# Executive Summary

The Washington, D.C., metropolitan area (WMA) is fortunate to have a highly reliable water supply system and a suite of supply alternatives to help meet the future challenges of population growth and climate change. The three major regional suppliers participate in a cooperative system of water supply planning and management which includes coordination and use of shared resources during droughts, regular joint planning studies, and agreement to share in the cost of new resources when the need arises. This study, by the Section for Cooperative Water Supply Operations on the Potomac (CO-OP) of the Interstate Commission on the Potomac River Basin (ICPRB), was conducted to assist the suppliers in the selection of new resources and operational measures to address the need for additional water supplies by 2040, as identified in a recent planning report (Ahmed *et al.*, 2015). This study also provides information on potential alternatives for the year 2085 to help ensure that options are available over a longer planning horizon. Alternatives have been evaluated according to their capabilities to increase future system reliability in the face of growing WMA demands, decreasing river flows due to upstream consumptive use, and the potential impacts of climate change.

## Current System

The WMA's primary source of water is the Potomac River. To augment river flow during drought, the area also relies on upstream reservoirs, Jennings Randolph, Savage, and Little Seneca. Three off-Potomac reservoirs in the Occoquan and the Patuxent watersheds are used on a daily basis. Current resources, including Loudoun Water's Quarry A, planned for operation in 2022, and proposed alternatives are shown in Figure ES-1 (numbers matching names in box on next page).

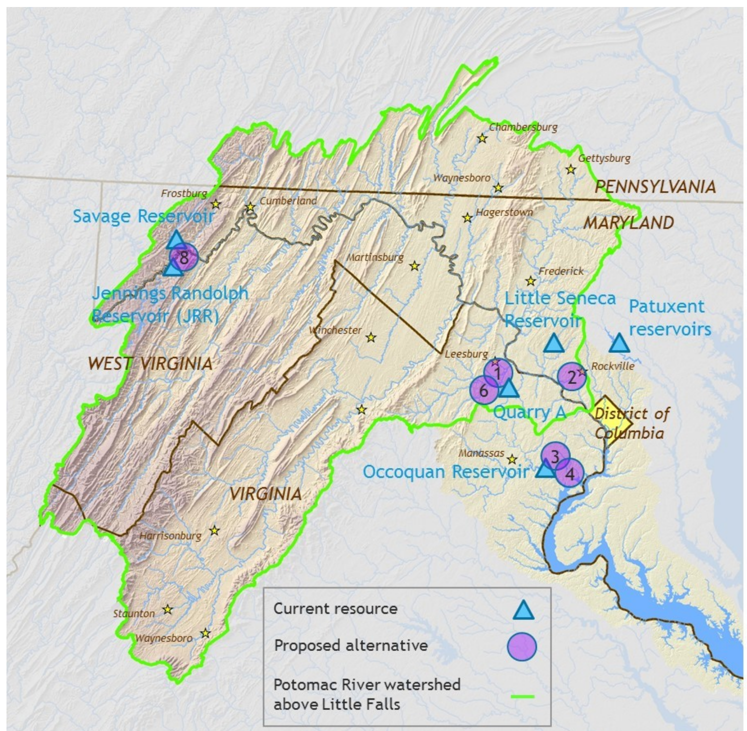


**FIGURE ES-1: POTOMAC RIVER BASIN**

The WMA's three major suppliers are Washington Aqueduct, Fairfax Water, and Washington Suburban Sanitary Commission (WSSC). Washington Aqueduct, a Division of the U.S. Army Corps of Engineers, provides water to the District of Columbia via the District of Columbia Water and Sewer Authority and to some Virginia suburbs. Fairfax Water serves most of the northern Virginia suburbs and WSSC primarily serves the Maryland suburbs in Montgomery and Prince George's counties. Collectively, these suppliers obtain approximately three quarters of their water from intakes on the Potomac River. In the near future, a fourth supplier, Loudoun Water, will initiate withdrawals from the Potomac River to meet a portion of its demand. Additionally, they will complete construction of the necessary infrastructure to store water in a retired quarry, "Quarry A", for use during droughts. Loudoun

Water also recently has acquired Beaverdam Reservoir, which could be used during droughts for Potomac River low flow augmentation.

## Proposed Alternatives

The alternative options for augmenting future supply, listed in the box to the right, are both structural and operational. The locations of the structural alternatives and some of the operational alternatives are indicated by number on Figure ES-1. Many have been the subject of past investigations by the WMA suppliers. Although some of the structural alternatives would provide water directly to only one or two WMA suppliers, all would provide regional benefits by increasing Potomac River flow. All structural alternatives would require significant investments in new infrastructure which would in most cases include new underground conduits to transfer raw and/or treated water from one part of the WMA system to another. The operational alternatives on the other hand would require little or no investment in costly infrastructure. They would, however, entail some costs, associated with new cooperative agreements, and/or contracts between water suppliers, and/or investment in research to develop new operational tools and policies.

**WMA Water Supply Alternatives**

*(numbering matches labels in Figure ES-1)*

***Structural Alternatives***

1. Luck Stone quarries in Loudoun Co., Virginia
   i. Luck 1: 2.5 billion gallons in 2040
   ii. Luck 2: 6.5 billion gallons by 2085
2. Travilah Quarry in Montgomery Co., Maryland
   i. 8.5 billion gallons (assumed)
3. Vulcan Quarry in Fairfax Co., Virginia
   i. Vulcan 1: 1.7 billion gallons by 2035
   ii. Vulcan 2: >17 billion gallons by 2085
4. Reverse osmosis water treatment plant using the Occoquan Estuary as a water source

***Operational Alternatives***

5. Cooperative use of Quarry A
6. Use of Beaverdam Reservoir for low flow augmentation
7. Improved river flow forecasts by 10%
8. Use of Jennings Randolph water quality storage for water supply during droughts
9. Reduction in upstream consumptive use
10. More stringent regional water use restrictions

## Climate Change Scenarios

According to projections from climate models, temperatures in the Potomac basin will rise whereas precipitation could rise or fall. Both temperature and precipitation have an impact on stream flows, and the range of available climate projections lead to a wide range of potential changes in water availability in the basin. This introduces tremendous uncertainty into water supply planning. ICPRB watershed modeling uses global climate model output downscaled to the Potomac basin by the U.S. Geological Survey (USGS). Results project changes in long-term average summer basin-wide stream flows ranging from -35 percent to +42 percent, with a median of +2 percent, over the period between 1995 and 2040. Between 1995 and 2085, the projected changes in average summer stream flows range from -54 percent to +36 percent, with a median of +4 percent. Water demand will also be affected by a changing climate. To take into account the uncertainty in future climate conditions, three future climate scenarios informed by past modeling results were developed for two scenarios years, 2040 and 2085. These are denoted in the table below as CC50, CC75, and CC90 (see Section 3.1 for further discussion):

| **SCENARIO YEAR** | | **2040** | | | **2085** | |
|---|---|---|---|---|---|---|
| **Climate change scenario** | **CC50** | **CC75** | **CC90** | **CC50** | **CC75** | **CC90** |
| Change in summer average basin-wide stream flow, % | +2 | -7 | -19 | +4 | -12 | -23 |
| Change in non-summer average basin-wide stream flow, % | +2 | -6 | -14 | +3 | -9 | -17 |
| Change in WMA precipitation, % | 6.3 | 2.4 | -2.9 | 11.3 | 5.4 | 1.4 |
| Change in WMA temperature, °F | 3.2 | 3.2 | 3.2 | 5.6 | 6.4 | 6.9 |

The future climate scenarios pose varying degrees of challenge to WMA system reliability, ranging from minor to severe. In 2040 under the CC50 scenario, stream flows actually increase slightly, yet due to increased regional demands, study results indicate that the current WMA water supply system would not be able to meet needs reliably during a severe drought. The addition to the current system of any single one of the alternatives, however, would be sufficient to ensure that needs could be met reliably under this scenario. For the most severe scenario, CC90, under which summer flows fall by 19 percent, Travilah is the only individual alternative able to meet regional needs in 2040 in case of severe drought.

## A Roadmap for the Future

**Recommended Strategies**

2040 Strategy A:

- Step 1: Operational alternatives #5-8 by 2025
- Step 2: Vulcan 1 by 2035
- Step 3: Luck 1 + improve 1-day flow forecast by 35% by 2040

2040 Strategy B:

- Step 1: Operational alternatives #5-8 by 2025
- Step 2: Vulcan 1 by 2035
- Step 3: Travilah by 2040

2085 Strategy:

- <u>All</u> quarry alternatives, along with operational alternatives #5-8

In general, study results indicate that combinations of alternatives will need to be in place to ensure system reliability in the future. Over the medium-term planning horizon of 2040, two strategies for phased implementation of alternatives are recommended for consideration and future discussion (see box on the left). These two combinations of alternatives were selected in part to ensure system reliability under a moderately severe climate scenario which results in a 7 percent decrease in average summer stream flows (CC75). The strategies also consider the need to protect the region from shortfalls in the decades leading up to 2040 and the need for steps toward broader regional cooperation to help prepare for more severe challenges which may arise in the decades after 2040. Over the longer-term planning horizon, by 2085, study results indicate that most of the ten alternatives will be needed to ensure system reliability.

The 2040 Strategy A is recommended if the region chooses not to pursue acquisition of Travilah Quarry or if that facility is unavailable in the near term. As a first step, it calls for work to begin on implementation of operational alternatives 5-8 (as numbered in the box on the previous page). Completion of these four measures by 2025 would provide some degree of protection against the potential impact of climate change during the years leading up to 2040. The second step of Strategy A is implementation of Vulcan Quarry Phase 1 by 2035, which already is planned by Fairfax Water. As a final step, Strategy A calls for implementation of Luck Stone Quarry B, along with further improvements in stream flow forecasts to help realize the benefits of this additional storage, by 2040. Step 1 alone – the implementation of operational alternatives 5-8 – is sufficient for system reliability under two of the 2040 climate change scenarios, CC50 and CC75. However, even after Vulcan Phase 1 and Luck Stone Quarry B are in place, Strategy A falls somewhat short of reliably meeting 2040 demands under the most severe scenario, CC90. None the less, Strategy A may prove to be a reasonable combination of alternatives for the region. A future evaluation could conclude that Strategy A would be effective in meeting 2040 demands, *if:* it is determined that demands are growing at a slower rate than forecasted; a new generation of global climate models or use of long-term trend data for model verification shrink the range of uncertainty for changes in basin stream flows; better than anticipated increases in the accuracy of stream flow forecasts are achieved; or better operational policies can be developed.

Strategy B involves acquisition of Travilah Quarry and the construction of infrastructure to carry raw water to and from the quarry and WSSC's Potomac treatment facility and to Washington Aqueduct's

Dalecarlia and McMillan treatment plants via Aqueduct's Great Falls intake. As a part of this recommendation, implementation of operational alternatives 5-8 and of Vulcan Quarry Phase 1 are included as first steps. These initial steps would provide protection against the potential impact of climate change in the years prior to completion of the Travilah project and would help increase regional cooperation and pave the way for measures needed in the decades following 2040. Strategy B would provide the region with a reliable water supply under a wide range of potential climate conditions, including the most severe scenario considered in this study, CC90. Strategy B also could be viewed as a "no regrets" option, because even if regional stream flows do not decrease, Travilah Quarry would serve another important function for the region. The quarry could provide an alternative water supply for both Aqueduct and WSSC in case of a contamination event on the Potomac River, with a limited quantity also available to the Fairfax Water system.

Results for the second scenario year, 2085, indicate that most of the ten alternatives need to be in place to ensure reliability under the range of climate scenarios. A future system that includes operational alternatives 5-8, Vulcan 2 (with an addition of the quarry's "Main Reservoir" with 17 billion gallons of storage), Luck 2 (including the addition of Quarry C with four billion gallons), and Travilah Quarry would be able to provide a reliable supply even under the most severe climate change scenario, CC90. Of course, these results should be considered highly preliminary, and meant to aid in long-term planning conducted in an "adaptive management" framework under the assumption that CO-OP will continue to update this evaluation as new data and information become available.

## Future Vulnerability to Flow Deficits

Study results highlight the future vulnerability of the WMA system to Potomac River flow deficits, that is, to river flow falling below the 100 million gallon per day minimum at Little Falls. These deficits will tend to increase and to reduce system reliability in future years, especially if rising demands are accompanied by decreases in average basin stream flows. Flow deficits may occur even on days in which the system has ample storage, due to the inherent inaccuracies in the one-day flow forecasts used to calculate Little Seneca Reservoir releases and other operational changes. Measures that were shown to be effective in reducing Potomac River flow deficits to take better advantage of available storage include:

a) use of Travilah Quarry, which because of its proximity to WSSC and Aqueduct treatment plants would be able to decrease Potomac withdrawals and quickly increase flow at Little Falls,
b) additional improvements in one-day flow forecasts, and
c) increases in minimum releases from reservoirs during droughts.

If acquisition of Travilah Quarry is not pursued in the near term, then resources need to be devoted to measures b) and c) above, in other words, to speed the improvement of one-day river flow forecasts and to develop other operational strategies to reduce the occurrence of deficits. This could be achieved by devoting more resources to CO-OP's development of its Low Flow Forecast System and by supporting research to better understand how to balance use of constant minimum releases and use of variable releases based on flow forecasts.

## Cost Considerations

Available cost information on the alternatives is summarized in this study. The information, however, is incomplete, and it is not possible at this time to provide cost-benefit comparisons of the alternatives. A future step in determining the best strategy will be the development of complete and comparable cost estimates for selected alternatives.