 50.00	$ 28,800	
Monthly Inspections (12@16hrs/each)	**192**	Hrs			
Quarterly Cleaning (4@96hrs/each)	**384**	Hrs			
Maintenance Costs					
Percentage of Construction	1.00%			$ 410,400	DC LTCP Assumption
Annual O&M				$ 539,916	
Net Present Worth				**$ 8,032,583**	

Table 3: Stormwater Nutrient and Sediment Costs

Item	QTY	Units	Unit Cost	Total	Comments
Annual Volume	15.3	MGY			
Total Suspended Solids					
TMDL Concentration	70.50	mg/L			
Dischage Concentration	6.0	mg/L			
Removed	64.50	mg/L			
Load	8225	lbs/yr	$80	$ 657,996	
Nitrogen					
TMDL Concentration	5.88	mg/L			
Dischage Concentration	3.0	mg/L			
Removed	2.88	mg/L			
Load	367	lbs/yr	$6,000	$ 2,203,521	
Phosphorous					
TMDL Concentration	0.78	mg/L			
Dischage Concentration	0.18	mg/L			
Removed	0.60	mg/L			
Load	77	lbs/yr	$25,000	$ 1,912,779	
Net Present Worth				$ 2,203,521	

COA LTCPU
T3-10-ft

Alternative T3-10-ft Diameter Tunnel
Date: 15-Oct-15
Prepared By: D. Dvorak
Checked By: J. McGettigan

Item	QTY	Units	Unit Cost	Total	Comments
003/004 Tunnel					
10' Tunnel from Dangerfield Road to NMF	**2,700**	LF	$4,250	$11,475,000	Guidance From Jacobs
Shaft 1 (15' diameter)	**75**	VLF	$26,000	$1,950,000	Guidance From Jacobs
Shaft 2 (20' diameter)	**90**	VLF	$32,000	$2,880,000	Guidance From Jacobs
Shaft 3 (15' diameter)	**100**	VLF	$26,000	$2,600,000	Guidance From Jacobs
10' Tunnel from CI to NMF	**400**	LF	$4,250	$1,700,000	Guidance From Jacobs
Diversion Structures	**2**	EA	$600,000	$1,200,000	Local Project Data (K&W)
48" Sewer	**300**	LF	$1,200	$360,000	DC LTCP
				$22,165,000	
Facilities					
Odor Control	**1**	EA	$750,000	$750,000	Allowance
Dewatering PS	1.5	MGD	Equation	$810,000	Cost Curve
Wet Weather PS	**1**	LS	$7,100,000	$7,100,000	TO-16 Estimate
Climber Screens	**1**	LS	$2,500,000	$2,500,000	Allowace
				$11,160,000	
Subtotal				*$33,325,000*	
Construction Contingency	35%			$11,663,750	
Construction Subtotal				$44,988,750	
Planning, Design, Construction Management, Administration, Permitting and Easements	35%			$15,746,063	
Land Acquisition	14,520	SF	$125	$1,815,000	
Easements			$38	$0	
Total Project				**$62,549,813**	

Table 2: Operational and Maintenance Cost Estimate

Item	QTY	Units	Unit Cost	Total	Comments
Operational Cost					
Treatment Cost at AlexRenew	17.0	MGY	$ 6.44	$ 109,480	$6.44/1,000 Gallons
Pumping Costs	9,008	kw-hrs	$ 0.08	$ 720.7	
Annual Volume	**17.0**	MGY			
Total Dynamic Head	**90**	ft			
Pump Efficiency	0.6				
Motor Efficiency	0.9				
Washdown Water (10% Tunnel Volume x 4)	600	TG	$ 4.00	$ 2,400	
Labor Costs	576	Hrs	$ 50.00	$ 28,800	
Monthly Inspections (12@16hrs/each)	**192**	Hrs			
Quarterly Cleaning (4@96hrs/each)	**384**	Hrs			
Maintenance Costs					
Percentage of Construction	1.00%			$ 449,888	DC LTCP Assumption
Annual O&M				$ 591,288	
Net Present Worth				**$ 8,796,875**	

Table 3: Stormwater Nutrient and Sediment Costs

Item	QTY	Units	Unit Cost	Total	Comments
Annual Volume	17.0	MGY			
Total Suspended Solids					
TMDL Concentration	70.50	mg/L			
Dischage Concentration	6.0	mg/L			
Removed	64.50	mg/L			
Load	9145	lbs/yr	$80	$ 731,585	
Nitrogen					
TMDL Concentration	5.88	mg/L			
Dischage Concentration	3.0	mg/L			
Removed	2.88	mg/L			
Load	408	lbs/yr	$6,000	$ 2,449,958	
Phosphorous					
TMDL Concentration	0.78	mg/L			
Dischage Concentration	0.18	mg/L			
Removed	0.60	mg/L			
Load	85	lbs/yr	$25,000	$ 2,126,700	
Net Present Worth				$ 2,449,958	

COA LTCPU
T3-12-ft

Alternative T3-12-ft Diameter Tunnel
Date: 15-Oct-15
Prepared By: D. Dvorak
Checked By: J. McGettigan

Item	QTY	Units	Unit Cost	Total	Comments
003/004 Tunnel					
12' Tunnel from Dangerfield Road to NMF	**2,700**	LF	$4,800	$12,960,000	Guidance From Jacobs
Shaft 1 (20' diameter)	**75**	VLF	$32,000	$2,400,000	Guidance From Jacobs
Shaft 2 (25' diameter)	**90**	VLF	$37,000	$3,330,000	Guidance From Jacobs
Shaft 3 (20' diameter)	**100**	VLF	$32,000	$3,200,000	Guidance From Jacobs
12' Tunnel from CI to NMF	**400**	LF	$4,800	$1,920,000	Guidance From Jacobs
Diversion Structures	**2**	EA	$600,000	$1,200,000	Local Project Data (K&W)
48" Sewer	**300**	LF	$1,200	$360,000	DC LTCP
				$25,370,000	
Facilities					
Odor Control	**1**	EA	$1,000,000	$1,000,000	Allowance
Dewatering PS	2.2	MGD	Equation	$1,040,000	Cost Curve
Wet Weather PS	**1**	LS	$7,100,000	$7,100,000	TO-16 Estimate
Climber Screens	**1**	LS	$3,000,000	$3,000,000	Allowace
				$12,140,000	
Subtotal				*$37,510,000*	
Construction Contingency	35%			$13,128,500	
Construction Subtotal				$50,638,500	
Planning, Design, Construction Management, Administration, Permitting and Easements	35%			$17,723,475	
Land Acquisition	14,520	SF	$125	$1,815,000	
Easements			$38	$0	
Total Project				**$70,176,975**	

Table 2: Operational and Maintenance Cost Estimate

Item	QTY	Units	Unit Cost	Total	Comments
Operational Cost					
Treatment Cost at AlexRenew	17.9	MGY	$ 6.44	$ 115,276	$6.44/1,000 Gallons
Pumping Costs	9,485	kw-hrs	$ 0.08	$ 758.8	
Annual Volume	**17.9**	MGY			
Total Dynamic Head	**90**	ft			
Pump Efficiency	0.6				
Motor Efficiency	0.9				
Washdown Water (10% Tunnel Volume x 4)	880	TG	$ 4.00	$ 3,520	
Labor Costs	576	Hrs	$ 50.00	$ 28,800	
Monthly Inspections (12@16hrs/each)	**192**	Hrs			
Quarterly Cleaning (4@96hrs/each)	**384**	Hrs			
Maintenance Costs					
Percentage of Construction	1.00%			$ 506,385	DC LTCP Assumption
Annual O&M				$ 654,740	
Net Present Worth				**$ 9,740,875**	

Table 3: Stormwater Nutrient and Sediment Costs

Item	QTY	Units	Unit Cost	Total	Comments
Annual Volume	17.9	MGY			
Total Suspended Solids					
TMDL Concentration	70.50	mg/L			
Dischage Concentration	6.0	mg/L			
Removed	64.50	mg/L			
Load	9629	lbs/yr	$80	$ 770,316	
Nitrogen					
TMDL Concentration	5.88	mg/L			
Dischage Concentration	3.0	mg/L			
Removed	2.88	mg/L			
Load	430	lbs/yr	$6,000	$ 2,579,662	
Phosphorous					
TMDL Concentration	0.78	mg/L			
Dischage Concentration	0.18	mg/L			
Removed	0.60	mg/L			
Load	90	lbs/yr	$25,000	$ 2,239,290	
Net Present Worth				$ 2,579,662	

Attachment B

CSO-002 Tunnel Cost Estimates

COA LTCPU
T5-8-ft

Alternative T5-8-ft Diameter Tunnel
Date: 15-Oct-15
Prepared By: D. Dvorak
Checked By:

Item	QTY	Units	Unit Cost	Total	Comments
002 Tunnel					
8' Tunnel from Dangerfield Road to NMF	**5,000**	LF	$3,600	$18,000,000	Guidance From Jacobs
Shaft 1 (20' diameter)	**100**	VLF	$32,000	$3,200,000	Guidance From Jacobs
Shaft 2 (15' diameter)	**80**	VLF	$26,000	$2,080,000	Guidance From Jacobs
Shaft 3 (20' diameter)	**70**	VLF	$32,000	$2,240,000	Guidance From Jacobs
8' Tunnel from CI to NMF	**0**	LF	$3,600	$0	Guidance From Jacobs
Diversion Structures	**1**	EA	$600,000	$600,000	Local Project Data (K&W)
48" Sewer	**0**	LF	$1,200	$0	DC LTCP
				$26,120,000	
Facilities					
Odor Control	**1**	EA	$500,000	$500,000	Allowance
Dewatering PS	1.9	MGD	Equation	$940,000	Cost Curve
Climber Screens	**1**	LS	$2,000,000	$2,000,000	Allowace
				$3,440,000	
Subtotal				*$29,560,000*	
Construction Contingency	35%			$10,346,000	
Construction Subtotal				$39,906,000	
Planning, Design, Construction Management, Administration, Permitting and Easements	35%			$13,967,100	
Land Acquisition	0	SF	$75	$0	
Easements		SF	$23		
Total Project				**$53,873,100**	

Table 2: Operational and Maintenance Cost Estimate

Item	QTY	Units	Unit Cost	Total	Comments
Operational Cost					
Treatment Cost at AlexRenew	36.8	MGY	$ 6.44	$ 236,992	$6.44/1,000 Gallons
Pumping Costs	19,500	kw-hrs	$ 0.08	$ 1,560.0	
Annual Volume	**36.8**	MGY			
Total Dynamic Head	**90**	ft			
Pump Efficiency	0.6				
Motor Efficiency	0.9				
Washdown Water (10% Tunnel Volume x 4)	760	TG	$ 4.00	$ 3,040	
Labor Costs	576	Hrs	$ 50.00	$ 28,800	
Monthly Inspections (12@16hrs/each)	**192**	Hrs			
Quarterly Cleaning (4@96hrs/each)	**384**	Hrs			
Maintenance Costs					
Percentage of Construction	1.00%			$ 399,060	DC LTCP Assumption
Annual O&M				$ 669,452	
Net Present Worth				**$ 9,959,755**	

Table 3: Stormwater Nutrient and Sediment Costs

Item	QTY	Units	Unit Cost	Total	Comments
Annual Volume	36.8	MGY			
Total Suspended Solids					
TMDL Concentration	70.50	mg/L			
Dischage Concentration	6.0	mg/L			
Removed	64.50	mg/L			
Load	19796	lbs/yr	$80	$ 1,583,666	
Nitrogen					
TMDL Concentration	5.88	mg/L			
Dischage Concentration	3.0	mg/L			
Removed	2.88	mg/L			
Load	884	lbs/yr	$6,000	$ 5,303,439	
Phosphorous					
TMDL Concentration	0.78	mg/L			
Dischage Concentration	0.18	mg/L			
Removed	0.60	mg/L			
Load	184	lbs/yr	$25,000	$ 4,603,680	
Net Present Worth				$ 5,303,439	

COA LTCPU
T5-10-ft

Alternative T5-10-ft Diameter Tunnel
Date: 15-Oct-15
Prepared By: D. Dvorak
Checked By:

Item	QTY	Units	Unit Cost	Total	Comments
002 Tunnel					
10' Tunnel from Dangerfield Road to NMF	**5,000**	LF	$4,250	$21,250,000	Guidance From Jacobs
Shaft 1 (20' diameter)	**100**	VLF	$32,000	$3,200,000	Guidance From Jacobs
Shaft 2 (20' diameter)	**80**	VLF	$32,000	$2,560,000	Guidance From Jacobs
Shaft 3 (20' diameter)	**70**	VLF	$32,000	$2,240,000	Guidance From Jacobs
10' Tunnel from CI to NMF	**0**	LF	$4,250	$0	Guidance From Jacobs
Diversion Structures	**1**	EA	$600,000	$600,000	Local Project Data (K&W)
48" Sewer	**0**	LF	$1,200	$0	DC LTCP
				$29,850,000	
Facilities					
Odor Control	**1**	EA	$750,000	$750,000	Allowance
Dewatering PS	2.9	MGD	Equation	$1,270,000	Cost Curve
Climber Screens	**1**	LS	$2,000,000	$2,000,000	Allowace
				$4,020,000	
Subtotal				*$33,870,000*	
Construction Contingency	35%			$11,854,500	
Construction Subtotal				$45,724,500	
Planning, Design, Construction Management, Administration, Permitting and Easements	35%			$16,003,575	
Land Acquisition	0	SF	$75	$0	
Easements	0	SF	$23		
Total Project				**$61,728,075**	

Table 2: Operational and Maintenance Cost Estimate

Item	QTY	Units	Unit Cost	Total	Comments
Operational Cost					
Treatment Cost at AlexRenew	39.9	MGY	$ 6.44	$ 256,956	$6.44/1,000 Gallons
Pumping Costs	21,143	kw-hrs	$ 0.08	$ 1,691.4	
Annual Volume	**39.9**	MGY			
Total Dynamic Head	**90**	ft			
Pump Efficiency	0.6				
Motor Efficiency	0.9				
Washdown Water (10% Tunnel Volume x 4)	1,160	TG	$ 4.00	$ 4,640	
Labor Costs	576	Hrs	$ 50.00	$ 28,800	
Monthly Inspections (12@16hrs/each)	**192**	Hrs			
Quarterly Cleaning (4@96hrs/each)	**384**	Hrs			
Maintenance Costs					
Percentage of Construction	1.00%			$ 457,245	DC LTCP Assumption
Annual O&M				$ 749,332	
Net Present Worth				**$ 11,148,174**	

Table 3: Stormwater Nutrient and Sediment Costs

Item	QTY	Units	Unit Cost	Total	Comments
Annual Volume	39.9	MGY			
Total Suspended Solids					
TMDL Concentration	70.50	mg/L			
Dischage Concentration	6.0	mg/L			
Removed	64.50	mg/L			
Load	21463	lbs/yr	$80	$ 1,717,073	
Nitrogen					
TMDL Concentration	5.88	mg/L			
Dischage Concentration	3.0	mg/L			
Removed	2.88	mg/L			
Load	958	lbs/yr	$6,000	$ 5,750,196	
Phosphorous					
TMDL Concentration	0.78	mg/L			
Dischage Concentration	0.18	mg/L			
Removed	0.60	mg/L			
Load	200	lbs/yr	$25,000	$ 4,991,490	
Net Present Worth				$ 5,750,196	

COA LTCPU
T5-12-ft

Alternative T5-12-ft Diameter Tunnel
Date: 15-Oct-15
Prepared By: D. Dvorak
Checked By:

Item	QTY	Units	Unit Cost	Total	Comments
002 Tunnel					
12' Tunnel from Dangerfield Road to NMF	**5,000**	LF	$4,900	$24,500,000	Guidance From Jacobs
Shaft 1 (25' diameter)	**100**	VLF	$37,000	$3,700,000	Guidance From Jacobs
Shaft 2 (20' diameter)	**80**	VLF	$32,000	$2,560,000	Guidance From Jacobs
Shaft 3 (25' diameter)	**70**	VLF	$37,000	$2,590,000	Guidance From Jacobs
12' Tunnel from CI to NMF	**0**	LF	$4,900	$0	Guidance From Jacobs
Diversion Structures	**1**	EA	$600,000	$600,000	Local Project Data (K&W)
48" Sewer	**0**	LF	$1,200	$0	DC LTCP
				$33,950,000	
Facilities					
Odor Control	**1**	EA	$1,000,000	$1,000,000	Allowance
Dewatering PS	4.2	MGD	Equation	$1,700,000	Cost Curve
Climber Screens	**1**	LS	$3,000,000	$3,000,000	Allowace
				$5,700,000	
Subtotal				*$39,650,000*	
Construction Contingency	35%			$13,877,500	
Construction Subtotal				$53,527,500	
Planning, Design, Construction Management, Administration, Permitting and Easements	35%			$18,734,625	
Land Acquisition	0	SF	$75	$0	
Easements		SF	$23		
Total Project				**$72,262,125**	

Table 2: Operational and Maintenance Cost Estimate

Item	QTY	Units	Unit Cost	Total	Comments
Operational Cost					
Treatment Cost at AlexRenew	42.4	MGY	$ 6.44	$ 273,056	$6.44/1,000 Gallons
Pumping Costs	22,467	kw-hrs	$ 0.08	$ 1,797.4	
Annual Volume	**42.4**	MGY			
Total Dynamic Head	**90**	ft			
Pump Efficiency	0.6				
Motor Efficiency	0.9				
Washdown Water (10% Tunnel Volume x 4)	1,680	TG	$ 4.00	$ 6,720	
Labor Costs	576	Hrs	$ 50.00	$ 28,800	
Monthly Inspections (12@16hrs/each)	**192**	Hrs			
Quarterly Cleaning (4@96hrs/each)	**384**	Hrs			
Maintenance Costs					
Percentage of Construction	1.00%			$ 535,275	DC LTCP Assumption
Annual O&M				$ 845,648	
Net Present Worth				**$ 12,581,113**	

Table 3: Stormwater Nutrient and Sediment Costs

Item	QTY	Units	Unit Cost	Total	Comments
Annual Volume	42.4	MGY			
Total Suspended Solids					
TMDL Concentration	70.50	mg/L			
Dischage Concentration	6.0	mg/L			
Removed	64.50	mg/L			
Load	22808	lbs/yr	$80	$ 1,824,659	
Nitrogen					
TMDL Concentration	5.88	mg/L			
Dischage Concentration	3.0	mg/L			
Removed	2.88	mg/L			
Load	1018	lbs/yr	$6,000	$ 6,110,484	
Phosphorous					
TMDL Concentration	0.78	mg/L			
Dischage Concentration	0.18	mg/L			
Removed	0.60	mg/L			
Load	212	lbs/yr	$25,000	$ 5,304,240	
Net Present Worth				$ 6,110,484	

Attachment C

CSO-002 Storage Tank Cost Estimates

COA LTCPU
Alternative 1 - 2.0 MG

Date: 16-Nov-15
Prepared By: D. Dvorak
Checked By: J. McGettigan

Table 1: Project Cost Estimate

Item	QTY	Units	Unit Cost	Total	Comments
002 Tank - Alternative 1					
Below Grade Storage Tank	2.0	MG	Equation	$11,970,000	Cost Curve
Pump Station	2.0	MGD	Equation	$800,000	Cost Curve
				$0	
				$0	
				$0	
				$0	
				$0	
				$12,770,000	
Facilities					
Odor Control	1	EA	$300,000	$300,000	Allowance
Diversion Structure	1	EA	$600,000	$600,000	
Screening Facilities	1	LS	$750,000	$750,000	Allowance
				$1,650,000	
Subtotal				*$14,420,000*	
Construction Contingency	35%			$5,050,000	
Construction Subtotal				*$19,470,000*	
Planning, Design, CM, Administration,	35%			$6,810,000	
Land Acquisition	48,000	SF	$75	$3,600,000	(L+100) x (W+100)
Total Project				**$29,880,000**	

Table 2: Operational and Maintenance Cost Estimate

Item	QTY	Units	Unit Cost	Total	Comments
Operational Cost					
Treatment Cost at AlexRenew	36.8	MGY	$ 6.44	$ 236,992	$6.44/1,000 Gallons
Pumping Costs	6,500	kw-hrs	$ 0.08	$ 520	
Annual Volume	36.8	MGY			
Total Dynamic Head	30	ft			
Pump Efficiency	0.6				
Motor Efficiency	0.9				
Washdown Water (10% Tank Volume x 4)	800	TG	$ 4.00	$ 3,200	
Labor Costs	574.5	Hrs	$ 50.00	$ 28,725	
Daily Check (365@0.5hrs/each)	182.5	Hrs			
Weekly Inspections (52@2hrs/each)	104	Hrs			
Monthly Inspections (12@8hrs/each)	96	Hrs			
Quarterly Cleaning (4@48hrs/each)	192	Hrs			
Maintenance Costs					
Percentage of Construction	1.50%			$ 292,050	DC LTCP Assumption
Annual O&M				$ 561,487	
Net Present Worth				$ 8,350,000	

Table 3: Stormwater Nutrient and Sediment Costs

Item	QTY	Units	Unit Cost		Total	Comments
Annual Volume	36.8	MGY				
Total Suspended Solids						
TMDL Concentration	70.50	mg/L				
Dischage Concentration	6.0	mg/L				
Removed	64.50	mg/L				
Load	19796	lbs/yr	$80	$	1,583,666	
Nitrogen						
TMDL Concentration	5.88	mg/L				
Dischage Concentration	3.0	mg/L				
Removed	2.88	mg/L				
Load	884	lbs/yr	$6,000	$	5,303,439	
Phosphorous						
TMDL Concentration	0.78	mg/L				
Dischage Concentration	0.18	mg/L				
Removed	0.60	mg/L				
Load	184	lbs/yr	$25,000	$	4,603,680	
Net Present Worth (Maximum Value)				$	5,303,439	

COA LTCPU
Alternative 1 - 3.0 MG

Date: 16-Nov-15
Prepared By: D. Dvorak
Checked By: J. McGettigan

Table 1: Project Cost Estimate

Item	QTY	Units	Unit Cost	Total	Comments
002 Tank - Alternative 1					
Below Grade Storage Tank	3.0	MG	Equation	$16,430,000	Cost Curve
Pump Station	3.0	MGD	Equation	$1,040,000	Cost Curve
				$0	
				$0	
				$0	
				$0	
				$0	
				$17,470,000	
Facilities					
Odor Control	1	EA	$450,000	$450,000	Allowance
Diversion Structure	1	EA	$600,000	$600,000	
Screening Facilities	1	LS	$1,125,000	$1,130,000	Allowance
				$2,180,000	
Subtotal				*$19,650,000*	
Construction Contingency	35%			$6,880,000	
Construction Subtotal				*$26,530,000*	
Planning, Design, CM, Administration,	35%			$9,290,000	
Land Acquisition	60,000	SF	$75	$4,500,000	(L+100) x (W+100)
Total Project				**$40,320,000**	

Table 2: Operational and Maintenance Cost Estimate

Item	QTY	Units	Unit Cost	Total	Comments
Operational Cost					
Treatment Cost at AlexRenew	39.9	MGY	$ 6.44	$ 256,956	$6.44/1,000 Gallons
Pumping Costs	7,048	kw-hrs	$ 0.08	$ 564	
Annual Volume	39.9	MGY			
Total Dynamic Head	30	ft			
Pump Efficiency	0.6				
Motor Efficiency	0.9				
Washdown Water (10% Tank Volume x 4)	1200	TG	$ 4.00	$ 4,800	
Labor Costs	574.5	Hrs	$ 50.00	$ 28,725	
Daily Check (365@0.5hrs/each)	182.5	Hrs			
Weekly Inspections (52@2hrs/each)	104	Hrs			
Monthly Inspections (12@8hrs/each)	96	Hrs			
Quarterly Cleaning (4@48hrs/each)	192	Hrs			
Maintenance Costs					
Percentage of Construction	1.50%			$ 397,950	DC LTCP Assumption
Annual O&M				$ 688,995	
Net Present Worth				$ 10,250,000	

Table 3: Stormwater Nutrient and Sediment Costs

Item	QTY	Units	Unit Cost		Total	Comments
Annual Volume	39.9	MGY				
Total Suspended Solids						
TMDL Concentration	70.50	mg/L				
Dischage Concentration	6.0	mg/L				
Removed	64.50	mg/L				
Load	21463	lbs/yr	$80	$	1,717,073	
Nitrogen						
TMDL Concentration	5.88	mg/L				
Dischage Concentration	3.0	mg/L				
Removed	2.88	mg/L				
Load	958	lbs/yr	$6,000	$	5,750,196	
Phosphorous						
TMDL Concentration	0.78	mg/L				
Dischage Concentration	0.18	mg/L				
Removed	0.60	mg/L				
Load	200	lbs/yr	$25,000	$	4,991,490	
Net Present Worth (Maximum Value)				$	5,750,196	

COA LTCPU
Alternative 1 - 4.0 MG

Date: 16-Nov-15
Prepared By: D. Dvorak
Checked By: J. McGettigan

Table 1: Project Cost Estimate

Item	QTY	Units	Unit Cost	Total	Comments
002 Tank - Alternative 1					
Below Grade Storage Tank	4.0	MG	Equation	$20,570,000	Cost Curve
Pump Station	4.0	MGD	Equation	$1,270,000	Cost Curve
				$0	
				$0	
				$0	
				$0	
				$0	
				$21,840,000	
Facilities					
Odor Control	1	EA	$600,000	$600,000	Allowance
Diversion Structure	1	EA	$600,000	$600,000	
Screening Facilities	1	LS	$1,500,000	$1,500,000	Allowance
				$2,700,000	
Subtotal				*$24,540,000*	
Construction Contingency	35%			$8,590,000	
Construction Subtotal				*$33,130,000*	
Planning, Design, CM, Administration,	35%			$11,600,000	
Land Acquisition	71,500	SF	$75	$5,362,500	(L+100) x (W+100)
Total Project				**$50,090,000**	

Table 2: Operational and Maintenance Cost Estimate

Item	QTY	Units	Unit Cost	Total	Comments
Operational Cost					
Treatment Cost at AlexRenew	42.4	MGY	$ 6.44	$ 273,056	$6.44/1,000 Gallons
Pumping Costs	7,489	kw-hrs	$ 0.08	$ 599	
Annual Volume	42.4	MGY			
Total Dynamic Head	30	ft			
Pump Efficiency	0.6				
Motor Efficiency	0.9				
Washdown Water (10% Tank Volume x 4)	1600	TG	$ 4.00	$ 6,400	
Labor Costs	574.5	Hrs	$ 50.00	$ 28,725	
Daily Check (365@0.5hrs/each)	182.5	Hrs			
Weekly Inspections (52@2hrs/each)	104	Hrs			
Monthly Inspections (12@8hrs/each)	96	Hrs			
Quarterly Cleaning (4@48hrs/each)	192	Hrs			
Maintenance Costs					
Percentage of Construction	1.50%			$ 496,950	DC LTCP Assumption
Annual O&M				$ 805,730	
Net Present Worth				$ 11,990,000	

COA LTCPU
Alternative 1 - 4.0 MG

Table 3: Stormwater Nutrient and Sediment Costs

Item	QTY	Units	Unit Cost		Total	Comments
Annual Volume	42.4	MGY				
Total Suspended Solids						
TMDL Concentration	70.50	mg/L				
Dischage Concentration	6.0	mg/L				
Removed	64.50	mg/L				
Load	22808	lbs/yr	$80	$	1,824,659	
Nitrogen						
TMDL Concentration	5.88	mg/L				
Dischage Concentration	3.0	mg/L				
Removed	2.88	mg/L				
Load	1018	lbs/yr	$6,000	$	6,110,484	
Phosphorous						
TMDL Concentration	0.78	mg/L				
Dischage Concentration	0.18	mg/L				
Removed	0.60	mg/L				
Load	212	lbs/yr	$25,000	$	5,304,240	
Net Present Worth (Maximum Value)				$	6,110,484	

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