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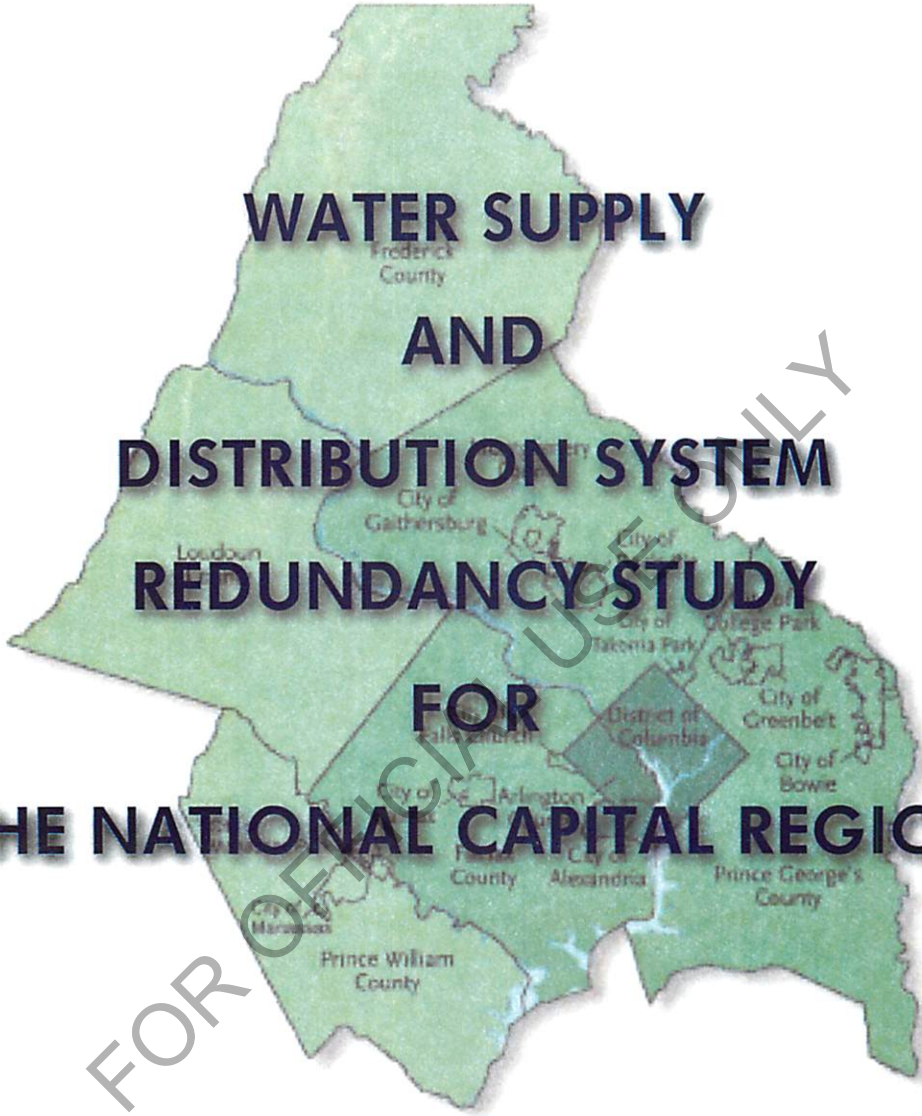
WATER SUPPLY AND DISTRIBUTION SYSTEM REDUNDANCY STUDY FOR THE NATIONAL CAPITAL REGION



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WATER SUPPLY AND DISTRIBUTION SYSTEM REDUNDANCY STUDY FOR THE NATIONAL CAPITAL REGION

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CHAPTER 1 – Executive Summary

1.1 BACKGROUND AND PROJECT OBJECTIVES

The objective of this evaluation is to identify significant water system infrastructure improvements that would enhance the overall reliability of the system throughout the region during an emergency event scenario. Emergency events which are considered in this evaluation include the loss of a major water treatment plant, an outage of a major water transmission main and region-wide loss of electrical power. The capability to deliver an adequate water supply to the region in these emergency situations was first evaluated utilizing the existing system infrastructure. Where the existing infrastructure was found to be inadequate to meet the supply goals set for this evaluation, the benefits of enhancing the regional water system with additional improvements were evaluated. The planning level scope and cost for these improvements are presented in this document.

The National Capital Region (NCR) includes the Metropolitan Washington Council of Governments member jurisdictions. The member jurisdictions of the National Capital Region are served by several water utility systems which draw supply from the Potomac River, the Occoquan Reservoir, Lake Manassas, Goose Creek and the Patuxent River. The central core of the NCR is supplied by three major water utility agencies which each have two water treatment plants servicing the area. These three agencies are as follows: Washington Aqueduct Division of the US Army Corps of Engineers, Baltimore District (WAD), Fairfax Water (FW), and the Washington Suburban Sanitary Commission (WSSC). Several other water utility agencies are wholesale customers of the major water suppliers. These include: DC Water and Sewer Authority (DC WASA), the City of Falls Church, Arlington County, Loudoun County Sanitation Authority (LCSA), Prince William County Service Authority (PWCSA), and the Virginia American Water Company (Alexandria). In addition, the City of Fairfax, the City of Manassas, and the City of Rockville serve large populations within the NCR.

One of the unique aspects of this project is that the hydraulic analysis work included the development of a computerized hydraulic model for the entire National Capital Region. As part of this model development, available hydraulic water system models from each jurisdiction were incorporated into one single large scale system. A skeletonized transmission system was created for those agencies which either did not have a hydraulic model or for which model data was not available. This is the first time that the National Capital Region has been integrated in such a fashion. This integrated model serves as a valuable planning tool for determining the capacities and the capabilities of sharing water supply between jurisdictions within the National Capital Region.

1.2 SUMMARY OF EXISTING AND FUTURE SYSTEM DEMANDS

The National Capital Region continues to experience significant population growth and this growth is forecasted to continue well into the future. In order to account for this growth, the water system demands used in this study are based on the current water system demand levels and forecasted future build-out demand levels. Water system demand data were collected from available sources such as water utility master plans and discussions with representative agencies. The demand data was then extrapolated to provide a uniform timescale for the demand forecasts. For this study, the year for the "current" scenario is 2005 and the year for the "build-out" scenario is 2030 (which was established based on discussions at the workshops during the course of this study).

In some cases, the available planning information from the individual water utilities did not extend as far as the 2030 planning year established for this study. In these cases, the COG Round 7 population forecasts were utilized as the basis to extrapolate future demands to the 2030 planning year in order to provide a uniform buildout planning year. The extrapolation was performed by utilizing the furthest available projected demand year such as 2015, 2020, or 2025 depending on the jurisdiction and taken to buildout based on the projected percent growth to 2030 from the Round 7 Cooperative Forecast. Water system demands used in this report are therefore aggregates of the various utilities own planning efforts and the Round 7 data.

The entire National Capital Region has been split into two major geographic areas in this study: 1) District of Columbia (DC) and Maryland Suburbs and 2) Northern Virginia. Existing and buildout average day demands for the National Capital Region are shown in **Table 1-1**. The entire NCR average day demand of 546 million gallons per day at present, as shown in **Table 1-1**, will increase to 682 million gallons per day. This represents a 25% increase in the overall system demands.

Table 1-1
Existing and Future Average Day Demands in National Capital Region

REGION	2005 DEMAND (MGD)	2030 DEMAND (MGD)	Overall Percent Growth
MARYLAND/DC	326	400	23%
VIRGINIA	220	282	28%
NATIONAL CAPITAL REGION	546	682	25%

1.3 OVERVIEW OF WATER SUPPLY

As part of developing a realistic representation of existing and future conditions within the regional water system, the current water supply capacities and planned future capacities of all the water treatment plants within the National Capital Region were identified and incorporated into the hydraulic model. The hydraulic model is effective and effective tool for planning necessary system improvements to meet the reliability requirements in the study area and throughout the planning period (2030). The review incorporated source water supplies, water treatment plants, and the primary water transmission system. A summary of current and projected future water supply capacities (based on treatment plant capacities) and water sources in the National Capital Region is given in **Table 1-2**.

Table 1-2

Current and Projected Future Water Treatment Capacities in the Region

Agency	WTP	Current (2005) Capacity (MGD)	Future (2030) Capacity (MGD)	Water Source
Washington Aqueduct	Dalecarlia	240	240	Potomac River
	McMillan	150	180	Potomac River
WSSC	Potomac	220	290	Potomac River
	Patuxent	72	110	Patuxent River / Rocky Gorge Reservoir
City of Rockville	Rockville	12	12	Potomac River
Fairfax Water	Corbalis	150	225	Potomac River
	Griffith	120	120	Occoquan River
City of Fairfax	Goose Creek	18	18	Goose Creek / Beaverdam Reservoir
Town of Leesburg	Kenneth Rollins	10	15	Potomac River
City of Manassas	City of Manassas	14	18	Lake Manassas
TOTAL SUPPLY CAPACITY		1,006	1,228	

1.4 CRITERIA FOR MINIMUM SERVICE LEVELS DURING AN EMERGENCY

Emergency water system planning requires the establishment of design criteria focused on providing an adequate supply capacity of water. The determination of what is an adequate supply is central to developing and analyzing emergency scenarios and developing the scope of supply improvement projects. As part of this evaluation, initial workshops were conducted with the participating jurisdictions within the National Capital Region in order to review and discuss the desired emergency capacity goals. As part of these discussions, the following supply goals were established for this evaluation:

- The water supply capacity goal for this study is set at a level equivalent to average day demand levels

- As an absolute minimum, the water supply capacity must be equivalent to 50-percent of projected average day demands.

Since water demands fluctuate significantly throughout the year, varying degrees of water restrictions will need to be implemented to ensure that water system demands can be curtailed to meet these goals. In order to reach average day demand conditions in the warm weather months, it is anticipated that water restrictions and conservation measures will be enforced throughout the region. In order to reach a 50-percent average day water demand condition, severe water restrictions would need to be strictly enforced to permit only health related activities such as washing, bathing and cooking. In previous drought emergencies, significant lowering of demands was achieved by imposing water restrictions. These measures have proven effective in reducing water consumption to levels approximating average day demand during normal high demand periods. Reducing levels to 50% of average day demand would be a significant challenge and is therefore considered the absolute minimum service goal for this project.

The means of implementing water restrictions within the customer base is not part of this project. This project will strictly focus on evaluating the performance capability of the water system infrastructure and identifying recommended enhancements to improve the performance to meet the established goals. Since each jurisdiction has established policies on enforcing water restrictions, this evaluation does not detail the protocol on how the restrictions are to be implemented. It is important to note, however, that the National Capital Region is considered to uniformly implement these restrictions. As such, if a supply emergency occurred in Maryland, for example, it is assumed that Northern Virginia would enforce water restrictions so that excess supply would be available for satisfying this deficit. Furthermore, it assumed that existing agreements between utilities can be modified to allow sharing of water resources.

Water distribution systems are dependent on consistent pressure in water mains to convey water into buildings through service line connections and to provide adequate flow and pressure at fire hydrants. In general, normal water pressures in distribution networks range from 60 to 80 pounds per square inch (psi), although some distribution systems can operate at lower pressures. When water distribution system pressures fall below 20 psi State Regulations often require customer notification in additional to other corrective measures. With internal pressures below 20 psi, the integrity of the water distribution system is potentially compromised. Therefore, a minimum water pressure goal of 20 psi was used for emergency water scenarios in this study.

1.5 SUMMARY OF EMERGENCY SCENARIOS

The National Capital Region could experience water supply disruptions due to natural or man-caused events. The two primary sets of problems identified for this report include interruptions to the raw water supplies for the region and interruptions to water treatment plant production.

Disruptions to the raw water sources can occur from disruptions to stream flow quantity (due to drought and flooding) or disruption of normal raw water quality (due to contamination). Although an extended period of drought can significantly reduce source water flow volume to the NCR water utilities, the current system of in-line and off-line reservoirs provide significant protection against a catastrophic loss of water supply.

As noted by the Interstate Commission on the Potomac River Basin (2020 Water Demand and Resource Availability Analysis), "The current system of resources is adequate to meet the most likely and high growth estimates of 2020 demands even if the worst drought of record was to be repeated." This report also noted that climate changes could impact flows in the Potomac, but lack of data and analysis preclude any changes to the current forecast of water availability.

Disruptions to water treatment plant production could occur due to problems with raw water supply within the respective reservoirs and river intakes or disruption of the supply pipelines, treatment units or other similar events that would cause the treatment plants to go off-line and out of production. Specific potential natural events such as hurricanes, wind-storms, flooding, lightning strikes or tornadoes, and man-made problems due to terrorism, vandalism or human error are not identified specifically in this evaluation. Rather, this evaluation focuses on the resultant loss of the supply and effect of reduced regional capacity.

With the exception of the Dalecarlia and McMillan Water Treatment Plants, each treatment plant operates independently and the scenarios for emergency planning will include an outage of only one water treatment plant in the National Capital Region. Dalecarlia and McMillan share a common raw water supply system including the Dalecarlia Reservoir. Accordingly, a scenario was considered that includes loss of both of these facilities. Disruptions of major water transmission mains are also a significant issue with regional reliability. As a result, four transmission main outage scenarios were also selected for consideration. The focus of selecting these four transmission mains was on the Arlington/Falls Church area and the WSSC area due to their proximity to the core DC area and the size and capacity of these facilities. A summary of all of the outage scenarios is included in **Table 1-3.**

Table 1-3
Emergency Scenarios Evaluated

Water Treatment Plant (WTP) Outage Scenarios	
Scenario 1	Dalecarlia WTP Outage
Scenario 2	McMillan WTP Outage
Scenario 3	Dalecarlia WTP & McMillan WTP Outage
Scenario 4	Potomac WTP Outage
Scenario 5	Patuxent WTP Outage
Scenario 6	Griffith WTP Outage
Scenario 7	Corbalis WTP Outage
Transmission Main Outage Scenarios	
Scenario TM1	FOWM Supply Pipe Interruption
Scenario TM2	Arlington Chain Bridge Supply Pipe Interruption
Scenario TM3	WSSC 96" & 48" TM Interruption
Scenario TM4	WSSC 72" & 42" & 60" TM Interruption

Each outage scenario was evaluated using the hydraulic computer model. In particular, the key issue with regional emergency supply planning is to have the ability to transmit water from one jurisdiction to an adjacent jurisdiction experiencing the emergency so that available supply capacity from the neighboring jurisdictions can be utilized and transmitted across jurisdictional boundaries. In order to assess the capacities of the system, an integrated hydraulic computer model was developed and utilized. Since the identified emergency scenarios are not a normal demand pattern that the systems were designed to handle, the ability for systems to share resources and to transmit large quantities of water supply across their boundaries poses a significant challenge.

1.6 USE OF RESERVE CAPACITY

In this evaluation, the term "Reserve Capacity" is used to describe the mathematical water production capacity that is available in excess of the forecasted demands within the National Capital Region. Water supply systems are typically designed to meet or exceed maximum day demand conditions. The maximum day demand reflects the expected highest demand day in a one year period. Since the emergency supply criteria in this evaluation is set to satisfy an average day demand condition or 50% of average day demands, there is additional supply capacity available to neighboring jurisdictions in order to mitigate supply deficits resulting from the scenarios identified previously in Table 1-3. The key to this evaluation is to maximize the ability to transmit this available supply throughout the region in order to enhance the regional water system reliability. **Table 1-4** provides a summary comparison of the total supply capacity, demand levels and reserve capacity for the National Capital Region in the 2005 and 2030 planning years.

Table 1-4
Reserve Capacity By Area Within the National Capital Region

Location	2005 Supply Capacity (MGD)	2005 Demand Levels		2005 Total Reserve Capacity Levels	
		50% Average Day	100% Average Day	At 50% Average Day	At 100% Average Day
Virginia	312	110	220	202	92
DC	390	71	142	319	248
Maryland	302	92	184	210	118
Location	**2030 Supply Capacity (MGD)**	**2030 Demand Levels**		**2030 Total Reserve Capacity Levels**	
		50% Average Day	**100% Average Day**	**At 50% Average Day**	**At 100% Average Day**
Virginia	396	141	282	255	141
DC	420	83	166	337	254
Maryland	414	117	234	297	180

1.7 RECOMMENDED PIPELINES AND PUMPING STATIONS TO ENHANCE RELIABILITY

Mass balances of water demands and supplies and hydraulic model simulations of the NCR water systems for the emergency scenarios indicate that potential improvements of piping and pumping facilities would be needed for the water systems in some of the emergency scenarios to sustain water service. There are three categories of potential infrastructure improvements described in this study: 1) piping improvements, 2) pumping station improvements, and 3) electrical/generator improvements.

A series of alternative improvements were evaluated to determine the minimum number of projects with the greatest impact to overall regional emergency reliability. Some of the proposed piping improvements would be connected with proposed pumping station improvements in order to enhance system hydraulics and the effectiveness of regional transmission of water. **Table 1-5** provides a summary of each emergency scenario and a listing of projects which are effective in maintaining the reliability of the water system in each of the scenarios. In total, seven transmission main improvements and four pumping station improvements are recommended.

Table 1- 5
Capital Improvements Identified with each Scenario

Water Treatment Plant (WTP) Outage		Improvement Identified	Comments
Scenario 1	Dalecarlia WTP Outage	NONE	Existing WSSC interconnections supply up to 22 MGD to WASA. Falls Church to utilize existing FW supply interconnections.
Scenario 2	McMillan WTP Outage	NONE	Falls Church to utilize FW supply with the Dunn Loring P.S to reduce demand of Dalecarlia
Scenario 3	Dalecarlia WTP & McMillan WTP Outage	A, B, C, D, E, F Langley, Dalecarlia and Corbalis PS Upgrades	Projects A and B deliver up to 141 MGD of supply to WASA from WSSC. Projects C, D and E allow Virginia to be supplied without Dalecarlia water. At 100% of average day, the river crossing project F is needed to supply a minimum of 24 MGD. The Langley Pump Station Upgrade provides 10 MGD to Falls Church from FW.
Scenario 4	Potomac WTP Outage	A, F, G Dalecarlia and Corbalis PS Upgrades	For 50% average day, Project A with enhanced pumping from Dalecarlia or Project F is needed. At 100% average day, Projects A, G and F are needed.
Scenario 5	Patuxent WTP Outage	NONE	Potomac WTP can meet system demands
Scenario 6	Griffith WTP Outage	NONE	Corbalis, and other Virginia plants can meet demands
Scenario 7	Corbalis WTP Outage	F	Although the Griffith WTP has adequate capacity at 50% demand levels, the transmission system may be limited in transmitting water north. Projects F and H are recommended in both the 50% and 100% demand scenarios.
Transmission Main Outage		**Improvement Identified**	**Comments**
Scenario TM1	Federally Owned Water Main Interruption at Key Bridge	NONE	Arlington County can open five existing interconnections in their Gravity 3 Zone to feed the Pentagon and Reagan National Airport.
Scenario TM2	Arlington Chain Bridge Supply Pipe Interruption	D	Arlington Utilizes Federally Owned supply Interconnections at Gravity 3 Zone and additional supply from Falls Church via Project D
Scenario TM3	WSSC 96" & 48" TM Interruption	NONE	Loss of 96" and 48" Mains near Potomac Plant. The system was found to be adequately looped to remain in operation without further improvements.
Scenario TM4	WSSC 72" & 42" & 60" TM Interruption	NONE	The 72", 42" and 60" mains are taken out of service at Columbia Pike and New Hampshire Ave. The system is found to have adequate looping to avoid regional interruption.

The proposed piping improvements as shown in **Table 1-6** are given at the largest capacities required to meet average day demands at the 2030 buildout demand levels. identified and can therefore satisfy hydraulic requirements for all emergency scenarios that have identified these projects.

Table 1-6
Potential Piping Improvements with Cost Estimates

ID	Location	Max. Flow (MGD)	Equivalent Diameter (in)	Length (ft)	Planning Level Project Cost (Millions)
A	WSSC Main Zone (495') To Dalecarlia Finished Water PS	117	66	22,000	43.6
B	WASA 3rd High Zone To WSSC Main Zone	24	36	6,000	6.6
C	Fairfax Water 1st High To Arlington County Gravity 2	10	24	8,000	5.3
D	Chesterbrook 4th Zone To Arlington County West Reservoir Zone	6	20	5,500	3.3
E	Fairfax Water Hospital Zone To Falls Church Chesterbrook 4th	6	20	26,000	15.7
F	Corbalis WTP To Potomac WTP	93	60	52,000	82.5
G	Rockville WTP TO WSSC Main Zone (495')	7	24	700	0.6

Total = $157.6 Million

Note #1: Cost for the potential interconnection between Corbalis WTP and Potomac WTP includes $12 Million for 3,500 ft of tunnel crossing of the Potomac River and 48,500 ft of open cut construction at a unit cost of $1300/ft.

The water utilities are also dependent on water pumping facilities at the water treatment plants and throughout the distribution network. Every pumping station is designed with redundant pumps for back-up to protect against mechanical failure. As a result, pumping station enhancements were also evaluated with particular interest with their need for on-site electrical power generation needs. Proposed pump station improvements and related cost estimates are given in **Table 1-7**. The cost estimates for the proposed pumps and VFDs in the Dalecarlia WTP are material/equipment costs only.

Table 1-7
Potential Pump Station Improvements with Cost Estimates

Item	Max Flow (MGD)	Planning Level Total Cost (Millions)
Langley Pump Station - Two Way Pumping Reconfiguration	21	$0.21
Dalecarlia Pump Station - Three New 36 MGD Pumps With VFD's	108	$8.0
Corbalis Finished Water Pump Station Interconnection With Pipeline Project "A"	93	$0.60
Potomac Finished Water Pump Station Interconnection With Pipeline Project "A"	93	$0.50
	Total =	**$9.31 Million**

1.8 STANDBY-BY ELECTRICAL POWER GENERATION IMPROVEMENTS TO ENHANCE RELIABILITY

The water treatment and water pumping facilities in the National Capital Region depend on a reliable supply of electrical power to operate. Although the national electric power grid is reliable and adequate for providing a steady supply of power to the NCR, prolonged regional outages have occurred throughout the United States, primarily due to natural events such as hurricanes. On-site standby electrical power generation systems at water treatment plants and pumping stations are the most reliable method of ensuring that electrical power is available for operating water pumping and treatment processes in the event of a failure of the normal electrical supply system.

Most of the treatment plants and water pumping stations in the NCR are connected to multiple power feeds from separate electric utility substations. These redundant systems remain vulnerable to outages in the regional electric power grid. On-site standby electrical power generation is the best way of minimizing the risk of loss of water supply due to power failures. Diesel powered reciprocating engines are the most reliable generator system for providing instantaneous replacement of electric power for facilities currently lacking power generation equipment.

Planning level costs for on-site standby electrical power generation systems were developed based on information provided by the water utilities. Although locations for sitting power generators at each facility were considered, issues such as public acceptance and permitting at specific sites were beyond the scope of this study. A planning level estimate of $40,639,000 is developed in Chapter 6 of this report.

1.9 SUMMARY OF TOTAL PROJECT COSTS

Planning level costs for all of the recommended facilities in this report are as follows:

- Proposed Transmission Mains = $157.6 Million
- Proposed Pumping Station Improvements = $ 9.3 Million
- Proposed Generator Improvements = $ 40.6 Million

Total Estimated Cost = $207.5 Million

Total Planning Level Cost Estimate =$208 Million

1.10 PROJECT IMPLEMENTATION TIERS

As part of the implementation of these recommended projects, it may be desirable to phase the projects by ranking the projects relative to cost and benefits. The following ranking of projects is suggested.

Tier 1 Projects: Tier 1 projects yield significant benefits relative to cost. With these projects, Washington, DC can be supplied to near average day demand levels by the proposed WSSC interconnections and WASA can, in turn, supply WSSC via the Dalecarlia WTP. Standby power generation projects are also included in Tier 1. These proposed generator projects will enhance the ability for the region's water system to remain in service in the event of a regional power failure. These projects and associated costs are as follows:

• LANGLEY PUMPING STATION UPGRADE	$ 0.21 MILLION
• PIPELINE "A" WSSC CONNECTION TO DALECARLIA	$ 43.6 MILLION
• PIPELINE "B" WSSC CONNECTION WASA 3RD HIGH	$ 6.6 MILLION
• DALECARLIA WTP PUMP STATION IMPROVEMENTS	$ 8.0 Million
• PIPELINE "G" WSSC CONNECTION WITH ROCKVILLE	$ 0.6 MILLION
• STANDBY ELECTRICAL POWER GENERATION	$ 40.6 Million
Total Tier 1 Project Cost	**$ 99.4 Million**

Tier 2 Projects: Tier 2 projects enhance the water transmission system eastward within Northern Virginia allowing Fairfax Water to serve as a backup supply to the existing transmission system from the District of Columbia. These projects ensure backup supply primarily to Arlington County and the City of Falls Church. These projects and associated costs are as follows:

• Pipeline "C" FW 1st High To Arlington County Gravity 2	$ 5.3 MILLION
• PIPELINE "D" FALLS CHURCH To Arlington County	$ 3.3 MILLION
• PIPELINE "E" FW TO FALLS CHURCH	$ 15.7 MILLION
Total Tier 2 Project Cost	**$24.3 Million**

Tier 3 Projects: Tier 3 projects provide a connection between the Fairfax Water Corbalis plant and the WSSC Potomac Plant. Although this tier of projects beneficial to the region, costs and constructability concerns may hamper the implementation of these projects. These projects and associated costs are as follows:

• PIPELINE "F" CORBALIS TO POTOMAC PLANT	$ 82.5 MILLION
• CORBALIS PUMPING STATION MODIFICATION	$ 0.6 MILLION
• POTOMAC PUMPING STATION MODIFICATION	$ 0.5 MILLION
Total Tier 3 Project Cost	**$83.6 Million**