PHASE 2 - EVALUATION OF TRAVILAH QUARRY FOR WATER SUPPLY STORAGE

Final Report

Prepared for:

Interstate Commission on the Potomac River Basin (ICPRB)

2 SEPTEMBER 2015

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LIST OF ACRONYMS AND ABBREVIATIONS

B&V	Black and Veatch
C&O	Chesapeake & Ohio
ICPRB	Interstate Commission on the Potomac River Basin
LCC	Life Cycle Costs
MDE	Maryland Department of the Environment
MDNR	Maryland Department of Natural Resources
MD SHA	Maryland State Highway Administration
MHT	Maryland Historic Trust
NEPA	National Environmental Policy Act
NPS	National Park Service
NPV	Net Present Value
OB&G	O'Brien & Gere Engineers, Inc.
O&M	Operating and Maintenance
OPCC	Opinion of Probable Construction Costs
OPOMC	Opinion of Probable Operations and Maintenance Cost
PCCP	Pre-stressed Concrete Cylinder Pipe
PEPCO	Potomac Electric Power Company
TBM	Tunnel Boring Machine
USACE	U.S. Army Corps of Engineers
USFWS	U.S. Fish and Wildlife Service
VA DEQ	Virginia Department of Environmental Quality
WSSC	Washington Suburban Sanitary Commission

1. INTRODUCTION

1.1 Background and Purpose

Black & Veatch (B&V) was retained by the Interstate Commission on the Potomac River Basin (ICPRB) to perform the feasibility study (the "study") of potential prerequisites for use of the Travilah Quarry (the "quarry") as a raw water supply storage facility, to supplement the existing water supply for the Washington Suburban Sanitary Commission (WSSC) and the Washington Aqueduct. The assessment was divided into two phases. The first phase of the study is focused on studying characteristics of the quarry for water storage potential and water quality aspects. The second phase assesses potential options for conveyance, pumping and presents life cycle costs for different alternatives.

B&V completed the first phase of the investigation and submitted a final report (refer to "*Phase 1-Evaluation of Travilah Quarry for Water Supply Storage, by Black & Veatch, dated October 3, 2014*"). The findings of the first phase of the study deemed the quarry suitable for the purposes of raw water storage, and presented estimated storage volumes based on the mining plans and B&V's experience from other similar projects. The following were the key findings of the first phase:

- The current storage available in the Quarry is approximately 7.3 BG, based on the quarry reservoir pool elevation of 350 feet above the mean sea level;
- The estimated ultimate storage in the Quarry is approximately 17.4 BG, based on the mining plans and quarry reservoir pool elevation of 350 feet above the mean sea level. The ultimate capacity is expected to be available sometime around 2060;
- Based on the field reconnaissance and assessment of geology, it was noted that the quarry walls are generally stable. There are natural discontinuities in the rock that may require grouting;
- It is expected that groundwater infiltration will be minimal, and hence the resulting quality of stored water will be in the range of available water treatment technologies;
- External pumping will be needed to fill the quarry. The management of water quality can be accomplished through inlet/outlet design and pumping strategies.

Subsequent to the acceptance of the Phase 1 report, the ICPRB directed B&V to initiate the Phase 2 investigations. Through this Phase 2 study, the preliminary investigation of the quarry conducted for the WSSC over a decade ago (OB&G, 2002) performed by O'Brien & Gere Engineers, Inc. (hereinafter referred to as the "OB&G Study") will be updated and expanded to include conceptual design and layout of the infrastructure necessary to use the quarry as a multipurpose reservoir for raw water storage for use by the Potomac Water Filtration Plant (hereinafter referred to as the "plant"). In addition, this Phase 2 study will also include conceptual design and layout of the infrastructure necessary to convey water from the quarry and plant to the Washington Aqueduct.

1.2 Scope of this Study

Phase 2 of this study consists of four tasks (Tasks No. 5 to No. 8) to focus on the sizing, routing and development of operational alternatives for raw water conveyance between WSSC's Potomac WFP and the quarry as well as integration of the quarry with the Washington Aqueduct's raw water supply.

Routing of Raw Water Conveyance for Quarry Fill and Withdrawal (Task 5)

This task includes updating the OB&G Study and further evaluation of options for raw water pumping and return flow between the WSSC Potomac WFP and the quarry, for a range of different pump and pipeline sizes.

Permitting Requirements (Task 6)

This task includes the evaluation of permitting requirements associated with the use of the quarry as a raw water supply facility, including withdrawal and discharge permits required for use of the quarry as a raw water supply facility and updating the regulatory issues discussed in the OB&G Study.

Routing of Raw Water Conveyance to the Washington Aqueduct's Raw Water Facilities (Task 7)

This task includes the evaluation of options to convey raw water from the quarry and plant to the Washington Aqueduct, including routing, sizing, design considerations, required right of way, and planning level cost estimates for future pipelines and tunnels.

Evaluation of Life Cycle Costs (Task 8)

This task includes the development of planning level capital cost and operations and maintenance (O&M) cost estimates, using the 2002 Study (O'Brien & Gere) and additional information gathered in this Feasibility Study.

1.3 Summary of Previous Work

Prior to the Phase 1 study, four earlier studies were performed to assess the use of Travilah Quarry for raw water supply storage. These studies include:

- Potomac WFP Facility Plan. O'Brien & Gere Engineers, Inc. (OB&G). September 13, 2002.
- Potomac Water Filtration Plant Reliability- Travilah Quarry Raw Water Storage Feasibility Study. C.C. Johnson & Malhotra, P.C. September 19, 2001.
- Montgomery County, MD Waste Management Study – Phase II Report Vol. 9 – Travilah Quarry Hydrogeologic Assessment Report. Woodward – Clyde Consultants, June 1986.
- Phase II – Quarry Balefill Feasibility Study (Montgomery County Office of Environmental Construction). Fugro Atlantic, Inc, December 1980.

The configurations described in the OB&G study, 2002, are used as the basis of the alternative conveyance options considered in this Phase 2 study. It is noted that the scope of the 2002 study was limited to raw water storage and water supply functions solely for use by the WSSC; consequently the sizes of the conveyance and pumping infrastructure discussed in OB&G, 2002 report are refined in the current study to reflect combined infrastructure needs for the WSSC and Washington Aqueduct. A summary of previous concepts for the use of the quarry as a raw water supply storage facility and the infrastructure required for quarry fill and withdrawal is presented.

Previous "Concept A": Near Surface Pipelines and Two New Pumping Stations

OB&G's Concept A included fill and withdrawal pipelines, a quarry fill pump station and a quarry withdrawal pump station, as well as quarry site improvements. The length of each pipeline would be approximately three (3) to four (4) miles, depending on the ultimate route chosen. The size of the pipelines would vary from 60” to 96” in diameter, depending on desired flow rates from 100 MGD to 300 MGD, respectively.

Concept A also included new quarry fill and quarry withdrawal pump stations. The quarry fill pump station, located at the WSSC Potomac WFP, would tie into the existing raw water pump station discharge at the plant and would pump raw water to the quarry up to elevation 400. The quarry withdrawal pump station, located at the quarry, would consist of either barge mounted pumps in the quarry or drilled wells located around the perimeter of the quarry. OB&G estimated pumping rates of 100 MGD to 300 MGD for both quarry fill and withdrawal.

The quarry site improvements would consist of sealing one face of the quarry as well as general site work to prepare the quarry for use as a raw water supply storage facility.

Previous “Concept B”: Tunnels & Modification of Existing Potomac Plant Pump Station

OB&G’s Concept B included fill and withdrawal tunnels in two different configurations (Concept B-1 and Concept B-2) and modification of the existing raw water pumping stations at the WSSC Potomac WFP as well as quarry site improvements as included in Concept A.

Concept B-1 included two separate tunnels, each approximately three (3) miles in length, which would vary from 96” to 120” in diameter and could provide a flow rate of up to 300 MGD. Concept B-2 included a 48” diameter fill pipeline inside of a 120” diameter withdrawal tunnel, of similar length. The 48” pipeline would provide quarry fill up to 60 MGD and the withdrawal tunnel would provide a flow rate up to 300 MGD.

Concept B also includes the modification of the existing raw water pumping stations at the WSSC plant by replacing existing pumps with higher head pumps to allow for dual use of the existing pumping stations for both delivering raw water to the plant and delivering raw water to the quarry for storage, as well as both locations simultaneously.

2. ASSUMPTIONS MADE FOR PHASE 2 ANALYSES

Several assumptions were used to refine and evaluate alternatives and to develop planning level cost estimates for the conveyance of raw water for quarry fill and withdrawal and for the conveyance of raw water to the Washington Aqueduct. The assumptions are described as follows:

2.1 Geotechnical and Geologic Assumptions

Based on the LIDAR Survey data from Montgomery County, Maryland, the highest ground surface elevation between the quarry and the WSSC Potomac WFP is assumed to be 400 feet above mean sea level. The elevation of the quarry at its lowest point around the perimeter is assumed to be 360 feet above mean sea level.

Based on the surface elevations from Google Earth, the ground surface elevations at the WSSC plant and at the Washington Aqueduct Facility at Great Falls are assumed to be at elevation 200 feet above mean sea level. The ground surface elevation at Old Angler’s Inn is assumed to be at elevation 150 feet above mean sea level.

Based on B&V's assessment during site visits, the depth to bedrock is assumed to be shallow at the quarry and in the corridor between the WSSC plant and the quarry. It is assumed that the bedrock is twenty (20) feet below the ground surface elevation at these locations.

Based on geotechnical information from WSSC's Potomac WFP as-builts, and similar information from other projects, the depth to bedrock is assumed to be shallow at the plant and at the Washington Aqueduct at Great Falls. The bedrock is assumed to be approximately at elevation 150 feet above mean sea level.

Based on B&V's high level assessment of the local geology, the depth to bedrock is assumed to be shallow at Old Angler's Inn and is assumed to be approximately twenty (20) feet below the ground surface elevation.

2.2 Potomac River and Potomac Plant Assumptions

The average water level of the Potomac River at the WSSC Potomaqc WFP is elevation 160.40 feet above mean sea level (WSSC, 1978).

The invert elevation of the Potomac WFP's intake is elevation 152 feet above mean sea level (WSSC, 1978).

The water level in the Potomac River at the intake can vary from approximately elevation 150 feet to elevation 190 feet, above the mean sea level.

2.3 Travilah Quarry Assumptions

The following assumptions are used to develop the facility configurations and layout of infrastructure:

- The maximum water surface elevation for storage in the quarry is elevation 350 feet above mean sea level (B&V, 2014).
- The invert elevation for intakes and outfalls at the connection with the quarry required for quarry fill and quarry withdrawal piping is placed at elevation 150 feet above mean sea level.
- The quarry fill rate is 60 MGD.
- The maximum quarry withdrawal rate is 400 MGD (200 MGD for the WSSC WFP and 200 MGD for the Washington Aqueduct).
- Quarry fill and withdrawal will not occur simultaneously.
- Quarry fill is assumed during periods when the water level in Potomac River is at or above 160.4 feet above mean sea level.

The ultimate estimated storage capacity of the quarry is 17.4 BG, which assumes an ultimate water surface elevation of 350 feet above mean sea level at capacity and a bottom quarry elevation of minus 100 (-100), one hundred feet below above mean sea level. Approximately 60% (10.2 BG) of the ultimate estimated storage capacity is located between elevation 350 feet and 150 feet above mean sea level. In order to obtain the remaining 7.2 BG, or approximately 40% of the ultimate estimated storage capacity located below elevation 150 feet above mean sea level, a separate lift station would be required to be constructed. Given the desired quarry withdrawal rate of 400 MGD and the differential head from elevation 150 feet to elevation -100 feet above mean sea level, a substantial lift station would be required to be constructed. The lift station would include several large vertical turbine pumps and due to the large anticipated size and number of pumps, this lift station is unlikely to be able to be barge mounted inside the quarry. It is anticipated that the capital costs for this lower lift station, including pumps and wet well, would be in excess of $50 Million.

Permanent facilities to dewater the quarry will be installed to elevation 150 feet above mean sea level. This allows for the quarry to be dewatered by gravity using the tunneled option or for the pipeline options with a single stage pump station which will be more cost effective than a two stage, 550 foot deep pump station that completely dewaters the quarry.

Temporary pumping facilities will be used below elevation 150 feet mean sea level to dewater the quarry's full storage capacity.

Estimates of current and projected capacity of the Travilah Quarry were developed in the Phase 1 Report. Estimated storage volumes at different points in time, corresponding to different quarry bottom elevations, are provided in Appendix A.

2.4 Washington Aqueduct Assumptions

The invert elevation of the intake for the Washington Aqueduct at Great Falls is 140.50 feet above the mean sea level (USACE, 2007).

The invert elevation of the Washington Aqueduct near Old Angler's Inn is assumed to be at approximately elevation 140 feet above the mean sea level.

3. OVERVIEW OF ALTERNATIVES AND COMPONENTS

3.1 Summary of Alternatives

Two functions were investigated as a part of this Phase 2 of the feasibility study: conveyance of raw water to and from the quarry to the Potomac plant, and conveyance of raw water from the Potomac plant to the Washington Aqueduct. Commensurate to these functions, two separate sets of alternatives have been developed. These sets of alternatives are referred to as "Quarry Fill/ Withdrawal", and "Washington Aqueduct Conveyance" alternatives, respectively. It is noted that for establishing raw water supply from the quarry to the Washington Aqueduct, one alternative from each set will be required.

Black & Veatch reviewed and evaluated Concepts A and B in the OB&G Study and developed the following Quarry Fill/Withdrawal alternatives for consideration in Phase 2:

- **One Tunnel and One Pumping Station Alternative**, which includes a deep tunnel along the utility corridor, and one pumping station at the WSSC plant.
- **Two Pipelines and Two Pumping Stations Alternative**, which includes two separate pipelines and two pumping stations at the WSSC plant and at the quarry. The alternative offers two options for the pipeline alignment, along Utility and Roadway Corridors.

  Black & Veatch also developed the following Washington Aqueduct Conveyance alternatives:

- **Conveyance Tunnel to Great Falls Alternative**, which includes a deep tunnel connecting the Quarry Fill Pumping Station to the existing facility near the Great Falls river intake. The alternative offers two options for the tunnel alignment, along Potomac River and C&O Canal.

- **Conveyance Tunnel/ Pipeline to Old Angler's Inn Alternative**, which includes a conveyance infrastructure connecting the Quarry Fill Pumping Station to the existing raw water conduits near the Old Angler's Inn. The alternative offers two options which include a deep tunnel along C&O Canal, and Open Cut along Roadway Right of Way.

These alternatives maximize the use of existing public right of way, while minimizing the number of utility conflicts and the requirements for easements and property acquisition. The Quarry Fill/Withdrawal alternatives have some components that are common and the Washington Aqueduct Conveyance alternatives. Likewise, both sets of alternatives have components that differ. These components are summarized in the following sections.

3.2 Components Common Among all Alternatives

3.2.1 Quarry Improvements

Improvements must be made to the Travilah Quarry before it can be utilized for raw water supply storage. These improvements are independent of the conveyance and pumping alternatives, and were illustrated in the Phase 1 Report. The anticipated improvements consist of the following:

- Environmental testing and possible removal of fill material currently being dumped into the quarry (per Section 4.2 of the Phase 1 Report).
- Quarry high wall stabilization measures (per Section 4.3 of the Phase 1 Report).
- Grouting of major discontinuities in the quarry, specifically Feature G along the southwest quarry rim (per Section 5.3 and 5.4 of the Phase 1 Report).
- Environmental testing for the potential of residual contaminants from mining activities in the quarry and asphalt production adjacent to the quarry (per Section 6.3 and 6.4 of the Phase 1 Report).

3.2.2 Quarry Fill Pump Station Location

Each Quarry Fill/Withdrawal Alternative requires a pump station at the WSSC Potomac plant to pump the raw water to the quarry. Besides pumping the water into the quarry for filling purposes, it is envisioned that this pumping station will serve as the junction for collection and distribution of the withdrawn water from the quarry. During this study, B&V identified a potential location for Quarry Fill Pump Station which was agreed by the WSSC team, subject to detailed engineering. The potential location is northwest of the existing Raw Water Pump Station No. 1 and behind the existing Potassium Permanganate Building at the plant. See Figure 1 for the proposed location.

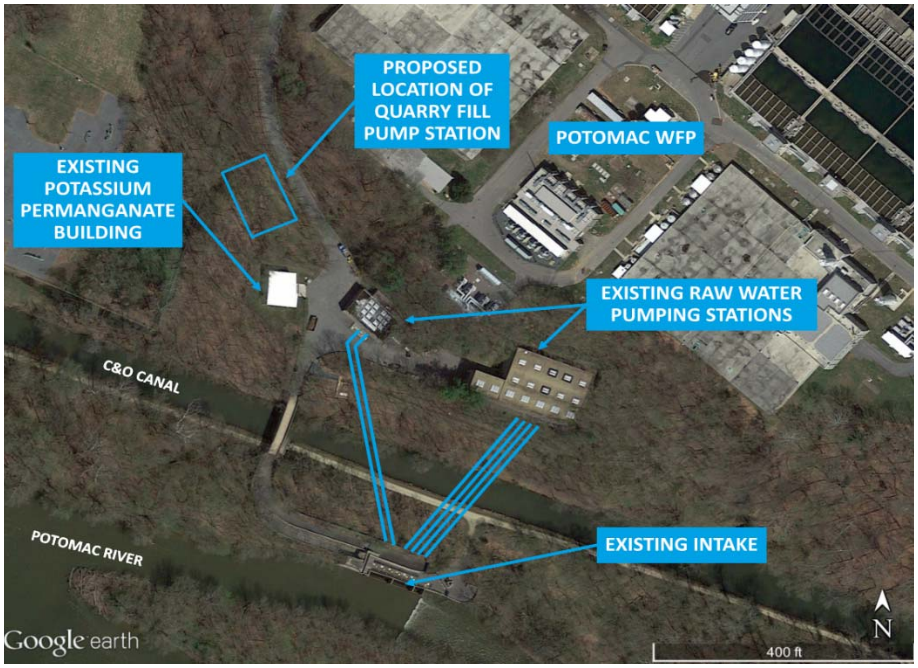

Figure 1 Proposed Quarry Fill Pump Station Location

3.2.3 Connections at the Potomac Plant

For filling the quarry, raw water from the WSSC's existing intake conduits will be pumped through the Quarry Fill Pump station to the quarry. New pipelines will be required to convey water from the point of connection to the Quarry Fill Pump station. It is envisioned that the proposed connection to the existing raw water intake conduits will be made on the suction side of either existing Pump Station 1, or existing Pump Station 2, or a combination of both. These pipes and connections may also serve the dual purpose of feeding the raw water from the quarry to the WSSC plant. Other options for connecting into the existing Raw Water Pump Stations were not developed because of the risk and potential constructability issues.

It also includes two separate connections, one to withdrawal piping (from the quarry) for collection of the withdrawn water, and the other to supply piping (to the Washington Aqueduct) for supply of raw water. These connections may require additional features such as flow control structures, energy dissipater, valves and isolation structures all of which are subjected to selection of an alternative and detail engineering during a later stage.

3.3 Components that Differ Among all Alternatives

3.3.1 Linear Infrastructure

At least two corridors of construction are available to construct linear infrastructure for the "Quarry Fill/ Withdrawal", and "Washington Aqueduct Conveyance" functions. In addition, the choice of construction methods (open cut or tunneled) provide additional options, all of which constitutes multiple alternatives for both the functions.

3.3.1.1 Corridors between Potomac Plant and Travilah Quarry

For each Quarry Fill/ Withdrawal Alternative, conveyance components will be required between the Quarry and the Quarry Fill Pump station. The area between the WSSC Potomac plant and the quarry is a mostly residential, with a limited number of direct routes between the two locations. Two possible corridors of construction were identified, which include an existing utility corridor and a roadway right of way corridor. These corridors are generally shown in Figure 2.

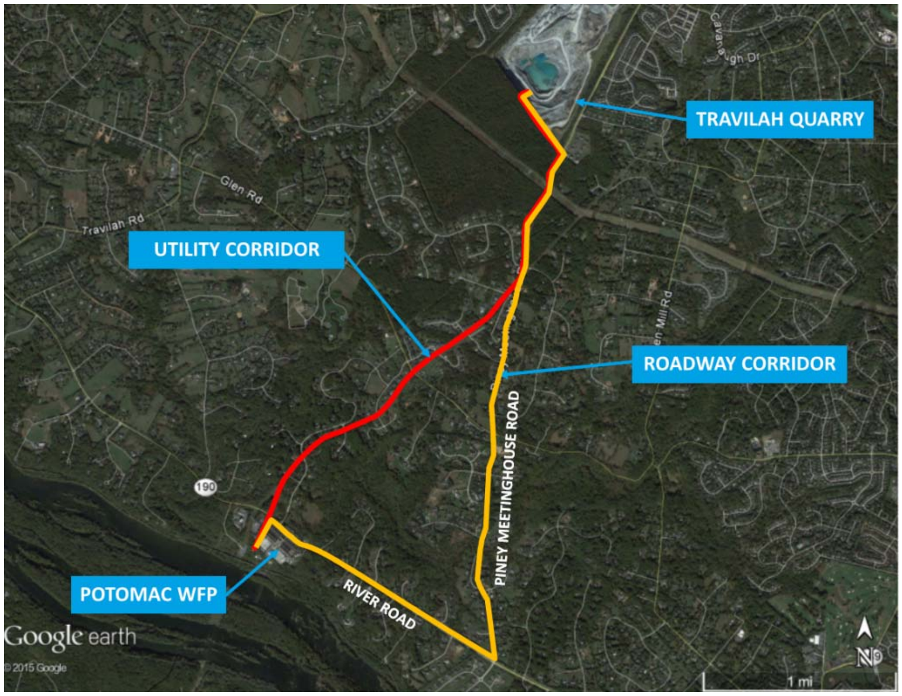

Figure 2 Corridors between Potomac Plant and Travilah Quarry

The utility corridor primarily runs from the southwest to the northeast between the plant and the quarry and was the chosen corridor for both Concepts A and B in the OB&G Study. The utility corridor contains five natural gas pipelines that are a part of the Transcontinental (TRANSCO) Gas Pipelines owned by the Williams Companies, Inc. which runs from the Gulf of Mexico to New York. According to GIS data, two 42", one 36", one 30" and one 26" gas pipeline exist along this utility corridor. In addition to the gas pipelines, two pre-stressed concrete cylinder pipe (PCCP) water transmission mains owned by the WSSC with diameters of 60" and 36" also are located along this utility corridor. A number or smaller diameter WSSC water and sewer lines also intersect the utility corridor and these lines are typically located along residential roadways that cross the utility corridor. The width of the existing utility easement(s) along this utility corridor is estimated to vary between 50 and 100 feet.

The primary roadway right of way corridor between the WSSC plant and the quarry is located along River Road (which primarily runs northwest to southeast) and along Piney Meetinghouse Road (which primarily runs north to south). A WSSC 66" diameter PCCP water transmission main is located within the right of way of River Road. Smaller diameter water and sewer lines, as well as overhead electrical and telecommunications lines run along and occasionally intersect both River Road and Piney Meetinghouse Road. The width of the right of way along River Road varies from approximately 50 feet to 150 feet. The width of the right of way along Piney Meetinghouse Road varies from less than twenty (20) feet to approximately 80 feet.

3.3.1.2 Corridors between Potomac Plant and Washington Aqueduct

For raw water supply to the Washington Aqueduct conveyance components will be required between the Quarry Fill Pump station and the point of connection to the existing raw water conduits. Two possible corridors of construction were identified, including a corridor along the Potomac River & Chesapeake & Ohio (C&O) Canal, and a roadway right of way corridor along River Road. These corridors were determined based on two possible tie-in locations to the existing Washington Aqueduct. The tie-in locations include near the existing intake of the Washington Aqueduct at Great Falls and along the Washington Aqueduct near Old Angler's Inn. These corridors are generally shown in Figure 3.

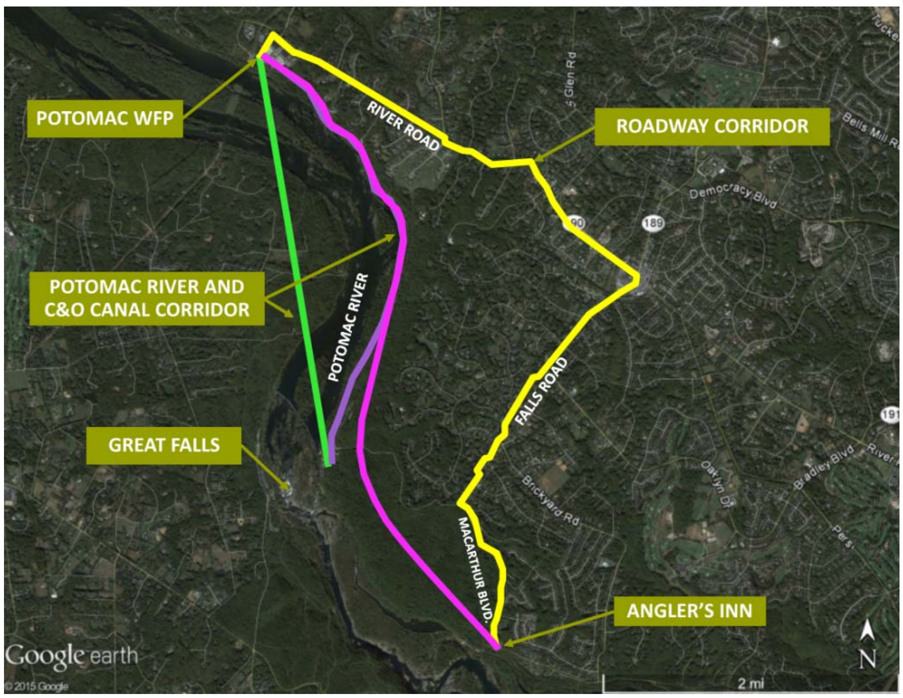

Figure 3 Corridors between Potomac Plant and Washington Aqueduct

The Potomac River and C&O Canal corridor primarily runs from the northwest to the southeast between the WSSC Potomac WFP and the Washington Aqueduct. Along this corridor, which is located for the most part within the flood plain of the Potomac River, little development exists. The following parks are located within the Potomac River floodplain: the C&O Canal National Historical Park, which is located on the Maryland side of the Potomac River and the Great Falls National Park and Riverbend Park, which are located on the Virginia Side of the Potomac River. Utilities are minimal along this corridor. An existing WSSC 8" diameter water line is located beneath MacArthur Boulevard and terminates near the roundabout inside the C&O Canal National Historical Park. The Potomac Interceptor, which is 84" diameter regional sewer, runs from the northwest to the southeast within the C&O Canal National Historical Park. In addition, the existing Washington Aqueduct runs beneath the C&O Canal within the C&O Canal National Historical Park from the intake location at the Washington Aqueduct Dam in the Potomac River to Old Angler's Inn, where the Washington Aqueduct begins to follow beneath MacArthur Boulevard to the east.

The roadway right of way corridor between the plant and the Washington Aqueduct is located along the right of way of River Road, Falls Road, and MacArthur Boulevard. River Road runs primarily northwest to southeast, Falls Road runs primarily northeast to southwest, and MacArthur Boulevard runs primarily northwest to southeast, for the portion of MacArthur Boulevard north of Old Angler's Inn. A WSSC 66" diameter PCCP water transmission main is located within the right of way of River Road from the WSSC plant to Falls Road. A WSSC 20" diameter PCCP or 16" diameter cast iron water line is located within the right of way of Falls Road for the majority of the length of Falls Road between River Road and MacArthur Boulevard. A WSSC 12" diameter ductile iron water line is located within the right of way of MacArthur Boulevard for the majority of the length of MacArthur Boulevard between Falls Road and Old Angler's Inn. Smaller diameter water and sewer lines, as well as overhead electrical and telecommunications lines run along and occasionally intersect River Road, Falls Road and MacArthur Boulevard. The width of the right of way along River Road varies from approximately 30 feet to over 150 feet in a few locations. The width of the right of way along Falls Road varies from approximately 35 feet to 150 feet. The width of the right of way along MacArthur Drive varies from approximately 40 feet to over 100 feet in a few locations.

3.3.1.3 Tunneling- Method of Construction

Tunnels are constructed by excavating a construction shaft and starter tunnel for a tunnel boring machine (TBM). The TBM will excavate at a slight upwards slope, which will allow for groundwater to drain back to the construction shaft, where it can then be pumped from the underground excavation. The tunnel will be supported through pattern of rock dowels, welded wire fabric, and support channels, if necessary, in the crown of the tunnel. Once excavation is complete, the TBM will either be backed out of the tunnel or be retrieved from a retrieval shaft located adjacent to the quarry. Any remaining portion of the tunnel that was not excavated by the TBM would be excavated by drill and blast methods.

3.3.1.4 Open Cut- Method of Construction

It is anticipated that the construction of the open cut alternatives will begin at the downstream end. Installation of the pipeline will be conducted using typical trench excavation methods. In the case of installation of two pipelines, excavation of a single trench for both pipelines to be installed simultaneously will occur if there is a sufficient amount of width available for construction. If there is not sufficient width available for simultaneous construction, the pipelines will have to be constructed one at a time using two smaller trenches. Due to the limited space available, the trenches will have to be excavated with vertical walls, which will be achieved by using common trench support systems, such as trench boxes or slide rail systems for excavations up to twenty (20) feet in depth. For any excavations greater than twenty (20) feet in depth, engineered support systems will be required, such as sheet piles, soldier piles and lagging, soil-mix walls or other pre-excavation ground support system will be required. The depth of cover above the pipelines will be kept at a minimum along these alignments, in order to reduce excavation and shoring costs. The pipelines must be kept at a sufficient depth to allow for adequate cover beneath existing utility lines and below existing roadways as well as providing sufficient cover at creek crossings.

3.3.2 Pumping / Energy Dissipation Requirements

Based on the choice of the alignment and depth of the linear infrastructure for "Quarry Fill/ Withdrawal", and "Washington Aqueduct Conveyance" functions, pumping and/or energy dissipation may vary. These requirements may also vary during operations due to change in water level in the quarry, although within the operating range. Numerous options of pump selection and energy dissipation methods are available that can be tailored to the needs of the projects. In general these options include variable frequency drives for pumps, and drop shafts, valve chambers or turbines methods for energy dissipation.

3.3.3 Operation and Maintenance

Operations and Maintenance is largely dependent on the standard practices of participating utilities that are in place. However, due to infrequent use of the infrastructure many of these practices may require customization to meet the desired goals. Following the selection of alternatives, a clear understanding of these goals can be developed during the detailed engineering phase of the project.

4. ALTERNATIVES FOR QUARRY FILL/ WITHDRAWAL

Two possible alternatives, based on system configurations were developed for connecting the Quarry Fill Pump Station to the Travilah Quarry.

4.1 One Tunnel and One Pumping Station Alternative

This alternative includes a deep tunnel and one pumping station at the WSSC Potomac WFP which will serve the functions of filling the quarry. This option is similar to Concept B-2 in the OB&G 2002 report with exceptions of a new Quarry Fill Pump station at the WSSC plant, and a larger tunnel diameter. The quarry fill pump station will be connected to the WSSC's existing intake pipe on the suction side of Raw Water Pump stations. The quarry fill pump station will pump raw water to the quarry via a 48" diameter quarry fill pipeline, which is located inside a 144" inside diameter concrete lined tunnel designed for water withdrawal. The quarry fill pipeline and quarry withdrawal tunnel will be located along the utility corridor shown in Figure 4. The depth of cover above the pipeline/tunnel will vary along the alignment from approximately 100' at the WSSC WFP to approximately 250' at the quarry. Raw water will exit the quarry fill pipeline at an intake/outfall structure, constructed in the southwestern wall of the quarry, with an invert elevation of 150 feet. For withdrawal purposes, the volume of water stored below the elevation of 150 feet will not be accessible without a lower level pump station being constructed.

For quarry withdrawal, raw water stored in the quarry will enter the quarry withdrawal tunnel via the intake/outfall structure. Due to the difference in elevations, the flow in the tunnel will be through gravity, under most of the operating range of quarry head. Energy dissipation will be required at the downstream end. The flow can then be directed to either or both of the raw water pumping stations at the WSSC plant and/or conveyed to the Washington Aqueduct. The concept profile for the tunnel and pump station is shown in Figure 5.

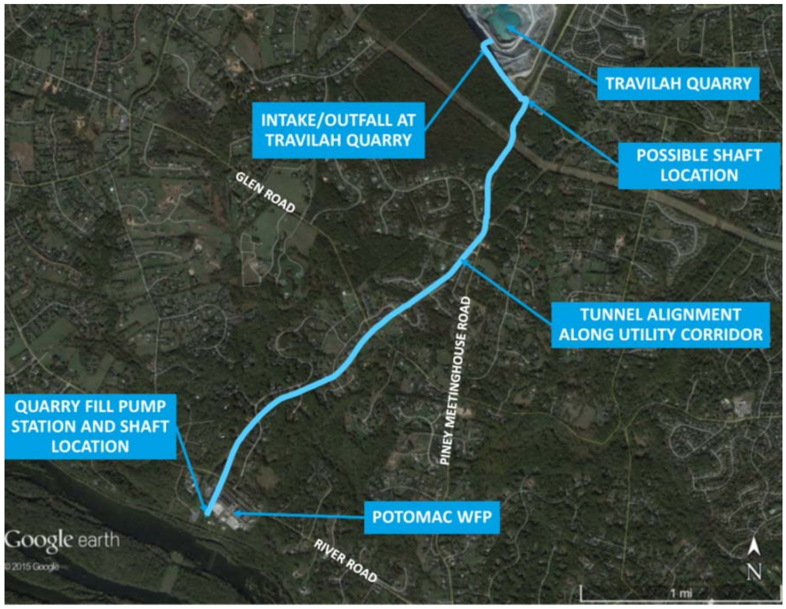

Figure 4 One Tunnel and One Pumping Station Alternative – Plan View

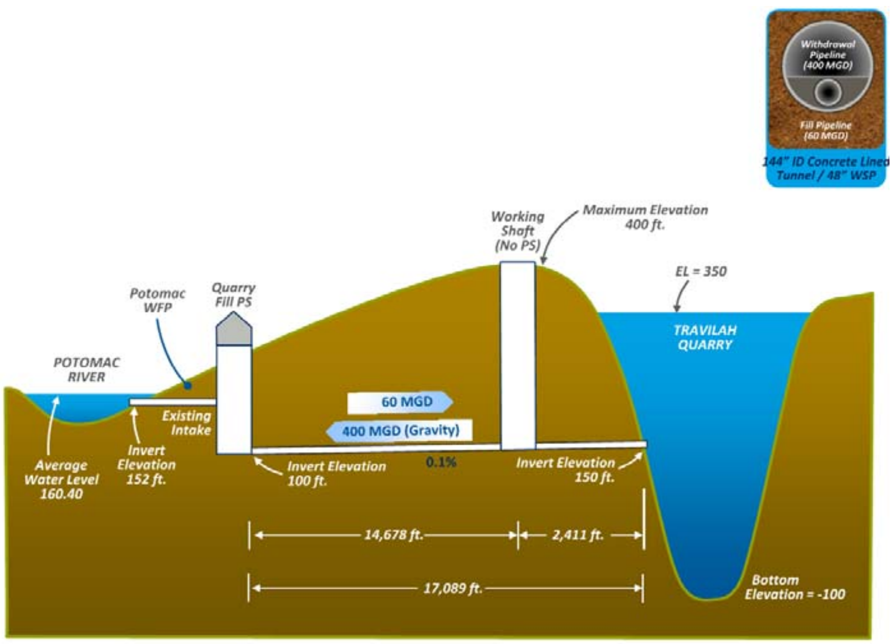

Figure 5 One Tunnel and One Pumping Station Alternative – Profile

A preliminary pump selection was performed in order to determine the size and number of pumps required and estimate power requirements for filling the quarry. A high level analysis concluded that six (6) vertical turbine pumps would be required for the quarry fill pump station in order to pump 60 MGD. Each of these pumps is rated at 1,250 horsepower and requires a minimum of 932 kilowatts of power. Water withdrawal from the quarry will not require pumping unless stored water below the invert elevation (150 ft above mean sea level) of the intake/outfall structure is needed.

4.2 Two Pipelines and Two Pumping Stations Alternatives

This alternative includes two separate pipelines and two pumping stations to serve dedicated functions of quarry filling and withdrawal. The option is similar to the Concept A of to OB&G's report with exceptions of a larger size for the withdrawal piping and a new pumping station. OB&G's Concept A estimated a maximum of 300 MGD for quarry withdrawal, while a quarry withdrawal rate of 400 MGD has been assumed for this report. Two concept alignments along Utility and Roadway Corridor are shown in Figure 6. The depth of cover above the quarry fill pipeline (and quarry withdrawal pipeline) will be kept at a minimum in order to reduce excavation and shoring costs, while providing appropriate cover for utility crossings or other utility conflicts. The concept profile for the two pipelines and pump stations is shown in Figure 7.

The quarry fill pipeline will include a 48" diameter pipeline that will run from the quarry fill pump station and terminate at a shaft adjacent to the quarry. The flow will drop inside of this drop structure and will be conveyed via a short tunnel by gravity to the intake/outfall structure constructed in the southwestern wall of the quarry. The ultimate height of the drop will vary based on the water level elevation in the quarry. For quarry withdrawal, raw water stored in the quarry will enter the short quarry withdrawal tunnel via the intake/outfall structure, with an invert elevation of 150 feet. Similar to the previous alternative, volume of water stored below the elevation of 150 feet will not be accessible for withdrawal without a lower level pump station being constructed. Raw water will flow by gravity from the quarry towards the shaft adjacent to the quarry, which will serve as a wet well for the quarry withdrawal pump station. The quarry withdrawal pump station will lift raw water and release at an elevation of approximately 400 feet to facilitate flow by gravity to the WSSC Potomac WFP via a 120" quarry withdrawal pipeline. The quarry withdrawal pipeline will terminate at the plant at a junction box, where the flow can then be directed to either or both of the raw water pumping stations at the plant and/or conveyed to the Washington Aqueduct as described. Appropriate energy dissipation will be required at this junction box via valve chambers or turbines or other means that will be designed in the detail engineering phase.

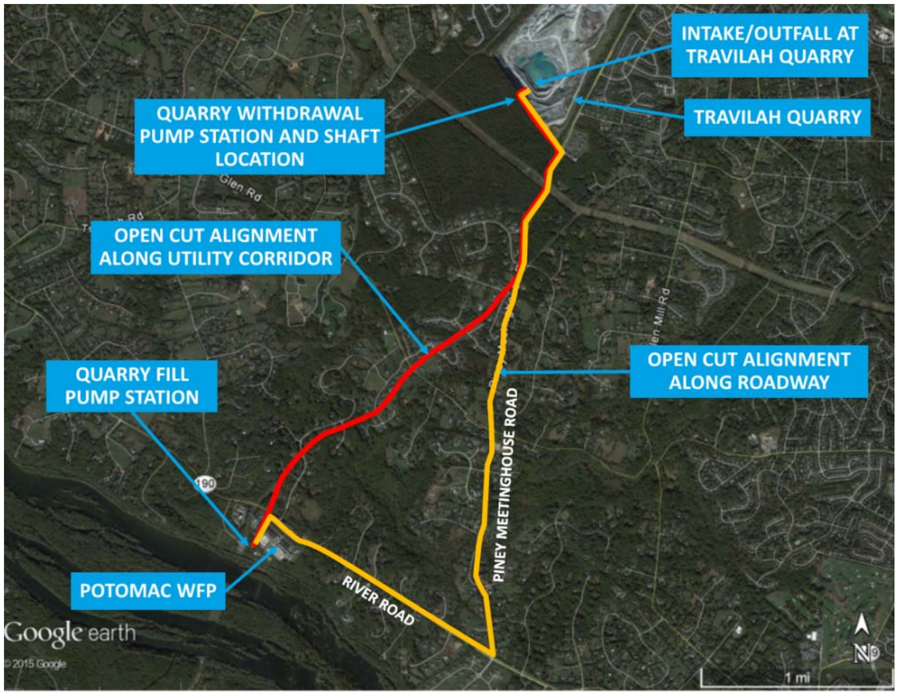

Figure 6 Two Pipelines and Two Pumping Stations Alternative Alignments – Plan View

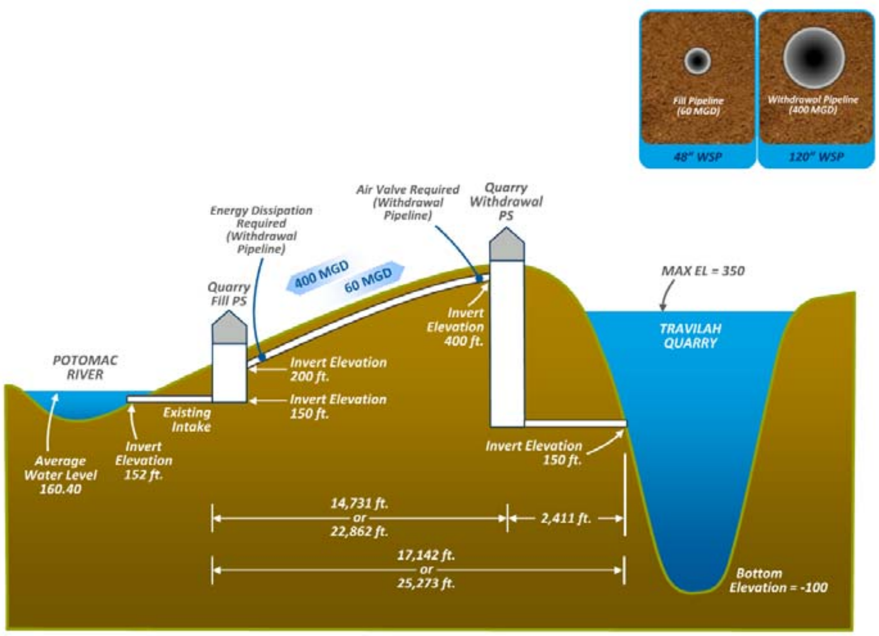

Figure 7 Two Pipelines and Two Pumping Stations Alternative Alignments – Profile

A preliminary pump selection was performed in order to determine the size and number of and estimate power requirements for the quarry fill pump station and quarry withdrawal pump station. A high level analysis concluded that four (4) vertical turbine pumps would be required for the quarry fill pump station in order to pump 60 MGD. Each of these pumps is rated at 1,250 horsepower and requires a minimum of 932 kilowatts of power. Similarly for water withdrawal sixteen (16) vertical turbine pumps would be required to pump 400 MGD. Each of these pumps is rated at 1,750 horsepower and requires a minimum of 1,305 kilowatts of power. It is further anticipated that additional electrical infrastructure to and at the quarry withdrawal pump station would be required as well as the addition of emergency standby generators would be required to power the quarry withdrawal pump station in the event power was not available from the electrical grid.

4.3 Evaluation of Alternatives for Quarry Fill and Withdrawal

4.3.1 Construction Access and Right of Way Requirements

4.3.1.1 One Tunnel and One Pumping Station Alternative

It is anticipated that the construction of tunnel for this alternative will begin at the WSSC Potomac WFP, through the excavation of a construction shaft and starter tunnel for a tunnel boring machine (TBM). The TBM will excavate from the plant to the quarry at a slight upwards slope, which will allow for groundwater to drain back to the construction shaft, where it can then be removed from the underground excavation. The tunnel will be supported through pattern of rock dowels, welded wire fabric, and support channels, if necessary, in the crown of the tunnel. Once excavation is complete, the TBM will either be backed out of the tunnel or be retrieved from a retrieval shaft located adjacent to the quarry. The remaining portion of the tunnel that could not be excavated by the TBM between the shaft and the quarry would be excavated by drill and blast methods. The intake/outfall structure will be constructed at the quarry and the tunnel lining will be installed from the quarry to the plant. Once the tunnel is completely lined, the 48” quarry fill pipeline and concrete backfill surrounding the pipeline in the invert of the tunnel can be placed from the quarry to the plant. The construction shaft at the plant will be lined, and the construction of the quarry fill pump station will begin at the plant. Once the quarry fill pump station is complete, connections will be made between the existing intake or raw water pump station(s) at the WSSC Potomac WFP and the quarry fill pump station, thus completing construction.

Construction of the shaft and quarry fill pump station at the plant will be performed entirely on WSSC property. Construction of the intake/outfall structure at the quarry will be performed on quarry property. The total width of permanent easement required for a tunnel is approximately 35 feet. It is anticipated that approximately 40 separate subterranean permanent easements will be required for the tunnel construction along the utility corridor. A portion of the tunnel alignment will be located within the right of way of Piney Meetinghouse Road. No subterranean easements will be required along this portion of the alignment subject to confirmation of width of the existing right of way during the detailed engineering phase. Access for construction purposes will therefore be limited to the quarry and the WSSC Potomac WFP, with no access requirements for construction along the tunnel alignment. A conceptual cross section of the tunnel along Piney Meetinghouse Road is shown in Figure 8.

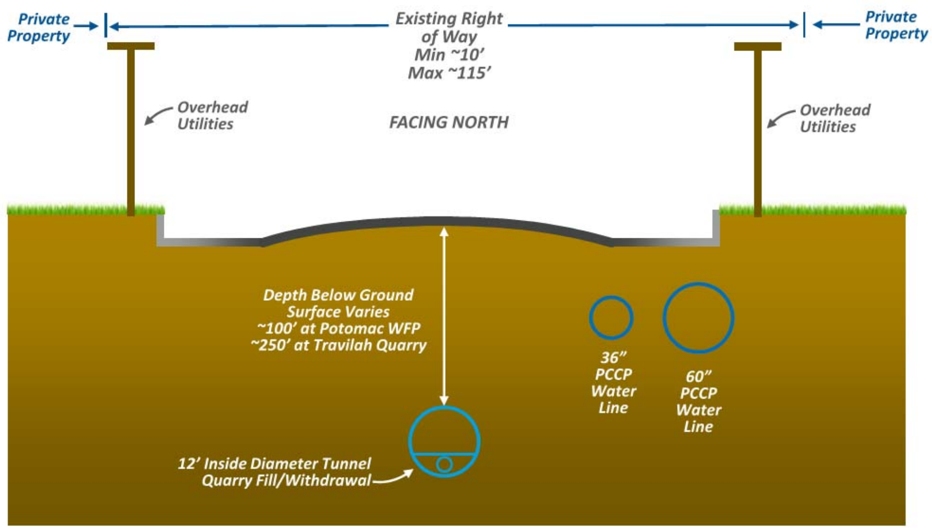

Figure 8 Concept Cross Section view of the Tunnel along Piney Meetinghouse Road

4.3.1.2 Two Pipelines and Two Pumping Stations Alternatives

It is anticipated that the construction of the pipelines for any of these alternatives will begin at the downstream end, at the WSSC Potomac WFP. Due to the limited space available, the trenches will have to be excavated with vertical walls, which will be achieved by using common trench support systems, such as trench boxes or slide rail systems for excavations up to twenty (20) feet in depth. For any excavations greater than twenty (20) feet in depth, engineered support systems will be required, such as sheet piles, soldier piles and lagging, soil-mix walls or other pre-excavation ground support system will be required. The depth of cover above the pipelines will be kept at a minimum along these alignments, in order to reduce excavation and shoring costs, however, the pipelines must be kept at a sufficient depth to allow for adequate cover beneath existing utility lines and below existing roadways as well as providing sufficient cover at creek crossings. A quarry shaft will be excavated adjacent to the quarry to serve as both the wet well for the quarry withdrawal pump station as well as for the quarry fill flow to drop down to the intake/outfall structure at the quarry. Once the shaft excavation is completed, a short tunnel section will then be excavated via drill and blast methods between the quarry shaft and the intake/outfall structure. The intake/outfall structure will be installed, the short tunnel section and the quarry shaft will be lined, and the quarry fill pipeline will be installed from the intake/outfall structure to the top of the quarry shaft. The construction of both of the quarry fill and quarry withdrawal pump stations can then begin and once complete, connections will be made between the existing intake or raw water pump station(s) at the plant and the quarry fill pump station, thus completing construction.

Construction of the quarry fill pump station at the plant will be performed entirely on WSSC property. Construction of the intake/outfall structure at the quarry will be performed on quarry property. It is anticipated that the quarry withdrawal pump station and associated wet well will be required to be constructed on Montgomery County property, located on the southwest side of the quarry, due to limited space outside of the rim of the quarry. The total width of temporary and permanent easement required for installation of the two pipelines is approximately 100 feet.

Additional easements would be required (total of 40 along utility corridor; total of 15 along road right of way) for construction and temporary access, much of these will be on private properties along the two corridors. For this alternative, access for construction purposes will be required at all locations along the alignment and at the quarry and the WSSC Potomac WFP. A conceptual cross section of the existing and new pipelines along River Road is shown in Figure 9.

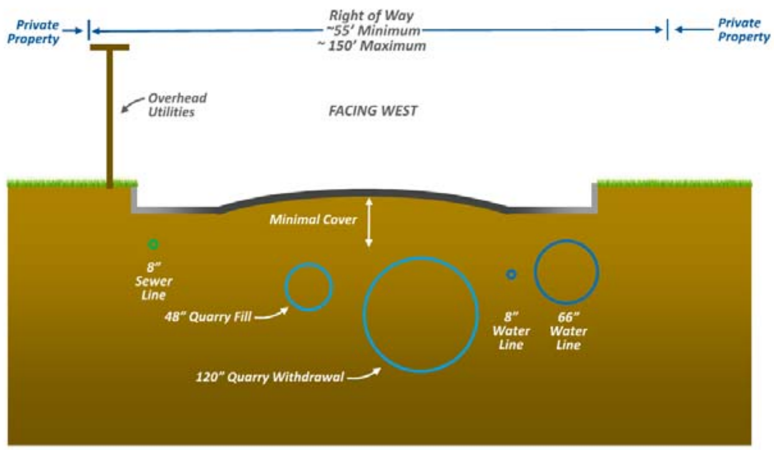

Figure 9 Concept Cross Section view of the Pipelines along River Road

During construction these options would require single lane / entire road closures along Piney Meetinghouse Road (for both alignment options) and River Road (only for road right of way alignment) which may present a significant issue for traffic diversion and community acceptance. It is noted that despite overcoming these challenges, there may be sections along the alignment where the available width of the existing utility easement may be insufficient to meet the WSSC Standards that require minimum separation of 20 feet between the pipes. Extension of existing easements outside the road right of way would be expensive and may potentially impact the project schedule.

4.3.2 Operations and Maintenance Requirements

Once the quarry is full, periodic operations for both the alternatives will be required for general upkeep of the infrastructure. Besides these periodic operations, the full scale operations commensurate to the intended design are expected to be less frequent. Likewise maintenance for both the alternatives would include periodic inspections, and potential repairs that are less frequent in nature. The financial aspects of the operations and maintenance is discussed later in the report; however a qualitative comparison is included in the evaluation.

4.3.2.1 One Tunnel and One Pumping Station Alternative

The alternative includes deep tunnel and pumping station that are expected to be less vulnerable to damage from outside forces, such as excavation or other surface impacts. Because of its depth and configuration, the operations of this alternative harness gravitational energy to the maximum and limit pumping to fewer scenarios. The operations of this alternative are dependent on the water level in the quarry that is expected to vary within a known operating range. Control of pumps, valves and energy dissipaters is needed to maintain the desired flow to the WSSC and Washington Aqueduct. For instance, the head at the downstream end of the tunnel will fluctuate with water levels in the quarry. Hence when the quarry is full, the head at the downstream end will require dissipation of excess head before it can flow by gravity to the WSSC and the Washington Aqueduct.

With continuous drop in quarry levels there will a stage beyond which pumping will be required to lift the water for supply to the WSSC and the Washington Aqueduct. Such variations in operations require active monitoring and control systems that alter the operations in response to the changes in quarry head. Specifics of these systems would be defined during the detailed design engineering phase.

Maintenance of this alternative will primarily include maintenance of valves, pumps and control systems. Most of these system components will be conveniently located at either ends of the tunnel, to facilitate ease in maintenance. Other maintenance will include infrequent inspections of the quarry fill and withdrawal tunnel. To facilitate such inspections, isolation valves at the ends of the tunnel should be considered during the design engineering phase.

4.3.2.2 Two Pipelines and Two Pumping Stations Alternatives

This alternative requires installation of relatively shallow pipelines that generally follow the profile of the existing ground surface. To overcome the irregularity in the terrain in either direction, pumping is required for quarry filling as well as during withdrawal. The pumping operations at both the ends are controlled such that the flow parameters are maintained across all operating ranges of quarry head. The primary advantage is that the flow is independent of quarry head, and most of the system controls are limited to controls in pumping. As a result of increased pumping, the energy efficiency of the system is much lower as compared to the tunneled alternative. Due to larger number of pumps, overall the controls are similar in number when compared to previous alternative, and hence there is no advantage in terms of reduction in operations.

Maintenance of this alternative will primarily include maintenance of pumps, air release valves and control systems. Most of these system components will be conveniently located at either end of the pipe, to facilitate ease in maintenance. Other maintenance will include scheduled inspections of the quarry fill pipeline and the withdrawal pipeline. To facilitate such inspections, entry ports at regularly placed intervals will be included during the design engineering phase. Since these pipelines run along residential neighborhood and roads, accessing the entry port locations for inspection of these pipes may potentially require permits for traffic diversion, and/ or Right of Entry agreements for private property access all of which is relatively more cumbersome than the inspections of the tunneled alternative.

4.3.3 Community Acceptance

4.3.3.1 One Tunnel and One Pumping Station Alternative

During construction, the community impacts of this alternative are limited to the WSSC plant and quarry locations; the expected impacts associated with to traffic disruption, noise, vibration, and dust, utility service disruption (overhead and underground), land use disruption (private and parks), disruption of residential access during construction, and loss of mature trees are confined to these locations. It is noted that construction vehicles will utilize the local roads for hauling construction materials equipment and tunnel spoils, but these vehicles will be directed to quarry and plant locations and hence will have lesser traffic impact as compared to the alternative involving open cut pipeline construction.

Operations & Maintenance (O&M) of any alternative can potentially cause impacts pertinent to noise, traffic, aesthetic and ambience that result from movement of resources such as service vehicles, material, equipment and manpower. The operations and maintenance of this alternative are confined to the WSSC plant location, with limited need to access the quarry. As a result all resources will be directed to the Potomac WFP location which is an existing WSSC facility. In addition, the discontinuation of mining operations is likely to reduce the existing impacts related to noise, traffic, aesthetic and ambience and therefore likely to improve community acceptance.

4.3.3.2 Two Pipelines and Two Pumping Stations Alternatives

The community impacts during construction are significant along the pipeline alignment, as well as the WSSC plant and the quarry locations. Despite preemptive mitigation measures for minimizing the impacts, the construction activities will impact neighboring communities potentially causing traffic disruption, noise, vibration, and dust, utility service disruption (overhead and underground), land use disruption (private and parks), disruption of residential access during construction, and loss of mature trees.

The operations of this alternative will be confined to the WSSC plant and quarry locations; however due to operations of the pumping station at the quarry, this alternative is expected to require access for service vehicles, material, equipment and manpower, which may cause impacts pertinent to noise, traffic, aesthetic and ambience. It is noted that many of these impacts would be similar to existing conditions associated with mining operations. It is therefore likely that, at the best, this alternative does not worsen the existing impacts from an O&M perspective. This alternative is less likely to be acceptable to the community as compared to the previous tunnel alternative.

4.4 Summary

Two alternatives for quarry fill/ withdrawal were developed and evaluated. These alternatives were evaluated based on constructability, operations and community acceptance criteria. The evaluation is based on desktop research, and observations and experiences on similar projects. Based on the evaluation it is appears that the One Tunnel & One Pump Station alternative has several advantages over the Two Pipelines & Two Pump Station alternatives. It is evident that the construction of the tunnel will be favorable as it reduces the overall impacts. Table 1 includes a summary of the characteristics for the Quarry Fill/ Withdrawal alternatives.

Table 1 Characteristics of Travilah Quarry Fill/ Withdrawal Alternatives

ALTERNATIVE	ONE TUNNEL AND ONE PUMPING STATION	TWO PIPELINES AND TWO PUMPING STATION	
		UTILITY CORRIDOR	ROAD ROW CORRIDOR
Tunnel Conveyance Length (ft)	17,105	400	400
Open Cut Conveyance Length (ft)	0	16,705	24,835
Total Conveyance Length (ft)	17,105	17,105	25,235
Shaft Depth at Plant (ft)	100	Not Required	Not Required
Shaft Depth at Quarry (ft)	250	250	250
Quarry Fill Conveyance Diameter (ft)	48”	48”	48”
Quarry Withdrawal Conveyance Diameter (ft)	144” (Area of Flow is Equivalent to a 120” Circular Area)	120”	120”
Preliminary Pump Selection for Quarry Fill Pump Station	Six (6) vertical turbine pumps (1,250 hp, 932 kW ea)	Four (4) vertical turbine pumps (1,250 hp, 932 kW ea)	
Preliminary Pump Selection for Quarry Withdrawal Pump Station	None Required	Sixteen (16) vertical turbine pumps (1,750 hp, 1,305 kW each)	
Easement Requirements	Approximately 40 Subterranean Easements	Approximately 40 Temporary and Permanent Easements	Approximately 15 Temporary and Permanent Easements
Property Acquisition Requirements	Plant and Quarry Only for Quarry Fill Pump Station	Plant and Quarry for Quarry Fill Pump Station, Portion of Montgomery County Property South of Quarry for Quarry Withdrawal Pump Station	
Traffic Control Requirements	None Required	Lane and/or Road Closures Along Piney Meetinghouse Road	Lane and/or Road Closures Along River Road & Piney Meetinghouse Road

5. ALTERNATIVES FOR WASHINGTON AQUEDUCT CONVEYANCE

Two possible alternatives, based on system configurations were developed for connecting the Quarry Fill Pump Station to the Washington Aqueduct. It is noted that a complete system configuration for raw water supply from the quarry to the Washington Aqueduct, requires a Quarry Fill/ Withdrawal in combination with a conveyance alternative.

5.1 Conveyance Tunnel to Great Falls

This alternative includes a tunnel connecting the Quarry Fill Pump Station and the existing raw water conduits near Great Falls intake. The tunnel will supply water to Washington Aqueduct during quarry withdrawal. Under most of the operating range, raw water from the quarry will be diverted to this tunnel under gravity after necessary energy dissipation. However, there may be instances when limited pumping is required to lift the water to a desirable head. In addition, the quarry fill pump station may be designed with additional pumps to facilitate pumping of water directly from the WSSC's intake, as an option. Based on the preliminary sizing, a 96" diameter welded steel pipe embedded inside the tunnel will be required. Two possible tunnel alignments have been identified between the WSSC Potomac WFP and the tie-in location to the Washington Aqueduct at Great Falls. These alignments include the Washington Aqueduct Tunnel Alignment along Potomac River to Great Falls and the Washington Aqueduct Tunnel Alignment along C&O Canal to Great Falls. The characteristics of both alignments are identical, except in routing location and length. The concept alignments are shown in Figure 10.

The Washington Aqueduct Tunnel Alignment along the Potomac River will cross underneath the Potomac River in two locations as well as underneath Riverbend Park, which is owned by the Fairfax County (Virginia) Park Authority. Depth of cover will vary along this alignment from approximately 50 feet underneath the Potomac River crossings to up to approximately 150 feet below the Riverbend Park. The Washington Aqueduct Tunnel Alignment along the C&O Canal follows directly underneath the existing C&O Canal Towpath, which is located on the National Park Service's C&O Canal National Historical Park property. Depth of cover will be consistent along this alignment at approximately 50 feet, except at the ends of the alignment, where cover will be slightly greater. Both tunnel alignments to the Washington Aqueduct at Great Falls will terminate at a shaft, which for purposes of a feasibility discussion, is located in a previously disturbed area, just south of the roundabout in MacArthur Boulevard in the C&O Canal National Historical Park at Great Falls. A short open cut pipeline would be required to be constructed between this shaft and the ultimate location of the tie-in to the existing raw water conduits at Great Falls Park. The concept profile for this alignment is shown in Figure 11.

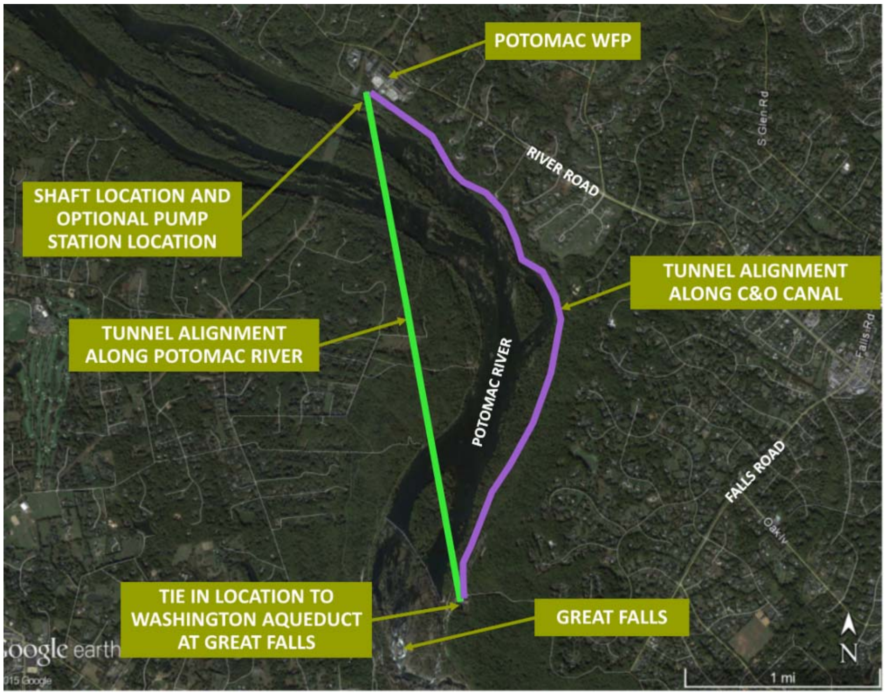

Figure 10 Conveyance Tunnel to Great Falls Alternative – Plan View

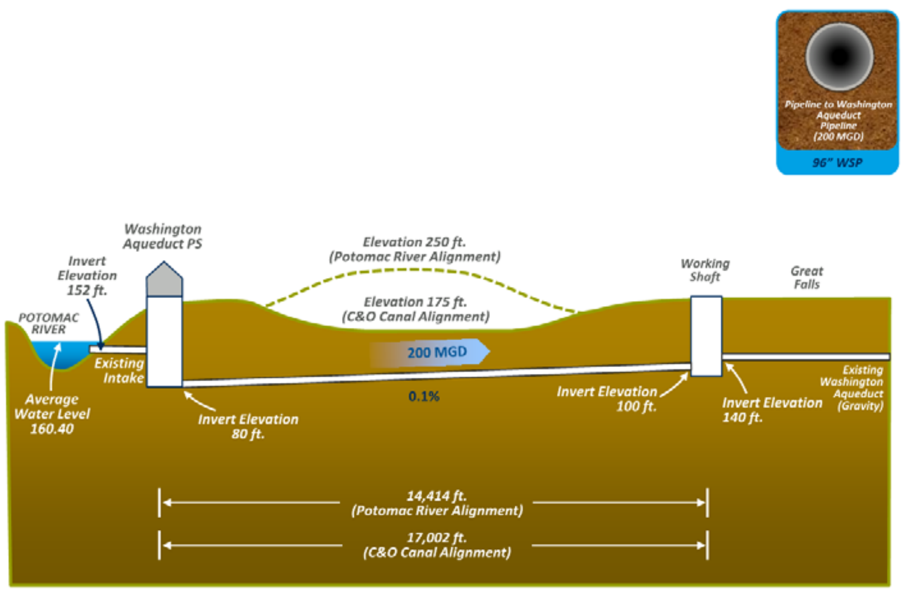

Figure 11 Conveyance Tunnel to Great Falls Alternative – Profile

A preliminary pump selection was performed in order to determine the size and number of pumps required as well as the estimated power requirements for water supply to the Washington Aqueduct. A high level analysis concluded that two (2) axial flow pumps would be required for the pump station in order to pump 200 MGD. Each of these pumps is rated at 500 horsepower and requires a minimum of 373 kilowatts of power.

5.2 Conveyance Tunnel/ Pipeline to Old Angler's Inn

This alternative includes a tunnel connecting the Quarry Fill Pump Station and the existing raw water conduits near Old Angler's Inn. The tunnel alignment follows C&O Canal and continues to the east of Great Falls under the C&O Canal National Historical Park and terminates at a shaft, which has been preliminarily located in a parking lot directly west of Old Angler's Inn. A short open cut pipeline section would be required to be constructed along MacArthur Boulevard between this shaft and the ultimate location of the tie-in to the Washington Aqueduct. Similar to the previous alternative, raw water from the quarry will be diverted to this tunnel under gravity after necessary energy dissipation. However, there may be instances when limited pumping is required to lift the water to a desirable head for facilitating gravity flow. In addition, the quarry fill pump station may be designed with additional pumps to facilitate pumping of water directly from the WSSC's intake, as an option. Based on the preliminary sizing, a 96" diameter welded steel pipe embedded inside the tunnel will be required. The tunnel will be located underneath C&O Canal National Historical Park property, and the depth of cover will vary along this alignment, from approximately 50 feet where the alignment directly follows underneath the C&O Canal Towpath to up to 200 feet where the alignment runs underneath the bluffs of the Potomac River, southeast of Great Falls. Pumping requirements for this conveyance tunnel will be similar to the tunnel connection at the Great Falls, as discussed in the previous section. The concept plan and profile of the conveyance tunnel is shown in Figures 12 and 13.

An alternative to the tunnel alignment would be an open cut alignment which follows the existing right of way along River Road, Falls Road, and MacArthur Boulevard. This alignment will terminate at a new junction box, which has been preliminarily located in a parking lot directly south of Old Angler's Inn. This junction box will connect the open cut alignment to the existing Washington Aqueduct. The vertical alignment of the pipeline will follow the existing ground surface and be laid with minimum cover, while taking appropriate measures for utility crossings or other utility conflicts. Given the topography along this alignment, raw water will require to be pumped regardless of the operating head at the quarry. Based on the preliminary sizing, a 96" diameter welded steel pipe will be required. A preliminary pump selection was performed in order to determine the size and number of pumps required as well as the estimated power requirements during withdrawal. A high level analysis concluded that eight (8) vertical turbine pumps would be required for the pump station in order to pump 200 MGD to the Washington Aqueduct. Each of these pumps is rated at 1,750 horsepower and requires 1,305 kilowatts of power. Under all operating conditions, energy dissipation near the Old Angler's Inn will be necessary for the pipeline option. Energy dissipation measures could include the use of valve chambers or turbines and would be located near the terminus of the alignment near Old Angler's Inn. The concept plan and profile of the conveyance pipeline is shown in Figures 14 and 15, respectively.

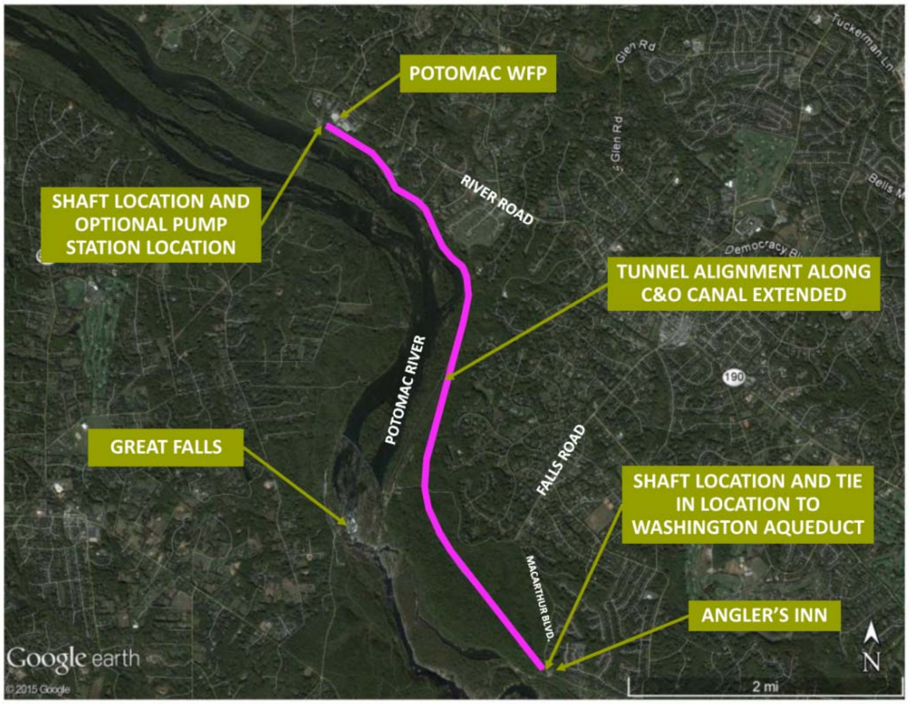

Figure 12 Conveyance Tunnel Alignment to Old Angler's Inn – Plan View

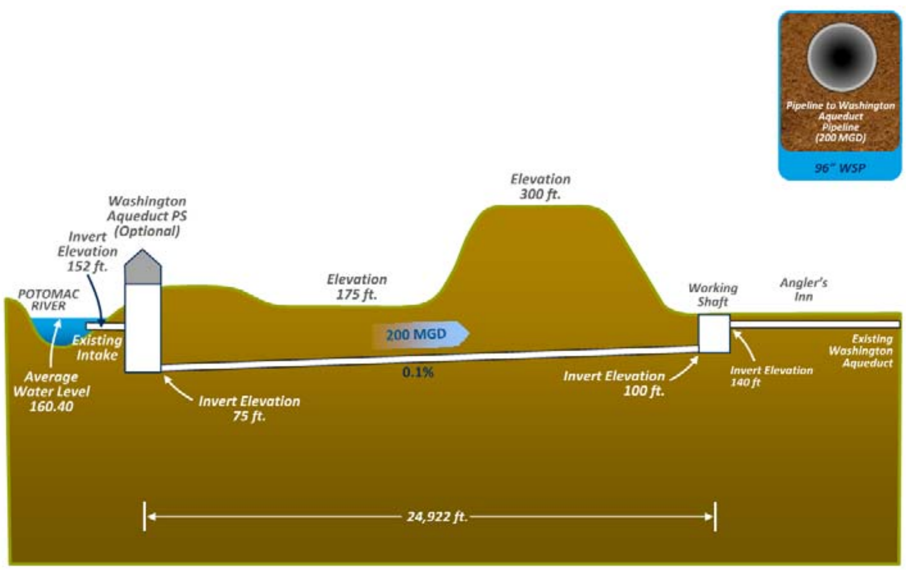

Figure 13 Conveyance Tunnel Alignment to Old Angler's Inn – Profile

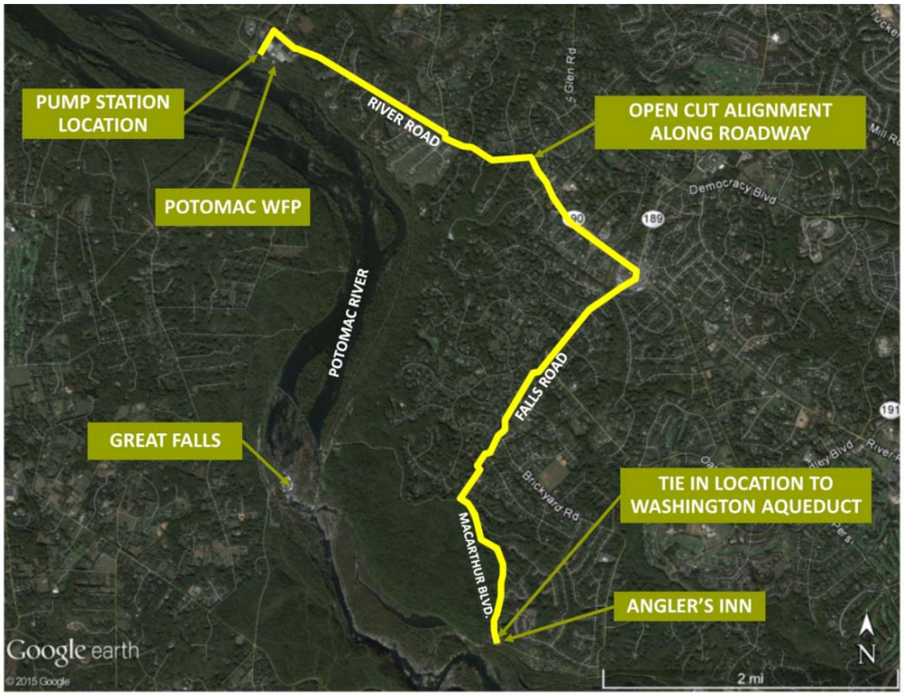

Figure 14 Conveyance Pipeline Alignment to Old Angler's Inn – Plan View

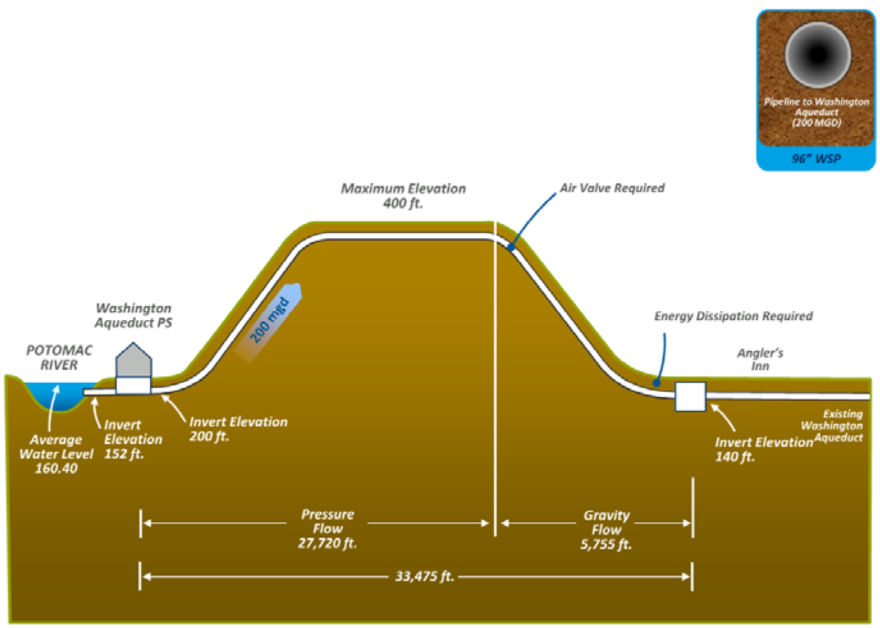

Figure 15 Conveyance Pipeline Alignment to Old Angler's Inn – Profile

5.3 Evaluation of Alternatives for Conveyance to Washington Aqueduct

5.3.1 Construction Access and Right of Way Requirements

5.3.1.1 Conveyance Tunnel to Great Falls

It is anticipated that the construction of this alternative will begin at the WSSC Potomac WFP, through the excavation of a construction shaft and starter tunnel for a TBM. The excavation will be similar to tunnel excavation described for Quarry Fill/ Withdrawal tunnel i.e. with a slight upward slope for draining groundwater, and with rock dowels, welded wire fabric and support channels in the crown of the tunnel, if necessary. Once excavation is complete, the TBM will either be backed out of the tunnel or be retrieved from a retrieval shaft located adjacent to the connection with the Washington Aqueduct. The tunnel will be required to be lined with welded steel pipe and the annular space between the exterior wall of the pipe and the excavated tunnel backfilled. Once the tunnel is lined, the construction shaft at the WSSC plant and the retrieval shaft near the connection to the Washington Aqueduct will be lined. The short portion of the alignment between the retrieval shaft and the tie-in location to the Washington Aqueduct would be constructed using open cut methods. The connection to the Washington Aqueduct would be under live conditions or require the Washington Aqueduct to be shut down for a short duration in order to complete the connection. Once the connection to the Washington Aqueduct is completed, connections will be made between the quarry withdrawal pipeline, the existing raw water intake and for pressure flow, the pump station at the WSSC plant.

Construction of the shaft and pump station at the plant will be performed entirely on WSSC property. Construction of the retrieval shaft, the short portion of the alignment constructed using open cut methods and the connection to the existing Washington Aqueduct would be performed on C&O Canal National Historical Park Property, which is land owned by the National Park Service (NPS). Subterranean easements would be required from the WSSC, the NPS, the State of Maryland and Fairfax County Park Authority, Virginia. The total width of permanent easement required for a tunnel is approximately 35 feet. Since most of the construction activities will be performed through the working shafts, it is expected that additional temporary construction easement may be required in the Great Falls vicinity for staging and material storage. In addition, construction access to vehicles, material, equipment and personnel would be required at the WSSC plant and the Great Falls location.

5.3.1.2 Conveyance Tunnel/ Pipeline to Old Angler's Inn

The construction of the tunnel will be similar to the excavation described for the previous alternative, with exceptions that the tunnel alignment will follow the C&O Canal and the tunnel will terminate at a shaft, which would be located in a parking lot directly west of Old Angler's Inn. The total width of permanent easement required for a tunnel is approximately 35 feet, and additional requirements for easement and construction access for the tunnel alignment are similar to previous alternative. However, the requirements for the Open Cut alignment are vastly different and hence summarized for comparison.

It is anticipated that the construction of the Open Cut alignment would begin at the WSSC Potomac plant and terminate near the tie-in to the Washington Aqueduct. Installation of the pipeline to the Washington Aqueduct will be conducted using typical trench excavation methods. Due to the limited space available within the existing roadway right of way, and to minimize lay back, trench support systems such as trench boxes or slide rail systems for excavation up to twenty (20) feet in depth. For any excavations greater than twenty (20) feet in depth, engineered support systems such as sheet piles, soldier piles and lagging, soil-mix walls, or other pre-excavation ground support system will be required. The depth of cover above the pipeline will be kept at a minimum along this alignment in order to reduce excavation and shoring costs. However the pipeline must be kept at a sufficient depth to allow for adequate cover beneath existing utility lines and below existing roadways as well as providing sufficient cover at creek crossings. Once the open cut pipeline is complete, the connections at the ends of the pipeline can be made. The connection to the Washington Aqueduct would require the Washington Aqueduct to be shut down for a short duration in order to complete the connection. Following which connections will be made between the quarry withdrawal pipeline, the existing raw water intake and the pump station at the WSSC plant.

Construction of the connections at the WSSC plant will be performed entirely on WSSC property. Construction of the connection to the Washington Aqueduct will be performed by utilizing the existing right of way along the MacArthur Boulevard. It is noted that MacArthur Boulevard has weight restrictions for vehicular traffic due to the shallow depth of the existing raw water conduits. Hence special measures may be required to protect the existing infrastructure and facilitate construction. Additional right way may be required for construction along the River Road, Falls Road and MacArthur Boulevard for construction and installation of the pipe. The total width of permanent easement required for the open cut alignment is 75 feet and with an additional 25 feet for temporary construction easement a total width of approximately 100 feet required all along the corridor. It is anticipated that this open cut alignment, would require significant lane closures and/or entire road closures along River Road, Falls Road, and MacArthur Boulevard for construction and installation of this pipeline. In addition, easements will be required along the open cut alignment for construction and maintenance of traffic simultaneously. Also, the open cut alignment would require an energy dissipation structure near the Old Angler's Inn, which requires additional space for construction, and hence pose constructability challenges.

5.3.2 Operations and Maintenance Requirements

Similar to the Quarry Fill/ Withdrawal alternatives, periodic operations are necessary for the upkeep of infrastructure regardless of the chosen alternatives. Similarly, full scale operations commensurate to the design intent are expected to be less frequent. Similarly, maintenance for both alternatives will include periodic inspections and potential repairs that are less frequent. Due to the configuration of the alternatives, O&M requirements for the two alternatives are different.

5.3.2.1 Conveyance Tunnel to Great Falls

This alternative offers a compact system configuration with the controls located near the Quarry Fill Pump Station and the existing facilities at the Great Falls. The configuration requires one energy dissipation structure at the WSSC plant that is common to the Quarry Fill/ Withdrawal alternative. In addition, the isolation valves at the two ends of the tunnel can have integrated facilities for control with the Quarry Fill Pump Station. Operationally, this configuration has lesser stress on human resources and provides a more compact system. Maintenance of this alternative primarily includes, valves, energy dissipation mechanisms, and control systems. Due to the compact nature, the system is easier to maintain and less demanding on resources.

5.3.2.2 Conveyance Tunnel/ Pipeline to Old Angler's Inn

This alternative offers a less compact system configuration since the connection to existing conduits (near the Old Angler's Inn) would be made at a new location (away from existing facilities at Great Falls). Similar to previous alternative, the tunnel alignment requires one energy dissipation structure at the plant and two isolation valves at the ends of the tunnel. The operations for the tunnel alignment will be similar to previous alternative with the exception of infrastructure located at the Old Angler's Inn, instead of the Great Falls. However the maintenance of the tunnel alignment would require access to the isolation valves, and hence may be a little cumbersome as compared to the previous alternative.

The Open Cut alignment, however has a significant impact on O&M activities, and is the least convenient among all the alternatives. The configuration requires air release valves, blow off valves and an additional energy dissipation structure near the Old Angler's Inn, all of which adds to the O&M aspects of the system. The isolation valves at the end of the pipeline would require access for routine maintenance. The pipeline will be equipped with entry port manholes that provide access for inspections at regular interval. Hence any inspection in future may require permits or Right of Entry agreements, which can be relatively cumbersome and time consuming.

5.3.3 Community Acceptance

5.3.3.1 Conveyance Tunnel to Great Falls

During construction most of the impacts for this alternative will be concentrated at the shafts that are located at the two ends of the tunnel. Since the working shaft at the WSSC Potomac WFP is within the secured premises, the community impacts for this end would be limited to construction related vehicular traffic pertinent to movement of material, equipment and personnel. The effect of this additional vehicular traffic is likely to cause noise, traffic, aesthetic and ambience related impacts and will be mostly concentrated around the WSSC plant premises. However, the construction impacts at the other end, near Great Falls, will be likely far more significant due to the construction of a deep shaft, retrieval of the TBM from the shaft, and installation of a short open cut pipeline for making the connection. The impacts will likely include disruption in park use, noise, dust, vibration, traffic disruption and some loss of mature trees. Since the park at the Great Falls is a well-used facility, it is expected that significant outreach and public education will be required to gain public acceptance.

O&M of this alternative is likely to have very little impact to the surrounding community. Most of the operations will be integrated into the existing facilities at the WSSC plant and at the Great Falls location, and hence less likely to have any noticeable impacts.

5.3.3.2 Conveyance Tunnel/ Pipeline to Old Angler's Inn

The construction of this tunnel alignment offers an advantage by minimizing the impacts at the Great Falls. However, these impacts are not completely eliminated and most of them are transferred to MacArthur Boulevard, near Old Angler's Inn. Most of the impacts for the tunnel alignment will therefore be concentrated at the WSSC Potomac plant and at MacArthur Boulevard near Old Angler's Inn. At these locations, the impacts will include noise, dust, vibration and potential disruption in utilities due to construction activities for the short open cut section and other structures. This will be in addition to the construction traffic that may potentially disturb the neighboring community.

On a comparative note, the construction of the Open Cut alignment is probably most severe in terms of community impacts since it requires construction along major arterial roads (River Road and Falls Road), that are well-used and that have few alternative routes. Construction activities along the open cut alignment are expected to be less confined and likely to impact a greater number of people than other alternatives. These impacts will include traffic disruption, noise, dust, vibration, disruption to public/ private access, disruption in utilities and potentially limited impacts to trees.

O&M of the tunnel and open cut alignments has very little impact to the community. Most of the operations will be integrated into the existing facilities at the WSSC Potomac WFP, and any noticeable impacts are less likely. Accessing infrastructure for inspections, maintenance and repairs may have noticeable impacts near the Old Angler's Inn, but such activities are not expected to be frequent and hence may not be significant from a community acceptance perspective.

5.4 Summary

Two alternatives for conveyance to Washington Aqueduct were developed and evaluated. These alternatives are evaluated based on constructability, operations and community acceptance criterions. The evaluation is based on desktop research, and observations & experiences on similar projects. Based on the evaluation it is appears that a Conveyance Tunnel to Great Falls has several advantages over the Conveyance Tunnel/ Pipeline to Old Angler's Inn alternative. However, the alternative may require robust community outreach to outline the benefits to the public. It is further noted that permits from NPS will be required for construction of any of the three tunnel alignments. Table 2 includes a summary of the characteristics of the Washington Aqueduct Conveyance alternatives.

Table 2 Characteristics of Conveyance Alternatives to Washington Aqueduct

ALTERNATIVE	CONVEYANCE TUNNEL TO GREAT FALLS		CONVEYANCE TUNNEL/ PIPELINE TO OLD ANGLER'S INN	
	ALONG POTOMAC RIVER	ALONG C&O CANAL	TUNNEL ALONG C&O CANAL	OPEN CUT ALONG ROADWAY ROW
Tunnel Conveyance Length (ft)	14,465	17,000	24,975	
Open Cut Conveyance Length (ft)	340	340	350	33,475
Total Conveyance Length (ft)	14,805	17,340	25,325	33,475
Shaft Depth at Plant (ft)	120	120	125	None Required
Shaft Depth at Washington Aqueduct (ft)	100	100	75	None Required
Conveyance Diameter (ft)	96" Welded Steel Pipe embedded inside the tunnel			96" Welded Steel

ALTERNATIVE	CONVEYANCE TUNNEL TO GREAT FALLS		CONVEYANCE TUNNEL/ PIPELINE TO OLD ANGLER'S INN	
	ALONG POTOMAC RIVER	ALONG C&O CANAL	TUNNEL ALONG C&O CANAL	OPEN CUT ALONG ROADWAY ROW
				Pipe
Preliminary Pump Selection for Pump Station	Two (2) axial flow pumps (500 hp, 373 kW each)			Eight (8) vertical turbine pumps (1,750 hp, 1,305 kW each)
Easement Requirements	Subterranean Easements from WSSC, U.S. Government, State of Maryland, Fairfax County Park Authority, and Nature Conservancy, Inc.	Subterranean Easements from WSSC and NPS		Temporary and Permanent Easements from WSSC, Others
Property Acquisition Requirements	WSSC and U.S. Government (For Shafts)			WSSC Only (For Shaft)
Traffic Control Requirements	None Required	None Required	None Required	Lane and/or Road Closures Along River Road, Falls Road, and MacArthur Boulevard

6. PERMITTING

6.1 Permitting Requirements

This section is based on desktop research for identifying permits required for conversion of the quarry to water supply storage and construction of raw water pumping facilities and pipelines/ tunnels to convey water to the WSSC Potomac WFP and to the Washington Aqueduct. It is noted that the permit requirements will get refined further following the selection of alternatives and subsequently with the progress of the project in design and construction phases. Permitting requirements are generally categorized as follows:

Utilities
Federal agencies
State and Local agencies

These categories and agencies are more generally described below, with the specific permit name, description, review period, and agency contact summarized and more fully described in the Permit Register attached as Appendix B of this report. The Permit Register is organized by the phase (study, design, construction, or start-up) in which these permits are generally applied for or obtained. Current links to the agency websites for application forms and/or detailed information are also included.

6.1.1 Permit Requirements by Affected Utilities

Other than a contractor requirement to contact Miss Utility, there is no Federal or State regulatory/permit requirements related to construction near the interstate gas transmission line. The gas mains in the Utility Corridor to the west of the WSSC Potomac WFP are owned by Transco, a subsidiary of Williams Partners, LP. Contact and coordination with Transco is recommended early in design process. If the work involves access within gas lines' right of way, a Right of Entry agreement needs to be signed with the gas company. Likewise, coordination for construction work near other gas lines along the roads will require coordination during the design phase. Contact and coordination would also be required with PEPCO for any overhead electrical lines and with Comcast, Verizon or other for underground cable utilities for the trenched alignments. On private property this may be accomplished through Right of Entry permits for which WSSC has a prescribed process.

6.1.2 Permit Requirements by Federal Agencies

Permits, consultations and/or reviews will be required from the National Park Service, the U.S. Army Corps of Engineers, and the U.S. Fish and Wildlife Service for the proposed construction.

6.1.2.1 National Park Service (NPS)

The project will require construction activities within the C&O Canal National Historic Park property. Several special use and research permits will be required for the proposed construction. Typically, the permitting process with NPS is extensive and requires prescriptive environmental assessment defined under National Environmental Policy Act (NEPA), which is very time consuming and somewhat subjective. WSSC is in the process of securing similar permissions needed for construction of a new Potomac River intake for the Potomac WFP.

6.1.2.2 U.S. Army Corps of Engineers (USACE)

USACE's review and permit approval is conducted in conjunction with the Maryland Department of the Environment's permit approval process for construction involving activities in wetlands, in floodplains, and activities that will cross or alter streams and waterways.

6.1.2.3 U.S. Fish and Wildlife Service (USFWS)

If a proposed action "may affect" Federally listed species or critical habitat, consultation with the USFWS is required. Since a Federal permit will be required for the project (e.g., §404 Permit), a USFWS consultation will be required.

6.1.3 Permit Requirements by State and Local Agencies

Permits and reviews may be required from the Maryland Department of Environment, Maryland Department of Natural Resources, the Maryland Historic Trust, the Maryland State Highway Administration, Virginia Department of Environmental Quality, Fairfax County, and the Washington Suburban Sanitary Commission.

6.1.3.1 Maryland Department of the Environment (MDE)

There are several MDE permits, which encompass construction activities, discharges, erosion and sediment control, wetlands, floodplains, streams and water appropriations, and hydrostatic testing, that will be required for the proposed construction. Those activities involving wetlands, floodplains, and activities that will cross or alter streams and waterways will be conducted in conjunction with the USACE's review and permit approval process.

6.1.3.2 Maryland Department of Natural Resources (MDNR)

Several MDNR reviews and permits, which encompass potential impacts to known locations of rare, threatened or endangered species and their habitats, and potential coastal zones will be required for the proposed construction.

6.1.3.3 Maryland Historic Trust (MHT)

One permit is required by MHT for the proposed construction. MHT Office of Preservation Services is the unit responsible for reviewing all state and federally assisted projects, to ensure compliance with the National Historic Preservation Act and other historic preservation laws and regulations.

6.1.3.4 Maryland State Highway Administration (MD SHA)

One permit is required by MD SHA for the proposed construction. This permit is required for construction access off of State highways. The permit application, along with Traffic Control Plan is required.

6.1.3.5 Virginia Department of Environmental Quality (VA DEQ)

For construction of conveyance tunnel to Great Falls, several DEQ permits may be required. These permits may include Groundwater Withdrawal Permit and Virginia Pollution Abatement for tunneling activities.

6.1.3.6 Fairfax County, Virginia

Right of way permission from Fairfax County Park Authority will be required should the conveyance tunnel that is routed under the Potomac River to Great Falls be selected.

6.1.3.7 Washington Suburban Sanitary Commission (WSSC)

To control erosion and sediment control runoff from construction sites, an Erosion and Sediment Control Plan approval is required from WSSC. However, coordination with MDE is also required since the area of work will involve construction activities on NPS property, and is greater than 5,000 square feet in size.

6.2 Permit Register

A Permit Register is provided that includes anticipated list of permits and the phase (study, design, construction, or start-up) in which these permits are generally pursued. The Permit Register is attached as Appendix B to this report.

7. EVALUATION OF LIFE CYCLE COSTS

The following section includes as assessment of Life Cycle Costs (LCC) for the two sets of conveyance alternatives. The LCC was derived as Net Present Value (NPV) using the Capital Cost and O&M Costs over a 100 year planning horizon and is based on the assumptions outlined in the following sections. It should be noted that the potential long lead time for this project and the permitting process may have an impact on the capital cost and project schedule that should be further evaluated as decisions on project timing are made.

7.1 Opinion of Probable Construction Costs

A conceptual Opinion of Probable Construction Costs (OPCC) were developed for each set of alternatives described in Section 4 and Section 5. Each OPCC was built based upon unit price data and validated with historical project information. Following assumptions were made for developing the OPCC:

- For both set of alternatives, the OPCC includes costs for excavation and lining of shaft(s), tunnel excavation and lining, tunnel pipe installation, open cut excavation, open cut pipe installation, open cut restoration, connections to the WSSC plant/ Washington Aqueduct, energy dissipation, and the pump station. Connection to quarry, and quarry improvements are considered as a part of Quarry Fill/Withdrawal Alternatives.
- For tunnel construction, it is assumed that excavation is performed entirely in competent rock. All shafts are assumed to be excavated through competent rock with minimal soil excavation. The excavated diameter for tunnel construction is assumed to be two feet larger than the diameter of the pipeline(s) to be installed inside the tunnel.
- For open cut construction, it is assumed that excavation is performed entirely in soil and that no rock excavation is required to be performed. Trench width associated with open cut construction was assumed to be one and a half (1.5) times the diameter of the pipeline and the depth of the trench was assumed to be two (2) times the diameter of the pipeline.

The OPCC includes a contingency of 30%.

7.1.1 Quarry Fill/ Withdrawal Alternatives

Table 3 includes a breakdown of the conceptual OPCC for the Quarry Fill/ Withdrawal alternatives.

Table 3 Opinion of Probable Construction Costs for Quarry Fill/ Withdrawal Alternatives

ALTERNATIVE	ONE TUNNEL AND ONE PUMPING STATION	TWO PIPELINES AND TWO PUMPING STATION	
	UTILITY CORRIDOR	UTILITY CORRIDOR	ROADWAY ROW CORRIDOR
Shaft Excavation and Lining at Plant	$1,600,000	$470,000	$470,000
Shaft Excavation and Lining at Quarry	$2,460,000	$37,780,000	$37,780,000
Tunnel Excavation	$43,010,000	$2,490,000	$2,490,000

ALTERNATIVE	ONE TUNNEL AND ONE PUMPING STATION	TWO PIPELINES AND TWO PUMPING STATION	
	UTILITY CORRIDOR	UTILITY CORRIDOR	ROADWAY ROW CORRIDOR
Tunnel Lining	$24,850,000	$740,000	$740,000
Tunnel Pipe Installation	$6,690,000	$440,000	$440,000
Open Cut Excavation		$27,570,000	$42,290,000
Open Cut Pipe Installation		$33,720,000	$50,140,000
Open Cut Restoration		$1,630,000	$3,390,000
Connection to Existing Intake and/or Pump Station(s) at Plant	$1,000,000	$1,000,000	$1,000,000
Connection to Quarry and Intake/Outfall Structure	$1,000,000	$1,000,000	$1,000,000
Energy Dissipation	$1,000,000	$2,000,000	$2,000,000
Pump Station at Plant	$2,970,000	$2,320,000	$2,320,000
Pump Station at Quarry		$12,120,000	$12,120,000
Quarry Improvements (Environmental Testing, Access Ramp Improvements, Highwall Stabilization Above Intake/Outfall, and Grouting of Feature G)	$5,940,000	$5,940,000	$5,940,000
Subtotal	$90,520,000	$129,220,000	$162,120,000
General Requirements (10% of Subtotal)	$9,052,000	$12,922,000	$16,212,000
Engineering, Administration and Legal (25% of Subtotal)	$22,630,000	$32,305,000	$40,530,000
Contingency (30% of Subtotal)	$27,156,000	$38,766,000	$48,636,000
Total	$149,358,000	$213,213,000	$267,498,000

Note: Dollar Amounts in 2015 U.S. Dollars.

7.1.2 Washington Aqueduct Conveyance Alternatives

Table 4 includes a breakdown of the conceptual OPCC for the Washington Aqueduct Conveyance alternatives.

Table 4 Opinion of Probable Construction Costs for the Washington Aqueduct Conveyance Alternatives

ALTERNATIVE	CONVEYANCE TUNNEL TO GREAT FALLS		CONVEYANCE TUNNEL/ PIPELINE TO OLD ANGLER'S INN	
	ALONG POTOMAC RIVER	ALONG C&O CANAL	ALONG C&O CANAL	ALONG ROADWAY ROW
Shaft Excavation and Lining at Plant	$1,580,000	$1,580,000	$1,650,000	$4,480,000
Shaft Excavation and Lining at Washington Aqueduct	$580,000	$580,000	$330,000	
Tunnel Excavation	$29,140,000	$32,440,000	$42,820,000	
Tunnel Lining	$1,970,000	$2,320,000	$3,410,000	
Tunnel Pipe Installation	$10,270,000	$12,070,000	$17,730,000	
Open Cut Excavation				$33,770,000
Open Cut Pipe Installation				$30,880,000
Open Cut Restoration				$3,340,000
Connection to Existing Intake and/or Pump Station(s) at Plant	$1,000,000	$1,000,000	$1,000,000	$1,000,000
Connection to Washington Aqueduct	$1,000,000	$1,000,000	$1,000,000	$1,000,000
Energy Dissipation				$1,000,000
Pump Station at Plant	$2,720,000	$2,720,000	$2,720,000	$6,110,000
Subtotal	$48,260,000	$53,710,000	$70,660,000	$81,580,000
General Requirements (10% of Subtotal)	$4,826,000	$5,371,000	$7,066,000	$8,158,000
Engineering, Administration and Legal (25% of Subtotal)	$12,065,000	$13,427,500	$17,665,000	$20,395,000
Contingency (30% of Subtotal)	$14,478,000	$16,113,000	$21,198,000	$24,474,000
Total	$79,629,000	$88,621,500	$116,589,000	$134,607,000

Note: Dollar Amounts in 2015 U.S. Dollars.

7.2 Opinion of Probable Operations and Maintenance Costs

A conceptual Opinion of Probable Operations and Maintenance Cost (OPOMC) was developed for each of the alignments identified in Section 4 and Section 5. The OPOMC was built based upon unit price data and validated with historical project information. Following assumptions were made for developing the OPOMC:

- The OPOMC includes costs for tunnel and open cut pipeline inspection, operations and maintenance of pump stations, and electricity costs in order operate the pump stations. For the tunnel and open cut pipeline inspections, it was assumed an inspection would be performed of the entire pipeline at a cost of $50,000 every ten (10) years.
- Annual operations and maintenance costs for the pump stations were calculated as four (4) percent of the capital costs of the pumps. These costs include material, manpower, consumable, and replacement costs. Electricity costs are added separately, and are calculated based on the assumed operating scenarios that are listed later in this section.
- Replacement of infrastructure components is assumed across the planning horizon. The following replacement cycle was assumed:
  - Tunnel and open cut pipelines are assumed to have a service life of 100 years
  - Valve vaults and pump station structures are assumed to have a service life of 50 years
  - Valves, pumps, and other mechanical equipment are assumed to have a service life of 25 years

Electricity costs were calculated for the following assumed scenarios:

- Annual Refill from Elevation 330 to Elevation 350 includes electricity costs for the Quarry Fill Pump Station to refill the quarry annually from Elevation 330 to Elevation 350 due to losses to groundwater or evaporation.
- Biennial Withdrawal from Elevation 350 to Elevation 150 includes electricity costs for the Quarry Withdrawal Pump Station to withdrawal water from the Quarry from Elevation 350 to Elevation 150. It was assumed water would be withdrawn from the quarry on a biennial basis for maintaining water quality in the quarry.
- Biennial Refill from Elevation 150 to Elevation 350 includes electricity costs for the Quarry Fill Pump Station to refill the quarry from Elevation 150 to Elevation 350. It was assumed the quarry would be refilled on a biennial basis after the biennial withdrawals.
- Biennial Use of the Pump Station to the Washington Aqueduct includes electricity costs for the pump station to pump water from the WSSC Potomac WFP to the Washington Aqueduct. It was assumed this would occur simultaneously with quarry withdrawal, on a biennial basis.

The OPOMC includes a contingency of 30%.

7.2.1 Quarry Fill/ Withdrawal Alternatives

Table 5 includes a breakdown of the conceptual OPOMC for the Quarry Fill/ Withdrawal alternatives.

Table 5 Opinion of Probable Operations and Maintenance Costs for the Quarry Fill/ Withdrawal Alternatives

ALTERNATIVE	ONE TUNNEL AND ONE PUMPING STATION	TWO PIPELINES AND TWO PUMPING STATION	
	UTILITY CORRIDOR	UTILITY CORRIDOR	ROADWAY ROW CORRIDOR
Tunnel and/or Open Cut Pipeline Inspection (Performed Every 10 Years)	$5,000	$5,000	$5,000
Quarry Fill Pump Station Operations and Maintenance	$48,000	$48,000	$48,000
Quarry Withdrawal Pump Station Operations and Maintenance		$256,000	$256,000
Electricity Costs for Quarry Annual Refill from Elevation 330 to Elevation 350	$231,000	$154,000	$154,000
Electricity Costs for Quarry Biennial Withdrawal from Elevation 350 to Elevation 150		$447,000	$447,000
Electricity Costs for Quarry Biennial Refill From Elevation 150 to Elevation 350	$798,000	$532,000	$532,000
Subtotal	$1,082,000	$1,442,000	$1,442,000
Contingency (30% of Subtotal)	$325,000	$433,000	$433,000
Total Annual Operations and Maintenance Costs	$1,407,000	$1,875,000	$1,875,000

Note: Dollar Amounts in 2015 U.S. Dollars.

7.2.2 Washington Aqueduct Conveyance Alternatives

Table 6 includes a breakdown of the conceptual OPOMC for the Washington Aqueduct Conveyance alternatives.

Table 6 Opinion of Probable Operations and Maintenance Costs for the Washington Aqueduct Conveyance Alternatives

ALTERNATIVE	CONVEYANCE TUNNEL TO GREAT FALLS		CONVEYANCE TUNNEL/ PIPELINE TO OLD ANGLER'S INN	
	ALONG POTOMAC RIVER	ALONG C&O CANAL	ALONG C&O CANAL	ALONG ROADWAY ROW
Tunnel and/or Open Cut Pipeline Inspection (Performed Every 10 Years)	$5,000	$5,000	$5,000	$5,000
Pump Station Operations and Maintenance	$80,000	$80,000	$80,000	$128,000
Electricity Costs for Biennial Use	$5,000	$9,000	$19,000	$224,000
Subtotal	$90,000	$94,000	$104,000	$357,000
Contingency (30% of Subtotal)	$27,000	$28,000	$31,000	$107,000
Total Annual Operations and Maintenance Costs	$117,000	$122,000	$135,000	$464,000

Note: Dollar Amounts in 2015 U.S. Dollars.

7.3 Net Present Value Analysis

The NPV of both set of alternatives is derived based on the OPCC and the OPOMC. Following assumptions were made for developing the OPOMC:

- A planning horizon of 100 years is used for development of NPV.
- OPOMC is assumed to be constant over the planning horizon.
- Discount rate is constant and at 4.5% for the planning horizon.

7.3.1 Quarry Fill/ Withdrawal Alternatives

Table 7 includes a breakdown of the conceptual OPOMC for the Quarry Fill/ Withdrawal alternatives.

Table 7 Net Present Value for the Quarry Fill/ Withdrawal Alternatives

ALTERNATIVE	ONE TUNNEL AND ONE PUMPING STATION	TWO PIPELINES AND TWO PUMPING STATION	
	UTILITY CORRIDOR	UTILITY CORRIDOR	ROADWAY ROW CORRIDOR
Initial Capital Costs (expressed as OPCC)	$149,358,000	$213,213,000	$267,498,000
Recurring O&M Costs (expressed as OPOMC)	$1,407,000	$1,875,000	$1,875,000
Present Worth of OPOMC	$30,883,443	$41,155,974	$41,155,974
Net Present Value	$180,241,443	$254,368,974	$308,653,974
NET PRESENT VALUE (ROUNDED to $ M)	$180,000,000	$254,000,000	$309,000,000
Flow Rate (MGD)	400	400	400
NPV/ MGD	$450,000	$635,000	$772,500

Note: Dollar Amounts in 2015 U.S. Dollars.

Based on the assessment of costs, the One Tunnel & One Pump Station alternative has the lowest NPV at $180M (approx). Incidentally, this alternative is expected to have the lowest community and environmental impacts, which makes it an attractive alternative for further consideration. Due to higher community and environmental impacts, other alternatives are less likely to compete with this alternative. A distant second option would be the Two Pipelines (along utility corridor) & Two Pump Stations alternative, with an estimated NPV of $254M (approx), however with relatively higher community and economic impacts than the tunnel alternative. It is also expected that the Two Pipelines (along Road Right of Way) & Two Pump Stations alternative may potentially have the highest community and environmental impacts, and with a NPV of $309M, the option should not be considered for further analysis.

7.3.2 Washington Aqueduct Conveyance Alternatives

Table 8 includes a breakdown of the conceptual OPOMC for the Washington Aqueduct Conveyance alternatives.

Table 8 Net Present Value for the Washington Aqueduct Conveyance Alternatives

ALTERNATIVE	CONVEYANCE TUNNEL TO GREAT FALLS		CONVEYANCE TUNNEL/ PIPELINE TO OLD ANGLER'S INN	
	ALONG POTOMAC RIVER	ALONG C&O CANAL	ALONG C&O CANAL	ALONG ROADWAY ROW
Initial Capital Costs (expressed as OPCC)	$79,629,000	$88,621,500	$116,589,000	$134,607,000
Recurring O&M Costs (expressed as OPOMC)	$117,000	$122,000	$135,000	$464,000
Present Worth of OPOMC	$2,568,133	$2,677,882	$2,963,230	$10,184,732
Net Present Value	$82,197,133	$91,299,382	$119,552,230	$144,791,732
Net Present Value (Rounded to $ M)	$82,000,000	$91,000,000	$120,000,000	$145,000,000
Flow Rate (MGD)	200	200	200	200
NPV/ MGD	$410,000	$455,000	$600,000	$725,000

Note: Dollar Amounts in 2015 U.S. Dollars.

Based on the assessment of costs, it is evident that Conveyance Tunnel to the Great Falls alternative has the lowest NPV and is ranged between $82M and $91M (approx), depending on the alignment. With similar community and environmental impacts, the Conveyance Tunnel to Old Angler's Inn (along C&O Canal) is a distant third choice with an estimated NPV of $120M (approx). It is expected that the Conveyance Pipeline to Old Angler's Inn (along Road Right of Way) may potentially have the highest community and environmental impacts, and with a NPV of $145M, this option should not be considered for further analysis.

7.4 Value Engineering Opportunities

Further analysis should be conducted in a future study to identify potential cost savings through value engineering. While other value engineering opportunities exist, two critical factors that should be looked at in detail are the quarry fill and withdrawal rates, and the lining of the tunnel.

7.4.1 Reduction Quarry Fill and Quarry Withdrawal Rates

The quarry fill rate of 60 MGD and the quarry withdrawal rate of 400 MGD were assumed for this study based on utility input. These flow rates should be analyzed in order to determine if they can be reduced, as reductions to these rates will affect the size of the linear systems and pumping stations required to convey the flow between the WSSC Potomac WFP and the quarry. For example, if the quarry withdrawal rate was reduced from 400 MGD to 300 MGD for the One Tunnel and One Pumping Station Alternative, the diameter of the tunnel liner required could be reduced by approximately one (1) foot, which would have the following effects on the OPCC for the following categories:

Table 9 Example Impact of Reducing the Flow Rate on OPCC for One Tunnel and One Pumping Station Alternative

ONE TUNNEL AND ONE PUMPING STATION ALONG UTILITY CORRIDOR	QUARRY WITHDRAWAL FLOW RATE OF 400 MGD	QUARRY WITHDRAWAL FLOW RATE OF 300 MGD	DIFFERENCE
Tunnel Excavated Diameter (ft)	14	13	1 ft
Tunnel Finished Diameter (ft) (Equivalent Circular Area)	10	9	1 ft
Tunnel Excavation	$43,010,000	$40,180,000	$2,830,000
Tunnel Lining	$24,850,000	$22,970,000	$1,880,000
Total	**$67,860,000**	**$63,150,000**	**$4,710,000**

7.4.2 Determining Need for Tunnel Lining

Based upon the limited existing geotechnical information that was available for this Study, it was assumed that a tunnel would be required to be lined. A future study that includes a geotechnical investigation along the tunnel alignments should investigate this requirement The cost to install a liner in the tunnel is roughly 15 percent of the total project cost presented in Section 7.1.

A tunnel constructed in high quality rock may still require lining to prevent or mitigate exfiltration from the tunnel. In addition, an unlined tunnel may be susceptible to stability issues over time, given the high internal pressures the tunnel will be subjected to during use followed by long periods of non-use.

8. CONCLUSIONS

The Travilah Quarry Phase 2 Study was performed to assess potential options for conveyance and pumping and develop life cycle costs for different alternatives. This Phase 2 study consisted of four tasks:

Assess Alternatives for Quarry Fill and Withdrawal

Two alternatives for quarry fill/ withdrawal were developed and evaluated. These alternatives included two different system configurations i.e. One Tunnel & One Pump Station, and Two Pipelines & Two Pump Stations alternatives. The first alternative (i.e. One Tunnel & One Pump Station) constitutes a deep tunnel along the existing Utility Corridor and a Pump Station at the Potomac plant. The second alternative (i.e. Two Pipelines & Two Pump Stations) offers two optional routes for pipeline, one along the existing Utility Corridor (along the existing gas lines and watermains) and the other existing Road Right of Way (along River Road and Piney Meetinghouse Road), and two separate Pump Stations at the Potomac plant and the Travilah Quarry.

Based on the evaluation it appears that One Tunnel & One Pump Station alternative has several economic and non-economic advantages over the Two Pipelines & Two Pump Stations alternatives in terms of constructability, operations, cost and community acceptance. This alternative requires minimum additional right of way, and can be constructed without much interference with the existing utilities and surface features along the alignment. This alternative appears to be least intrusive to the community and the environment during construction and operations, as the disturbances are mostly confined to the WSSC plant site and the Quarry, where there are already activities due to the existing operations. Due to these reasons, it is expected that this alternative will be favored during permitting and has greater potential for public acceptance. Over a period of 100 years, this alternative is the least expensive and is expected to have a NPV of $180M, which is approximately $450 Thousand/ MGD.

Assess Alternatives for Conveyance to Washington Aqueduct

Two alternatives for conveyance to Washington Aqueduct were developed and evaluated. These alternatives included two different system configurations based on points of connection -- Conveyance Tunnel to the Great Falls or Conveyance Tunnel/ Pipeline to Old Anglers' Inn alternatives. The first alternative (Conveyance Tunnel to the Great Falls) offers two alignment route options: one along the Potomac River (under Riverbend Park) and the other along the C&O Canal. The second alternative (i.e. Conveyance Tunnel/ Pipeline to Old Anglers' Inn) offers two alignment route options, one tunnel along the C&O Canal (extended to the Old Angler's Inn), and the other along the existing road right of way (along River Road, Falls Road and MacArthur Blvd).

Based on the evaluation it appears that Conveyance Tunnel connection to the Great Falls location has several advantages over the Conveyance Tunnel/ Pipeline connection to the Old Anglers' Inn location in terms of constructability, operations, cost and community acceptance. This alternative can be constructed without much interference with the existing utilities and surface features along the alignment. Because of the existing infrastructure at Great Falls, it is expected that this alternative offers a relatively compact system in terms of ease of system integration and O&M. Since the Great Falls Park is owned and managed by the NPS, the construction activities for this alternative will be subject to extensive federal permitting. However, permitting may still be managed with a methodical proactive approach and by effectively communicating the benefits and advantages of this system over the other alternatives. It is expected that the construction activities required to make a connection between the new tunnel and the existing infrastructure will temporarily affect the Park in ways that may require additional mitigating actions. Overall, the community impacts for the Great Falls alternative are expected to be less severe than the Conveyance options to the Old Angler's Inn. Over a period of 100 years, the Great Falls alternative is less expensive, and the NPV is expected to range between $82M and $91M, which is approximately $410,000/ MGD and $455,000/ MGD, respectively.

Assess Permitting Requirements

Desktop research was employed to identify anticipated permits for construction of Quarry Fill/ Withdrawal, and Washington Aqueduct Conveyance alternatives. It is noted that the permit requirements will be refined further following the selection of alternatives and subsequently with the progress of the project in design and construction phases. Due to the nature of the project, it is expected that there will be many required permits, which may require extensive time and effort and affect the project schedule. While, it is difficult to determine specifics of each permit, it is expected that the permits from federal agencies such as NPS (NEPA-related permits) and USACE (Section 404 permit) are among the most time consuming. A preliminary list of permits with the specific permit name, description, review period, and agency contact is summarized and more fully described in the Permit Register attached as Appendix B of this report. The permitting efforts documented are in addition to the temporary / permanent easements and Right of Entry permissions that will be required from private entities such as homeowners or private property owners that are within the project corridor. In addition, extensive outreach with the nearby community will be needed to communicate the benefits and impacts of the project alternatives, in accordance with NPS and Montgomery County standard processes.

Develop and Evaluate Life Cycle Costs

Life Cycle Costs (LCC) were prepared for the two sets of alternatives. The LCC cost is expressed as Net Present Value (NPV) in $M/ MGD, using the Capital Cost and O&M Costs that is expected to be incurred over a 100-year planning horizon. The LCC was developed based upon unit price data which was validated with historical project information. In general a contingency of 30% was used for development of the LCC. Based on the analyses performed in this report, the aggregated NPV for the two recommended alternatives is expected to be between $262M and $271M. These numbers are based on a daily raw water demand of 400 MGD (200 MGD each for the WSSC and the Washington Aqueduct). It is noted that the costs will be refined with the progress of the project development, as more site specific inputs are available. Similarly, there are opportunities to utilize Value Engineering principles and perform sensitivity analyses to develop a design that is optimally priced.

9. REFERENCES

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Potomac WFP Reliability and Water Quality Study. O'Brien & Gere Engineers, Inc. (OB&G). September 13, 2002.

USGS, Geologic Map and Database of the Frederick 30'X60' Quadrangle, Maryland, Virginia, and West Virginia, Southworth, et al, 2002.

Washington Aqueduct Data Book – Water Supply District of Columbia – Great Falls to McMillian Reservoir. U.S. Army Corps of Engineers (USACE). 2007.

Washington Suburban Sanitary Commission – WSSC Engineering Records Information (WERI) GIS Data. Accessed February to March 2015.

APPENDIX A: Travilah Quarry Estimates of Current and Projected Storage Capacity

Estimates of current and projected capacity of the Travilah Quarry were developed as a part of the Phase 1 Report on the Evaluation of the Travilah Quarry for Water Supply Storage. Two estimates were prepared:

- The estimated volume as of 2014 based on survey data from 2008-2009 and an assumed quarry production rate between 2009 and 2014; and
- The projected ultimate storage volume that could be utilized in the quarry based on an assumed maximum build out scenario.

Table A-1, below includes the estimated storage volumes for the two scenarios between various bottom elevations and a reservoir high level of 350feet above mean sea level. The bottom of the Travilah Quarry is currently at approximately elevation +0.0 feet above mean sea level. Based on the quarry operator's current plan at ultimate build out the bottom of the quarry will be at an elevation of approximately -100 feet above mean sea level. During development of the concept profiles for the alternatives, it was assumed that the intake/outfall structure will be constructed in the southwestern wall of the quarry, with an invert elevation of 150 feet. The elevation 150 feet was selected to limit the depth of the pumping station so single stage pumping could be conducted, thereby reducing the cost of the pump station substantially. Under this assumption, the volume of water stored below the elevation of 150 feet will not be accessible for withdrawal, unless separate pumping arrangements are made.

Table A-1 Travilah Quarry Estimates of Current and Ultimate Storage Volume

ASSUMED BOTTOM ELEVATION OF QUARRY ELEVATION (FEET)	CURRENT STORAGE VOLUME UP TO ELEVATION 350 (2014 ESTIMATE) VOLUME (BG)	ULTIMATE STORAGE VOLUME UP TO ELEVATION 350 (ASSUMING ULTIMATE QUARRY BUILD OUT) VOLUME (BG)
150	5.6	10.0
100	6.3	11.9
0	6.9	15.0
-100	6.9*	17.4

* The current bottom elevation of the quarry is at approximately elevation 0.

APPENDIX B:
Permit Register

PERMIT REGISTER - ANTICIPATED LIST OF PERMITS TO BE OBTAINED
ICPRB - Travilah Quarry Evaluation for Water Storage Study

No.	Permit Name	Description	Website Links to Application Forms and/or Information	Review Period	Contact	Agency	Phone
FEASIBILITY STUDY PHASE							
FS-1	National Park Service- Special Use Permit	A "Special Use Construction Permit" will be required by the NPS for activites within the C&O Canal National Historic Park property. A plan of action for each activity must be submitted to the NPS and then the NPS will put it into a permit form. This permit is required to perform topographic or other survey, and other environmental studies by the engineering consultants.	http://www.nps.gov/choh/planyourvisit/upload/C-OCanalPermitForm.pdf	Reasonably quick once information is obtained in the permit application.	Mr. Leigh Zahm	NPS C&O Canal NHP- Compliance Office	301-745-5815
FS-2	National Park Service- Research Permit	An NPS Research Permit will be required to conduct any special studies that may be required on NPS property, for example wetlands, archaeology, etc.	http://www.nps.gov/choh/parkmgmt/researchpermit.htm	Approvals are typically fairly quick- 1-2 weeks.	Chris Stubbs, Jen Ryan	NPS C&O Canal NHP-	301-714-2210
DESIGN ENGINEERING PHASE							
DE-1	Nontidal Wetlands Permit (Joint Federal/State Application for Floodplains, Wetlands, Waterways)	To protect wetlands by authorizing only necessary and unavoidable impacts. Applicants are required to demonstrate that proposed impacts to nontidal wetlands are necessary and unavoidable. The application review process first eliminates, then reduces impacts through avoidance and minimization. An alternatives analysis may be required as part of this process. Required for any activity that alters a nontidal wetland or its 25-foot buffer.The current General Permit (MDSPGP-4) will expire on September 30 2016. Under the current regulations and conditions of the MDSPGP-4, an individual permit is required in this case if the total wetlands impacts exceed 1 acre. Note: Need wetlands survey in areas affected by construction to determine applicability. If wetlands present, need to determine if they are on list of wetlands of special state concern, which require 100-foot buffer.	http://www.mde.state.md.us/programs/Water/WetlandsandWaterways/PermitsandApplications/Pages/Programs/WaterPrograms/Wetlands_Waterways/permits_applications/nontidal_permits.aspx	If General Permit, >60 days after COMPLETE application received. If Individual permit, >4 months.	Amanda Sigillito;	MDE/WMA Nontidal Wetlands & Waterways Division	410-537-3766
DE-2	Section 10 Obstruction to Navigable Waters (Joint Fed./State Appl. For Floodplains, Waterways, etc.)	Section 10 covers construction, excavation, or deposition of materials in, over, or under navigable waters of the U.S., or any work which would affect the course, location, condition, or capacity of those waters. Required for work in the Potomac River, which is considered navigable up to Cumberland for the purposes of Section 10.	http://www.nab.usace.army.mil/Portals/63/docs/Regulatory/Aquaculture/WaterColumnAquaculture_checklist_20110829.pdf	Part of JPA review	Vera Jaffe	USACE Regulatory Branch, MD Southern Section	410-962-6144
DE-3	§404 Permit for Discharge of Dredged or Fill Material into Waters of the U.S. (Joint Fed./State App.)	Required for any activity that involves filling waters of the U.S., including rivers and wetlands.	http://water.epa.gov/lawsregs/guidance/cwa/dredgdis/	4 months--minor projects; 8 months--major projects	Vera Jaffe	USACE Regulatory Branch, MD Southern Section	410-962-6144
DE-4	§401 Water Quality Certification (Joint Federal/State Appl. for Floodplains, Wetlands, Waterways)	To prevent violations of water quality standards. MDE must certify that any discharge to waters will comply with applicable CWA provisions. Required for wetlands and waterways construction permits.	http://water.epa.gov/lawsregs/guidance/wetlands/sec401.cfm	4 months--minor projects; 8 months--major projects	Bill Seiger@MDE; Vera Jaffe@COE	USACE Regulatory Branch, MD Southern Section	MDE 410-537-3821; COE 410-962-6144

PERMIT REGISTER - ANTICIPATED LIST OF PERMITS TO BE OBTAINED ICPRB - Travilah Quarry Evaluation for Water Storage Study							
No.	**Permit Name**	**Description**	**Website Links to Application Forms and/or Information**	**Review Period**	**Contact**	**Agency**	**Phone**
DE-5	Waterways Construction Permit (Joint Federal/State Application for Floodplains, Wetlands, Waterways)	To prevent increased flooding and impacts to river channel, wetlands, floodplains, and impacts to fish and wildlife. Required for construction in river and 100-year floodplain	http://www.mde.state.md.us/programs/Water/WetlandsandWaterways/DocumentsandInformation/Pages/programs/waterprograms/wetlands_waterways/documents_information/guide.aspx	4 months--minor projects; 8 months--major projects	Bill Seiger	MDE/WMA Waterway Construction Division	410-537-3821
DE-6	Dam Safety Permit (Joint Federal/State Application for Floodplains, Wetlands, Waterways)	To ensure that dams are built and operated properly to protect public safety. Issued in two steps: Plan Development Permit, authorizing detailed design, and Waterways Construction Permit, authorizing construction. Required for construction of a dam or similar waterway obstruction. Note: Futher discussion with MDE is needed to confirm that impoundment behind the berm will not be classified as a dam.	http://www.mde.state.md.us/programs/Water/DamSafety/PermitProcess/Pages/Programs/WaterPrograms/Dam_Safety/permit/dampermit.aspx	6 months	Brian Clevenger	Maryland's stormwater management program to the Sediment, Stormwater And Dam Safety Program	410-537-3554
DE-7	National Park Service- Special Use Permit	A "Special Use Construction Permit" will be required by the NPS for activites within the C&O Canal National Historic Park property. A plan of action for each activity must be submitted to the NPS and then the NPS will put it into a permit form. This permit may be required to perform any detailed site engineering that includes additional geotechnical investigations, engineering surveys, utility survey etc.	http://www.nps.gov/choh/planyourvisit/upload/C-OCanalPermitForm.pdf	Reasonably quick once information is obtained in the permit application.	Mr. Leigh Zahm	NPS C&O Canal NHP- Compliance Office	301-745-5815
DE-8	U.S. Fish & Wildlife Service Consultation	Section 7 of the Endangered Species Act requires that a Federal permitting action is "not likely to jeopardize the continued existence of any endangered species or threatened species or result in the destruction or adverse modification of the habitat of such species." If a proposed action "may affect" Federally listed species or critical habitat, consultation with the USFWS is required. Since a Federal permit will be required for the project (e.g., §404 Permit), USFWS consultation will be required.	http://www.fws.gov/endangered/laws-policies/section-7.html	30 days for species list, Indeterminate for Consultation duration.	Trevor Clark	USFWS Chesapeake Bay Field Office, Annapolis MD	410-573-4527
DE-9	MDNR Environmental Review	Maryland Department of Natural Resources (MDNR) Wildlife Heritage Service is mandated to ensure that "actions authorized, funded, or carried out by other State agencies do not jeopardize the continued existence of listed species." To accomplish this mandate, MDNR conducts Environmental Reviews to identify potential impacts to known locations of rare, threatened or endangered species and their habitats. They do not issue a permit. Listed species for Montgomery County are presented on the MDNR website at: www.dnr.state.md.us/wildlife/espaa.html An ER can take considerably longer than the 30 days published in MDNR's WHS documents.	http://www.dnr.state.md.us/wildlife/Plants_Wildlife/er.asp	>30 days for MDNR to complete the review	Lori Byrne; and Greg Golden	MDNR's Wildlife and Heritage Service	410-260-8573; and 410-260-8331

PERMIT REGISTER - ANTICIPATED LIST OF PERMITS TO BE OBTAINED ICPRB - Travilah Quarry Evaluation for Water Storage Study							
No.	**Permit Name**	**Description**	**Website Links to Application Forms and/or Information**	**Review Period**	**Contact**	**Agency**	**Phone**
DE-10	MDNR's Critical Area Regulation	The Chesapeake Bay Critical Area Act (CAA) was passed to protect the Chesapeake Bay and its tributaries from resource degradation (primarily from development). The Critical Area Act designated all lands within 1,000 feet of tidal waters or adjacent tidal wetlands as "critical area." Since the proposed project area is substantially further than 1,000 feet from tidal waters, and Montgomery County is not one of the 16 listed counties, the requirements of the CAA are not directly applicable	http://www.dnr.state.md.us/criticalarea/regulations.asp		Kate Charbonneau	MDNR Critical Area Commission	410-260-3475
DE-11	National Historic Preservation Act Consultation	Section 106 of the National Historic Preservation Act requires federal agencies to take into account the effects of their undertakings on historic properties, and to afford the Advisory Council on Historic Preservation a reasonable opportunity to comment. If the proposed action meets the criteria for an "undertaking" or has the potential to cause effects to historic properties, consultation with the State Historic Preservation Officer (SHPO) is required (36 CFR 800). The review should also consider historic properties included in State or local registers or inventories and any additional important cultural, traditional, or historic properties. Maryland Historical Trust's (MHT) Office of Preservation Services is the unit responsible for reviewing all state and federally assisted projects, to ensure compliance with historic preservation laws and regulations.	http://mht.maryland.gov/projectreview.html	30 days	Cole, Elizabeth	MHT Office of Preservation Services	410-514-7631
DE-12	Water Appropriation and Use Permit -- Groundwater Withdrawal	To authorize reasonable uses of Maryland waters while protecting the resource. Required if dewatering occurs for greater than 30 days or if pumping rate exceeds 10,000 gal per day.	http://www.mde.state.md.us/programs/Permits/WaterManagementPermits/Documents/www.mde.state.md.us/assets/document/permit/MDE-WMA-PER001.PDF	90 days < 10,000 gpd; 18 month > 10,000 gpd	John Grace	MDE/WMA Water Supply Program	410-537-3714
DE-13	Erosion and Sediment Control Plan Approval	To control soil erosion and sediment runoff from construction sites. Required for land clearing, land disturbance or grading within the limits of work. WSSC has its own approval authority, however coordination with MDE is required as the work involves construction activities on federal land. Required if > 5000 sq. ft. are disturbed.	http://www.wsscwater.com/file/EngAndConst/Home%20Owners/ESC_PERMIT_Major_short.pdf	~6 months	Tracy, Jim	MDE/WMA Sediment, SW and Dam Safety Program	410-537-3566
DE-14	General Discharge Permit (NPDES) for Storm Water Associated with Construction Activity	State Discharge Permit No. 03 GP; General NPDES Permit No. MDR10. To control stormwater runoff during construction. Required if area of disturbance > 1 acre.	http://www.mde.state.md.us/programs/Permits/WaterPermits/Pages/permits/watermanagementpermits/mdr10.aspx	>50 days	Karen Smith	MDE/WMA Compliance Program	410-537-3510
DE-15	Stormwater Management Plan Approval	To prevent stream bank erosion by controlling the rate of stormwater runoff from newly developed areas. Required by regulation if > 5000 sq. ft. are disturbed.	http://www.mde.state.md.us/programs/Water/StormwaterManagementProgram/SedimentandStormwaterHome/Pages/Programs/WaterPrograms/sedimentandstormwater/home/index.aspx	~6 months	Tracy, Jim	MDE/WMA Sediment, SW and Dam Safety Program	410-537-3566

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ICPRB - Travilah Quarry Evaluation for Water Storage Study

No.	Permit Name	Description	Website Links to Application Forms and/or Information	Review Period	Contact	Agency	Phone
DE-16	Water & Sewerage Construction Permit	To ensure that infrastructure projects throughout the State are designed on sound engineering principles and comply with State design guidelines to protect water quality and public health. Required for major modifications of public water systems	http://www.mde.state.md.us/programs/Permits/WaterManagementPermits/Documents/ECPP/MDE-WMA-PER019-Rev.doc	3 months	John Gesswein	MDE/WMA Engineering & Capital Projects Program	410-537-3760
DE-17	NRI/ FSD and FCP and Road side Tree Permit	This requires approval of a Forest Conservation Plan which is based on the assessment of impacts based on Natural Resources Inventory and Forest Stand Delineation. The road side tree permit is generally issued by WSSC, and is reviewed by DNR as a part of this package. DNR may choose to engage National Park Service for reviewing the Forest / Tree impact on NPS land.	http://www.dnr.state.md.us/forests/pdfs/fcaapplication.pdf	TBD	Marion Honeczy	MDNR	410 260-8511
DE-18	General Discharge Permit (NPDES) for Hydrostatic Testing of Tanks and Pipelines	Full Name = General Permit For Discharges From Tanks, Pipes, and Other Containment Structures at Facilities other Than Oil Terminals, General Discharge Permit No. 00-HT, General NPDES Permit No. MDG67 To control wastewater from the flushing or hydrostatic testing of pipes, pipelines, or tank. Required unless discharge is untreated water and < 10,000 gallons. Note: Clarification is needed whether this will be an update NOI to the existing WSSC permit or this will be a separate permit. Need discussions with MDE	http://www.mde.state.md.us/programs/Permits/WaterManagementPermits/WaterDischargePermitApplications/Documents/GDP%20-%20HT%20Documents/11_HT_PERMIT_FINAL.pdf	>60 days	Paul Hlavinka	MDE/WMA General Permits Division	410-537-3634
DE-19	General Discharge Permit (NPDES) for Mineral Mines, Quarries, Borrow Pits	To control discharges of infiltrated ground water, wastewater from material processing, stormwater from mine site, wastewater from washing mixer trucks and concrete mixing equipment.	http://www.mde.state.md.us/assets/document/permit/minmine_per.pdf	>60 days	Paul Hlavinka	MDE/WMA General Permits DivisionGeneral Permits and Technical Support	410-537-3634
DE-20	General Discharge Permit (NPDES) for Storm Water Discharges Associated with Industrial Activity	General Discharge Permit No. 02-SW, NPDES Permit No. MDR Should not be required -- not an industrial category covered by this permit.	http://www.mde.state.md.us/programs/Permits/WaterManagementPermits/WaterDischargePermitApplications/Pages/Permits/watermanagementpermits/water_applications/stormwater.aspx	>60 days	Paul Hlavinka	MDE/WMA General Permits Division	410-527-3323
DE-21	Discharge Permit (NPDES) for Wastewater Discharge (groundwater from dewatering)	To control wastewater discharges to surface water or groundwater. Required if discharge of ground water from de-watering is > 10,000 gpd or is contaminated. Note: Could be issued by MDE Industrial Permits group.	http://www.mde.state.md.us/programs/Permits/WaterManagementPermits/WaterDischargePermitApplications/Documents/GDP%20-%20HT%20Documents/11_HT_PERMIT_FINAL.pdf	9 months--minor project; 12 months--major project	Curt Dalton	Municipal Discharge Permits Division	410-537-3675

PERMIT REGISTER - ANTICIPATED LIST OF PERMITS TO BE OBTAINED ICPRB - Travilah Quarry Evaluation for Water Storage Study							
No.	**Permit Name**	**Description**	**Website Links to Application Forms and/or Information**	**Review Period**	**Contact**	**Agency**	**Phone**
DE-22	Discharge Permit (NPDES) for Wastewater Discharge (solids discharge)	To control wastewater discharges to surface water or groundwater. Need to notify MDE of expected change in solids discharge, as required by section II.B.1 "Change in Discharge" of the existing NPDES permit for solids discharge (# 95-DP-1055): "Anticipated facility expansions, production increases or decreases, or process modifications which will result in new, different, or an increased discharge of pollutants shall be reported by the permittee by at least 180 days prior to the changed discharge or, if such changes will not violate the effluent limitations specified in this permit, by notice to the Department."	http://www.mde.state.md.us/programs/Permits/WaterManagementPermits/WaterDischargePermitApplications/Documents/GDP%20-%20HT%20Documents/11_HT_PERMIT_FINAL.pdf	180 days	Curt Dalton	Municipal Discharge Permits Division	410-537-3675
DE-23	Non-Coal Mining Permit	To minimize the effects of mining on the environment, provide proper land reclamation, and ensure public safety. Required if the excavation and removal of material from the site is not completed within 18 months.	http://www.mde.state.md.us/programs/Land/mining/Permit%20Applications/Pages/Programs/LandPrograms/mining/applications/index.aspx	7 months	Larrimore, C. Edmon	Mining Program	410-537-3557
DE-24	Utility Permit	This permit is required for construction access off of State highways. The permit application, along with Traffic Control Plan is required.	http://sha.md.gov/OOC/Utility-Permit-Application.pdf	~30 days	Mark Loeffler	MD SHA, 9300 Kenilworth Ave, Greenbelt, MD 20770	301-513-7492
DE-25	Virginia Groundwater Withdrawal Permit	Permit for withdrawal of Groundwater may be required as per Groundwater Withdrawal Permit Regulation 9 VAC 25-610-10. If applicable, this permit will apply only to Conveyance Tunnel to Great Falls along the Potomac River (crossing through Virginia).	http://www.deq.virginia.gov/Portals/0/DEQ/Water/GroundwaterPermitting/B_APPLICATION.pdf	~ 45 days	TBD	VA DEQ	TBD
DE-26	Virginia Pollution Abatement Permit	This permit may be required for disposal of waste generated from the tunnel construction activities for the Conveyance Tunnel to Great Falls.	http://www.deq.virginia.gov/Portals/0/DEQ/Water/VirginiaPollutionAbatement/VPA_Pmt_Appl_Form-C_10-1995.pdf	~45 days	TBD	VA DEQ	TBD
DE-27	Gas Transmission Line Coordination	Other than contractor requirement to contact Miss Utility, there are no federal or state regulatory/permit requirements related to construction near the interstate gas transmission line. Contact with the pipeline owner is recommended early in design process. Coordination with Gas Company will be required. If the work involves access in Gas Lines' Right of Way, a Right of Entry agreement needs to be signed.	http://co.williams.com/williams/safety/damage-prevention/	TBD	TBD	TBD	TBD

PERMIT REGISTER - ANTICIPATED LIST OF PERMITS TO BE OBTAINED ICPRB - Travilah Quarry Evaluation for Water Storage Study							
No.	**Permit Name**	**Description**	**Website Links to Application Forms and/or Information**	**Review Period**	**Contact**	**Agency**	**Phone**
CONSTRUCTION PHASE (to be obtained by CONTRACTOR)							
CON-1	National Park Service- Special Use Permit	A "Special Use Construction Permit" will be required by the NPS for activites within the C&O Canal National Historic Park property. A plan of action for each activity must be submitted to the NPS and then the NPS will put it into a permit form. This permit is required for actual construction activities.	http://www.nps.gov/choh/planyourvisit/upload/C-OCanalPermitForm.pdf	Reasonably quick once information is obtained in the permit application.	Mr. Leigh Zahm	NPS C&O Canal NHP- Compliance Office	301-745-5815
CON-2	Non-Coal Mining Permit (for Contractor)	Mining of non-coal minerals (sand, gravel, clay, limestone, granite, shale and dimension stone) is an essential activity. To minimize the effects of mining on the environment, provide proper land reclamation, and ensure public safety, a permit is required to conduct surface mining.	http://www.mde.state.md.us/programs/Land/mining/Permit%20Applications/Pages/Programs/LandPrograms/mining/applications/index.aspx	A decision on the application typically made within 30 days; Permit typically takes 7 months	Edmon Larrimore	MDE- Land management Administration-Mining Program	420-537-3557
CON-3	Air Quality Permit to Construct (for Contractor)	To control air emissions and protect air quality. Project is not expected to cause emissions of regulated pollutants Note: Assumes no new emergency generators or fuel-fired heating equipment (e.g., boilers, furnaces) are constructed under scope of this project.	http://www.mde.state.md.us/programs/Permits/AirManagementPermits/AirQualityGeneralPermit/Pages/index.aspx				
START-UP AND COMMISSIONING PHASE							
COM-1	Water Appropriation and Use Permit -- Surface Water Withdrawal	To authorize reasonable uses of Maryland waters while protecting the resource. Note: WSSC will not be requesting a change in its existing authorized withdrawal. However, a permit may be required for commisioning of the quarry even if there is no increase in water withdrawal. (COMAR 26.17.06.03.A(3): "A person who shall obtain a permit from the Department includes: (3) A person planning to build any structure or impoundment which will horizontally or vertically move water from its source of natural occurrence;"). May not be required because waterways construction permit will be required. Further discussion with MDE is needed.	http://www.mde.state.md.us/programs/Permits/WaterManagementPermits/Documents/www.mde.state.md.us/assets/document/permit/MDE-WMA-PER001.PDF	90 days < 10,000 gpd; 18 month > 10,000 gpd	John Grace	MDE/WMA Water Supply Program	410-537-3714

Project	ICPRB Co-Op Water Supply Evaluation	**COMMENT TRACKING FORM**
Title	Phase 2 - Evaluation of Travilah Quarry for Water Supply Storage	
Date	Review Draft - May 8 , 2015	

Comment	**Reviewer**	**Reference (Sheet or Spec Section)**	**Comment**	**Response (Include initials of responder, either PM or Consultant)**
1	JP	1.1	pg. 1, first sentence, the purpose was to perform a study ("the study") of the feasibility of "potential prerequisites for use …" not to assess the feasibility study.	Comment Accepted. This change will be made. (CH)
2	JP	1.1	pg. 1, third paragraph, first sentence, remove the hyphen between "Phase", "1" and "2"; not used throughout the rest of the document.	Comment Accepted. This change will be made. (CH)
3	JP	1.1	pg. 1, third paragraph, second sentence, add "(WFP)" after Potomac Water Filtration Plant.	Comment Noted. Often we use "WFP" in lieu of the phrase "Water Filtration Plant." In this case we wanted to ensure the reader understands our use of "the plant" as a substitute for the Potomac WFP. (PK)
4	JP	2.1	pg. 4, fourth bullet in the list, this gives depth to bedrock at the Washington Aqueduct at Great Falls as an elevation whereas the other two bullets give depth to bedrock in feet below surface. This should be consistent.	Comment Noted. We want to be clear about our assumptions related to ground surface elevation and depth to bedrock, where they are relevant to the analysis. Sometimes we provide both pieces of information. (PK)
5	JP	3.3.1.1	pg. 7, first sentence, "Quarry Fill/ Withdrawal Alternatives" should be singular.	This change will be made. (CH)
6	JP	3.3.1.1	pg. 8, fourth sentence, Washington Suburban Sanitary Commission does not need to be spelled out, it's defined previously on page 1.	This change will be made. (CH)
7	JP	3.3.1.2	pg. 9, the abbreviation C&O for Chesapeake & Ohio should appear in the first paragraph of this section at the bottom of page 8 rather than on page 9 in the second paragraph.	This change will be made. (CH)
8	JP	3.3.1.3	pg. 10, last sentence, replace "could" with "would".	This change will be made. (CH)
9	JP	4.3.1.2	pg. 17, last sentence of the last paragraph, what would be the impact of the insufficiency available width of the existing utility easements to meet WSSC standards, would this make the alignment not possible or just increase the expense?	Easements could likely be extended outside road right of ways but at an additional expense. This will be noted. (CH)
10	JP	4.3.2.1	pg. 17, first sentence appears to be missing some text; should read something like "… that are expected to be less vulnerable …"	This change will be made. (CH)

Project	ICPRB Co-Op Water Supply Evaluation	COMMENT TRACKING FORM
Title	Phase 2 - Evaluation of Travilah Quarry for Water Supply Storage	
Date	Review Draft - May 8 , 2015	

Comment	Reviewer	Reference (Sheet or Spec Section)	Comment	Response (Include initials of responder, either PM or Consultant)
11	JP	Table 1	pg. 20, how is 23, 235 ft of Total Conveyance Length arrived at? Is this the yellow lines in Figure 6?	Yes, the yellow line length of 25,235 ft is based on the data in Google Earth.
12	JP	5.1	pg. 21, first paragraph, third sentence, "H" stutter.	Comment Accepted. This change will be made. (CH)
13	JP	5.3.1.1	pg. 26, first paragraph, second sentence, there seems to be some text missing between "groundwater," and "rock dowels".	Comment Accepted. Text will be added. (CH)
14	JP	5.3.1.2	second paragraph, fourth sentenced, top of pg. 27, "will be required" is repeated in the sentence.	Comment Accepted. This change will be made. (CH)
15	JP	7.2	pg. 36, last bullet item should be "OPOMC".	Comment Accepted. This change will be made. (CH)
16	JP	8	pg. 41, penultimate sentence of first full paragraph, should read ", it is expected that this alternative will be…"	Comment Accepted. This change will be made. (CH)
17	JP	8	pg. 42, would it be possible to have another section with a discussion of some adjustments that could be considered that would have an effect on reducing the total costs, e.g. reducing the required quarry discharge from 400 MGD to 300 MGD or less.	Comment Accepted. Capacity vs. Cost sensitivity analysis is a worthwhile activity that is recommended for further refinement of design concepts, but beyond the intent and scope of this feasibility study. Some details and data are not well-defined at this point. A high level assessment targeting the major cost elements will be included in Section 7 to provide insight on the subject. (CH)
1	FW	p.1, Section 1.	Define all acronyms either the first time they are used or in a separate table upfront. In particular, the "plant" is used throughout; needs to be specific when referring to WSSC's water treatment plant.	A listing of acronyms have been added to the report after the table of contents. (CH)
2	FW	p.3, Section 2.1	Grammatical suggestion: "The ground surface elevation high between the quarry and the plant is……" Clarify is this height? or is this the maximum observed elevation?	Comment Accepted. This will be clarified. (CH)
3	FW	p. 4, Section 2.3	Clarify the "average flow" during which quarry would occur from the Potomac River. Filling would be a function of seasonality, flow in the river, etc. Characterize filling to more accurately describe the conditions that would prompt filling and any high-level considerations (i.e...water quality).	Comment Accepted. The sentence will be reworded. (PK)

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Comment	**Reviewer**	**Reference (Sheet or Spec Section)**	**Comment**	**Response (Include initials of responder, either PM or Consultant)**
4	FW	p.8, Section 3.1.1.	Grammatical suggestion: Replace "pipeline" with "pipelines" when referring to Transco pipelines.	Comment Accepted. This change will be made. (CH)
5	FW	p.17, Section 4.3.1	Grammatical suggestion: "the available width of the existing utility easement may be insufficient to meet the WSSC Standards that require a minimum separation of 20 feet between the pipes."	Comment Accepted. This change will be made. (CH)
6	FW	p.36, Section 7.2	Provide clarification/context for the scenarios assumed in developing the electricity cost estimates.	Comment Noted. Electricity Costs will vary based on Operations for Quarry Refill and Withdrawal. Detailed planning of operations will require discussions between all the stakeholders to define operational objectives. For the purposes of this study, the scenarios were assumed as stated in Section 7.2. Two key aspects assumed include 1) annual refill to account for losses, and 2) Biennial operations to ensure water quality. (OF)
7	FW	Section 7.1.1 and Section 7.1.2	Substantial cost for lining of tunnels. Do they need to be lined?	Comment Noted. At this preliminary stage it is recommended that costs be carried to line the tunnels. The quality of the rock is not known along the alignment. Even if the rock quality is good it is highly likely a liner will be needed to prevent/mitigate leakage from the tunnel, and an unlined tunnel will be susceptible to stability issues given the high pressures it will be subjected to followed by dewatered periods. However, regardless of this recommendation, text will be added to the report to indicate the potential cost savings for eliminating the liner (CH)

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1	WSSC - asked during conference call 5/26	Section 7	What impact does the potential long lead time for this project have on the financial analysis presented?	Comment Noted. It will be noted in the report that material lead times and impacts to schedule will need to be considered during the detailed engineering phase of the project. In general, longer lead times may impact the schedule that may potentially add cost to the project. Such analyses and value engineering opportunities will be considered to control project costs , when engineering details are available.
2	WSSC - asked during conference call 5/26	Section 7	The effort related to coordination with other agencies (for permitting, ROW acquisition, etc.) will be extensive as was noted so in the report. Is this effort fully valued in the financial analysis?	Comment Noted. It is acknowledged that the level of effort related to coordination with other agencies is likely to be extensive. Currently, 25% of the subtotal of the probable construction costs are assumed for engineering, administration, and legal work. An additional 30% contingency is added to cover items that cannot be quantified at this stage. (OF)
3	WSSC	Section 4.1, page 12	Volume of water assumed to be above 150' (invert elevation) for this alternative?	Yes it is; this will be clarified. (CH)
4	WSSC	Section 4.2. page 13	Is the full volume of water in the quarry accessible by the high level pumping configuration outlined or only water above invert elevation of 150'	Only to elevation 150'. A second pump station would need to be used to access water below 150'. There are alternatives that should be explored as the design concept progresses (CH)
1	WA	2.1	The third and fifth bullet states that the depth of the bedrock is shallow .... Please refer the source of this.	A reference or basis of this assumption will be provided. (CH)
3	WA	2.3	spell out "msl" in the last bullet.	This change will be made. (CH)
4	WA	3.1	Third bullet state an existing pumping station at Great Falls. It is just an intake and not the pumping station.	This change will be made. (CH)
6	WA	3.2.1	No cost estimate is provided for Quarry Improvements. These costs should be part	A line item was included for quarry improvements. More detail will be added to the table to provide some

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7			Section 7 Evaluation of Life Cycle Costs.	breakdown for this item. (CH)
8	WA	3.2.2	Figure 1 is hard to see and needs to be improved.	Comment Accepted. The figure will be replaced with a Google Earth image. (FO)
9	WA	3.3.1.1	Take out the word area after residential.	Comment Accepted. This change will be made. (CH)
10	WA	3.3.1.2, Page 9	Change MacArthur Drive to Boulevard.	Comment Accepted. This change will be made. (CH)
11	WA	3.3.1.2, Page 9	The 84" gravity sewer is called "Potomac Interceptor" and is a regional sewer.	Comment Accepted. This change will be made. (CH)
12	WA	4.3.2.1, Page 18	Change the word "easy" to "ease" in third last sentence.	Comment Accepted. This change will be made. (CH)
13	WA	5.1, Page 21	There is a typo in the fourth line (HHHowever).	Comment Accepted. This change will be made. (CH)
14	WA	5.1, Page 22	It is mentioned that two axial flow pumps, rated at 500 hp, are required for WA. What	Comment Noted. Each pump is rated for half the flow. (BG)
15			is redundancy of these pumps? Each is rated for what flow?	Due to infrequent use of these facilities, there is no additional redundancy assumed for the pumps. (BG)
16			Why the pumps are needed at the Potomac Plant to convey quarry water to WA?	For Tunnel Option (between Plant and the Quarry), the operating head at the Quarry is variable. Below certain head conditions, the available residual head on the downstream end of the tunnel (at the plant) will be insufficient to facilitate gravity flow to the WA.
17			Does not enough head available to bring water to WA intakes via gravity?	
18	WA	Table 1, Page 20	What is the redundancy on pumps for both options?	Due to infrequent use of these facilities, there is no redundancy assumed for the pumps in this study. (BG)
19	WA	7.1	What is the basis of cost numbers used in Section 7?	The Cost Estimate is based on unit price data and validated with historical project information (OF)
20	WA	Table 7, Page 39	A salvage value of 5% is used for NPV. Is it realistic?	This assumption is consistent with other Business Case Evaluations performed for WSSC. (OF)

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Date	Review Draft - May 8 , 2015	

Comment	Reviewer	Reference (Sheet or Spec Section)	Comment	Response (Include initials of responder, either PM or Consultant)
1	CS	2.1	Could you please document the bases of the assumptions in Section 2.1.	Comment Accepted. This will be added. (CH) Bullet #1 - Quarry Survey Data from Montgomery County ,MD; Bullet #2 - Ground Surface Elevations - Google Earth; Bullet #3 - Bedrock elevation at quarry was obtained from site visit performed during Phase 1; Bullet #4 - Bedrock elevation at plant is based on the geotechnical information from plant as-builts as well as geotechnical information obtained during study of the intake. This information was also assumed for the Washington Aqueduct location, as the ground surface elevation is similar.; Bullet #5 - Limited information was available at Old Angler's Inn, it was assumed bedrock was similar at this location. (BG)
2	CS	2.3	Some place in the report could you please provide the following related to the assumed quarry pipe invert elevation of 150 feet above MSL: a) a table relating quarry water level and storage for the quarry when it has reached ultimate storage capacity; b) a table relating quarry water level and storage for the quarry at current capacity; and c) a paragraph describing considerations that led to the assumption of a 150 ft invert elevation, and cost considerations and physical constraints associated with any potential deviation of the invert elevation from 150 ft.	Comment accepted. This will be added in an Appendix (CH)

Project	ICPRB Co-Op Water Supply Evaluation	WSSC
Title	Phase 2 - Evaluation of Travilah Quarry for Water Supply Storage	COMMENT TRACKING FORM
Date	Review Draft -Additional comments received after June 16, 2015	

Comment	Reviewer	Reference (Sheet or Spec Section)	Comment	Response (Include initials of responder, either PM or Consultant)
1	WSSC - asked during conference call 5/26	Section 7	What impact does the potential long lead time for this project have on the financial analysis presented?	This comment is included as WSSC's question No. 1 (Line 30, page 4) on the previous comment tracking form.
2	WSSC - asked during conference call 5/26	Section 7	The effort related to coordination with other agencies (for permitting, ROW acquisition, etc.) will be extensive as was noted so in the report. Is this effort fully valued in the financial analysis?	This comment is included as WSSC's question No. 2 (Line 31, page 4) on the previous comment tracking form.
3		Section 4.1, page 12	Volume of water assumed to be above 150' (invert elevation) for this alternative?	This comment is included as WSSC's question No. 3 (Line 32, page 4) on the previous comment tracking form.
4		Section 4.2. page 13	Is the full volume of water in the quarry accessible by the high level pumping configuration outlined or only water above invert elevation of 150'	This comment is included as WSSC's question No. 4 (Line 33, page 4) on the previous comment tracking form.
5	R Steiner		Is there anything at this stage of consideration that would prohibit the design phase allowing for water to be withdrawn from the river and sent directly to WA, without going up to the Quarry and back?	No. B&V, July 13, 2015 Ops Cte mtg
6	R Steiner		Inconsistency in the cost for inspection between the text and tables	The inspections are assumed at 10 year intervals. For the purpose of calculating annual O&M cost, the inspection cost is spread over the 10 year period instead of adding it every 10th year. This is a conservative assumption. Therefore, in the table the cost of inspection is divided by 10 (OF).

7	R Steiner		Question the application of 5% salvage value being applied to all capital costs (including fixed infrastructure ~ shafts, tunnels, trenches, etc.) where there might in fact be costs associated with decommissioning for some aspects of the project.	Comment noted. The use of salvage value has been removed from the calculation (OF).
8	Brian Halloran (WSSC)	Section 7	Overall- I feel like the explanation of the costs is lacking in detail. I understand that the basis for the costs is preliminary, as no detailed engineering has been undertaken; however, I think the detail is lacking with regard to them explaining how they developed the operating and maintenance costs and the life cycle costs. Some of their assumptions are vague, which make it difficult to discern what is the actual assumption being employed in the analysis. Additionally, there is virtually no discussion as to the basis for their assumptions. So, some of my thoughts stem from this lack of detail. It is possible that some of the questions/concerns that I have are easily answered or already incorporated into the analysis, but that I am just not able to determine that from the brief descriptions	We are hopeful that the discussions and text added provides greater clarity. We are avaialable to answer specific questions. (PK)
9	Brian Halloran (WSSC)	Section 7.2	As you pointed out in your earlier email, the text states that the inspections cost is $50,000 every 10 years, but the O&M tables use a figure of $5,000 every 10 years. Whichever figure is incorrect needs to be adjusted to the correct figure.	See response to comment No. 6; an annual O&M cost is presented in the table (OF).
10	Brian Halloran (WSSC)	Section 7.2	While they have inspection costs for the tunnel and pipelines, they have no maintenance costs for these items. The maintenance costs included in the analysis are described as being for the pump stations.	Due to infrequent use, maintenance costs of the linear infrastructure are not specifically identified. However a 30% contingency is included in the O&M cost of the alternatives. Hence only the inspection cost is identified separately.
11	Brian Halloran (WSSC)	Section 7.2	On page 36, the report states that “annual operations and maintenance costs for the pump stations were calculated as four (4) percent of the capital costs of the pumps. These costs include material, manpower, consumable, replacement costs and electric costs.” This statement raises several questions, which are as follows:	
			A. Using the one tunnel and one pumping station alternative as an example, the listed cost from Table 3 for the pumping station at the plant is $2.97 million. Four percent of this figure would be $118,800. The figure listed in Table 5 is $48,000, which equates to approximately 1.6%. I find similar discrepancies for the other alternatives for both the connection to the quarry and the connection to the Washington Aqueduct. It is possible that they are basing this cost on a lower cost just for the pumps and that the $2.97 million figure includes the costs of the structures as well. However, as noted below, this does not fully solve the confusion with this statement.	As the report states, it's 4% of the cost of pumps, not the entire pumping station. The cost of pumps is estimated as $ 1.2M, hence 4% of 1.2M = $ 48,000 (OF)

			B. I do not understand the statement that the costs include the costs of replacement. Is this replacement of minor parts, or is this somehow an annuitized accounting for the replacement of the pumps and valves every 25 years and the pumping station structure every 50 years? If it is the latter, then there may be other questions, based on some of the other questions I have about the assumptions employed in the analysis.	Comment noted. The replacement costs are not assumed separately at the 25th and 50th years, instead 4% of the pumps' cost is included every year to cover O&M and replacement. Due to the infrequent operation of these facilities, O&M is expected to be minor, and most of this cost can be used for replacement of pumps, valves etc (OF).
			C. I also do not understand the statement that the costs include the electric costs. They have separated out electric costs in Table 5 and Table 6. These electric costs exceed the 4.0% figure cited in this sentence.	Comment accepted. Electric costs are separate and are not part of 4%. The statement in the report will be corrected for clarification (OF).
12	Brian Halloran (WSSC)	Section 7.2	I am curious as to the assumptions employed in calculating the cost of electricity.	The electric cost are calculated based on pump ratings, hours of operations, volume of water to be pumped, and average unit prices from Bureau of Labor website for Washington-Baltimore area (OF).
			A. They do not state how much electricity they are assuming is consumed, nor how much they are assuming it costs on average per kilowatt hour of electricity. I would be particularly interested in the cost assumption and comparing that to WSSC's current average rate per kilowatt hour. Also, are they assuming on-peak and off-peak usage, or a cost conscious plan that tries to only use off-peak electricity.	unit price of electricity used for analyses = $ 0.135 per kWH as per BLS (see link). http://www.bls.gov/regions/mid-atlantic/news-release/AverageEnergyPrices_WashingtonDC.htm
			B. For the one tunnel and one pumping station option, the cost for electricity to refill the quarry from elevation 350 from elevation 150 is only 3.45 times the cost to refill the quarry from elevation 330 to elevation 350, despite the elevation difference being 10 times. Based on some of the figures and tables, I assume that the quarry is wider at the top than the bottom, which would explain some of this difference. Additionally, there may be some efficiency factors included in the calculation, but I would be interested in knowing more about these differences.	Comment noted. We took into account the quarry volume and shape to determine the pumping costs (OF).

			C. Also, if it is more efficient to pump more water at once, then would it not make sense in the biennial years that the refill from 150 to 350 occurs, if possible, to coincide the annual refill in some way. That would produce operating efficiencies and reduce the cost of the annual refill. This may be limited by the interplay between the annual refilling and the biennial refilling. There is no system for withdrawing water below an elevation of 150, so the annual refill to elevation 350 may have to occur prior to the biennial withdraw from elevation 350 to elevation 150.	Comment noted. Operational efficiency can be accomplished by looking into different quarry fill and withdrawal scenarios. The evaluation is beyond the scope of this study (OF).
13	Brian Halloran (WSSC)	Section 7.3	On page 38, it states that the period for the net present value analysis is 100 years. I would probably use a period longer than this. On page 36, it states that the service lives are 100 years, 50 years, and 25 years for the tunnel and pipes, valve vaults and pump station structures, and valves, pumps, and other mechanical equipment, respectively. So, I would align my analysis to end at the end of the 100th year following construction. That way, the analysis would end at the end of the service life of the tunnel and the most recent replacements for the other equipment and structures. This could potentially address all or some of the salvage value issue that you raised in your prior email.	Comment noted. The analysis runs to the end of the 100th year; so no replacement is used in the 100th year. See response to comment No. 7 regarding salvage (OF).
14	Brian Halloran (WSSC)	Section 7.3	On page 38, it states that "OPOMC is assumed to be constant over the planning horizon." This implies to me that they are not escalating the operations and maintenance costs from year to year. This appears to be confirmed by a simple check of the net present value of the OPOMC listed in Table 7 and Table 8 (granted I had to make some assumptions due to lack of knowledge regarding the timing in their analysis). This raises several questions, as follows:	
			A.Is their net present value analysis on a nominal or real basis? If it is on a real basis, what is the rationale behind the 4.5% discount rate?	Nominal rate.
			B. This could result in an underestimation of the net present value of the life cycle costs. Have they undertaken an annuitization process to smooth the costs over the years? What was this process and does it properly address the issue of moving costs between years having an effect on the net present value? This implies a pretty thorough analysis, while the language in the report suggests a higher level preliminary analysis given the lack of detailed engineering.	Comment noted. This analysis is preliminary and cost is developed per AACE guidelines. The level of sophistication and detail outlined in the comment may be more applicable as the design progresses in later phases of the project (OF).
15	Brian Halloran (WSSC)	Section 7.3	I too am a bit uncomfortable with the 5% salvage value. They have not explained what is salvageable. Is this accounting for remaining life, scrap metal value, or both? Their answer to the question on the salvage value in the comments does not reduce the discomfort. They stated that "this assumption is consistent with other Business Case Evaluations performed for WSSC." To me, this is a non-answer and ignores the potential for projects to have different salvage values based on the type of project.	Comment noted. See response to comment No.6 (OF).

16	Brian Halloran (WSSC)	Section 7.3	I agree with your comment in your prior email that the lack of any discussion of decommissioning costs is a potential weakness in the analysis. Unless all of the equipment and structures are being abandoned in place, there would likely be decommissioning costs. They could be netting the decommissioning costs out of the salvageable value, but there is no mention of that and that would only increase the concerns about the salvageable value seeming high.	Comment noted. See response to comment No.7 (OF).
17	Brian Halloran (WSSC)	Section 7.3	In Table 7 and 8, the construction costs have not been present valued. Therefore, they either are not escalating the construction costs out to the assumed date of construction, or they are assuming an escalation rate for the construction equal to the discount rate of 4.5%. However, there is no discussion on this in the report.	Comment noted. The construction costs are based on year 2015 (see footnote on Table 3 &4). At this stage of analysis, construction duration and schedule are not known, and they are not escalated.
18	Brian Halloran (WSSC)	Section 7.3	The salvage value in Table 7 and Table 8 has not been present valued. Essentially, they are assuming that the value of the salvageable equipment escalates at a rate equal to the discount rate of 4.5%.	Comment noted. Salvage has been removed from the calculation.
19	Brian Halloran (WSSC)	Section 7.3	I do not see an accounting for replacement costs in Table 7 and Table 8, so that would suggest that they have either been included in the operating and maintenance costs or that they have not been included in the analysis.	Comment noted. Replacement costs are covered in O&M costs (OF).
20	Brian Halloran (WSSC)	Table 1	On page 20, the open cut conveyance length for the road ROW corridor option under the two pipelines and two pumping stations alternative appears to be incorrect. The total conveyance is listed at 25,235 feet, but the tunnel and open cut lengths do not sum to this figure. I think the open cut figure is the source of the discrepancy.	Comment accepted. The open-cut length will be corrected.
21	Brian Halloran (WSSC)	Table 1	Also on page 20, under the shaft depth at quarry, the one tunnel and one pumping station alternative has a note about there being a contractor's option. I did not see anything elsewhere in the report about this contractor's option, so I found it a bit odd to see it in the table without any explanation in the body of the report.	Comment accepted. The note will be deleted.