Investigation of Potential Environmental Impacts due to the use of Phosphate-based Corrosion Inhibitors in the District of Columbia

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Executive Summary

Background

The quality of drinking water supplied to District of Columbia (DC) residents is the responsibility of several organizations. The Washington Aqueduct Division (the Aqueduct) of the U.S. Army Corps of Engineers owns and operates two water treatment plants, the Dalecarlia and McMillan plants, in DC. The Aqueduct sells treated water to the DC Water and Sewer Authority (WASA), Arlington County, Virginia, and the City of Falls Church, Virginia. DC WASA delivers treated water to district residents through more than 1,200 miles of water mains. Region III of the U.S. Environmental Protection Agency (EPA) is responsible for making sure that water produced and delivered to DC residents meets all Federal drinking water regulations.

Although lead is seldom present in natural waters, lead can leach from household plumbing into drinking water. In 1991, EPA promulgated the Lead and Copper Rule to reduce customers' lead exposure through tap water. This rule sets an Action Level for lead of 15 micrograms per liter (µg/L) based on the 90^{th} percentile of all tap water samples. An exceedance of the Action Level is not a violation, but can trigger other requirements such as additional and corrosion control treatment.

In June 2002, DC WASA exceeded EPA's lead action level for the first time since 1993, with the 90^{th} percentile level at 75 µg/L. The two monitoring periods in 2003 were also above the lead action level, with 90^{th} percentile lead levels of 40 µg/L and 63 µg/L, respectively.

In February 2004, the Technical Expert Working Group (TEWG) was formed to facilitate and expedite ongoing research and develop a strategy to reduce lead in the District's drinking water. The TEWG includes representatives from EPA, the Washington Aqueduct, DC WASA, DC Department of Health (DOH), the Centers for Disease Control and Prevention (CDC), Arlington County Department of Public Works, Falls Church Department of Environmental Services, and outside consultants.

In April 2004, based on the results of a desk top study and other research, the TEWG recommended that orthophosphate be added at the Dalecarlia and McMillan water treatment plants to control corrosion of lead materials. An independent peer review panel of national corrosion experts believed that, based on experiences of other utilities, zinc orthophosphate could solve DC WASA's corrosion problem. They suggested maintaining a stable pH of approximately 7.7 and flushing the system to distribute the zinc orthophosphate. These recommendations were adopted by the TEWG.

Any phosphate or zinc added at the Dalecarlia and McMillan water treatment plants will make its way either to area wastewater plants or directly to receiving streams (e.g., through storm sewers or combined sewer overflow discharges). In April 2004, the Cadmus Group, Inc., was tasked by EPA Region III to investigate the potential negative environmental impacts of the increased zinc and phosphorus concentrations. Early findings indicated that the increased zinc loading to Arlington County Water Pollution Control Plant (WPCP) could have a negative impact on biological wastewater treatment processes. More testing is needed to define safe levels; however, EPA-published advisory levels indicated that the zinc addition could be a problem. Based on the information presented in this report, the Washington Aqueduct and its customers (DC WASA, Arlington County, and the City of Falls Church), with EPA approval, made the decision on May 27, 2004, to use the originally recommended corrosion inhibitor, orthophosphate. The final orthophosphate dosing strategy for the District is as follows:

- Passivation dose of 3 mg/L as phosphate (PO_4) at the tap on average for 1 to 6 months
- Maintenance dose of approximately 1 mg/L as PO_4 at the tap on average indefinitely after passivation dose

Although the Washington Aqueduct does not plan to use zinc orthophosphate at this time, this report includes an evaluation of the potential impacts of zinc in case a decision is made in the future to use zinc orthophosphate instead of straight orthophosphate. For all analyses, zinc is assumed to be added to drinking water along with the orthophosphate at a concentration of approximately 0.3 mg/L during passivation, and 0.1 mg/L during the maintenance dose.

Purpose

The purpose of this report is to present results from a screening analysis to identify potential negative impacts from zinc orthophosphate addition to drinking water. It addresses impacts to operation of wastewater treatment facilities and to the quality of receiving waters. It provides background information on the three localities served (DC, Arlington, and Falls Church City) and describes the steps that were taken to make the assessment, even if no significant impact was identified.

Methodology

Methods that were used in this analysis are described below.

- Researched State experience with phosphate-based corrosion inhibitors.
- Identified water quality criteria and designated uses for streams in DC WASA, Arlington County, and the City of Falls Church service areas.
- Researched local regulations related to potable water discharges, combined sewer overflow (CSO) discharges, total maximum daily loads (TMDLs), and wastewater discharges.
- Identified sensitive species in area and evaluated their susceptibility to increased zinc concentrations.

- Estimated zinc and phosphorus loads to affected areas.
- Contacted local wastewater treatment plants and conducted interviews and site visits. Where available, gathered information on future changes to permits or treatment systems (e.g., plans to decrease CSOs and bypasses).

Because the purpose of this work was to identify potential problems, the results of quantitative analyses are based on conservative assumptions where data were not available. Sources of information are cited and assumptions laid out for each analysis.

Findings

Of the six States that responded to Cadmus' telephone questionnaire, four contain systems that use zinc orthophosphate as a corrosion inhibitor. State representatives reported that the dosing strategy for DC appears consistent with practices in their States. There were very few concerns with respect to environmental impacts of using zinc orthophosphate.

In spite of these positive findings, we identified three potential negative environmental impacts that could result from adding zinc to the drinking water:

1. The available toxicity data indicate that endangered species in Rock Creek are potentially sensitive to zinc, although specific data for the endangered species were not available. Increased zinc concentrations in Rock Creek in the vicinity of the endangered species could result from a potable water discharge directly to the stream (e.g., a main break) or a CSO discharge. The likelihood of negative impacts are small, however, due to dilution factors.

2. Both Rock Creek and the Anacostia River have TMDLs for heavy metals, including zinc. Zinc addition to drinking water could increase the total zinc loading to the Anacostia River through CSO discharges by up to 10 percent.

3. Based on EPA guidance and other studies, it is believed that the proposed zinc increase during the passivation dose (+ 0.3 mg/L) and possibly during the maintenance dose (+ 0.1 mg/L) could inhibit nitrification and activated sludge processes at the Arlington County WPCP. Because inhibitory levels vary among plants, bench or pilot-scale testing is recommended to identify true safe operating levels at the Arlington plant. As noted previously, the recommended treatment strategy was changed from zinc orthophosphate to straight orthophosphate because of this finding.

The impacts of adding straight orthophosphate to drinking water are expected to be minor. Senior personnel at affected wastewater treatment plants reported that neither plant operations nor effluent water quality would be adversely impacted by the additional phosphate in drinking water, although they recognized there would be increased chemical and sludge disposal costs.

It is unlikely that phosphate in drinking water discharged directly to the environment (e.g., during car washing, lawn watering, and distribution system maintenance activities) would permanently change the phosphorus level of receiving streams since these discharges are short in duration and represent only a small fraction of the total stream flow. The additional phosphorus could, however, contribute to the total phosphorus loading to the Chesapeake Bay. Based on published reports, the current annual phosphorus load to the Chesapeake Bay is approximately 18.8 million pounds. Our screening level analysis estimates that the increased annual phosphorus loading through CSO discharges and plant bypasses is a very small fraction (0.01 to 0.02 percent) of the total annual phosphorus load. The contribution from phosphate in drinking water is expected to decrease in the future as CSO discharges and plant bypass events are eliminated.

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1.0 Introduction

1.1 Background

The Washington Aqueduct Division (the Aqueduct) of the U.S. Army Corps of Engineers owns and operates two water supply intakes and two water treatment plants, the Dalecarlia and McMillan plants, in Washington DC. The Aqueduct sells treated water to the District of Columbia Water and Sewer Authority (DC WASA), Arlington County, Virginia, and the City of Falls Church, Virginia. DC WASA, the Arlington County, and the City of Falls Church Department maintain three separate distribution systems to deliver treated drinking water to approximately 900,000 customers.

In June 2002, DC WASA exceeded the U.S. Environmental Protection Agency's (EPA's) lead action level in drinking water for the first time since 1993. The two monitoring periods in 2003 were also above the lead action level of 0.015 mg/L (15 micrograms per liter, μg/L), with 90^{th} percentile lead levels of 40 μg/L and 63 μg/L, respectively.

In response to the lead action level exceedance, EPA Region III determined that a review of the Optimal Corrosion Control Treatment (OCCT), originally completed in 1994, was needed. In the spring of 2003, EPA initiated this review using the services of Dr. Marc Edwards from Virginia Tech. Preliminary findings by Dr. Edwards indicated that the increase in lead levels could be related to the conversion from free chlorine to combined chlorine (or chloramines) for secondary disinfection in November 2000. Additional studies and data collection were recommended to better understand the problem. DC WASA began collecting additional data and performing studies in December 2003.

In February 2004, the Technical Expert Working Group (TEWG) was formed to facilitate and expedite ongoing research conducted by both DC WASA and the Aqueduct and to develop a strategy to reduce lead in the District's drinking water. The TEWG is comprised of representatives from EPA, DC WASA, the Washington Aqueduct, DC Department of Health (DOH), the Center for Disease Control and Prevention (CDC), Arlington County Department of Public Works (DPW), Falls Church Department of Environmental Services (DES), and outside consultants.

In early March 2004, the TEWG released their Action Plan to Reduce the Occurrence of Lead Leaching from Service Lines, Solder or Fixtures into Tap Water in the District of Columbia, Arlington County, and Falls Church (the Action Plan). A copy of the Action Plan is available on EPA's web site.[1] The plan set forth a 3-part research strategy, including desktop, laboratory, and full scale studies. This research was to be conducted by various members of the TEWG.

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[1] Available at http://www.epa.gov/region03/Action_Plan_to_Reduce_Pb_3_10_04.pdf.

In April 2004, The Aqueduct and their consultant, CH2M HILL, completed a desktop analysis of potential treatment options and recommended that orthophosphate be added at the treatment plants to create a passivating layer on the lead pipe and prevent corrosion. A complete copy of this report is available on EPA's web site.[2] An independent peer review panel of national corrosion experts reviewed the desktop analysis and, based on experience of other systems, suggested that zinc (Zn) orthophosphate could solve DC WASA's corrosion problem. They suggested maintaining a stable pH of approximately 7.7; flushing the system to distribute the zinc orthophsophate; and conducting partial, followed by system-wide, application of zinc orthophosphate as soon as facilities could be constructed. These recommendations were considered by the TEWG and incorporated into their Action Plan.

In April, 2004, EPA Region III tasked The Cadmus Group, Inc., to investigate the potential environmental impacts of using a phosphate (PO4) based chemical to control corrosion. As a result of this exercise, Cadmus and EPA learned of a potential problem with the application of zinc orthophosphate. Arlington County wastewater engineers expressed concern that increased zinc loading could have a negative impact on biological wastewater treatment processes. More testing is needed to define safe levels; however, based on EPA-published advisory levels, the TEWG made the decision on May 27, 2004, to implement the original recommendation, orthophosphate. More information on the potential impacts of zinc is provided later in this report.

1.2 Purpose

Drinking water distributed by DC WASA, Arlington, and Falls Church City can either be collected in sanitary sewers and conveyed to wastewater plants for treatment, or be discharged to the environment (e.g., by direct discharge to receiving streams or through storm sewer systems). Figure 1 shows the possible pathways through which drinking water from the Washington Aqueduct enters area waterways. More detail on the receiving streams in DC, Arlington, and Falls Church are in Section 2.

The purpose of this report is to present results from a screening analysis to identify potential negative impacts from zinc orthophosphate addition to drinking water. It addresses impacts to operation of wastewater treatment facilities and to the quality of receiving waters. It provides background information on the three localities served and describes the steps that were taken to make the assessment, even if no significant impacts were identified. The level of analysis in this report is based on conservative assumptions in some cases and is not at the level of detail needed to quantify the impacts with a high degree of certainty. We recommend further study to determine the magnitude and likelihood of these impacts under the current corrosion control scenario.

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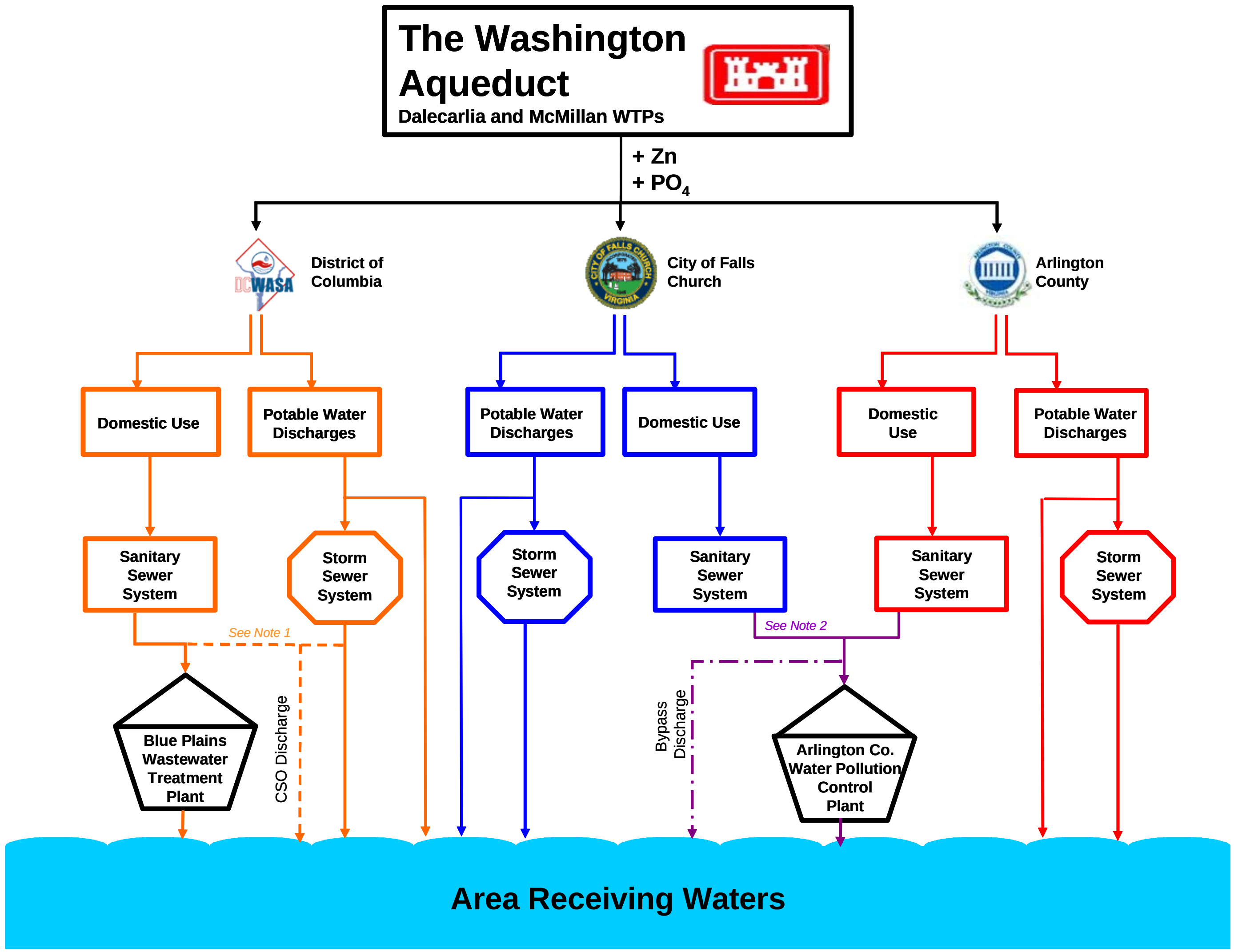
[2] Available at http://www.epa.gov/dclead/CorrosionControl.pdf.

Figure 1. Water Flow Diagram for the Affected Area



LEGEND

Combined System
Separate System

Note 1: Approximately 1/3 of the DC WASA sewer system is combined, meaning that all storm water and sanitary sewer flow goes to the treatment plant except during high flow conditions when it is discharged to receiving streams through Combined Sewer Overflows (CSOs). The remaining 2/3 of the WASA system is served by separate storm and sanitary sewer systems. All of Falls Church and Arlington are served by separate sanitary and storm sewer systems.

Note 2: Some wastewater from the City of Falls Churchgoes to the Alexandria Sanitation Authority via Fairfax County's collection system.

As of the date of this report, straight orthophosphate is scheduled to be added at the Washington Aqueduct treatment plants rather than zinc orthophosphate due to preliminary findings from this study related to potential wastewater treatment concerns. This report, however, includes an impact analysis of the potential increased loadings of both zinc and phosphorus in case a decision is made to use zinc in the future.

1.3 Assumed Corrosion Inhibitor Dosing Strategy for The District

To quantify potential impacts of adding zinc and phosphate to the distribution system, Cadmus used the following assumptions for the zinc orthophosphate dosing strategy based on the results of the Washington Aqueduct desk top study and independent peer review recommendations:

General Operating Parameters

- Zinc to phosphate ratio of 1:10
- Operation at a stable pH of approximately 7.7

Assumptions for Passivation Dose

- 3 to 5 milligrams per liter (mg/L) as PO_4 in the distribution system, which is equivalent to approximately 1 to 1.6 mg/L as total phosphorus (P). Average of 3 mg/L at the tap.
- 0.3 to 0.5 mg/L of zinc in the distribution system. Average of 0.3 mg/L at the tap.

Assumptions for Maintenance Dose

- 0.5 to 1.5 mg/L as PO_4 in the distribution system, which is equivalent to approximately 0.2 to 0.5 mg/L as total P.
- 0.05 to 0.15 mg/L of zinc in the distribution system.

The length of time that the initial passivation dose will be applied system-wide is unknown at this time. Experts recommend anywhere from 1 to 6 months, then reducing the dose to the maintenance level. It is anticipated that only the maintenance dose will be applied in subsequent years.

1.4 Document Organization

The remainder of this report is organized as follows:

2.0 State Experiences with Corrosion Inhibitors
3.0 Potential Impacts of Discharges to Receiving Streams
4.0 Potential Impacts to Wastewater Treatment Plants
5.0 References

2.0 State Experiences with Corrosion Inhibitors

To assess the extent that phosphate-based compounds are used to control corrosion and determine if there have been any documented environmental impacts associated with their use, Cadmus contacted representatives from several State drinking water programs. States with a large number of lead service lines, as identified in a 1990 survey commissioned by the American Water Works Association (AWWA) (AWWARF, 1996) were targeted. Hawaii was also selected due to a reported possible link between skin and eye irritations and the use of zinc orthophosphate. Table 1 lists the targeted states that provided information.[3]

The following questions were asked of each State's drinking water program office:

1) What is the prevalence of phosphate-based corrosion inhibitor use in your State, particularly among the large surface water systems? What is the primary form of phosphate-based corrosion inhibitor used? What range of concentrations are typically used?

2) Would your State generally approve the dosing strategy for The District (as described in Section 1.3)?

3) Do you know of any cases where detrimental impacts to wastewater plant operations or to natural waters occurred due to the use of phosphate-based corrosion inhibitors? Are you aware of any decisions in your State about the use of phosphate-based corrosion inhibitors that were made based on concerns about detrimental impacts to natural waters? Are you aware of any concerns about human health impacts as a result of zinc being introduced when zinc orthophosphate is added as a corrosion inhibitor?

Table 1 provides a summary of State responses. Results show that corrosion control strategies vary among states. Zinc orthophosphate is used in Massachusetts and New York. In Wisconsin and Illinois, orthophosphates or polyphosphate blends are more common. Systems in Missouri do not use phosphate-based corrosion inhibitors at all.

[3] Note that the number of states contacted was limited to meet information collection requirements (the Paperwork Reduction Act of 1995 requires approval by the Office of Management and Budget for collection of information from more than nine non-Federal respondents).

Table 1. State Experience with Phosphate-Based Corrosion Inhibitors

State	Use of Phosphate-Based Corrosion Inhibitor	Typical Concentrations	Known or Potential Environmental Problems
Hawaii	There are four systems that use phosphate-based corrosion inhibitors. One system serving 8,000 uses zinc orthophosphate. A second system serving approximately 50,000 previously used zinc orthophosphate, but converted to orthophosphate and plans to convert to soda ash.	All systems target a residual phosphate concentration of 1 mg/L. Hawaii would generally approve the strategy for The District, although they expressed reservations about the potential impacts of the high dose on wastewater treatment.	In one system, customers complained of skin rashes and eye irritations when zinc orthophosphate was introduced. The system switched to orthophosphate, but health problems continued. Hawaii has found no research suggesting that skin rashes and eye irritations can be caused by the phosphate.
Illinois	Phosphate addition is the most prevalent corrosion control strategy in the State, although pH / alkalinity adjustment is most common for large surface water systems. Blended polyphosphates are the most common form used mainly because of cost (they tend to be cheaper than zinc orthophosphate) and easiest to use (they are neutral unlike phosphoric acid).	Illinois requires minimum orthophosphate concentrations of 0.2 to 1.2 mg/L for maintenance. They said that the concentrations planned for use in The District seem appropriate.	None
Massachusetts	There are approximately 90 systems in Massachusetts using phosphates for corrosion control. They range from small systems serving <100 people to large systems serving >100,000. Systems use a mix of orthophosphate, polyphosphates, zinc orthophosphate, and phosphate blends. Nearly half of the systems use zinc orthophosphate.	A passivation dose of 3.0 mg/L and maintenance concentration of 1.0 mg/L at the tap are typical. Massachusetts would generally approve of the corrosion control strategy as long as pilot studies showed it was warranted.	None
Missouri	Missouri waters have enough alkalinity and high enough pH to practice $CaCO_3$ precipitation for corrosion control. No systems use phosphate-based corrosion inhibitors.	NA	NA

State	Use of Phosphate-Based Corrosion Inhibitor	Typical Concentrations	Known or Potential Environmental Problems
New York	Of the 19 largest water systems in New York, 17 provide corrosion control, 10 of those use either zinc orthophosphate, phosphate alone, or polyphosphate	The State recommends a residual level of 2 to 3 mg/L, but leaves it to the discretion of the system. According to State personnel, the initial level proposed for use in The District seems high, but the maintenance dose seems reasonable. New York State would most likely approve the District's corrosion control strategy with proper review.	There have been wastewater issues for some systems In New York. One system is using a lower dose of phosphate because of discharge concerns. Another did not use phosphate-based inhibitors at all because of concerns about algae growth in finished water reservoirs.
Wisconsin	Most of large systems practice corrosion control using orthophosphate or blended phosphate.	Systems target a residual phosphate concentration of 1 to 3 mg/L	One system did not select phosphate for corrosion control because of concerns about high phosphorus discharges to receiving streams. They opted instead to replace all lead service lines.

The dosing strategy for DC WASA appears consistent with practices in other States. There were few concerns with respect to environmental impacts with the following exceptions:

- One system in New York and one in Wisconsin elected not to use a phosphate-based corrosion inhibitors because of phosphorus discharge concerns to lakes.

- One system in New York elected not to use a phosphate-based corrosion inhibitor because of concerns that there would be algal growth in uncovered finished water reservoirs.

It is important to note that this is only a small representation of practices in other states. We suggest that EPA conduct a complete survey of corrosion control practices in the U.S.

3.0 Potential Impacts of Discharges to Receiving Streams

As described in Section 1.3, the approved corrosion control strategy for DC WASA involves the addition of a phosphate-based corrosion inhibitor. If zinc orthophosphate is used, zinc will be added at a ratio of 1:10 to the phosphate. A passivation dose targeting 3 mg/L PO_4 at the tap (and 0.3 mg/L of zinc) will be applied for several months, followed by a maintenance dose of approximately 1 mg/L PO4 at the tap (and 0.1 mg/L of zinc).

As shown in Figure 1, there are many ways that treated drinking water discharges directly to receiving streams without treatment. Any potable water that goes to a storm sewer or directly to a receiving stream is called a “potable water discharge” for the purposes of this report. Other types of discharges that go directly to receiving streams, not to the wastewater plants, are combined sewer overflow (CSO) discharges in DC and bypasses around the treatment plant in Arlington.

Because zinc is a heavy metal, one concern is that zinc could settle and accumulate in the sediments of smaller water bodies. There is also evidence that zinc may be toxic to aquatic species, including endangered species that are found within the District. In addition, Rock Creek and the Anacostia River are impaired for metals, and there are total maximum daily loads for zinc for several water bodies in the service area.

Phosphorus itself is not toxic. However, excess loadings of nutrients, including orthophosphate, cause algal populations to grow rapidly, or “bloom.” The algal blooms turn the water brown or blue-green, and prevent sunlight from reaching underwater vegetation. The resulting die-off of vegetation can adversely affect the habitat and food supplies of shellfish, fish, and waterfowl. Secondly, as algae die, they sink to the bottom and decay. During this process, bacteria consume large amounts of dissolved oxygen from the water, thereby lowering levels of dissolved oxygen. Consequently, this depletion of the dissolved oxygen levels also may affect other organisms that depend on dissolved oxygen to survive.

It is not anticipated that increased phosphorus in discharges would permanently change the phosphorus level of small streams or the Potomac and Anacostia Rivers, since these discharges likely represent only a small percentage of the total stream flow. However, the additional phosphorus will contribute to the total phosphorus loading to the river basins and the Chesapeake Bay.

Section 3.1 characterizes the impacted waters in the District of Columbia, northern Virginia, and the Chesapeake Bay. Section 3.2 provides a description of the types of discharges that can potentially impact these waters and how these discharges are regulated. Lastly, Section 3.3 identifies three potential negative environmental impacts of untreated discharges on receiving waters.

3.1 Impacted Waters and Their Water Quality Standards

Within the service area of DC WASA and its consecutive systems in Virginia are dozens of small and medium-sized streams. These streams are tributaries of the Potomac and Anacostia Rivers. The Potomac and Anacostia Rivers, in turn, drain to the Chesapeake Bay. Tables 2, 3, and 4 list the streams within the service areas of the District, Arlington County, and The City of Falls Church.

Some of the streams are listed as specially-designated, either as Special Waters of the District of Columbia (SWDC) or as impaired or nutrient enriched waters. Two water bodies in the District are listed as habitat to endangered species.

The following sections provide an overview of the designated uses and applicable in-stream criteria related to zinc and phosphorus within the affected service areas.

3.1.1 District of Columbia

A list of streams within the District is provided in Chapter 11 of the District of Columbia Municipal Regulations. Because DC WASA supplies water throughout the District, all waters listed are assumed to be within the service area. Cadmus identified 15 streams and wetlands within the DC WASA service area (see Table 2).

Cadmus researched the District of Columbia Municipal Regulations to identify whether any water quality criteria (WQC) for zinc or phosphorus are applicable to the waters of the District of Columbia. Cadmus also reviewed designated and special uses of these waters.

All streams within the DC WASA service area in the District are designated for one or more of the following uses: primary contact recreation; secondary contact recreation and aesthetic enjoyment; protection and propagation of fish, shellfish, and wildlife; protection of human health related to consumption of fish and shellfish; and navigation, as shown in Table 2.

In addition, Battery Kemble Creek and Rock Creek are designated as Special Waters of the District of Columbia (SWDC). The District defines SWDC as any water segments that are of higher water quality than needed for their current use, or have scenic or aesthetic importance. The District requires that water quality in SWDC-designated segments be maintained at or above the current level, and that existing nonpoint source discharges, storm water discharges, and storm sewer discharges to SWDC segments be controlled through BMPs and regulatory programs.

Chapter 11 of the District of Columbia Municipal Regulations establishes water quality standards (WQS) for the waters of the District of Columbia, as authorized by Section 5 of the Water Pollution Control Act of 1984 (D.C. Law 5-188; D.C. Official Code §8-103.01 *et seq*.).[4] Table 2 shows in-stream criteria for zinc and phosphorus for all identified District of Columbia streams.

[4] Cadmus also reviewed the National Toxics Rule, which establishes criteria for toxic contaminants for states not complying with Section 303(c)(2)(B) of the Clean Water Act. No additional relevant criteria for the District or Virginia were identified.

Table 2. Designated Uses and Criteria for Streams in the DC WASA Service Area

Streams	Designated Uses	Dissolved Zinc @ Hardness of 100 mg/L $CaCO_3$ (see box 1)	Phosphorus	Notes
Anacostia River	A, B, C, D, E	0.106 mg/L	NA	
- Beaver Dam Branch	A, B, C, D, E	0.106 mg/L	NA	
- Water Gardens	A, B, C, D, E	0.106 mg/L	NA	
Battery Kemble Creek	A, B, C, D	0.106 mg/L	NA	Special Water of DC
C&O Canal	A, B, C, D, E	0.106 mg/L	NA	
Hickey Run	B, C, D	0.106 mg/L	NA	
Oxon Run	A, B, C, D	0.106 mg/L	NA	
Potomac River	A, B, C, D, E	0.106 mg/L	NA	
Rock Creek	A, B, C, D, E	0.106 mg/L	NA	Special Water of DC
- Broad Branch	A, B, C, D, E	0.106 mg/L	NA	
- Piney Branch	A, B, C, D, E	0.106 mg/L	NA	
Tidal Basin	A, B, C, D, E	0.106 mg/L	NA	
Washington Ship Channel	A, B, C, D, E	0.106 mg/L	NA	
Watts Branch	B, C, D	0.106 mg/L	NA	
Wetlands	C, D	0.106 mg/L	NA	

Source: District of Columbia Municipal Regulations, Chapter 11.

Key to Designated Uses: A = Primary contact recreation; B = Secondary contact recreation and aesthetic enjoyment; C = Protection and propagation of fish, shellfish, and wildlife; D = Protection of human health related to consumption of fish and shellfish; E = Navigation. **For waters with multiple uses, the most stringent standards or criteria apply.**

Dissolved zinc numeric criteria for waters in the District of Columbia are calculated based on hardness. (See Box 1.) Assuming a hardness of 100 mg/L calcium carbonate ($CaCO_3$),[5] the numerical continuous chronic criterion for dissolved zinc is calculated as 0.106 mg/L.[6] (Based on the allowable hardness–between 25 and 400 mg/L–the numeric dissolved zinc criterion for District waters may range from 0.033 mg/L to 0.343 mg/L.) There are no phosphorus limits for the streams in the DC WASA service area. It should be noted that Rock Creek and the Anacostia River are impaired for metals. See Section 3.3.2 for more information on Total Maximum Daily Loads (TMDLs) for these waters.

Box 1: Calculating the DC Dissolved Zinc Criterion

The numerical criterion for dissolved zinc is calculated, in µg/L, as follows:

$$e^{(0.8473[\ln(\text{hardness})] + 0.7614)}$$

Where,
e = base e exponential function.
ln = natural log function.
Hardness = mg/L $CaCO_3$ (between 25 and 400 mg/L).

Assuming that hardness = 100 mg/L $CaCO_3$, the numerical criterion for dissolved zinc is 0.106 mg/L.

3.1.2 Arlington County, Virginia

To identify streams in the Arlington County Department of Public Works service area, Cadmus obtained County-produced maps of streams and watersheds. Twenty-eight streams within the Arlington County service area were identified. All of these streams are tributaries of the Potomac River (see Table 3).

Cadmus researched the WQS in the Virginia Administrative Code to identify designated uses and whether any water quality criteria for zinc or phosphorus are applicable to the identified waters within the Arlington County service area.

All waters in the State, including wetlands, are designated for the propagation and growth of a balanced, indigenous population of aquatic life, including game fish, which might reasonably be expected to inhabit them; wildlife; and the production of edible and marketable natural resources, e.g., fish and shellfish (as well as other uses, such as recreation). Abel Lake Reservoir (Long Branch) and the Potomac River /Four Mile Run/Pimmit Run are also designated as public water supplies (PWS).

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[5] Average hardness values for the Anacostia River and Rock Creek are provided in the TMDLs (see section 3.3.2) (89.4 and 110 mg/L $CaCO_3$, respectively). 100 mg/L was used as a typical value.

[6] The Criteria Continuous Concentration (CCC) is the highest concentration of a pollutant to which aquatic life can be exposed for an extended period of time (a 4-day average) without deleterious effects.

Table 3. Designated Uses and Water Quality Criteria for Streams in the Arlington County Service Area

Streams	Designated Uses	Dissolved Zinc @ Hardness of 70 mg/L $CaCO_3$ (see Box 2)	Phosphorus	Notes
Abel Lake Reservoir (Long Branch)	PWS, Note 1	9.100 mg/L 0.0785 mg/L (more stringent applies)	Total P: 0.18 mg/L (Note 2)	Nutrient Enriched Waters
Arlington Branch	Note 1	0.0785 mg/L	Total P: 0.18 mg/L (Note 2)	
Arlington Forest Branch	Note 1	0.0785 mg/L	Total P: 0.18 mg/L (Note 2)	
Bailey's Branch	Note 1	0.0785 mg/L	Total P: 0.18 mg/L (Note 2)	
Colonial Village/Rocky Run	Note 1	0.0785 mg/L	Total P: 0.18 mg/L (Note 2)	
Crossman Run	Note 1	0.0785 mg/L	Total P: 0.18 mg/L (Note 2)	
Doctor's Branch	Note 1	0.0785 mg/L	Total P: 0.18 mg/L (Note 2)	
Donaldson Run	Note 1	0.0785 mg/L	Total P: 0.18 mg/L (Note 2)	
Four Mile Run	Note 1	0.0785 mg/L	Total P: 0.18 mg/L (Note 2)	Nutrient Enriched Waters
Gulf Branch	Note 1	0.0785 mg/L	Total P: 0.18 mg/L (Note 2)	
Little Pimmit Run	Note 1	0.0785 mg/L	Total P: 0.18 mg/L (Note 2)	
Long Branch	Note 1	0.0785 mg/L	Total P: 0.18 mg/L (Note 2)	
Lower Long Branch	Note 1	0.0785 mg/L	Total P: 0.18 mg/L (Note 2)	
Lubber Run	Note 1	0.0785 mg/L	Total P: 0.18 mg/L (Note 2)	

Table 3. Designated Uses and Water Quality Criteria for Streams in the Arlington County Service Area

Streams	Designated Uses	Dissolved Zinc @ Hardness of 70 mg/L $CaCO_3$ (see Box 2)	Phosphorus	Notes
Nauck Branch	Note 1	0.0785 mg/L	Total P: 0.18 mg/L (Note 2)	
Pimmit Run	Note 1	0.0785 mg/L	Total P: 0.18 mg/L (Note 2)	
Potomac River/Four Mile Run/Pimmit Run	PWS, Note 1	9.100 mg/L 0.0785 mg/L (more stringent applies)	Total P: 0.18 mg/L (Note 2)	Nutrient Enriched Waters
- East Branch	PWS, Note 1	9.100 mg/L; 0.0785 mg/L (more stringent applies)	Total P: 0.18 mg/L (Note 2)	Nutrient Enriched Waters
- West Branch	PWS, Note 1	9.100 mg/L; 0.0785 mg/L (more stringent applies)	Total P: 0.18 mg/L (Note 2)	Nutrient Enriched Waters
Rixey Branch	Note 1	0.0785 mg/L	Total P: 0.18 mg/L (Note 2)	
Roaches Run	Note 1	0.0785 mg/L	Total P: 0.18 mg/L (Note 2)	
Rocky Run	Note 1	0.0785 mg/L	Total P: 0.18 mg/L (Note 2)	
Spout Run	Note 1	0.0785 mg/L	Total P: 0.18 mg/L (Note 2)	
Stohman's Run	Note 1	0.0785 mg/L	Total P: 0.18 mg/L (Note 2)	
Torreyson Run	Note 1	0.0785 mg/L	Total P: 0.18 mg/L (Note 2)	
Upper Long Branch	Note 1	0.0785 mg/L	Total P: 0.18 mg/L (Note 2)	
Westover Branch	Note 1	0.0785 mg/L	Total P: 0.18 mg/L (Note 2)	

Table 3. Designated Uses and Water Quality Criteria for Streams in the Arlington County Service Area

Streams	Designated Uses	Dissolved Zinc @ Hardness of 70 mg/L $CaCO_3$ (see Box 2)	Phosphorus	Notes
Windy Run	Note 1	0.0785 mg/L	Total P: 0.18 mg/L (Note 2)	

Source: 9 VAC 25-260 - Virginia Water Quality Standards. Dissolved zinc criteria as calculated by Arlington County Watershed Management Plan.
PWS = public water system
Note 1: All State waters, including wetlands, are designated for the following uses: recreational uses, e.g., swimming and boating; the propagation and growth of a balanced, indigenous population of aquatic life, including game fish, which might reasonably be expected to inhabit them; wildlife; and the production of edible and marketable natural resources, e.g., fish and shellfish. **For those waters with multiple designated uses, the most stringent criteria apply.**
Note 2: Policy for the Potomac River Embayments (9 VAC 25-415-40).

The Virginia State Water Control Board establishes WQS at 9 VAC 25-260, Virginia Water Quality Standards. Further, 9 VAC 25-260 references Section 40 of Chapter 415, Policy for the Potomac River Embayments, which contains effluent guidelines for Nutrient Enriched Waters (NEW) of the state.

Cadmus reviewed the 2002 Virginia Water Quality Assessment (i.e., 305(b)) Report for the Potomac-Shenandoah River Basin (VA DEQ, 2003), which summarizes water quality conditions from 1996 through 2000, by water body segment. A review of data on streams within Arlington County revealed exceedances of phosphorus limits at water quality sampling stations in Four Mile Run, Pimmit Run, and Long Branch. Specifically, four violations were recorded in two monitoring stations on Pimmit Run; four in Four Mile Run (at two stations); and one sample revealed an exceedance in Long Branch. No phosphorus violations were recorded in any other water quality monitoring stations in Arlington County. (The report provided no specific water quality values associated with the violations.)

The WQC for dissolved zinc is a function of total hardness, expressed as mg/L of $CaCO_3$ and the water effect ratio (WER). (See Box 2.) Arlington County's Watershed Management Plan calculates a chronic aquatic life criterion of 0.0785 mg/L and an acute criterion of 0.0867 mg/L, based on a hardness of 70 mg/L using the equations in Box 2. Additionally, Abel Lake Reservoir (Long Branch), and the East Branch and West Branch of the Potomac River/Four Mile Run/Pimmit Run, which are designated as public water supplies, have dissolved zinc limitations of 9.100 mg/L. However, because these water bodies are also designated for the propagation and growth of aquatic life, the more stringent limitation applies.

Box 2: Calculating the Virginia Dissolved Zinc Criterion

Freshwater values are a function of total hardness and the WER. The WQC is calculated in µg/L using the following equation:

$$WER[e\ \{^{0.8473[\ln(hardness)]+0.884\}}]\ (CFc)$$

Where,
WER = 1 (unless shown otherwise under 9 VAC 25-260-140.F and listed in 9 VAC 25-260-310).
e = base e exponential function.
ln = natural log function.
Hardness = mg/l $CaCO_3$ (between 25 and 400).
CFc (conversion factor) = 0.986.

Assuming a hardness of 70 mg/l $CaCO_3$, and WER of 1; the dissolved zinc WQC is calculated as 0.0785 mg/L.

Phosphorus effluent limits in Virginia apply under the Policy for the Potomac Embayments, which aims to control point source discharges of conventional pollutants into Virginia embayment waters of the Potomac River. These watershed segments are subject to effluent limitations for total phosphorus. Specifically, the monthly average effluent from all wastewater treatment plants located within those segments must remain at or below 0.18 mg/L (9 VAC 25-415-40). (The Policy sets effluent limits for BOD_5, total suspended solids, and ammonia as well.) The Policy is applicable to waters of the Potomac and its tributaries, from the fall line at Chain Bridge in Arlington County to the Route 301 bridge in King George County. This includes all of the streams within Arlington County.

3.1.3 City of Falls Church, Virginia

Based on a review of the City of Falls Church's web site, 17 streams were identified within the portion of the City of Falls Church. All of these streams are tributaries of the Potomac River. See Table 4.

Designated uses for the streams in the City of Falls Church, as with all waters in the State, include the propagation and growth of a balanced, indigenous population of aquatic life, including game fish, which might reasonably be expected to inhabit them; wildlife; and the production of edible and marketable natural resources, e.g., fish and shellfish (in addition to other uses, such as recreation).

Applicable zinc and phosphorus criteria for water bodies within the City of Falls Church are presented in Table 4. Virginia Water Quality Standards and the Policy for the Potomac River

Embayments, described in Section 3.1.2, apply to water segments within the City of Falls Church.

A review of the Virginia 305 (b) Report water quality inventory data revealed no phosphorus limit violations in any stream segments within the City of Falls Church. (VA DEQ, 2003)

Based on a hardness of 70 mg/l $CaCO_3$ the dissolved zinc criterion for all waters within the City of Falls Church is 0.0785 mg/L (see Box 2). Portions of Four Mile Run, a nutrient enriched water, are located within the City of Falls Church. The phosphorus monthly average limitation of 0.18 mg/L applies to this section of Four Mile Run.

Table 4. Designated Uses and Water Quality Criteria for Streams in the City of Falls Church Service Area

Streams	Designated Uses	Dissolved Zinc @ Hardness of 70 mg/L CaCO3 (see box 2)	Phosphorus	Notes
Bailey's Branch	Note 1	0.0785 mg/L	Total P: 0.18 mg/L (Note 2)	
Four Mile Run	Note 1	0.0785 mg/L	Total P: 0.18 mg/L (Note 2)	Nutrient Enriched Waters
Stohman's Run	Note 1	0.0785 mg/L	Total P: 0.18 mg/L (Note 2)	
- Brice Branch	Note 1	0.0785 mg/L	Total P: 0.18 mg/L (Note 2)	
- Church Branch	Note 1	0.0785 mg/L	Total P: 0.18 mg/L (Note 2)	
- Coe Branch	Note 1	0.0785 mg/L	Total P: 0.18 mg/L (Note 2)	
- Ellison Branch	Note 1	0.0785 mg/L	Total P: 0.18 mg/L (Note 2)	
- Grove Branch	Note 1	0.0785 mg/L	Total P: 0.18 mg/L (Note 2)	
- Gundry Branch	Note 1	0.0785 mg/L	Total P: 0.18 mg/L (Note 2)	
- Henderson Branch	Note 1	0.0785 mg/L	Total P: 0.18 mg/L (Note 2)	
- Parker Branch	Note 1	0.0785 mg/L	Total P: 0.18 mg/L (Note 2)	
- Reagan Branch	Note 1	0.0785 mg/L	Total P: 0.18 mg/L (Note 2)	
- Sewall Branch	Note 1	0.0785 mg/L	Total P: 0.18 mg/L (Note 2)	
Tripps Run	Note 1	0.0785 mg/L	Total P: 0.18 mg/L (Note 2)	
- Grossman Branch	Note 1	0.0785 mg/L	Total P: 0.18 mg/L (Note 2)	

Table 4. Designated Uses and Water Quality Criteria for Streams in the City of Falls Church Service Area

Streams	Designated Uses	Dissolved Zinc @ Hardness of 70 mg/L CaCO3 (see box 2)	Phosphorus	Notes
- Osborn Branch	Note 1	0.0785 mg/L	Total P: 0.18 mg/L (Note 2)	
- Trammell Branch	Note 1	0.0785 mg/L	Total P: 0.18 mg/L (Note 2)	

Source: 9 VAC 25-260 - Virginia Water Quality Standards.

Note 1: All State waters, including wetlands, are designated for the following uses: recreational uses, e.g., swimming and boating; the propagation and growth of a balanced, indigenous population of aquatic life, including game fish, which might reasonably be expected to inhabit them; wildlife; and the production of edible and marketable natural resources, e.g., fish and shellfish. **For those waters with multiple designated uses, the most stringent criteria apply.**

Note 2: Policy for the Potomac River Embayments (9 VAC 25-415-40).

3.1.4 The Chesapeake Bay

An estimated 18.8 million pounds of phosphorus currently enter the Chesapeake Bay each year (Chesapeake Bay Foundation, 2003). Nutrient pollution is a significant concern for the health of the Chesapeake Bay and the species that inhabit it. Algal blooms reduce the sunlight penetrating the water surface, which can kill submerged vegetation. Furthermore, depleted oxygen supplies are affecting many species in the bay, including fish and crab populations.

Cooperative efforts between the District of Columbia; the states of Maryland, Virginia, and Pennsylvania; and the Federal Government are aimed at reducing nutrient levels in the Chesapeake Bay. In 1983 and 1987, these parties signed agreements to reduce the amount of nitrogen and phosphorus entering the Bay by 40 percent by 2000. Among the pollution-reduction strategies put into place were state-wide bans on detergents with phosphorus; runoff controls; and wastewater treatment plant improvements. Water sampling data indicate a general decrease in phosphorus levels between 1985 to 1993 (Correll, no date). The Chesapeake Bay Program has raised concerns recently that phosphorus reductions in the Bay have not been as great as reported. It cites discrepancies between computer-modeled estimates of nutrient reduction and USGS water quality monitoring data. The USGS data indicate no reductions in observed concentrations of phosphorus in most of the major rivers draining to the Bay; data indicate no trends in loadings from the Potomac (Chesapeake Bay Program, 2004).

In June 2000, the Chesapeake Bay Program partners (the agencies listed in the previous paragraph) adopted the Chesapeake 2000 agreement. Among the actions in the Chesapeake 2000 strategic plan to improve water quality in the Bay and its rivers is to assign load reductions for nitrogen and phosphorus to each major tributary of the Bay. The Program's goal for 2010 is an average annual target loading of 12.8 million pounds of phosphorus from all sources.

3.2 Characteristics of Discharges

Cadmus has identified three main categories of discharges that could go directly to receiving waters without treatment:

- Potable water discharges, which include distribution system discharges (e.g., flushing) and user discharges (lawn watering, etc.) directly to receiving streams or through storm sewers directly to receiving streams.
- Combined sewer overflow events (The District only)
- Wastewater treatment plant bypasses (Arlington County only)

The mechanism by which they enter receiving waters is depicted in Figure 1. This section describes these discharges, discusses how they are regulated, and describes the fate and transport of the zinc and phosphorus as a result of these discharges.

3.2.1 Potable Water Discharges to Streams or Storm Sewers

Types of Discharges

Direct discharges of potable water from the distribution system can be the result of planned or unplanned water system events. Planned potable water discharge events are managed by the system and include drainage of storage facilities, flushing new or replacement pipes, flushing within problem areas, unidirectional flushing, or pipeline draining. Unplanned potable water discharges occur with little or no advance warning. They include tank overflows, blown fire hydrants, and damage to the distribution system, e.g., from construction or traffic accidents. Water main breaks and flushing (unidirectional, discolored water, etc.) are very common in most systems.

The duration of a discharge event and the volume of water released per event vary widely. To the best of our knowledge, DC WASA, Arlington County, and The City of Falls Church have not prepared an estimate of total volume lost through distribution system discharges per year.

In addition to distribution system discharges, discharges of potable water to streams or storm sewers can result from customer activities such as lawn watering, car washing, and pool draining. Most of these discharges would be relatively low volume and short duration and would infiltrate into the ground water.

Water systems can take steps to minimize potable water discharges in order to conserve water and control costs. Best management practices (BMPs) are employed to prevent potable water discharges, minimize the water loss during a discharge event, or treat the water as it is discharged to reduce the impact on stream water quality or aquatic species. Most of this treatment is designed to remove chlorine or control pH.[7]

Fate of Potable Water Discharges

Distribution system discharges and user discharges can either seep into the groundwater, flow directly to a receiving stream, or enter a municipal storm sewer system. The proportion that enters the storm sewer system is a factor of the amount of impervious cover in the service area. In urban areas, such as those served by DC WASA, Arlington County, and the City of Falls Church, the proportion of land with impervious cover can be quite high.

The configuration of storm sewer systems can either be “combined,” where the storm water flow mixes with domestic wastewater and generally ends up at the wastewater treatment plant (WWTP), or “separate,” where there are separate piping system for storm runoff and sanitary waste. In the case of a separate system, the flow goes directly to a receiving stream without treatment (some municipalities have or require minimal treatment, e.g., sand filters, for that discharge).

In The District, approximately one third of the storm sewers are combined, meaning that except under extreme peak flow conditions, all stormwater discharges go directly to the Blue Plains Wastewater Treatment Plant. The remaining two thirds of the collection system is classified as separate. All of Arlington County’s collection system is classified as separate. In Fairfax County (including the City of Falls Church), storm sewers are discharged to holding ponds, then discharged directly to receiving streams.

Regulations Governing Storm Water Discharges

The District, Arlington, and Fairfax County all have Municipal Separate Storm Sewer System (MS4) permits. These permits have specific requirements with regard to controlling discharges from industrial and construction sites, monitoring of these discharges, enforcement activities for violators, financial responsibilities, and annual reporting and implementation planning. As discussed in this section, potable water discharges are not specifically regulated in any of the affected jurisdictions.

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[7] An upcoming AWWARF project, *Environmental Impacts of Non-Treatment Discharges From Drinking Water Utilities* (Project 2937), will document the types, quantity, and environmental impacts of potable water discharges from utility operations. The project is scheduled to be complete in 2006.

The DC Permit (No. DC0000221, April 19, 2000) includes a storm water pollution prevention program and storm water monitoring requirements. The April 2000 permit addresses potable water discharges in Part 1 where it defines authorized discharges:

> *Nothing in this permit prohibits the following sources when properly managed so that water quality is not impaired and the requirements of the Clean Water Act are: clear water flows...water line flushing, ...**discharges from potable water sources**."*

The permit also allows many customer use discharges, such as landscape irrigation, lawn watering, and resident car washing. The permit is currently being revised; however, EPA Region III staff noted that they do not expect the language on authorized discharges to change.

Arlington County's MS4 permit (VA0088579) requires the County to monitor storm water runoff at representative outfalls and to demonstrate that it has effective management practices in place to control urban storm water to the "maximum extent practicable." While the permit sets goals related to phosphorus reductions (see below on the Chesapeake Bay Preservation Ordinance Task Force), it relies on implementation of BMPs to reduce storm water pollutants. The MS4 permit does not specifically address potable water discharges. Four outfalls are covered by the County's MS4 permit (located at Little Pimmit Run, Colonial Village, Rocky Run, and Middle Four Mile Run). The County is also required to prepare a Watershed Management Plan (WMP) that characterizes the conditions of waterways and provides recommendations to control pollutants (Arlington County Department of Environmental Services, 2001).

Arlington County's WMP was developed at the same time the County Board created the Arlington County Chesapeake Bay Preservation Ordinance Task Force, whose role is to review the County's current ordinance and program and to recommend measures, including nutrient controls, by which the County could further prevent harm to the Bay. Between 1985 and 1998, the County reduced its contribution of phosphorus to the Potomac River Basin from 6.9 percent of the basin-wide total in 1985, to approximately 1.2 percent of the total in 1998. This is primarily due to improved wastewater treatment technology and more stringent phosphorus discharge limits.

Arlington's WMP reports zinc levels ranging from 0.0229 mg/l (at a low density residential site) to 0.117 mg/l (medium density residential) at the four Arlington MS4 outfall monitoring points. The plan associated the zinc levels to automobile sources. No specific recommendations for controlling heavy metals are presented in the WMP, however.

The City of Falls Church is covered under Virginia's General Permit for discharges of storm water from small municipal separate storm sewer systems (VAR040). The draft General Permit requires systems to develop, implement and enforce a storm water management program to reduce the discharge of pollutants from the MS4 to the maximum extent practicable to protect water quality. Potable water discharges are not addressed in the general permit.

3.2.2 Combined Sewer Overflows (The District Only)

Approximately one third of The District (12,478 acres) is served by a combined sewer system (CSS), which was primarily constructed prior to 1900. This system is designed to convey wastewater to the treatment plant and to prevent wet weather flow from exceeding the hydraulic capacity of the sewers and/or the treatment plant. There are a total of 60 combined sewer overflow (CSO) outfalls listed in DC WASA's National Pollutant Discharge Elimination System (NPDES) permit that discharge to the Anacostia, Rock Creek, and the Potomac River. A map of the CSO outfalls and CSS drainage areas can be found on DC WASA's web site.[8]

DC WASA prepared a CSS Long Term Control Plan (LTCP) as required by their NPDES permit. The LTCP describes the development and selection of a plan to control CSO discharges. The LTCP planning effort began in 1998 and a draft of the LTCP was made available to the public and submitted to EPA and the District Department of Health (DOH) in June 2001. In August 2002, DC WASA submitted a Final LTCP to EPA and DOH for approval. A copy of the plan is available on DC WASA's web site.[9]

The LTCP projects that over $1 billion will be needed to substantially reduce CSO discharges from approximately 2.5 billion gallons per year to under 200 million gallons per year. DC WASA estimates that it will take up to 40 years to implement the entire plan if they do not receive outside financial assistance. If significant outside financial assistance is obtained, the LTCP reports that it is feasible to accelerate the schedule to a 15-year implementation time frame. Negotiations between EPA and DC WASA regarding LTCP implementation are ongoing.

EPA Region III, DC WASA, and Arlington County officials estimated that between 25 and 33 percent of the CSO discharge volume is domestic wastewater. Addition of zinc orthophosphate to the drinking water distribution system would generally be reflected by proportional increases in wastewater zinc and orthophosphate concentrations. There may be some loss if phosphates bind to metals, but as a conservative estimate, it is assumed that the target zinc and phosphate residual concentrations at the tap make their way into the wastewater stream.

Appendix A presents detailed calculations that attempt to quantify the increased zinc and phosphorus loads to the Anacostia and Potomac Rivers and Rock Creek through CSO discharges. Estimates are based on number of overflow events and average volume as modeled by DC

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[8] Available at http://www.dcwasa.com/education/css/combined_sewer.cfm.

[9] Available at http://www.dcwasa.com/education/css/Complete%20LTCP%20For%20CD.pdf

WASA for an average rainfall year (DC WASA, 2002).[10] Note that only those CSOs that are predicted to overflow in an average rainfall year are shown in the tables.

Tables A.1, A.2, and A.3 in Appendix A represent a range of possible increased loadings based on different length of the passivation dose (see Section 1.3 for details on the corrosion control strategy). Table A.1 can be viewed as a worst case, with a high zinc orthophosphate passivation target of 3 mg/L as PO_4 for 6 months, and a maintenance dose of 1 mg/L as PO_4 for 6 months in the first year. Table A.2 shows the increased loading with a passivation dose for one month and a maintenance dose for the remainder of the year. Table A.3 shows impacts for a maintenance dose only (after year 1 of zinc orthophosphate application). Table 5 below summarizes the results.

The potential impacts of these increases in zinc and phosphorous loadings depend on the existing loads to these waters. We were not able to identify any publically available phosphorous loading data; however, existing zinc loads through CSO discharges are documented in TMDLs for Rock Creek and the Anacostia River. Section 3.2.3 provides a comparison of the estimated TMDL zinc loadings to the estimated increase in zinc loadings resulting from zinc orthophosphate treatment.

Table 5. Summary of Predicted Increase in Zinc and Phosphorus Loads in Combined Sewer Overflow Discharges

Water	Predicted Increased Zinc Loading (lbs/year)	Predicted Increased P Loading (lbs/year)
Anacostia River	351 to 706	1,163 to 2,348
Potomac River	175 to 352	580 to 1,170
Rock Creek	13 to 27	45 to 90
TOTAL	539 to 1,085	1,788 to 3,608

Source: Appendix A. Ranges reflect different durations of the passivation dose (0 to 6 months)

3.2.3 Wastewater Plant Bypasses (Arlington County Only)

The Arlington County Water Pollution Control Plant (WPCP) treats nearly all of the wastewater from Arlington County as well as wastewater from portions of Fairfax County, Alexandria City, and Falls Church City. The current plant rated capacity is 30 million gallons per day (MGD).

[10] Only average year data were publically available for use in the screening analysis. Cadmus recommends working with DC WASA to obtain peak year flows and more precise estimates of the percentage of domestic wastewater (in both average and peak storm events) to do follow-up evaluations.

The total average flow to the plant was nearly 30 MGD in FY2002 (Arlington County 2001 Master Plan update). Peak storm water flow, however, has been as high as approximately 130 MGD. The primary reason for the high stormwater flow is the pre-1968 plumbing code, which allowed foundation drains to be directly connected to the sanitary sewer system (Arlington County 2001 Master Plan Update). This code was changed in 1968 and precludes foundation drains from being connected to the sanitary system.

When the influent flow exceeds the plant's hydraulic capability based on secondary clarification, partially treated wastewater is discharged directly to Four Mile Run. Wastewater engineers estimate that approximately 33 percent of this flow is domestic sewage. In the past, these bypasses occur at a rate of 8 per year with an average discharge volume of 10.6 million gallons per event. The facility installed a 4.9 MG equalization tank in October 2000 which, based on prior studies and in addition to other improvements, is believed to be able to reduce the frequency and volume of bypasses by 50 percent over a five year time period.

Arlington County has a plan in place to reduce nearly all bypasses by 2012. The County is beginning construction of additional equalization tanks that will reduce bypasses based on an updated study by approximately 50 percent in 2007. Additional facilities that will eliminate nearly all bypass discharges are scheduled for construction by 2012.

Since bypass water is mostly untreated, it is likely that increased zinc and phosphorus loads in Arlington County and City of Falls Church drinking water would be discharged directly to Four Mile Run. Some of the flow to the Arlington WPCP does not have the additional zinc and orthophosphate concentrations (e.g., Alexandria City), but officials estimate the majority of the plant inflow is from Arlington County and City of Falls Church. Thus, for the purposes of this assessment, it is assumed that all of the domestic wastewater bypass flow has additional zinc and phosphate concentrations.

To estimate the potential increase in zinc and phosphorus loadings to Four Mile Run as a result of Arlington WPCP bypass flow, we used the following assumptions:

- A total of 84.8 million gallons (MG) is bypassed per year (8 events / year * 10.6 MG / event).

- 33 percent of the bypass flow (28.0 million gallons) is domestic sewage. All domestic sewage has increased zinc and phosphorus concentrations (3 mg/L PO_4, 0.3 mg/L zinc) during passivation dose; average of 1 mg/L PO_4 and 0.1 mg/L zinc during maintenance dose.

- A range for the duration of the passivation dose is 0 to 6 months (In the first year, the passivation dose may be applied for up to 6 months. The maintenance dose would be applied in subsequent years.)

Based on these assumptions and the corrosion inhibitor dosing strategy described in Section 1.3, the estimated additional zinc loading is approximately 25 to 48 lbs per year, and the estimated additional phosphorus (total P) loading is approximately 77 to 155 lbs per year. These loadings will decrease by up to 50 percent by 2007 and should be minimal by 2012.

The potential impacts of these projected increases in zinc and phosphorous loadings depend on the existing zinc and phosphorous loads to Four Mile Run. Existing phosphorous and zinc loading data for Four Mile Run were not found in the literature; therefore there is no basis for comparison. The estimated yearly increase in loads appears small, however, when compared to the projected increased zinc and phosphorous loads to Rock Creek and the Anacostia River through CSO discharges (as reported in Section 3.2.2). Impacts to Four Mile Run will be reduced in the future as Arlington County increases wastewater plant capacity and minimizes the occurrence of plant bypasses.

3.3 Potential Impacts of Increased Zinc and Phosphorus in Potable Water Discharges

Based on the information in the previous sections and additional research, we have identified three potential negative environmental impacts associated with adding zinc orthophosphate to the D.C. system. These findings represent results of screening analyses and need further study before they are determined to be real problems.

Impacts of increased zinc and phosphorus loads (in Sections 3.3.2 and 3.3.3) are based solely on additional zinc and phosphorus concentrations in CSO discharges in DC and wastewater treatment plant bypasses in Arlington. Data were not available to estimate the increased loads as a result of potable water discharges directly to receiving streams or to separate storm water systems to receiving streams.

3.3.1 Toxicity of Zinc to Aquatic Species

Zinc Toxicity Reported in the Literature

Although zinc is an essential element for both humans and fish, low concentrations of dissolved zinc in natural waters have been shown to be harmful to many aquatic species. Elevated zinc concentrations can be particularly toxic to certain species of algae, crustaceans, and salmonids. Zinc has an especially strong impact on macro-invertebrates such as molluscs and crustaceans (Irwin et. al., 1997). The Environmental Contaminants Encyclopedia reports that “in the aquatic environment, zinc toxicity is more often associated with direct toxicity of elevated concentrations of zinc in the water (through disruption of internal ion balance) rather than dietary or food chain toxicity” (Irwin et. al., 1997).

EPA’s Quality Criteria for Water (USEPA, 1986a) reports that based on acute toxicity data for 43 species of freshwater animals, sensitivity to zinc ranges from approximately 0.051

mg/L for the *Ceriodaphnia reticulata* to 89 mg/L for a damselfly at a hardness of 50 ug/L. Chronic toxicity data was provided for only two freshwater invertebrates: the *Daphnia magna* with a chronic zinc toxicity value of approximately 0.047 mg/L and the caddisfly, with a chronic sensitivity greater than 5 mg/L. Chronic zinc toxicity values for seven freshwater fish species ranged from approximately 0.037 mg/L for the flagfish to 0.85 mg/L for the brook trout.

The range of zinc inhibitory levels for freshwater plants is greater than for animals. Growth of one algae species, *Selenastrum capriocornutum*, was inhibited by a zinc concentration of 0.03 mg/L. Inhibitory levels of several green algae species, however, exceeded 200 mg/L.

Of special concern to potential discharges of zinc into receiving waters are endangered or threatened species that inhabit streams in the District or northern Virginia. Cadmus researched the U.S. Fish and Wildlife Service's (USFWS) Threatened and Endangered Species System (TESS) searchable data base for information on aquatic endangered species that may inhabit streams within the service area. To identify the specific distribution of any identified endangered or threatened species, the TESS data base findings were cross-referenced against species distribution maps in the NatureServe *Explorer* database.

Two endangered species were identified within the District of Columbia—the Hay's Spring amphipod (*Stygobromus hayi*) and the shortnose sturgeon (*Acipenser brevirostrum*). The Hay's Spring amphipod is unique to Rock Creek, and is found in two locations–south of Military Road between Nicholson and Emerson Streets, NW and approximately between the National Zoo and the Connecticut Avenue Bridge.[11] The shortnose sturgeon lives within the lower Potomac River. Both the shortnose sturgeon and the Hay's Spring amphipod are threatened primarily due to habitat loss and increased urbanization. (NatureServe *Explorer*) No aquatic endangered species were identified as living in the water bodies within the service area of Arlington County or the City of Falls Church. Table 6 provides information on the two aquatic species that are listed as endangered and under the protection of the Endangered Species Act.

Table 6. Endangered/Threatened Species in Streams in the DC WASA Service Area

Scientific Name	Common Name	Status	Habitat
Acipenser brevirostrum	Shortnose sturgeon	Endangered	Lower Potomac
Stygobromus hayi	Hay's Spring amphipod	Endangered	Rock Creek

Source: Threatened and Endangered Species System (TESS), USFWS

[11] The literature mentions the known locations for the Hay's Spring amphipod as numbering between two and five; all are within Rock Creek, and near the National Zoo.

Internet searches, including a review of the USFWS Web site, produced no information regarding the vulnerability of either of these species to zinc. However, the literature does address zinc toxicity of related species, including a variety of freshwater amphipod species and sturgeon.

- Studies of freshwater amphipods indicate a high sensitivity to zinc that is comparable to that of other sensitive invertebrate taxa. Studies seem to indicate that various amphipod species exhibit toxicity at differing zinc concentrations. The fresh water amphipod, *Gammarus sp.* exhibited an acute toxicity value of 0.315 mg/L (the calculated acute criterion is 0.117 mg/L based on a hardness value of 100 mg/L $CaCO_3$). Median lethal concentrations (based on 7-day exposure) for amphipods of 0.159 mg/L were reported. *Hyalella azteca* were shown to be significantly more sensitive to lower zinc concentrations in chronic tests than observed in acute exposures. (Besser and Leib, retrieved 2004).

- No studies showing acute zinc toxicity levels specific to any sturgeon species were identified. However, studies from British Columbia and the Caspian Sea link metals contamination to dysfunction in sturgeon (Cannings and Ptolemy, 1998; Caspian Environment, 2004). Sturgeon can concentrate chemical contaminants, including metals such as zinc.

Background Levels of Zinc in Area Receiving Streams

A search of publically available literature revealed a limited amount of data on zinc concentrations in natural waters in DC and Virginia. The Rock Creek Final TMDL Report (DC DOH, 2004) provides zinc monitoring results for different stretches of Rock Creek in the District. Results for the water column were variable, with approximately 32 percent of samples below the detection limit. Many of the data were below 0.020 mg/L, but some were as high as 0.135 mg/L (based on 47 data points). Storm water flows had much higher total zinc concentrations, ranging from 0.1 to approximately 0.4 mg/L. The sediment concentration ranged from 63 micrograms per gram (µg/g) to 73µg/g. The report identified potential sources of zinc including hospitals, colleges, universities, automobile tires and engine oil, and carwashes.

The Washington D.C. Department of Health measured background concentrations of zinc in Rock Creek at Connecticut Avenue. The range found was from less than 0.02 mg/L to 0.08 mg/L with an average of about 0.03 mg/L.

The TAM/WASP Toxics Screening Level Model for the Tidal Portion of the Anacostia (ICPRB, April 2003) reported an average zinc concentration of 0.004 mg/L in the water column at the Potomac confluence of the Anacostia river. This is based on non-storm samples.

The concentration of zinc in CSO discharges to the Anacostia, Rock Creek, and the Potomac River were evaluated in the DCWASA's Long Term Control Plan (DC WASA 2002).

The report presented 97th percentile daily values calculated using the statistics model developed by the Virginia Department of Environmental Quality. Results for zinc, shown in Table 4-7 of the LTCP report, range from approximately 0.08 to 0.15 mg/L for CSO discharges and 0.12 to 0.19 mg/L for separate storm water discharges. All 97th percentile values were greater than the Acute Water Quality Standard of 0.0679 mg/L at a system-wide average CSO hardness of 54 mg/L.

Fate and Transport of Zinc used for Corrosion Control

The zinc orthophosphate used for corrosion control is usually manufactured by combining either zinc chloride or zinc sulfate with phosphoric acid (AWWARF, 1996). The zinc is extremely soluble at low pH and its solubility decreases with increasing pH. The literature does not provide information on how much zinc precipitates out onto the walls of the distribution system to help form the protective coating versus how much remains in solution and passes into the waste stream.

Changes in pH in the waste stream may cause the zinc to change form. A rise in pH could precipitate out zinc while lower pH could cause zinc to dissolve. Organics in the sewage can also complex zinc. Sedlak et al. found that metals in sewage often complex with ethylenediamminetetraacetic acid (EDTA), a common organic in wastewater, to form soluble EDTA complexes.

Dilution of the waste stream in a water body can cause other transformations of zinc to occur. pH changes again will be significant. Organic complexes may also dissociate in the water bodies, either due to biological degradation of the organic compounds or if the zinc is displaced by stronger complexing metals. For example, Sedlak et al. found that high concentrations of iron could displace up to 30 percent of zinc bound in EDTA complexes. Overall it seems likely that a significant portion of the zinc released to water bodies will be in the dissolved form. The exact speciation of the zinc will depend on the water quality parameters of the end mixture of water, especially pH, organic content, and concentrations of other metals.

The literature reports that most common fate of zinc in natural water is incorporation into sediments (Irwin et. al., 1996). However, a small amount may remain either dissolved in water or as fine suspended particles. The level of dissolved zinc in water may increase as the pH decreases. Most of the zinc in soil is bound to the soil and does not dissolve in water.

Discharge Scenarios and Impacts on Receiving Streams

As stated in Section 3, Cadmus has identified three types of discharges that can go directly to receiving streams without treatment:

- Potable water discharges, which include distribution system discharges (e.g., flushing) and user discharges (lawn watering, etc.) directly to receiving streams or through storm sewers directly to receiving streams.
- Combined sewer overflow events (The District only)
- Wastewater treatment plant bypasses (Arlington County only)

Discharge from the distribution system to a receiving stream with no dilution can have up to 0.5 mg/L of dissolved zinc, which is much greater than the acute criterion. CSO discharges are estimated to be 33 percent domestic wastewater, which would reduce the overall zinc concentration in the waste stream to an average of 0.1 mg/L.

The zinc concentration from any type of discharge would be diluted by the water in the stream. Although mixing zones are not allowed in streams or areas where endangered species are present, examining the likely dilution will aid in determining the extent of possible damage from any potable water discharge. USGS data show that average annual Rock Creek flows just below West Beach Drive vary between 45 and 116 ft^3/sec. During summer months the flow can be as low as 18 ft^3/sec. This means the flow of the creek can vary anywhere between about 8,000 gpm during low flow periods to upwards of 50,000 gpm during storm events. The Anacostia River can vary between 1,800 and 387,000 gpm, with an average of 33,000 gpm.

Based on discussions with utility personnel, we assumed that typical flow rates of water main breaks ranged from 30 to 200 gpm (this range is not absolute, flows may be higher or lower). To determine the range of possible dilutions provided by the natural water, two worst case scenarios have been evaluated: 1) a large main break during low flow months, and 2) a large volume CSO discharge during a storm. Flows for Rock Creek are used because it has the smallest flow, and therefore the lowest dilution factor. It is also the location of the endangered species. Table 7 provides assumptions and final dilution concentration for these two worst case scenarios

Table 7. Estimated Dilution of Discharges of Zinc into Rock Creek

Scenario	Assumptions				Final Diluted Zinc Concentration (mg/L)
	Stream Flow (gpm)	Discharge Flow (gpm)	In-Stream Zinc Concentration (mg/L) [1]	Discharge Concentration (mg/L)	
Main Break	Low flow, 8,000	200	0.08	0.5	0.090
CSO	Storm flow, 20,000	2,000	0.08	0.1	0.082

1. High end of range of DC Department of Health monitoring data

Even though the flow can be very high, the concentration of zinc in the CSO discharge is close to the in-stream concentration and will not likely have a negative impact. For main breaks, the stream provides enough flow to dilute the concentration to near background levels. The immediate concentrations at the point of entry, however would be close to the discharge concentration of 0.5 mg/L, and would gradually dissipate until the background concentration was reached. The time and distance over which it would take to reach the eventual dilution level would depend on the stream depth, flow, and geometry at the point of the break.

As a rough order of magnitude estimate the time of mixing is equal to:

$$T = \alpha(8/f)^{1/2}/0.07vd.$$

where α is the dispersion coefficient and typically varies between 0.4 and 0.8 for natural streams, f is the coefficient of friction, v is the velocity and d is the stream depth. For a = 0.6, f = 0.035, a stream depth of 1 foot and a flow rate of 8,000 gpm, the time of mixing is approximately 70 seconds. The distance over which the mixing would occur would be approximately 125 feet.

The biggest threat related to zinc toxicity appears to be a high flow-rate discharge from the distribution system (e.g., a large water main break) that flows directly into Rock Creek during a dry period. The endangered Hay's Spring amphipod lives within two springs in Rock Creek, clustered around the National Zoo. A potable water discharge into Rock Creek that has up to 0.5 mg/L of zinc could temporarily exceed the WQC of 0.106, and could approach concentrations shown to be toxic to *Gammarus sp.* The extent of the toxic concentration is likely to be small, however, covering no more than 125 feet from the point of entry.

3.3.2 Increased Zinc Loading to Impaired Waters

A Total Maximum Daily Load (TMDL) is the amount of pollutant that a waterbody can assimilate without exceeding the established water quality standard for that pollutant. Through a TMDL, pollutant loads can be distributed or allocated to point sources and nonpoint point source (NPS) discharging to the waterbody. The calculation must include a margin of safety to ensure that the waterbody can be used for the purposes the State has designated and account for seasonal variation in water quality.

On the EPA Region III Website, there are approved TMDLs for metals for Rock Creek (February 2004) and the Anacostia River (August 2003).[12] The TMDLs present results of a source assessment for zinc and monitoring results to characterize existing concentrations.

For Rock Creek, the Chronic Continuous Criteria (CCC) for dissolved zinc is approximately 0.113 mg/L, and the Criteria Maximum Concentration (CMC) is approximately 0.124 mg/L at a hardness of 110 mg/L CaCO3. The final TMDL report for Rock Creek states that under existing conditions, zinc concentrations do not exceed the CCC or the CMC at any time during a three-year modeling period. Thus, the TMDL for Rock Creek is based on existing conditions. Table 7 summarizes both existing conditions and the TMDL for two discharges of interest– CSOs and storm water runoff– for upper and lower Rock Creek. Note that the TMDL is in the form of total zinc (not dissolved).

According to the Anacostia River Final TMDL report for metals (DC DOH, 2003), the CCC for dissolved zinc is approximately 0.094 mg/L and the CMC is 0.104 at a hardness of 89.4 mg/L. Section 5.4.2 of the report, however, states that based on predictive models, the concentration of the zinc in the water column does not exceed WQS. Thus, the TMDL for the Anacostia River is based on existing conditions. Existing average total zinc loads to the Anacostia River are presented in Table 8 (DC DOH, 2003). These loads meet water quality standards for zinc with a margin of safety. Thus, the total allowable load reflects a 1 percent reduction for the TMDL. Note that the TMDL is in the form of total zinc (not dissolved).

[12] See http://www.epa.gov/reg3wapd/tmdl/dc_tmdl/index.htm

Table 8. Total Maximum Daily Loads for Zinc in Affected Areas

Water Body	Source of Zinc	Existing Average Annual Total Zinc Loads (lb / year)	TMDL for Total Zinc (lbs / Year)
Final Rock Creek TMDL for Zinc			
Upper Rock Creek	CSO	0	0
	Storm Water Runoff	365.04	346.79
Lower Rock Creek	CSO	11.15	10.59
	Storm Water Runoff	351.14	333.58
Total	CSO	11.15	10.59
	Storm Water Runoff	716.18	680.37
Final Anacostia River TMDL for Zinc			
Anacostia River and Tributaries (District of Columbia Load)	CSO	2,332	2,309
	Sub watersheds (84.1 percent of area in DC)	3,828	Storm water runoff (allowable): 4,306
	Watts Branch (47 percent of area in DC)	522	
	Total	6,682	6,615

Source: Rock Creek and Anacostia approved TMDLs (DC DOH, 2003)

From Table 5, the predicted increased zinc loading to Rock Creek resulting from corrosion control treatment ranges from 13 to 27 lbs per year from CSOs alone. This does not take into account potable water discharges from user activities or distribution system activities such as hydrant flushing or water main breaks, which could have even higher concentrations of zinc. At the high end of the range, the addition of the zinc orthophosphate would almost triple zinc loadings to Rock Creek through CSO discharges. The projected increase through CSO discharges, however, is still very small (less than 5 percent) compared to the zinc loading to Rock Creek through storm water discharges.

Increased zinc loads to the Anacostia River appear to be even more of a concern than for Rock Creek. From Table 5, the increased zinc loading through CSO discharges to the Anacostia River is 351 to 706 lbs per year. This does not take into account potable water discharges from user activities or distribution system activities such as hydrant flushing or water main breaks, which could have even higher concentrations of zinc. At the high end of the range, the addition of zinc orthophosphate to drinking water could increase the total loading through CSO discharges by approximately 30 percent (from 2332 to 3038 lbs / year), and increase the total zinc loading from all sources by approximately 10 percent (from 6,682 to 7,388 lbs / year).

3.3.3 Increased Phosphorus Loading to the Potomac and Chesapeake Bay

This section attempts to estimate the amount of phosphorus attributable to CSOs and bypasses due to the addition of zinc orthophosphate[13]. Note that the estimates of additional phosphorus loading do not include potable water discharges resulting from user activities or distribution system activities such as flushing and water main breaks.

Table 9 summarizes estimated phosphorus loading via CSOs and bypasses, assuming 3 mg/L PO_4 passivation dose from 0 to 6 months. (In the first year, the passivation dose may be applied for up to 6 months. The maintenance dose would be applied in subsequent years.)

Table 9. Estimated Phosphorus Loadings due to Combined Sewer Overflows and Bypasses

Discharge	Total Estimated Annual Volume (MG / year)	Estimated Additional P Loading (pounds / year)
CSO	1,970	1,788 to 3,608
Bypasses	85	77 to 155
Total	2,055	1,865 to 3,763

Sources: Table 5 and Section 3.2.3

[13] This evaluation is the same for a 3 mg/L straight orthophosphate dose (no zinc)

The addition of zinc orthophosphate to drinking water could result in an additional 1,865 to 3,763 lbs per year of total phosphorus to the Potomac River Basin and Chesapeake Bay. The current annual phosphorus load to the Chesapeake Bay is estimated at 18.8 million pounds. The additional loading via CSOs and bypasses due to zinc orthophosphate treatment represents a very small fraction (0.01 to 0.02 percent) of phosphorus loading to the Chesapeake Bay.[14] The Chesapeake Bay Program's goal for 2010 is an average annual target loading of 12.8 million pounds of phosphorus from all sources (current loadings are 18.8 million pounds).

The total 1998 phosphorus discharge to the Potomac River Basin is 539,111 pounds per year, of which northern Virginia point sources contributed approximately ten percent (Arlington WMP). The additional loadings would increase the Potomac River Basin by 0.3 to 0.7 percent.

Any increase in phosphate to the Chesapeake Bay is undesirable; however, the increase from zinc orthophosphate (or straight orthophosphate) addition appears minor compared to existing loads.

4.0 Potential Impacts to Wastewater Treatment Plants Operations

As stated in Section 1.3, the targeted residual phosphate concentration is 3 mg/L as phosphate (PO_4) (corresponding to approx. 1 mg/L as total phosphorus, or P) with a zinc concentration of 0.3 mg/L at the tap during passivation. After several months, the dose will be reduced to a maintenance concentration of approximately 1 mg/L PO_4 and 0.1 mg/L zinc at the tap. The exact duration of the passivation dose during the first year of application is unknown.

The addition of PO_4 and zinc to drinking water will be accompanied by changes in the wastewater flow. Generally, the concerns related to increased zinc and phosphate loadings are the ability of the wastewater plant to continue to operate without upset, interference, or pass-through of pollutants, and possible violation of the NPDES permit. The pH during the orthophosphate application will also be decreased, representing a change in another variable in the wastewater treatment process.

The purpose of this section is to summarize the expected impacts of increased phosphorus and zinc loading on wastewater treatment.

[14] As noted in Section 3.1.4, USGS data indicate no reductions in observed concentrations of phosphorus in most of the major rivers draining to the Bay, including the Potomac. The actual loading data are not available on the Web; however it is likely that, given the magnitudes involved, the relative fraction of the phosphorus loading to the Potomac River and Chesapeake Bay due to the addition of zinc orthophosphate would not change observed concentrations significantly.

As shown in Figure 1, we have identified two treatment plants that would receive water from the Washington Aqueduct (from either the Dalecarlia or McMillan Treatment Plants) with elevated zinc and phosphate concentrations:

- *Blue Plains Advanced Wastewater Treatment Plant (Blue Plains).* Except for CSO discharges, drinking water that is collected in the sanitary sewer system in DC ends up at Blue Plains.

- *Arlington County Water Pollution Control Plant (Arlington WPCP).* Except for bypasses, most of the drinking water distributed in Arlington County that is collected in the sanitary sewer system ends up at the Arlington WPCP. A very small portion is sent to Blue Plains. Drinking water distributed by the City of Falls Church is also sent to the Arlington WPCP (based on personal communications with City of Falls Church personnel).

The next two sections summarize existing treatment processes and evaluate the potential impacts of increased phosphate and zinc loading on plant operations and effluent water quality. Much of the information in these sections is based on an interview with Aklileye Tesfaye and Walt Bailey at the Blue Plains Operations Center on May 17, 2004, and an interview with Larry Slattery at the Arlington WPCP on May 20, 2004.

4.1 Existing Conditions

Blue Plains is the world's largest advanced wastewater treatment facility, rated at an average flow of 370 million gallons per day (MGD), with a peak wet weather capacity of over 1 billion gallons per day. Approximately 45 percent of the average flow comes from the District (approximately 140 MGD). Another 45 percent is from Prince Georges and Montgomery Counties in Maryland, and the remaining 10 percent comes from Fairfax and Arlington Counties in Virginia.

Liquids handling processes at Blue Plains include primary and secondary treatment, nitrification/denitrification, filtration, and disinfection. Solids handling processes include a degritting and grinding facility, gravity thickeners, dissolved air flotation thickeners, dewatering centrifuges, sludge loading and post liming. Treated effluent is discharged to the Potomac River, and the main disposal method for biosolids is land application.

Phosphorus is removed in the primary sedimentation tanks by adding ferric chloride at a rate of approximately 64,000 lbs per day. Blue Plains is not specifically designed to remove metals such as zinc, however, zinc is removed as part of the treatment of domestic wastewater.

The Arlington County WPCP is an advanced wastewater treatment plant that receives wastewater from nearly all parts of Arlington Country, and also from sections of Alexandria, Fairfax County, and Falls Church City. All areas of the plant have the capacity to treat 40 MGD of flow, except the biological nutrient process which has a 30 MGD capacity.

Liquids handling processes at the Arlington WPCP include preliminary, primary, secondary, and tertiary treatment consisting of gravity filtration, granular activated carbon adsorption, and disinfection/dechlorination. Solids handling processes include a gravity thickener, flotation thickener, sludge dewatering centrifuges, and lime stabilization. Treated effluent is discharged to Four Mile Run. Since 1998, biosolids have been land applied to permitted sites in rural Virginia and Maryland. However, the plant was restricted from land applying biosolids for most of 2001 due to odors, and therefore biosolids were landfilled during that time period.

Ferric chloride is added at two locations in the Arlington WPCP at an average rate of approximately 7,000 lbs per day to precipitate soluble phosphorus. The Arlington WPCP is not specifically designed to remove metals such as zinc, however, it is removed as part of the treatment of domestic wastewater.

Table 10 shows the NPDES effluent limits for total phosphorus and the average influent and effluent concentrations for both Blue Plains and the Arlington WPCP. Blue Plains and Arlington County achieve approximately 96 percent and 99 percent phosphorus removal, respectively.

Table 10. Influent, Effluent, and National Pollutant Discharge Elimination System (NPDES) Permit Limits for Total Phosphorus

Wastewater Treatment Plant	Influent Total P concentration (mg/L)	Effluent Total P concentration (mg/L)	NPDES Permit Limits for Total P (mg/L)
Blue Plains	3.5 - 4.0 (based on interviews with plant personnel)	0.12	0.18
Arlington WPCP	6.9 (2000 data)	0.07 (2001 data)	0.18

Note: Data is for most recent year unless otherwise noted.
Total P = total phosphorus

Table 11 shows the average influent and effluent zinc concentrations for both Blue Plains and the Arlington WPCP. Also shown is the allowable zinc concentration in land applied sludge and the measured concentrations. Note that for both plants, the measured level is significantly below the permitted level.

Table 11. Concentrations of Zinc in Plant Influent, Effluent, and Sludge

Wastewater Treatment Plant	Influent Zinc concentration (mg/L)	Effluent Zinc concentration (mg/L)	Permitted Allowable Zinc in Sludge (mg/kg)	Measured Zinc in Sludge (mg/kg)
Blue Plains	0.0616, 0.0843 (2003 avg, max)	0.0199, 0.0235 (2003 avg, max)	2,500	281 (avg), 362 (max)
Arlington WPCP	0.18 (current average)	0.01 (based on a few data points)	2,800	200 - 300

4.2 Projected Impacts on Wastewater Plant Operations

Impacts of Increased Phosphorus Load

The addition of phosphorus to drinking water will result in the following impacts at wastewater treatment plants:

- increases in the amount of ferric chloride needed to remove phosphorus
- increased solids production

DC WASA performed an assessment of these impacts and their costs for Blue Plains. Calculations provided by Aklile Tesfaye, DC WASA, were based on the passivation dose for an entire year. Larry Slattery, Division Chief of the Water Pollution Control Division for the Arlington County WPCP, worked with The Cadmus Group, Inc. to develop rough estimates of additional ferric chloride needed to precipitate the additional total phosphorus loading assuming a maintenance dose of one year. Cadmus modified results from both plants to represent a range of passivation and maintenance dose durations. Table 12 summarizes these results.

The total increased cost at Blue Plains to remove additional phosphorus using ferric chloride is potentially over $1 million per year during the passivation dose, but is expected to drop to less than $400,000 per year during the maintenance dose . This is a relatively small fraction of DC WASA's approved FY 2005 operating budget of approximately $275 million (DC WASA, 2004). The total increased cost for the Arlington WPCP to remove additional phosphorus using ferric chloride could be as high as $80,000 per year during the passivation dose. Chemical and sludge disposal costs during the maintenance period are expected to be much lower (less than $30,000 per year). Similar to increased costs for Blue Plains, increased costs for Arlington are a relatively small fraction of the proposed FY 2005 operating budget of $14 million per year for the Arlington County Water Pollution Control Division (Arlington, 2004).

Wastewater treatment managers for Blue Plains and the Arlington WPCP who were interviewed for this study indicated that the increase in ferric chloride needed to remove phosphorus and associated sludge production would not adversely impact plant operations.

Table 12. Additional Ferric Chloride Needed and Additional Sludge Produced due to Increased Total Phosphorus Loading at Blue Plains and Arlington WPCP

Duration of Passivation Dose	Blue Plains				Arlington WPCP (rough estimates)			
	Annual Additional Fe (lbs Fe/year)	Annual increase in $FeCl_3$ cost ($)	Annual Additional Sludge (tons/year)	Annual increase in sludge disposal cost ($)	Annual Additional $FeCl_3$ (lbs dry $FeCl_3$/year)	Annual increase in $FeCl_3$ cost ($)	Annual Additional Sludge (tons/year)	Annual increase in sludge disposal cost ($)
One year	1,104,490	$364,532	1,349	$809,310	626,454	$68,910	472	$17,000
6 months	736,327	$243,021	899	$539,540	417,636	$45,940	315	$11,333
1 month	429,524	$141,762	525	$314,732	243,621	$26,798	184	$6,611
0 months (maintenance dose)	368,163	$121,511	450	$269,770	208,818	$22,970	157	$5,667

Source:

1) Original calculations provided by Aklile Tesfaye of DC WASA and Walt Bailey and Larry Slattery of Arlington County.

2) Arlington WPCP values based on 40 MGD plant flow (worst case).

Impacts of Increased Zinc Loading

Zinc can be toxic to the biomass responsible for the biological treatment at a wastewater treatment plant. As the concentration of zinc increases, the performance of the wastewater treatment plant decreases. The biological process most sensitive to zinc inhibition is nitrification, the conversion of ammonia nitrogen to nitrate. The activated sludge treatment process, responsible for the bulk of BOD removal, can also be affected by the increase of zinc. The impact of concern is the accumulation of zinc in sludge and the effects it may have on the chosen sludge disposal option.

EPA's *Guidance Manual on the Development and Implementation of Local Discharge Limitations Under the Pretreatment Program* (1987) includes data on inhibitory limits for zinc, as shown in Table 13. EPA recommends that site-specific inhibition data be developed when inhibition is determined to be the limiting criteria in the development of a maximum allowable headworks load.

Table 13. Inhibitory limits for Zinc

	Inhibitory Limit (mg/L)	Reference
Activated Sludge	0.3 - 5	(Anthony, R.M. and L.H. Briemburst, 1981)
	5 - 10	(Jenkins, D.I. and Associates, 1984)
Nitrification	0.08 - 0.5	(Russell, L.L., et al., 1984) (Anthony, R.M. and L.H. Briemburst, 1981)

EPA's 1987 guidance manual is currently being revised, but indications are that these inhibitory limits are unlikely to change.

We have performed a literature review and found that other studies support EPA's published zinc inhibitory limits:

- As per a 2003 article by S.R. Juliastuti et al., zinc has an inhibitory effect on nitrification of 12 percent at 0.08 mg/L, and on activated sludge at zinc concentrations greater than 0.3 mg/L. At a zinc concentration of 1.2 mg/L, the inhibition of nitrification is complete.

- A 1994 WEF publication (Eysenbach, 1994) reports inhibitory levels of 0.08 - 0.5 mg/L on net maximum specific growth rate of the autotrophic biomass in nitrification.

However, other studies suggest that inhibitory limits may be much higher.

- Madoni et al. (1996) reported that 0.57 mg/L zinc affects only certain species, and that zinc concentrations greater than 10 mg/L are toxic to the "majority of organisms" involved in the activated sludge process.

- Cardinaletti et al. (1990) reported zinc concentrations between 0.6 – 1.2 mg/L as having no negative effects on the protozoan population of the activated sludge.

- Sharma et al. (2001) reported the results of a large pilot plant able to accept much higher loadings of zinc (30 mg/l total and 7.6 mg/l dissolved zinc).

Detailed data on the inhibitory effects of various metals are not available for the Arlington WPCP. Based on EPA guidance and other studies it is believed that the proposed zinc increase during the passivation dose (+ 0.3 mg/L) and possibly during the maintenance dose (+0.1 mg/L) could potentially inhibit nitrification and activated sludge processes at the Arlington County Plant. Pilot plant or bench scale inhibition studies are recommended to estimate the inhibition levels for zinc at each of these WWTPs.

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Appendix A: Predicted Increase in Zinc and Phosphorus Loads from CSO Discharges

Table A.1 Predicted Increase in Zinc and Phosphorus Loads from CSO Discharges
Scenario 1: Passivation Dose for 6 Months, Maintenance Dose for 6 Months (worst case)

					Increased zinc load			Increased P load		
CSO NPDES No.	Description	No. of CSO Over-flows	CSO Overflow Volume (MG/yr)	Percent of overflow that is domestic sewage	Increased zinc in domestic sewage (mg/L)	Increased zinc in domestic sewage (lbs/MG)	Estimated Increase zinc loading (lb / year)	Increased P in domestic sewage (mg/L)	Increased P in domestic sewage (lbs/MG)	Estimated Increase P loading (lb / year)
		A	B	C	D	E=D*8.35	F = B*C*E	G	H=G*8.35	I=B*C*H
	Anacostia River CSOs									
005	Fort Stanton	73	16.54	33%	0.20	1.67	9.12	0.67	5.55	30.29
006	Fort Stanton	5	0.11	33%	0.20	1.67	0.06	0.67	5.55	0.20
007	Fort Stanton	64	36.97	33%	0.20	1.67	20.37	0.67	5.55	67.71
009	B. St./New Jersey Ave	53	16.84	33%	0.20	1.67	9.28	0.67	5.55	30.84
010	B. St./New Jersey Ave	18	247.21	33%	0.20	1.67	136.24	0.67	5.55	452.77
012	Tiber Creek	6	21.74	33%	0.20	1.67	11.98	0.67	5.55	39.82
013	Canal Street Sewer	28	9.78	33%	0.20	1.67	5.39	0.67	5.55	17.91
014	Navy Yard	49	38.98	33%	0.20	1.67	21.48	0.67	5.55	71.39
015	Navy Yard	12	0.72	33%	0.20	1.67	0.40	0.67	5.55	1.32
016	Navy Yard	24	13.3	33%	0.20	1.67	7.33	0.67	5.55	24.36
017	Navy Yard	32	20.05	33%	0.20	1.67	11.05	0.67	5.55	36.72
018	Navy Yard	35	4.70	33%	0.20	1.67	2.59	0.67	5.55	8.61
019	NE Boundary - Swirl Eff	36	645.64	33%	0.20	1.67	355.81	0.67	5.55	1182.49
019	NE Boundary - Swirl Byp	13	209.17	33%	0.20	1.67	115.27	0.67	5.55	383.09
	SUBTOTAL	**448**	**1,282**				**706**			**2,348**
	Potomac River CSOs									
020	Easby Point	21	54.81	33%	0.20	1.67	30.21	0.67	5.55	100.38
021	Potomac Pumping Sta.	30	458.43	33%	0.20	1.67	252.64	0.67	5.55	839.61
022	I St. - 22nd St, NW	30	30.04	33%	0.20	1.67	16.56	0.67	5.55	55.02
024	W Rock Creek Diversion	17	16.23	33%	0.20	1.67	8.94	0.67	5.55	29.73
025	31st & K St NW	14	0.23	33%	0.20	1.67	0.13	0.67	5.55	0.42
027	Georgetown	72	52.50	33%	0.20	1.67	28.93	0.67	5.55	96.15
028	37th St - Georgetown	13	0.49	33%	0.20	1.67	0.27	0.67	5.55	0.90
029	College Pond	56	26.00	33%	0.20	1.67	14.33	0.67	5.55	47.62
	SUBTOTAL	**253**	**639**				**352**			**1,170**
	Rock Creek CSOs									
031	Penn Ave	9	0.22	33%	0.20	1.67	0.12	0.67	5.55	0.40
033	N St. - 25th St	6	4.48	33%	0.20	1.67	2.47	0.67	5.55	8.21
034	Slash Run Trunk Sewer	9	0.23	33%	0.20	1.67	0.13	0.67	5.55	0.42
036	Mass Ave & 24th	29	1.64	33%	0.20	1.67	0.90	0.67	5.55	3.00
037	Kalorama Circle West	3	0.05	33%	0.20	1.67	0.03	0.67	5.55	0.09
040	Biltmore St	1	0.03	33%	0.20	1.67	0.02	0.67	5.55	0.05
043	Irving St.	1	0.15	33%	0.20	1.67	0.08	0.67	5.55	0.27
045	Lamont St.	2	0.03	33%	0.20	1.67	0.02	0.67	5.55	0.05
046	Park Road	2	0.01	33%	0.20	1.67	0.01	0.67	5.55	0.02
047	Ingleside Terr.	3	0.25	33%	0.20	1.67	0.14	0.67	5.55	0.46
048	Oak St-Mt Pleasant	2	0.08	33%	0.20	1.67	0.04	0.67	5.55	0.15
049	Piney Branch	25	39.73	33%	0.20	1.67	21.90	0.67	5.55	72.77
057	Cleveland	15	2.32	33%	0.20	1.67	1.28	0.67	5.55	4.25
058	Connecticut Ave.	0	0.00	33%	0.20	1.67	0.00	0.67	5.55	0.00
	SUBTOTAL	**107**	**49**				**27**			**90**
	GRAND TOTAL	**808**	**1,970**				**1,085**			**3,608**

Sources:

A, B DC WASA Recommended CSS LTCP (July 2002). Table 6-2 for predicted discharges for average year with Phase 1 controls and pump station rehabilitation in place. Only CSO's with predicted discharges in the average rainfall year are shown.

C Based on conservatively high estimates provided by EPA Region III, Arlington County, and DC WASA personnel

D, G Average concentration based on 6 months passivation dose (targeted 3 mg/L PO4, equivalent to approx. 1 mg/L P, and 0.3 mg/L of zinc), 6 months at the maintenance dose (targeted approx 1 mg/L PO4, equivalent to approx 0.33 mg/L P, and 0.1 mg/L of zinc)

Table A.2 Predicted Increase in Zinc and Phosphorus Loads from CSO Discharges
Scenario 2: Passivation Dose for 1 Month, Maintenance Dose for 11 Months

					Increased zinc load			Increased P load		
CSO NPDES No.	Description	No. of CSO Over-flows	CSO Overflow Volume (MG/yr)	Percent of overflow that is domestic sewage	Increased zinc in domestic sewage (mg/L)	Increased zinc in domestic sewage (lbs/MG)	Estimated Increase zinc loading (lb / year)	Increased P in domestic sewage (mg/L)	Increased P in domestic sewage (lbs/MG)	Estimated Increase P loading (lb / year)
		A	B	C	D	E=D*8.35	F = B*C*E	G	H=G*8.35	I=B*C*H
Anacostia River CSOs										
005	Fort Stanton	73	16.54	33%	0.12	0.97	5.29	0.39	3.22	17.58
006	Fort Stanton	5	0.11	33%	0.12	0.97	0.04	0.39	3.22	0.12
007	Fort Stanton	64	36.97	33%	0.12	0.97	11.83	0.39	3.22	39.28
009	B. St./New Jersey Ave	53	16.84	33%	0.12	0.97	5.39	0.39	3.22	17.89
010	B. St./New Jersey Ave	18	247.21	33%	0.12	0.97	79.13	0.39	3.22	262.69
012	Tiber Creek	6	21.74	33%	0.12	0.97	6.96	0.39	3.22	23.10
013	Canal Street Sewer	28	9.78	33%	0.12	0.97	3.13	0.39	3.22	10.39
014	Navy Yard	49	38.98	33%	0.12	0.97	12.48	0.39	3.22	41.42
015	Navy Yard	12	0.72	33%	0.12	0.97	0.23	0.39	3.22	0.77
016	Navy Yard	24	13.3	33%	0.12	0.97	4.26	0.39	3.22	14.13
017	Navy Yard	32	20.05	33%	0.12	0.97	6.42	0.39	3.22	21.31
018	Navy Yard	35	4.70	33%	0.12	0.97	1.50	0.39	3.22	4.99
019	NE Boundary - Swirl Eff	36	645.64	33%	0.12	0.97	206.67	0.39	3.22	686.06
019	NE Boundary - Swirl Byp	13	209.17	33%	0.12	0.97	66.96	0.39	3.22	222.26
	SUBTOTAL	**448**	**1,282**				**410**			**1,362**
Potomac River CSOs										
020	Easby Point	21	54.81	33%	0.12	0.97	17.54	0.39	3.22	58.24
021	Potomac Pumping Sta.	30	458.43	33%	0.12	0.97	146.74	0.39	3.22	487.13
022	I St. - 22nd St, NW	30	30.04	33%	0.12	0.97	9.62	0.39	3.22	31.92
024	W Rock Creek Diversion	17	16.23	33%	0.12	0.97	5.20	0.39	3.22	17.25
025	31st & K St NW	14	0.23	33%	0.12	0.97	0.07	0.39	3.22	0.24
027	Georgetown	72	52.50	33%	0.12	0.97	16.81	0.39	3.22	55.79
028	37th St - Georgetown	13	0.49	33%	0.12	0.97	0.16	0.39	3.22	0.52
029	College Pond	56	26.00	33%	0.12	0.97	8.32	0.39	3.22	27.63
	SUBTOTAL	**253**	**639**				**204**			**679**
Rock Creek CSOs										
031	Penn Ave	9	0.22	33%	0.12	0.97	0.07	0.39	3.22	0.23
033	N St. - 25th St	6	4.48	33%	0.12	0.97	1.43	0.39	3.22	4.76
034	Slash Run Trunk Sewer	9	0.23	33%	0.12	0.97	0.07	0.39	3.22	0.24
036	Mass Ave & 24th	29	1.64	33%	0.12	0.97	0.52	0.39	3.22	1.74
037	Kalorama Circle West	3	0.05	33%	0.12	0.97	0.02	0.39	3.22	0.05
040	Biltmore St	1	0.03	33%	0.12	0.97	0.01	0.39	3.22	0.03
043	Irving St.	1	0.15	33%	0.12	0.97	0.05	0.39	3.22	0.16
045	Lamont St.	2	0.03	33%	0.12	0.97	0.01	0.39	3.22	0.03
046	Park Road	2	0.01	33%	0.12	0.97	0.00	0.39	3.22	0.01
047	Ingleside Terr.	3	0.25	33%	0.12	0.97	0.08	0.39	3.22	0.27
048	Oak St-Mt Pleasant	2	0.08	33%	0.12	0.97	0.03	0.39	3.22	0.09
049	Piney Branch	25	39.73	33%	0.12	0.97	12.72	0.39	3.22	42.22
057	Cleveland	15	2.32	33%	0.12	0.97	0.74	0.39	3.22	2.47
058	Connecticut Ave.	0	0.00	33%	0.12	0.97	0.00	0.39	3.22	0.00
	SUBTOTAL	**107**	**49**				**16**			**52**
	GRAND TOTAL	**808**	**1,970**				**630**			**2,093**

Sources:

A, B — DC WASA Recommended CSS LTCP (July 2002). Table 6-2 for predicted discharges for average year with Phase 1 controls and pump station rehabilitation in place. Only CSO's with predicted discharges in the average rainfall year are shown.

C — Based on conservatively high estimates provided by EPA Region III, Arlington County, and DC WASA personnel

D, G — Average concentration based on 1 month passivation dose (targeted 3 mg/L PO4, equivalent to approx. 1 mg/L P, and 0.3 mg/L of zinc), 11 months at the maintenance dose (targeted approx 1 mg/L PO4, equivalent to approx 0.33 mg/L P, and 0.1 mg/L of zinc)

Table A.3 Predicted Increase in Zinc and Phosphorus Loads from CSO Discharges
Scenario 3: Maintenance Dose for 12 Months

					Increased zinc load			Increased P load		
CSO NPDES No.	Description	No. of CSO Over-flows	CSO Overflow Volume (MG/yr)	Percent of overflow that is domestic sewage	Increased zinc in domestic sewage (mg/L)	Increased zinc in domestic sewage (lbs/MG)	Estimated Increase zinc loading (lb / year)	Increased P in domestic sewage (mg/L)	Increased P in domestic sewage (lbs/MG)	Estimated Increase P loading (lb / year)
		A	B	C	D	E=D*8.35	F = B*C*E	G	H=G*8.35	I=B*C*H
					Anacostia River CSOs					
005	Fort Stanton	73	16.54	33%	0.10	0.83	4.53	0.33	2.75	15.01
006	Fort Stanton	5	0.11	33%	0.10	0.83	0.03	0.33	2.75	0.10
007	Fort Stanton	64	36.97	33%	0.10	0.83	10.13	0.33	2.75	33.55
009	B. St./New Jersey Ave	53	16.84	33%	0.10	0.83	4.61	0.33	2.75	15.28
010	B. St./New Jersey Ave	18	247.21	33%	0.10	0.83	67.71	0.33	2.75	224.34
012	Tiber Creek	6	21.74	33%	0.10	0.83	5.95	0.33	2.75	19.73
013	Canal Street Sewer	28	9.78	33%	0.10	0.83	2.68	0.33	2.75	8.88
014	Navy Yard	49	38.98	33%	0.10	0.83	10.68	0.33	2.75	35.37
015	Navy Yard	12	0.72	33%	0.10	0.83	0.20	0.33	2.75	0.65
016	Navy Yard	24	13.3	33%	0.10	0.83	3.64	0.33	2.75	12.07
017	Navy Yard	32	20.05	33%	0.10	0.83	5.49	0.33	2.75	18.20
018	Navy Yard	35	4.70	33%	0.10	0.83	1.29	0.33	2.75	4.27
019	NE Boundary - Swirl Eff	36	645.64	33%	0.10	0.83	176.84	0.33	2.75	585.92
019	NE Boundary - Swirl Byp	13	209.17	33%	0.10	0.83	57.29	0.33	2.75	189.82
	SUBTOTAL	**448**	**1,282**				**351**			**1,163**
					Potomac River CSOs					
020	Easby Point	21	54.81	33%	0.10	0.83	15.01	0.33	2.75	49.74
021	Potomac Pumping Sta.	30	458.43	33%	0.10	0.83	125.56	0.33	2.75	416.03
022	I St. - 22nd St, NW	30	30.04	33%	0.10	0.83	8.23	0.33	2.75	27.26
024	W Rock Creek Diversion	17	16.23	33%	0.10	0.83	4.45	0.33	2.75	14.73
025	31st & K St NW	14	0.23	33%	0.10	0.83	0.06	0.33	2.75	0.21
027	Georgetown	72	52.50	33%	0.10	0.83	14.38	0.33	2.75	47.64
028	37th St - Georgetown	13	0.49	33%	0.10	0.83	0.13	0.33	2.75	0.44
029	College Pond	56	26.00	33%	0.10	0.83	7.12	0.33	2.75	23.60
	SUBTOTAL	**253**	**639**				**175**			**580**
					Rock Creek CSOs					
031	Penn Ave	9	0.22	33%	0.10	0.83	0.06	0.33	2.75	0.20
033	N St. - 25th St	6	4.48	33%	0.10	0.83	1.23	0.33	2.75	4.07
034	Slash Run Trunk Sewer	9	0.23	33%	0.10	0.83	0.06	0.33	2.75	0.21
036	Mass Ave & 24th	29	1.64	33%	0.10	0.83	0.45	0.33	2.75	1.49
037	Kalorama Circle West	3	0.05	33%	0.10	0.83	0.01	0.33	2.75	0.05
040	Biltmore St	1	0.03	33%	0.10	0.83	0.01	0.33	2.75	0.03
043	Irving St.	1	0.15	33%	0.10	0.83	0.04	0.33	2.75	0.14
045	Lamont St.	2	0.03	33%	0.10	0.83	0.01	0.33	2.75	0.03
046	Park Road	2	0.01	33%	0.10	0.83	0.00	0.33	2.75	0.01
047	Ingleside Terr.	3	0.25	33%	0.10	0.83	0.07	0.33	2.75	0.23
048	Oak St-Mt Pleasant	2	0.08	33%	0.10	0.83	0.02	0.33	2.75	0.07
049	Piney Branch	25	39.73	33%	0.10	0.83	10.88	0.33	2.75	36.05
057	Cleveland	15	2.32	33%	0.10	0.83	0.64	0.33	2.75	2.11
058	Connecticut Ave.	0	0.00	33%	0.10	0.83	0.00	0.33	2.75	0.00
	SUBTOTAL	**107**	**49**				**13**			**45**
	GRAND TOTAL	**808**	**1,970**				**539**			**1,788**

Sources:

A, B DC WASA Recommended CSS LTCP (July 2002). Table 6-2 for predicted discharges for average year with Phase 1 controls and pump station rehabilitation in place. Only CSO's with predicted discharges in the average rainfall year are shown.

C Based on conservatively high estimates provided by EPA Region III, Arlington County, and DC WASA personnel

D, G Average concentration based on 12 months at the maintenance dose (targeted approx 1 mg/L PO4, equivalent to approx 0.33 mg/L P, and 0.1 mg/L of zinc)