TOTAL MAXIMUM DAILY LOAD (TMDL) FOR ZINC IN THE WHITE CLAY CREEK NEW CASTLE COUNTY, DELAWARE

Technical Background and Basis Document

August 1, 1999

State of Delaware
Department of Natural Resources and Environmental Control
Division of Water Resources
Watershed Assessment Section

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EXECUTIVE SUMMARY

The White Clay Creek drains a small (107.2 mi^2) and scenic watershed in southeastern Pennsylvania and northern Delaware. The waters of the White Clay are used for a variety of purposes, including public and industrial water supply, irrigation, put-and-take trout fishing, and general aquatic life maintenance and propagation. Testing by the Delaware Department of Natural Resources and Environmental Control (DNREC) and others has shown that the concentration of zinc in the White Clay Creek below Paper Mill Road occasionally does not meet applicable water quality standards intended to protect aquatic life.

To begin to remedy this situation, the DNREC has developed a Total Maximum Daily Load (TMDL) for zinc in the White Clay Creek. A TMDL specifies the maximum allowable mass loading of a pollutant (i.e., pounds per day) that can be delivered to a waterbody while still assuring that applicable water quality standards are met. A TMDL is composed of three components, including a Waste Load Allocation (WLA) for point source discharges, a Load Allocation (LA) for nonpoint sources, and a Margin of Safety (MOS) to account for uncertainties regarding the relationship between mass loading and resulting water quality. In simple terms, a TMDL attempts to match the strength, location, and timing of pollution sources within a watershed with the inherent ability of the receiving water to assimilate the pollutant without adverse impact.

The source of zinc to the White Clay Creek is the now idle National Vulcanized Fiber (NVF) site located in Newark, Delaware, plus creek sediments adjacent to the NVF site.

The DNREC has determined that the greatest amount of zinc loading that the White Clay Creek can accommodate during critical low flow conditions is 6.73 pounds of zinc per day. Loadings in excess of this amount would be expected to violate applicable water quality criteria. This 6.73 pounds of zinc per day, which is the TMDL for the Red Clay Creek, is allocated as shown in the table below.

Zinc TMDL for the White Clay Creek, New Castle County, Delaware

TMDL (#/d)	LA_{NVF} (#/d)	LA_{up} (#/d)	MOS (#/d)
6.73	3.5	3.07	0.16

In this table, LA_{NVF} refers to the allowable zinc loading from NVF Newark site and adjacent creek sediments, LA_{up} refers to the zinc loading in the Creek just prior to passing by the NVF Newark site, and MOS refers to the margin of safety. Based upon the analyses contained in this report, the DNREC concludes with a reasonable degree of scientific certainty that water quality standards for zinc will be met in the White Clay Creek once the mass loading requirements listed in the above table are reached. This TMDL covers the main stem of the White Clay Creek from Paper Mill Road in Newark to the Creek confluence near Stanton, Delaware.

The DNREC will provide public notice that it intends to adopt the zinc TMDL for the White Clay Creek as a State regulation. This notice will appear within the August 1, 1999 Delaware Register of Regulations. The Register will also announce a public hearing to gather comments on the proposed TMDL regulation. That hearing will be held on Tuesday, September 7, 1999, between 8:00 and 9:00 p.m., at the New Castle office of the Division of Air and Waste Management, Delaware Department of Natural Resources and Environmental Control, 391 Lukens Drive, New Castle, Delaware. Oral and/or written comments can be provided concerning the proposed TMDL regulation at the time of the public hearing, or otherwise can be submitted in writing by 4:30 p.m., September 15, 1999.   All comments should be directed to the attention of Mr. Rod Thompson, Hearing Officer, DNREC, 89 Kings Highway, Dover, DE, 19901; facsimile: (302) 739-6242.

Following the hearing and consideration of the comments received, the DNREC will move to adopt the TMDL regulation and submit it to the U.S. EPA for their review and approval, all prior to December 31, 1999. If the State of Delaware fails to establish this TMDL by December 31, 1999, the EPA must do so by December 31, 2000.

1. INTRODUCTION

1.1 Purpose

The purpose of this report is to document the technical basis of the Total Maximum Daily Load (TMDL) for zinc in the White Clay Creek in northern New Castle County, Delaware.

1.2 Background

Section 303(d) of the Federal Clean Water Act (CWA) and implementing regulations (40 CFR 130.7) require the establishment of Total Maximum Daily Loads (TMDLs) for water quality limited segments. A water quality limited segment is a waterbody or portion of a waterbody (e.g., a length of river, an area of an estuary, a pond or wetland, etc.) in which water quality does not meet applicable water quality standards, and/or is not expected to meet applicable water quality standards, even after the application of technology-based effluent limitations required by sections 301(b) and 306 of the Clean Water Act. The Delaware Department of Natural Resources and Environmental Control (DNREC) has identified the main stem of the White Clay Creek as being water quality limited due to zinc concentrations in excess of applicable water quality standards (DNREC, 1996; DNREC, 1998a). Therefore, a TMDL is needed for this waterbody.

A TMDL specifies the maximum allowable mass loading of a pollutant (i.e., pounds per day) that can be delivered to a waterbody while still assuring that applicable water quality standards are met. A TMDL is composed of three components, including a Waste Load Allocation (WLA) for point source discharges, a Load Allocation (LA) for nonpoint sources, and a Margin of Safety (MOS) to account for uncertainties regarding the relationship between mass loading and resulting water quality. In simple terms, a TMDL attempts to match the strength, location, and timing of pollution sources within a watershed with the inherent ability of the receiving water to assimilate the pollutants without adverse impact.

There are five (5) basic requirements of Section 303(d) and its implementing regulation. These requirements include the following:

1. Identification of water quality limited segments still requiring TMDLs;
2. Establishing a priority ranking for the identified segments, including an identification of waters targeted for TMDL activities during the next two year period;
3. Developing TMDLs/WLAs/LAs in accordance with the priority ranking through monitoring, modeling, and data analysis;
4. Incorporating approved loadings into permits and other pollution control requirements; and
5. Providing opportunity for public participation during steps 1, 2, 3, and 4.

Federal regulations instruct the States to satisfy the first two requirements by submitting a list of water quality-limited segments along with their prioritization to the EPA for review and approval by April 1 of every even numbered year. This list and associated prioritization is commonly referred to as the State's CWA 303(d) List. If a State fails to satisfy this listing requirement, the Clean Water Act and implementing regulations instruct the EPA to develop the list. With regard to requirement 3 above, the Clean Water Act and implementing regulations direct the States to submit all TMDLs to the EPA for approval/disapproval. Again, the Act and regulations require the EPA to develop the TMDLs if the State fails to do so. Unlike the listing and prioritization steps, however, development and submission of TMDLs are not mandated to occur on a biennial schedule. Rather, Federal regulations contemplate that EPA and the State will jointly establish a schedule for the development and submission of TMDLs/WLAs/LAs. Such a schedule was developed by Delaware DNREC and the EPA in 1997 in conjunction with and in response to a citizens lawsuit concerning the administration of the TMDL program in Delaware (ALS et. al., 1996). The joint schedule is memorialized in a Memorandum of Understanding between the Secretary of DNREC and the Regional Administration of the EPA (DNREC/EPA, 1997). Among the deadlines included in the schedule is a commitment by the DNREC to establish a TMDL for zinc in the White Clay Creek by December 31, 1999. The Memorandum of Understanding provides the EPA with an additional year to establish the White Clay Creek zinc TMDL in the event that DNREC fails to meet its deadline.

1.3 Report Organization

Following the background information provided in this chapter, Chapter 2 presents a detailed characterization of zinc concentrations and mass loadings in the White Clay Creek. Chapter 3 then derives the zinc TMDL for the White Clay Creek and documents the assumptions used in that derivation. Chapter 4 identifies the next steps in the TMDL process, including public participation and the development of an implementation plan which the DNREC refers to as a Pollution Control Strategy (PCS). And finally, Chapter 5 provides a listing of references used to support the TMDL. Appendices present raw and processed data tables and selected calculations.

2. CHARACTERIZATION

2.1 Environmental Setting

The White Clay Creek watershed covers a total drainage area of 107.2 square miles in southeastern Pennsylvania and northern Delaware. The area is split almost evenly between the two States, (roughly 57% in PA and 43% in DE). The mainstem of the Creek is fed by three branches (East, Middle and West), all of which are located in Pennsylvania. The mainstem enters Delaware south of Landenberg, PA and north of Newark, Delaware in the vicinity of the historic area known as the "wedge." The Creek then flows southward through Newark, after which it veers sharply to the east where it continues towards its confluence with the Christina River near Stanton, Delaware. The length of the Delaware portion of the White Clay Creek mainstem is approximately14 miles. The lower 2.3 miles of the Creek is influenced by tidal backwater from the Christina River. The Creek is nevertheless fresh (<5 ppt salinity) for its entire length.

The stream flows at the Delaware Park Race Track (east of Newark), have ranged from an instantaneous maximum of 11,600 cubic feet per second (cfs) in 1989 to an instantaneous minimum of 4.7 cfs in 1966, with a long term (1932 to1998, partial) median of 77 cfs, (James, et. al., 1999).

Much has been written about the environmental attributes and land use patterns of the White Clay Creek watershed, and so that information is not repeated here. The interested reader is directed elsewhere, (DOI, 1998).

The waters of the White Clay have been used for a variety of purposes, including public and industrial water supply, irrigation, put-and-take trout fishing, and general aquatic life maintenance and propagation. Furthermore, the portion of the Creek from the PA/DE border down to Paper Mill Road is designated as "Waters of Exceptional Recreational or Ecological Significance" in Delaware's Surface Water Quality Standards in light of the unique flora and fauna that are known to exist over this reach.

One historic use of the Creek was to cool paper making processes at the National Vulcanized Fiber (NVF) facility in Newark, Delaware. That facility, located along the banks of the White Clay Creek just downstream from Paper Mill Road, produced waterleaf paper and vulcanized fiber products. The facility began manufacturing in the late nineteenth century and operated up to its closing in 1990. Zinc chloride was used in the fiber bonding process and was then recovered to produce a zinc chloride sludge. This sludge was the primary waste generated at the facility. During operations, zinc was discharged to the White Clay Creek from an NPDES permitted outfall consisting primarily of non-contact cooling water. In addition, it is likely that fugitive zinc was released from the facility to the White Clay Creek from leaky operations and spillage, given the age of the facility. These releases are no longer active, but erosion of zinc contamination soils from the site can continue to deliver zinc to the White Clay Creek during storm events. Efforts are now underway to redevelop this site for non-manufacturing uses by new site owners, Commonwealth Management, Incorporated. The new owners plan to remediate the site by excavating zinc contaminated soils and adjacent Creek sediments under the direction of the State of Delaware Hazardous Substance Cleanup Act - Voluntary Cleanup Program, (DNREC, 1999).

2.2 Applicable Water Quality Standards

As noted previously, the DNREC identified the mainstem of the White Clay Creek as being water quality limited due to zinc concentrations in excess of applicable water quality standards. This section provides a brief overview of water quality standards and also identifies and discusses the applicable water quality standards for zinc in the White Clay Creek.

Water quality standards include a specification of the beneficial use or uses to be made of a water body (referred to as the water's designated uses) and the water quality criteria intended to protect the use or uses. The State of Delaware Surface Water Quality Standards (As Amended, February 26, 1993) lists the following designated uses for the White Clay Creek: public, industrial, and agricultural water supply; primary and secondary contact recreation; fish, aquatic life and wildlife; cold water fish (put-and-take), and ERES (DNREC, 1993). The DNREC's decision to list the White Clay on its 303(d) list was based upon exceedances of Delaware's zinc criteria for the protection of aquatic life. Those criteria are listed below.

$$\text{Freshwater Acute Criterion (ug/L)} = e^{(0.8473[\ln(\text{hardness})] + 0.8604)}$$

$$\text{Freshwater Chronic Criterion (ug/L)} = e^{(0.8473[\ln(\text{hardness})] + 0.7614)}$$

The DNREC interprets these criteria on a "total" zinc basis (rather than "dissolved") and has developed the zinc TMDL for the White Clay Creek on this basis accordingly. The acute criterion is a 1-hour average concentration not to be exceeded more than once in any three year period, while the chronic criterion is a 4-day average concentration, also with a 3 year return period. Note that both of these criteria increase as a function of water hardness. For hardness values between 100 mg/L and 200 mg/L, these criteria range between approximately 100 ug/L to 200 ug/L.

The above criteria are based on "national" criteria developed by the EPA, (EPA, 1987). These criteria are intended to protect a broad assemblage of freshwater plants and animals from the short and longer term toxic effects of zinc. In the case of fish, a number of behavior and physiological effects are known to occur when test organisms are exposed to zinc, (Sorensen, 1991). Behavioral effects that have been reported include avoidance response, feeding rate changes, and changes in movement patterns. With respect to physiological effects, it has been reported that fish exposed to increased zinc levels exhibit increased ventilation rate and frequency of coughing and a concomitant decrease in oxygen utilization. Presumably, these inter-related respiratory effects are caused by excess zinc adsorption to gill membranes, which in turn decreases functional surface area for oxygen transfer and oxygen diffusion capacity. Additional information concerning the types of adverse effects that excess zinc can have on aquatic life and the associated effect levels is available through the EPA's on-line database AQUIRE, (EPA, 1999).

Because the above criteria are expressed as a function of hardness, there is not a single numerical value for the acute criterion and a single numerical value for the chronic criterion that apply under all circumstances. Rather, to determine whether a particular ambient water sample contains a zinc concentration that exceeds one or both of the criteria, the hardness value for that sample must first be substituted into the criteria equations and then the resulting concentrations are compared to the total zinc concentration in that same sample. For purposes of developing the TMDL, however, it is necessary to select a "design" hardness value that accounts for the critical conditions in the stream. In accordance with Section 9.3(a)(i) of Delaware's Surface Water Quality Standards, the selection of an appropriate hardness value is a site-specific determination that is determined on a case-by-case basis by DNREC. This issue will be addressed in a subsequent section of this report.

As noted previously, the acute and chronic criteria both increase as a function of hardness. In other words, the toxicity of zinc decreases as hardness increases. Although the exact reason this is so is still an area of active research, it has been postulated that calcium and magnesium, which are the major divalent cations that contribute to hardness, compete with zinc, which is also a divalent cation, for binding sites on biological surfaces. Because less zinc is able to come into contact with the organism, the true exposure actually experienced by the organism is reduced, which in turn translates into less severe effects. In addition to this competitive factor, harder water also tends to have higher ionic strength, which may act to electrostatically inhibit the sorption of zinc to binding sites on the biological surfaces. Both of these phenomena, and all other physical, chemical, and biological factors that tend to moderate or mitigate toxicity, collectively determine was is known as a pollutant's "bioavailabilty."

Although Delaware's water quality criteria for zinc are expressed on a "total" metal basis, and the TMDL for zinc in the White Clay Creek has been developed based upon "total" zinc, DNREC nevertheless recognizes the importance of considering the bioavailable fraction of the metal in assessing the likelihood of adverse effects to aquatic life. Bioavailability is taken into account by converting the "total" metal criteria to a "dissolved" basis and then by comparing the resulting dissolved criteria to dissolved metal measurements for ambient water samples. The conversion of the total zinc criteria to a dissolved basis is done simply by multiplying the total criteria by total to dissolved conversion factors. To convert the acute zinc criterion (expressed on a total basis) to a dissolved basis, the total criterion is multiplied by 0.978. Similarly, to convert the chronic zinc criterion (expressed on a total basis) to a dissolved basis, the total criterion is multiplied by 0.986. These conversion factors were taken from values published by the EPA in 1995, (Stephan, 1995). Again, this approach was taken to supplement, not to supercede, the "total" metal approach taken to establish the zinc TMDL for the White Clay Creek.

The final point to be made in this section is that the water quality criteria necessary to protect aquatic life from the toxic affects of zinc are significantly more stringent than concentrations that are associated with increased risk to humans. The author has previously estimated an informal guideline of 3 mg/L (i.e., 3000 ug/L) as protective of human health, (Greene, 1995). The aquatic life criteria (at typical hardness values) are more than an order of magnitude (i.e., >10x) more stringent than this informal human health guideline. The aquatic life criteria are the controlling criteria for the White Clay Creek TMDL.

2.3 Assessment of Zinc Concentrations and Mass Loading in the White Clay Creek

An initial step in the TMDL process is to compile and analyze information on the concentrations, flows, and mass loadings for the pollutant of concern, in this case, zinc. This section presents the concentration and mass loading information for zinc in the water column of the White Clay Creek and also presented data concerning zinc levels observed in groundwater, sediment, and fish tissue of the White Clay watershed.

2.3.1 Routine Water Quality Monitoring Data

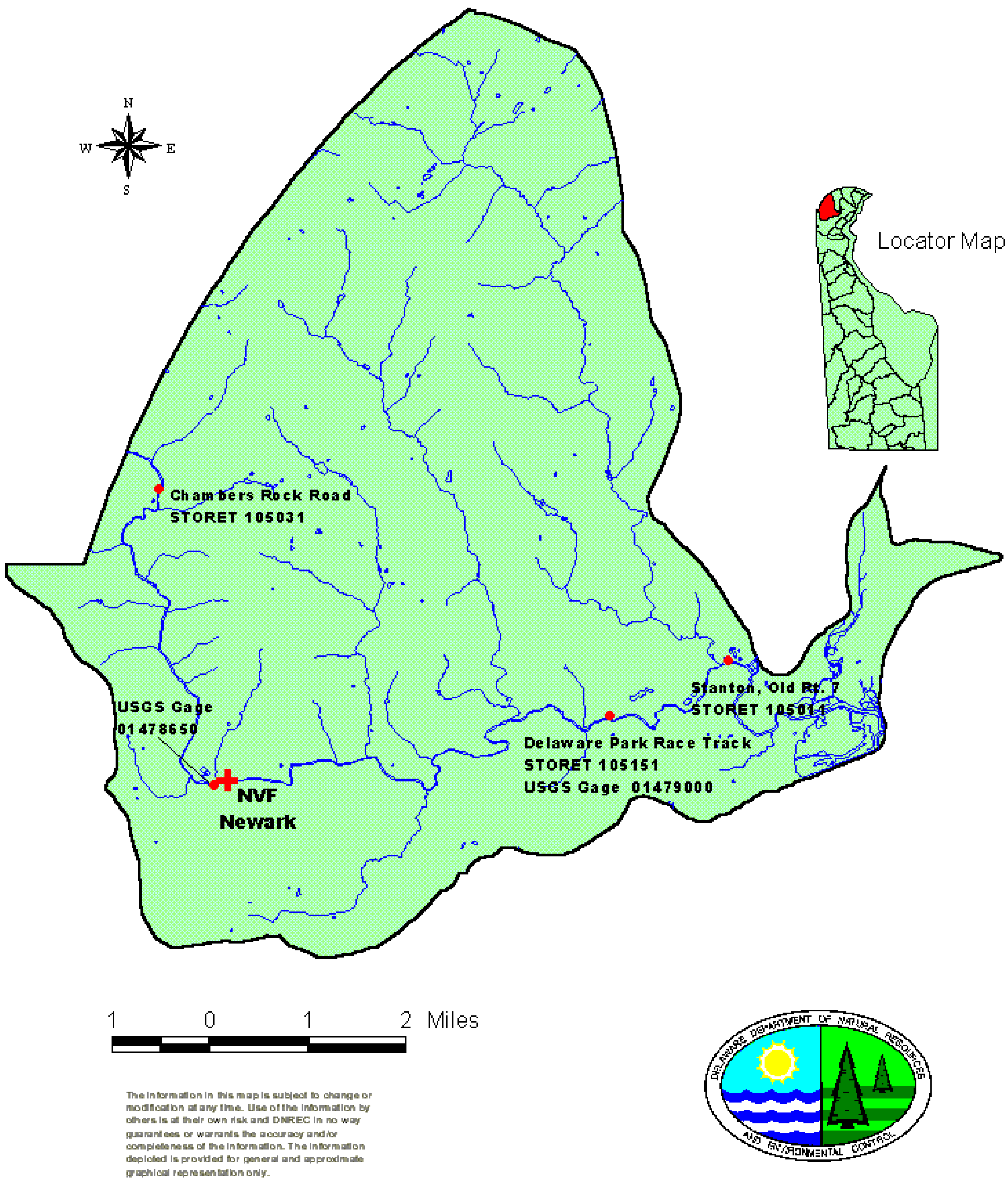
The Delaware DNREC performs routine water quality monitoring at 3 locations along the mainstem of the White Clay Creek. These 3 stations are identified in Table 1 below and are also shown in Figure 1. Water samples are collected at these three stations on a monthly to quarterly basis and are analyzed for total zinc, dissolved zinc, hardness, pH, and temperature, along with several other parameters. Total and dissolved zinc are analyzed using EPA Method 200.7, inductively coupled plasma, atomic emission spectrometry (ICAP-AES).

Table 1. Routine Monitoring Station in the White Clay Creek

Sampling Location	Station ID	River Miles Above (-) or Below (+) NVF, Newark	Number of Data Points	Period of Record Considered
Chambers Rock Rd.	105031	-4.2	45	7/21/93 - 9/15/98
DE Park Race Track	105151	+5.5	46	7/21/93 - 9/15/98
Stanton, DE	105011	+7.4	41	3/14/94 - 9/15/98

Table 1 specifies the period of record considered for each station, the number of samples taken over the period, and the number of river miles above (-) or below (+) the NVF, Newark site. The number of river miles above or below the NVF Newark site has relevance because the primary source of zinc to the White Clay Creek is this site and the adjacent Creek sediments.

Figure 1. White Clay Creek Watershed
New Castle County, Delaware



Appendix A of this report presents information on zinc concentration, streamflow, and zinc mass loading for the 3 stations listed in Table 1. For each station, 4 separate pages of printout are provided. The first page provides the sample date, streamflow, total zinc concentration, dissolved zinc concentration, the percentage of zinc in the dissolved form, the mass loading of total zinc, and the mass loading of dissolved zinc. Streamflow and mass loading are not provided for the Stanton station because flows were not readily available for that station. The second page provides summary statistics for zinc concentration (for all 3 stations) and mass loading (for the 2 stations other than Stanton). Summary statistics are provided for the full record considered as well as for individual water years, (i.e., October 1 through September 30). The third page lists the hardness reported for each day along with the computed acute and chronic criteria for zinc. And finally, the fourth page compares the measured zinc concentrations presented on the first page to the criteria listed on the third page.

Several explanatory notes are offered to clarify the data and information presented in Appendix A. First, the zinc and hardness concentrations at Chambers Rock Road were assumed to be representative of the concentrations at Paper Mill Road. This assumption is justified in that the reach of the White Clay between Chambers Rock Road and Paper Mill Road is largely a nature preserve with sparse development, no point source discharges, and a heavily wooded stream corridor. Paper Mill Road is of interest because it is located immediately upstream from the NVF Newark site and we wish to characterize “background’ conditions for the site. Furthermore, there is a USGS stream gage located 200 feet upstream from Paper Mill Road, thus allowing computation of mass loading. The Paper Mill Road gage is known as the “White Clay Creek at Newark” gage. The station number is 01478650 and the area above this gage is 69 square miles.

Since this gage was not operational until March of 1994, it was necessary to extrapolate flows to this site from the downstream gage for dates prior to March of 1994. The downstream gage is referred to as the “White Clay Creek near Newark” gage, station number 01479000, with a drainage area of 89.1 square miles. This gage is located directly adjacent to the Delaware Park Race Track, and as such is sometimes referred to as the “White Clay at the Track” gage. With this information, flows at Paper Miller Road prior to March of 1994 were extrapolated as follows:

Flow at Paper Mill Road = [Flow at DE Race Track x (69/89.1)]

The column headers “TZinc” and “DZinc” in Appendix A represent total zinc and dissolved zinc, respectively. The abbreviation “DQC” refers to “data qualifier code” in the column headers immediately following the total zinc and dissolved zinc concentrations. For example, the symbol “<“ may appear in the DQC column, indicating that the laboratory did not detect zinc above the detection limit of the instrument. In those situation, ½ of the detection limit was substituted for the non-detected result in order to allow subsequent calculations with the concentration data. Total zinc concentrations found to be present in a sample at less than the instrument detection limit are “J” qualified, meaning that the concentration is an estimated value. Finally, “K” qualified results for dissolved zinc measurements signify that total zinc was found at very low levels (i.e, less than 20 ug/L), and consequently, the samples for dissolved zinc were not analyzed.

The column labeled "Mass Load Total Zinc" was calculated as the product of the total zinc concentration and the associated streamflow for that day. Similarly, "Mass Load Dissolved Zinc" was computed by multiplying the dissolved zinc concentration by streamflow.

Finally, "CMC_t" on the third of each group of 4 pages in Appendix A refers to the acute zinc criterion expressed on a total basis, and "CCC_t" refers to the chronic zinc criterion, also expressed on a total basis. Similarly, "CMC_d" refers to the acute criterion expressed on a dissolved basis, and "CCC_d" refers to the chronic criterion on a dissolved basis. The comparisons between the computed criteria and the sample results are shown on the fourth of each group of 4 pages and is expressed as the ratio of the sample result to the associated criterion. This ratio is identified as an "Ecorisk Index." Indices greater than 1 signify that the concentration of zinc in the sample exceeded the corresponding criterion, while indices less than 1 mean that the sample did not exceed the criterion.

With the above explanatory notes in mind, an examination of the data and information presented in Appendix A reveals the following key features regarding zinc in the White Clay Creek:

- **Finding 1:** The concentrations of total and dissolved zinc at the Paper Mill Road station are very low, often registering non-detected results of 10 ug/L. In fact, the median total zinc concentration over the record was 10 ug/L. The maximum for the 5-year record was only 63.9 ug/L at the upstream station. At the Race Track station, the median total zinc concentration was 26.9 ug/L and the maximum was 126.9 ug/L. This maximum occurred in November of 1993. Finally, the median at the Stanton station was 24.1 ug/L and the maximum was 103.6 ug/L, occurring in July of 1994.

- **Finding 2:** There were no criteria exceedances at the upstream station and only a few exceedances at the downstream monitoring stations. Presumably, there may have been more frequent exceedances closer to the NVF Newark site had there been a monitoring station closer to the site. The acute and chronic criteria for total zinc were exceeded at the Race Track station on November 15, 1993, and again on September 17, 1996. The flow at the Race Track during the November 1993 excursion was 55 cfs, while the flow during the September 1996 excursion was 562 cfs. The only other criteria exceedances occurred on July 18, 1994 at the Stanton station. Both the acute and chronic criteria for total zinc were exceeded on that day. The flow at the Race Track on that day was a modest 132 cfs. There were no exceedances of the zinc criteria expressed on a dissolved basis at any of the stations for the approximate 5-year record examined.

- **Finding 3:** The median mass loading of total zinc at the Paper Miller Road Station over the roughly 5-year period was 3.07 pound per day. The peak annual median was 5.34 pounds per day during water year 1996, and the minimum annual median was 1.7 pounds per day during water year 1998. At the Race Track, the 5-year median was 9.08 pounds of zinc per day. The highest annual median, 24.65 pounds per day, occurred during water year 1994. The lowest annual median, 3.61 pounds per day, occurred during water year 1995. Mass loadings were not computed for Stanton.

- **Finding 4:** Regression analyses performed between total zinc, streamflow, hardness, and total suspended solids revealed weak relationships at both the Paper Mill Road and Race Track stations. In general, total zinc increased as a weak function of streamflow at both stations, with a slightly stronger relationship for the downstream station. The increase of total zinc with increasing streamflow appeared to be related to increased suspended solids during higher flows, although these relationships not compelling. Finally, there were weak inverse relationships between streamflow and hardness at both the upstream and downstream sites.

2.3.2 NVF Newark Facility Evaluation

As noted earlier, the new owners of the NVF Newark site, Commonwealth Management Inc., are performing a voluntary cleanup at the site. A Facility Evaluation (FE) was performed in the spring of 1998 that included sampling of soil, groundwater, surface water, and sediments, (Environmental Alliance, 1998). The table below summarizes the results for zinc testing at the site.

Table 2. Concentrations of Zinc Detected at the NVF Newark Site

Media	Maximum Concentration	Geometric Mean
Surface Soils	109,000 mg/kg	7621.9 mg/kg
Subsurface Soils	8950 mg/kg	330.1 mg/kg
Groundwater	46.2B ug/L	NA
White Clay Creek Sediment	3,720 mg/kg	261.4 mg/kg
White Clay Creek Water	18.5B ug/L	NA

Note from the table that the concentration of zinc in the surface soils, and to a lesser degree, in the subsurface soils, is elevated. Further, the concentration of zinc in the White Clay Creek sediments is also moderately elevated. However, the concentration of zinc in the surface water adjacent to the site had low concentrations of zinc, as did the site groundwater.

Based on these findings, the Final Plan of Remedial Action for the Site (DNREC, 1999) calls for the excavation of zinc impacted soils and Creek sediments, followed by on-site entombment or off-site disposal. The Plan specifies that Creek sediments in excess of 410 mg/kg must be excavated. This is the NOAA Effects Range Median concentration. Following excavation, the Plan also specifies that a biological assessment must be performed to verify recovery of the benthic community.

3. TOTAL MAXIMUM DAILY LOAD

This chapter derives the zinc TMDL for the White Clay Creek and documents the assumptions used in that derivation. As noted in the introduction, a TMDL specifies the maximum allowable mass loading of a pollutant (i.e., pounds per day) that can be delivered to a waterbody while still assuring that applicable water quality standards are met. In simple terms, a TMDL attempts to match the strength, location, and timing of pollution sources within a watershed with the inherent ability of the receiving water to assimilate the pollutant without adverse impact. Also as discussed in the introduction, a TMDL is composed of three components, including a Waste Load Allocation (WLA) for point source discharges, a Load Allocation (LA) for nonpoint sources, and a Margin of Safety (MOS) to account for uncertainties regarding the relationship between mass loading and resulting water quality.

In order to derive a zinc TMDL for the White Clay Creek, it is first necessary to identify the critical, or design, conditions upon which the TMDL is to be based. The specification of design conditions is important because these conditions determine the frequency at which water quality criteria would be expected to be met under the TMDL. As was shown in the previous chapter, the concentration of zinc in the Red Clay Creek downstream from NVF Newark increases as a weak function of increasing streamflow and suspended solids. The increase in zinc in this case is believed to occur in response to erosion of zinc contaminated soils off of the NVF site, as well as in response to resuspension of zinc contaminated sediments in the Creek. The excavation of the contaminated soils and Creek sediments is assumed to be at least part of a presumptive remedy for any water quality criteria violations that may occur during high streamflows and runoff. However, residual zinc may be left at this site which must be accounted for in this TMDL.

The true critical condition for this TMDL can be thought of as a combination of low streamflow and a slug input of zinc from site runoff and sediment resuspension. For this reason, it is still necessary to develop and adopt a low flow TMDL for zinc for the White Clay Creek. The State of Delaware Surface Water Quality Standards specifies that the 1Q10 flow, which is the lowest 1 day average flow that occurs once in any 10-year period, be used with acute aquatic life criteria. Similarly, the Delaware Standards specify that the 7Q10 flow, which is the lowest 7 day average flow that occurs once in any 10-year period, be used with chronic aquatic life criteria.

Because the gage at Paper Mill Road has only been in operation since 1994, an insufficient record exists to compute 7Q10 and 1Q10 flow statistics. However, a 7Q10 flow has been previously estimated for this location through extrapolation from the USGS gage located at the Race Track. The extrapolated 7Q10 flow at Paper Mill Road has been reported as 7.27 MGD, which is equivalent to11.25 cfs, (Yaeck, 1997). No 1Q10 flow estimate was available for this site so an estimate was made by multiplying the 7Q10 flow by the statewide average ratio of 1Q10 to 7Q10 flows determined from16 long-term flow gages in Delaware. That ratio was determined to be 0.68, (DNREC, 1988). In other words, on average, the magnitude of the 1Q10 flow is two-thirds that of the 7Q10. Applying this ratio, the estimated 1Q10 flow at Paper Mill Road is 7.65 cfs.

In addition to streamflow, the other important design variable for this TMDL is the hardness of the Creek. The hardness chosen was 148 mg/L, which was the value measured at the Chambers Rock Road station on September 11, 1995. The streamflow at Paper Mill Road on that day was 5.9 cfs, which is very close to the 1Q10 flow mentioned above. At the design hardness of 148 mg/L , the applicable freshwater acute criterion for this TMDL is computed as 163.1 ug/L. The applicable freshwater chronic criterion at the design hardness is 147.8 ug/L. Both of these criteria are expressed on a total zinc basis.

With the above critical flows and applicable criteria in hand, the zinc TMDL for the White Clay Creek can now be determined. The total amount of zinc that the White Clay Creek can accommodate in the vicinity of NVF Newark and points downstream and still meet the acute criterion under design conditions is computed as the product of the 1Q10 design flow and the acute criterion. This product is the TMDL for acute impacts, which shall be abbreviated in this report as $TMDL_a$. In a similar manner, in order to ensure that the chronic criterion is met under the design conditions, the total amount of zinc that the White Clay Creek can accommodate in the vicinity of NVF Newark and points downstream is computed as the product of the 7Q10 design flow and the chronic criterion. This product is the TMDL for chronic impacts, which is abbreviated as $TMDL_c$ in this report. These two calculations appear below.

$$TMDL_a = (163.1\ ug/L)(7.65\ cfs)(0.005394) = 6.73 \text{ pounds per day}$$

$$TMDL_c = (147.8\ ug/L)(11.25\ cfs)(0.005394) = 9.28 \text{ pounds per day}$$

To ensure that both the acute and chronic criteria are met under the design conditions, the more stringent of the two TMDLs listed above must be met. Therefore, <u>the zinc TMDL for the White Clay Creek is 6.73 pounds per day</u>. The basic assumption of this formulation is that zinc acts as a conservative substance which exhibits its maximum in-stream concentration directly adjacent to the NVF Newark site. The other fundamental assumption is that zinc released from the NVF facility to the White Clay Creek mixes rapidly and completely with the background, or upstream, loading of zinc.

The final technical requirement to complete the zinc TMDL for the Red Clay Creek is to specify the individual components of the TMDL. In this case, the major components of the TMDL include a load allocation for NVF Newark site (LA_{NVF}), a load allocation to account for zinc loading in the Creek immediately upstream and just prior to mixing with NVF's load (LA_{up}), and a Margin of Safety (MOS) for uncertainties. This is expressed mathematically in the equation below.

$$TMDL = LA_{NVF} + LA_{up} + MOS$$

We start with the background loading from upstream, $LA_{up.}$ As was shown in Section 2.3.1, the median mass loading at Paper Mill Road (immediately upstream from the NVF Newark site) is 3.07 pounds of zinc per day. This is the value specified for LA_{up} in this TMDL.

The Margin of Safety (MOS) for this TMDL has been set at 0.16 pounds of zinc per day, which represents slightly more than 2 % of the TMDL. This small margin of safety reflects the fact that criteria violations are not frequently observed at the present time and that there is a cleanup underway at the primary source of zinc to the Creek.

By difference, the final component of the TMDL, LA_{NVF}, is computed as 3.5 pounds of zinc per day.

$$
\begin{aligned}
LA_{NVF} &= TMDL - LA_{up} - MOS \\
&= 6.73 - 3.07 - 0.16 \\
&= 3.5 \text{ pounds of zinc per day}
\end{aligned}
$$

The table below provides a final summary of the zinc TMDL for the White Clay Creek. This TMDL covers the entire main stem of the White Clay Creek from Paper Mill Road to the confluence near Stanton, Delaware. Based upon the analyses contained herein, the DNREC concludes with a reasonable degree of scientific certainty that water quality standards for zinc will be met in the White Clay Creek once the mass loading requirements listed in the table are reached.

Table 3. Zinc TMDL for the Red Clay Creek, New Castle County, Delaware

TMDL (#/d)	LA_{NVF} (#/d)	LA_{up} (#/d)	MOS (#/d)
6.73	3.5	3.07	0.16

4. NEXT STEPS

This chapter concludes by identifying the next steps in the White Clay Creek zinc TMDL process. First, the TMDL and its component parts will be published as proposed regulations in the August 1, 1999 State of Delaware Register of Regulations. The TMDL and its component parts will be identified as individual regulatory articles. On this same date in the Delaware Register, an announcement will be made that a public workshop and public hearing will be held to answer questions concerning the proposed TMDL and to take formal comments on the regulatory articles, respectively. The workshop and hearing will also be announced on August 1st and 4th, 1999, in the News Journal and Delaware State News.

The workshop and hearing are scheduled as follows:

Public Workshop

The workshop will be held on Tuesday, September 7, 1999, between 4:00 and 5:00 p.m., at the New Castle office of the Division of Air and Waste Management, Delaware Department of Natural Resources and Environmental Control, 391 Lukens Drive, New Castle, Delaware.

Public Hearing

The hearing will be held on Tuesday, September 7, 1999, between 8:00 and 9:00 p.m., at the New Castle office of the Division of Air and Waste Management, Delaware Department of Natural Resources and Environmental Control, 391 Lukens Drive, New Castle, Delaware.

Oral and/or written comments can be provided on the proposed regulatory articles at the time of the public hearing, or otherwise can be submitted in writing by 4:30 p.m., September 15, 1999. All comments should be directed to the attention of Mr. Rod Thompson, Hearing Officer, DNREC, 89 Kings Highway, Dover, DE, 19901; facsimile: (302) 739-6242.

Following the close of the hearing record, the Hearing Officer will evaluate the comments received and will make a recommendation to the Secretary of the Department of Natural Resources and Environmental Control to adopt one or more of the articles as proposed, withdrawal one or more of the articles, or to modify one or more of the articles based upon the record. The Secretary will accept or reject the recommendations and will promptly publish a Secretary's Order and final regulation. The Order and final regulatory articles will be published in the Delaware Register of Regulations on November 1, 1999, (tentatively). The final articles and supporting documentation will then be submitted to the U.S. EPA for their review and approval. As noted in the introductory chapter, if the State fails to establish this TMDL by December 31, 1999, the EPA will have one additional year to do so.
Under the assumption that this TMDL will be established by December 31, 1999, the State will

then proceed to develop a Pollution Control Strategy (PCS) to guide implementation of the TMDL. The PCS will be developed by the DNREC in concert with affected parties, the interested public, and the DNREC's ongoing Whole basin Management Program. As a goal, the PCS will be completed within 1 year of the TMDL adoption date.

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APPENDIX A

Summary of Routine Ambient Monitoring Data for the White Clay Creek (Period Generally Covering Fall, 1993 Through Fall, 1998)

White Clay Creek at Paper Mill Road
Concentration and Mass Loading Characterization
(Note: Total and Dissolved Zinc Concentrations are from Chambers Rock Road)

Date	Flow at PaperM Rd (cfs)	TZinc (ug/L)	TZinc DQC	DZinc (ug/L)	DZinc DQC	TZinc with NDs=1/2DL (ug/L)	DZinc with NDs=1/2DL (ug/L)	Percent Dissolved	Mass Load Total Zn (lb/day)	Mass Load Dissolved Zn (lb/day)	TSS (mg/L)
93/07/21	36.4	20	<			10	NA	NA	1.96	NA	4
93/08/18	33.3	20	<			10	NA	NA	1.80	NA	1
93/09/23	32.5	21		20	<	21	10	47.6	3.68	1.75	1
93/10/19	34.1	20	<			10	NA	NA	1.84	NA	4
93/11/15	42.6	21.6		20	<	21.6	10	46.3	4.96	2.30	2
93/12/14	63.5	20	<			10	NA	NA	3.43	NA	1
94/03/14	398	23.4		20	<	23.4	10	42.7	50.24	21.47	15
94/04/18	120	49		42		49	42	85.7	31.72	27.19	1
94/05/16	216	23.3		20	<	23.3	10	42.9	27.15	11.65	63
94/06/14	44	63.9		20	<	63.9	10	15.6	15.17	2.37	4
94/07/18	42	20	<			10	NA	NA	2.27	NA	26
94/08/15	33	20	<			10	NA	NA	1.78	NA	3
94/09/12	16	20	<			10	NA	NA	0.86	NA	1
94/10/17	22	20	<			10	NA	NA	1.19	NA	3
94/12/12	57	20	<			10	NA	NA	3.07	NA	6
95/01/17	48	20	<			10	NA	NA	2.59	NA	4
95/03/13	64	20	<			10	NA	NA	3.45	NA	3
95/04/17	44	20	<			10	NA	NA	2.37	NA	6
95/05/15	48	20	<			10	NA	NA	2.59	NA	6
95/06/19	17	20	<			10	NA	NA	0.92	NA	5
95/07/17	39	20	<			10	NA	NA	2.10	NA	23
95/08/14	13	20	<			10	NA	NA	0.70	NA	6
95/09/11	5.9	20	<			10	NA	NA	0.32	NA	7
95/10/16	43	20	<			10	NA	NA	2.32	NA	4
95/11/13	97	20	<			10	NA	NA	5.23	NA	6
96/01/29	146	20	<			10	NA	NA	7.88	NA	7
96/02/12	104	20	<			10	NA	NA	5.61	NA	5
96/03/11	87	20	<			10	NA	NA	4.69	NA	3
96/04/15	99	20	<			10	NA	NA	5.34	NA	2
96/05/13	164	20	<			10	NA	NA	8.85	NA	1
96/06/10	111	20	<			10	NA	NA	5.99	NA	16
96/07/15	95	20	<			10	NA	NA	5.12	NA	5
96/09/17	380	43.9		20	<	43.9	10	22.8	89.99	20.50	214
96/11/18	95	20	<			10	NA	NA	5.12	NA	2
97/01/13	167	20	<			10	NA	NA	9.01	NA	5
97/03/17	145	20	<			10	NA	NA	7.82	NA	4
97/05/27	76	9.4	J			9.4	NA	NA	3.85	NA	6
97/07/14	31	13.9		3.6	J	13.9	3.6	25.9	2.32	0.60	6
97/09/15	21	11.1		10	U	11.1	5	45.0	1.26	0.57	6
97/11/17	37	7	J			7	NA	NA	1.40	NA	1
98/01/12	37	9.54	J		K	9.54	NA	NA	1.90	NA	1
98/03/17	76	3.66			K	3.66	NA	NA	1.50	NA	1
98/05/19	76	17		13.4		17	13.4	78.8	6.97	5.49	4
98/07/21	32	15.5		4.2	J	15.5	4.2	27.4	2.68	0.73	6
98/09/15	20	6.02	J		K	6.02	NA	NA	0.65	NA	4

White Clay Creek at Paper Mill Road
Summary Statistics for Zinc Concentration and Mass Loading

CONC. STATS FOR 7/21/93 - 9/15/98

	TZinc (ug/L)	DZinc (ug/L)
avg	13.98	NA
median (50%tile)	10.00	NA
minimum	3.66	NA
maximum	63.90	42.00

MASS LOADING STATS FOR 7/21/93 - 9/15/98

	TZinc (#/day)	DZinc (#/day)
avg	7.82	NA
median (50%tile)	3.07	NA
minimum	0.32	0.57
maximum	89.99	27.19

CONC. STATS FOR 10/19/93 - 9/12/94 (WY '94)

avg	23.12	NA
median (50%tile)	10.00	NA
minimum	10.00	NA
maximum	63.90	42.00

MASS LOADING STATS FOR 10/19/93 - 9/12/94 (WY '94)

avg	13.94	NA
median (50%tile)	4.19	NA
minimum	0.86	2.30
maximum	50.24	27.19

CONC. STATS FOR 10/17/94 - 9/11/95 (WY '95)

avg	10.00	NA
median (50%tile)	10.00	NA
minimum	10.00	NA
maximum	10.00	NA

MASS LOADING STATS FOR 10/17/94 - 9/11/95 (WY '95)

avg	1.93	NA
median (50%tile)	2.24	NA
minimum	0.32	NA
maximum	3.45	NA

CONC. STATS FOR 10/16/95 - 9/17/96 (WY '96)

avg	13.39	NA
median (50%tile)	10.00	NA
minimum	10.00	NA
maximum	43.90	10.00

MASS LOADING STATS FOR 10/16/95 - 9/17/96 (WY '96)

avg	14.10	NA
median (50%tile)	5.34	NA
minimum	2.32	NA
maximum	89.99	20.50

CONC. STATS FOR 11/18/96 - 9/15/97 (WY '97)

avg	10.73	NA
median (50%tile)	10.00	NA
minimum	9.40	3.60
maximum	13.90	5.00

MASS LOADING STATS FOR 11/18/96 - 9/15/97 (WY '97)

avg	4.90	NA
median (50%tile)	4.49	NA
minimum	1.26	0.57
maximum	9.01	0.60

CONC. STATS FOR 11/17/97 - 9/15/98 (WY '98)

avg	9.79	NA
median (50%tile)	8.27	NA
minimum	3.66	4.20
maximum	17.00	13.40

MASS LOADING STATS FOR 11/17/97 - 9/15/98 (WY '98)

avg	2.52	NA
median (50%tile)	1.70	NA
minimum	0.65	0.73
maximum	6.97	5.49

Chambers Rock Road/Paper Mill Road
Freshwater Aquatic Life Criteria for Zinc

Date	THard (mg/L)	CMC_t (ug/L)	CCC_t (ug/L)	CMC_d (ug/L)	CCC_d (ug/L)
93/07/21	104	121.0	109.6	118.3	108.0
93/08/18	112	128.8	116.7	126.0	115.0
93/09/23	92	109.0	98.8	106.6	97.4
93/10/19	90	107.0	96.9	104.7	95.6
93/11/15	84	101.0	91.4	98.7	90.2
93/12/14	88	105.0	95.1	102.7	93.8
94/03/14	92	109.0	98.8	106.6	97.4
94/04/18	92	109.0	98.8	106.6	97.4
94/05/16	114	130.8	118.4	127.9	116.8
94/06/14	128	144.2	130.7	141.1	128.8
94/07/18	108	124.9	113.1	122.2	111.5
94/08/15	134	150.0	135.8	146.7	133.9
94/09/12	148	163.1	147.8	159.5	145.7
94/10/17	124	140.4	127.2	137.3	125.4
94/12/12	112	128.8	116.7	126.0	115.0
95/01/17	110	126.9	114.9	124.1	113.3
95/03/13	118	134.6	121.9	131.7	120.2
95/04/17	120	136.6	123.7	133.6	122.0
95/05/15	110	126.9	114.9	124.1	113.3
95/06/19	128	144.2	130.7	141.1	128.8
95/07/17	88	105.0	95.1	102.7	93.8
95/08/14	134	150.0	135.8	146.7	133.9
95/09/11	148	163.1	147.8	159.5	145.7
95/10/16	118	134.6	121.9	131.7	120.2
95/11/13	100	117.0	106.0	114.4	104.5
96/01/29	98	115.0	104.2	112.5	102.7
96/02/12	106	122.9	111.4	120.2	109.8
96/03/11	116	132.7	120.2	129.8	118.5
96/04/15	98	115.0	104.2	112.5	102.7
96/05/13	98	115.0	104.2	112.5	102.7
96/06/10	96	113.0	102.4	110.6	101.0
96/07/15	108	124.9	113.1	122.2	111.5
96/09/17	144	159.4	144.4	155.9	142.3
96/11/18	114	130.8	118.4	127.9	116.8
97/01/13	102	119.0	107.8	116.4	106.3
97/03/17	104	121.0	109.6	118.3	108.0
97/05/27	94	111.0	100.6	108.6	99.2
97/07/14	122	138.5	125.4	135.4	123.7
97/09/15	128	144.2	130.7	141.1	128.8
97/11/17	124	140.4	127.2	137.3	125.4
98/01/12	126	142.3	128.9	139.2	127.1
98/03/17	110	126.9	114.9	124.1	113.3
98/05/19	118	134.6	121.9	131.7	120.2
98/07/21	123	139.5	126.3	136.4	124.5
98/09/15	133	149.0	135.0	145.7	133.1

Chambers Rock Road/Paper Mill Road
Zinc Criteria Exceedance

Date	CMC_t Ecorisk Index	CCC_t Ecorisk Index	CMC_d Ecorisk Index	CCC_d Ecorisk Index
93/07/21	0.083	0.091	NA	NA
93/08/18	0.078	0.086	NA	NA
93/09/23	0.193	0.213	0.094	0.103
93/10/19	0.093	0.103	NA	NA
93/11/15	0.214	0.236	0.101	0.111
93/12/14	0.095	0.105	NA	NA
94/03/14	0.215	0.237	0.094	0.103
94/04/18	0.449	0.496	0.394	0.431
94/05/16	0.178	0.197	0.078	0.086
94/06/14	0.443	0.489	0.071	0.078
94/07/18	0.080	0.088	NA	NA
94/08/15	0.067	0.074	NA	NA
94/09/12	0.061	0.068	NA	NA
94/10/17	0.071	0.079	NA	NA
94/12/12	0.078	0.086	NA	NA
95/01/17	0.079	0.087	NA	NA
95/03/13	0.074	0.082	NA	NA
95/04/17	0.073	0.081	NA	NA
95/05/15	0.079	0.087	NA	NA
95/06/19	0.069	0.077	NA	NA
95/07/17	0.095	0.105	NA	NA
95/08/14	0.067	0.074	NA	NA
95/09/11	0.061	0.068	NA	NA
95/10/16	0.074	0.082	NA	NA
95/11/13	0.085	0.094	NA	NA
96/01/29	0.087	0.096	NA	NA
96/02/12	0.081	0.090	NA	NA
96/03/11	0.075	0.083	NA	NA
96/04/15	0.087	0.096	NA	NA
96/05/13	0.087	0.096	NA	NA
96/06/10	0.088	0.098	NA	NA
96/07/15	0.080	0.088	NA	NA
96/09/17	0.275	0.304	0.064	0.070
96/11/18	0.076	0.084	NA	NA
97/01/13	0.084	0.093	NA	NA
97/03/17	0.083	0.091	NA	NA
97/05/27	0.085	0.093	NA	NA
97/07/14	0.100	0.111	0.027	0.029
97/09/15	0.077	0.085	0.035	0.039
97/11/17	0.050	0.055	NA	NA
98/01/12	0.067	0.074	NA	NA
98/03/17	0.029	0.032	NA	NA
98/05/19	0.126	0.139	0.102	0.111
98/07/21	0.111	0.123	0.031	0.034
98/09/15	0.040	0.045	NA	NA

White Clay STORET No. 105151 (DE Park Race Track)
Concentration and Mass Loading Characterization

Date	Flow at Track (cfs)	TZinc (ug/L)	TZinc DQC	DZinc (ug/L)	DZinc DQC	TZinc with NDs=1/2DL (ug/L)	DZinc with NDs=1/2DL (ug/L)	Percent Dissolved Zinc	Mass Load Total Zn (lb/day)	Mass Load Dissolved Zn (lb/day)	TSS (mg/L)
93/07/21	47	32.5		26.1		32.5	26.1	80.3	8.24	6.62	5
93/08/18	43	41.5		20	<	41.5	10	24.1	9.63	2.32	4
93/09/23	42	30.6		23.2		30.6	23.2	75.8	6.93	5.26	1
93/10/19	44	40.4		40.5		40.4	40.5	100.0	9.59	9.61	5
93/11/15	55	126.9		37.2		126.9	37.2	29.3	37.65	11.04	3
93/12/14	82	46.6		28.5		46.6	28.5	61.2	20.61	12.61	2
94/03/14	427	74.4		25.6		74.4	25.6	34.4	171.38	58.97	35
94/04/18	141	37.7		35.3		37.7	35.3	93.6	28.68	26.85	4
94/05/16	274	64.4		48.3		64.4	48.3	75.0	95.19	71.39	227
94/06/14	62	24.2		20	<	24.2	10	41.3	8.09	3.34	6
94/07/18	132	43.8		20	<	43.8	10	22.8	31.19	7.12	159
94/08/15	42	20	<			10	NA	NA	2.27	NA	3
94/09/12	21	22.6		20	<	22.6	10	44.2	2.56	1.13	1
94/10/17	26	20	<			10	NA	NA	1.40	NA	1
94/12/12	81	26.2		22.5		26.2	22.5	85.9	11.45	9.83	10
95/01/17	67	20	<			10	NA	NA	3.61	NA	5
95/02/13	38	38.5		38.2		38.5	38.2	99.2	7.89	7.83	17
95/03/13	102	21.1		20	<	21.1	10	47.4	11.61	5.50	2
95/04/17	58	20	<			10	NA	NA	3.13	NA	5
95/05/15	67	20	<			10	NA	NA	3.61	NA	6
95/06/19	20	20	<			10	NA	NA	1.08	NA	2
95/07/17	57	29.7		23.1		29.7	23.1	77.8	9.13	7.10	38
95/08/14	18	20	<			10	NA	NA	0.97	NA	8
95/09/11	11	66.1		20	<	66.1	10	15.1	3.92	0.59	7
95/10/16	62	23.7		24		23.7	24	100.0	7.93	8.03	12
95/11/13	139	27.7		34.5		27.7	34.5	100.0	20.77	25.87	19
95/12/11	46	36.4		30.1		36.4	30.1	82.7	9.03	7.47	2
96/01/29	212	66.5		37.7		66.5	37.7	56.7	76.05	43.12	9
96/02/12	137	56.6		33.3		56.6	33.3	58.8	41.83	24.61	3
96/03/11	119	27.4		28.2		27.4	28.2	100.0	17.59	18.10	3
96/04/15	149	31.7		27		31.7	27	85.2	25.48	21.70	1
96/05/13	183	24.4		21		24.4	21	86.1	24.09	20.73	2
96/06/10	164	32.2		20	<	32.2	10	31.1	28.49	8.85	45
96/07/15	125	20	<			10	NA	NA	6.74	NA	12
96/09/17	562	103		20	<	103	10	9.7	312.28	30.32	46
96/11/18	109	20	<			10	NA	NA	5.88	NA	2
97/01/13	167	20	<			10	NA	NA	9.01	NA	5
97/03/17	188	20	<			10	NA	NA	10.14	NA	3
97/05/27	96	29.1		15.6		29.1	15.6	53.6	15.07	8.08	1
97/07/14	38	42.2		36.2		42.2	36.2	85.8	8.65	7.42	11
97/09/15	31	15.5		8.6	J	15.5	8.6	55.5	2.59	1.44	2
97/11/17	47	20.6		12.5		20.6	12.5	60.7	5.22	3.17	1
98/01/12	57	25.3		29.6		25.3	29.6	100.0	7.78	9.10	3
98/03/17	108	20.6		20.1		20.6	20.1	97.6	12.00	11.71	1
98/05/19	86	26.4		20.1		26.4	20.1	76.1	12.25	9.33	3
98/09/15	24	8.25	J		K	8.25	NA	NA	1.07	NA	4

White Clay STORET No. 105151 (DE Park Race Track)
Summary Statistics for Zinc Concentration and Mass Loading

CONC. STATS FOR 7/21/93 - 9/15/98

	TZinc (ug/L)	DZinc (ug/L)
avg	32.49	17.54
median (50%tile)	26.90	23.60
minimum	8.25	10.00
maximum	126.90	48.30

MASS LOADING STATS FOR 7/21/93 - 9/15/98

	TZinc (#/day)	DZinc (#/day)
avg	25.00	11.00
median (50%tile)	9.08	8.97
minimum	0.97	0.59
maximum	312.28	71.39

CONC. STATS FOR 10/19/93 - 9/12/94 (WY '94)

avg	49.10	24.54
median (50%tile)	42.10	28.50
minimum	10.00	10.00
maximum	126.90	48.30

MASS LOAD STATS FOR 10/19/93 - 9/12/94 (WY '94)

avg	40.72	20.21
median (50%tile)	24.65	11.04
minimum	2.27	1.13
maximum	171.38	71.39

CONC. STATS FOR 10/17/94 - 9/11/95 (WY '95)

avg	21.96	9.44
median (50%tile)	10.00	22.50
minimum	10.00	10.00
maximum	66.10	38.20

MASS LOAD STATS FOR 10/17/94 - 9/11/95 (WY '95)

avg	5.26	2.81
median (50%tile)	3.61	7.10
minimum	0.97	0.59
maximum	11.61	9.83

CONC. STATS FOR 10/16/95 - 9/17/96 (WY '96)

avg	39.96	23.25
median (50%tile)	31.70	27.60
minimum	10.00	10.00
maximum	103.00	37.70

MASS LOADING STATS FOR 10/16/95 - 9/17/96 (WY '96)

avg	51.84	18.98
median (50%tile)	24.09	21.22
minimum	6.74	6.74
maximum	312.28	43.12

CONC. STATS FOR 11/18/96 - 9/15/97 (WY '97)

avg	19.47	10.07
median (50%tile)	12.75	15.60
minimum	10.00	8.60
maximum	42.20	36.20

MASS LOAD STATS FOR 11/18/96 - 9/15/97 (WY '97)

avg	8.56	2.82
median (50%tile)	8.83	7.42
minimum	2.59	1.44
maximum	15.07	8.08

CONC. STATS FOR 11/17/97 - 9/15/98 (WY '98)

avg	20.23	16.46
median (50%tile)	20.60	20.10
minimum	8.25	8.25
maximum	26.40	29.60

MASS LOAD STATS FOR 11/17/97 - 9/15/98 (WY '98)

avg	7.66	6.66
median (50%tile)	7.78	9.21
minimum	1.07	3.17
maximum	12.25	11.71

DELAWARE PARK RACE TRACK
Freshwater Aquatic Life Criteria for Zinc

Date	THard (mg/L)	CMC_t (ug/L)	CCC_t (ug/L)	CMC_d (ug/L)	CCC_d (ug/L)
93/07/21	100	117.0	106.0	114.4	104.5
93/08/18	100	117.0	106.0	114.4	104.5
93/09/23	66	82.3	74.5	80.5	73.5
93/10/19	84	101.0	91.4	98.7	90.2
93/11/15	76	92.7	84.0	90.7	82.8
93/12/14	76	92.7	84.0	90.7	82.8
94/03/14	82	98.9	89.6	96.7	88.3
94/04/18	96	113.0	102.4	110.6	101.0
94/05/16	74	90.7	82.1	88.7	81.0
94/06/14	104	121.0	109.6	118.3	108.0
94/07/18	44	58.4	52.9	57.1	52.1
94/08/15	106	122.9	111.4	120.2	109.8
94/09/12	128	144.2	130.7	141.1	128.8
94/10/17	140	155.6	141.0	152.2	139.0
94/12/12	88	105.0	95.1	102.7	93.8
95/01/17	96	113.0	102.4	110.6	101.0
95/02/13	112	128.8	116.7	126.0	115.0
95/03/13	104	121.0	109.6	118.3	108.0
95/04/17	108	124.9	113.1	122.2	111.5
95/05/15	104	121.0	109.6	118.3	108.0
95/06/19	136	151.8	137.5	148.5	135.6
95/07/17	78	94.8	85.9	92.7	84.7
95/08/14	122	138.5	125.4	135.4	123.7
95/09/11	120	136.6	123.7	133.6	122.0
95/10/16	86	103.0	93.3	100.7	92.0
95/11/13	82	98.9	89.6	96.7	88.3
95/12/11	112	128.8	116.7	126.0	115.0
96/01/29	80	96.9	87.7	94.7	86.5
96/02/12	92	109.0	98.8	106.6	97.4
96/03/11	102	119.0	107.8	116.4	106.3
96/04/15	92	109.0	98.8	106.6	97.4
96/05/13	92	109.0	98.8	106.6	97.4
96/06/10	80	96.9	87.7	94.7	86.5
96/07/15	94	111.0	100.6	108.6	99.2
96/09/17	78	94.8	85.9	92.7	84.7
96/11/18	104	121.0	109.6	118.3	108.0
97/01/13	98	115.0	104.2	112.5	102.7
97/03/17	98	115.0	104.2	112.5	102.7
97/05/27	86	103.0	93.3	100.7	92.0
97/07/14	118	134.6	121.9	131.7	120.2
97/09/15	120	136.6	123.7	133.6	122.0
97/11/17	116	132.7	120.2	129.8	118.5
98/01/12	110	126.9	114.9	124.1	113.3
98/03/17	106	122.9	111.4	120.2	109.8
98/05/19	84	101.0	91.4	98.7	90.2
98/09/15	128	144.2	130.7	141.1	128.8

DELAWARE PARK RACE TRACK
Zinc Criteria Exceedance

Date	CMC_t Ecorisk Index	CCC_t Ecorisk Index	CMC_d Ecorisk Index	CCC_d Ecorisk Index
93/07/21	0.278	0.307	0.228	0.250
93/08/18	0.355	0.392	0.087	0.096
93/09/23	0.372	0.411	0.288	0.316
93/10/19	0.400	0.442	0.410	0.449
93/11/15	1.368	1.511	0.410	0.449
93/12/14	0.502	0.555	0.314	0.344
94/03/14	0.752	0.830	0.265	0.290
94/04/18	0.334	0.368	0.319	0.350
94/05/16	0.710	0.784	0.545	0.596
94/06/14	0.200	0.221	0.085	0.093
94/07/18	0.750	0.829	0.175	0.192
94/08/15	0.081	0.090	NA	NA
94/09/12	0.157	0.173	0.071	0.078
94/10/17	0.064	0.071	NA	NA
94/12/12	0.250	0.275	0.219	0.240
95/01/17	0.088	0.098	NA	NA
95/02/13	0.299	0.330	0.303	0.332
95/03/13	0.174	0.193	0.085	0.093
95/04/17	0.080	0.088	NA	NA
95/05/15	0.083	0.091	NA	NA
95/06/19	0.066	0.073	NA	NA
95/07/17	0.313	0.346	0.249	0.273
95/08/14	0.072	0.080	NA	NA
95/09/11	0.484	0.534	0.075	0.082
95/10/16	0.230	0.254	0.238	0.261
95/11/13	0.280	0.309	0.357	0.391
95/12/11	0.283	0.312	0.239	0.262
96/01/29	0.687	0.758	0.398	0.436
96/02/12	0.519	0.573	0.312	0.342
96/03/11	0.230	0.254	0.242	0.265
96/04/15	0.291	0.321	0.253	0.277
96/05/13	0.224	0.247	0.197	0.216
96/06/10	0.332	0.367	0.106	0.116
96/07/15	0.090	0.099	NA	NA
96/09/17	1.086	1.199	0.108	0.118
96/11/18	0.083	0.091	NA	NA
97/01/13	0.087	0.096	NA	NA
97/03/17	0.087	0.096	NA	NA
97/05/27	0.283	0.312	0.155	0.170
97/07/14	0.313	0.346	0.275	0.301
97/09/15	0.113	0.125	0.064	0.071
97/11/17	0.155	0.171	0.096	0.105
98/01/12	0.199	0.220	0.239	0.261
98/03/17	0.168	0.185	0.167	0.183
98/05/19	0.262	0.289	0.204	0.223
98/09/15	0.057	0.063	NA	NA

White Clay STORET No. 105011(Stanton, Old Rt. 7 Bridge)
Concentration Characterization

Date	TZinc (ug/L)	TZinc DQC	DZinc (ug/L)	DZinc DQC	TZinc with NDs=1/2DL (ug/L)	DZinc with NDs=1/2DL (ug/L)	Percent Dissolved	TSS (mg/L)
94/03/14	57.6		25.9		57.6	25.9	45.0	39
94/04/18	20	<			10	NA	NA	3
94/05/16	87.7		20	<	87.7	10	11.4	200
94/06/14	24		20	<	24	10	41.7	4
94/07/18	103.6		20	<	103.6	10	9.7	237
94/08/15	31.3		22.3		31.3	22.3	71.2	14
94/09/12	20	<			10	NA	NA	4
94/10/17	22.2		20	<	22.2	10	45.0	2
94/12/12	28.2		29.7		28.2	29.7	100.0	9
95/01/17	20.7		20	<	20.7	10	48.3	3
95/02/13	39.6		33.7		39.6	33.7	85.1	17
95/03/13	24		20	<	24	10	41.7	4
95/04/17	20.7		20	<	20.7	10	48.3	6
95/05/15	20	<			10	NA	NA	9
95/06/19	20	<			10	NA	NA	1
95/07/17	30.4		20	<	30.4	10	32.9	54
95/08/14	20	<			10	NA	NA	4
95/09/11	20	<			10	NA	NA	7
95/10/16	20	<			10	NA	NA	10
95/11/13	35.2		31.1		35.2	31.1	88.4	22
95/12/11	23.3		22.9		23.3	22.9	98.3	4
96/01/29	61.1		35.6		61.1	35.6	58.3	13
96/02/12	42.6		32.9		42.6	32.9	77.2	3
96/03/11	29.6		24.4		29.6	24.4	82.4	7
96/04/15	29.2		27.4		29.2	27.4	93.8	3
96/05/13	23.5		27.6		23.5	27.6	100.0	6
96/06/10	37.2		20	<	37.2	10	26.9	46
96/07/15	20.6		22.4		20.6	22.4	100.0	13
96/09/17	43.3		20	<	43.3	10	23.1	116
96/11/18	20	<			10	NA	NA	4
97/01/13	27.6		25.5		27.6	25.5	92.4	4
97/03/17	20	<			10	NA	NA	6
97/05/27	18.7		18.8		18.7	18.8	100.0	7
97/07/14	31.3		14.6		31.3	14.6	46.6	2
97/09/15	11.7		13.3		11.7	13.3	100.0	7
97/11/17	25		13.7		25	13.7	54.8	4
98/01/12	27.9		14.3		27.9	14.3	51.3	1
98/03/17	31.5		24.5		31.5	24.5	77.8	1
98/05/19	24.1		20.7		24.1	20.7	85.9	6
98/07/21	24.4		15.3		24.4	15.3	62.7	6
98/09/15	13.4		8.5	J	13.4	8.5	63.4	3

White Clay Creek at Stanton
Summary Statistics for Zinc Concentration

CONC. STATS FOR 3/14/94 - 9/15/98

	TZinc (ug/L)	DZinc (ug/L)
avg	28.32	NA
median (50%tile)	24.10	NA
minimum	10.00	8.50
maximum	103.60	35.60

CONC. STATS FOR 3/14/94 - 9/12/94 (WY '94 partial)

avg	46.31	NA
median (50%tile)	31.30	NA
minimum	10.00	10.00
maximum	103.60	25.90

CONC. STATS FOR 10/17/94 - 9/11/95 (WY '95)

avg	20.53	NA
median (50%tile)	20.70	NA
minimum	10.00	10.00
maximum	39.60	33.70

CONC. STATS FOR 10/16/95 - 9/17/96 (WY '96)

avg	32.33	NA
median (50%tile)	29.60	NA
minimum	10.00	10.00
maximum	61.10	35.60

CONC. STATS FOR 11/18/96 - 9/15/97 (WY '97)

avg	18.22	NA
median (50%tile)	15.20	NA
minimum	10.00	10
maximum	31.30	25.50

CONC. STATS FOR 11/17/97 - 9/15/98 (WY '98)

avg	24.38	16.17
median (50%tile)	24.70	14.80
minimum	13.40	8.50
maximum	31.50	24.50

Stanton
Freshwater Aquatic Life Criteria for Zinc

Date	THard (mg/L)	CMC_t (ug/L)	CCC_t (ug/L)	CMC_d (ug/L)	CCC_d (ug/L)
94/03/14	80	96.9	87.7	94.7	86.5
94/04/18	106	122.9	111.4	120.2	109.8
94/05/16	76	92.7	84.0	90.7	82.8
94/06/14	114	130.8	118.4	127.9	116.8
94/07/18	54	69.4	62.9	67.9	62.0
94/08/15	112	128.8	116.7	126.0	115.0
94/09/12	122	138.5	125.4	135.4	123.7
94/10/17	122	138.5	125.4	135.4	123.7
94/12/12	94	111.0	100.6	108.6	99.2
95/01/17	100	117.0	106.0	114.4	104.5
95/02/13	110	126.9	114.9	124.1	113.3
95/03/13	104	121.0	109.6	118.3	108.0
95/04/17	102	119.0	107.8	116.4	106.3
95/05/15	108	124.9	113.1	122.2	111.5
95/06/19	114	130.8	118.4	127.9	116.8
95/07/17	76	92.7	84.0	90.7	82.8
95/08/14	128	144.2	130.7	141.1	128.8
95/09/11	116	132.7	120.2	129.8	118.5
95/10/16	94	111.0	100.6	108.6	99.2
95/11/13	66	82.3	74.5	80.5	73.5
95/12/11	98	115.0	104.2	112.5	102.7
96/01/29	82	98.9	89.6	96.7	88.3
96/02/12	100	117.0	106.0	114.4	104.5
96/03/11	98	115.0	104.2	112.5	102.7
96/04/15	92	109.0	98.8	106.6	97.4
96/05/13	80	96.9	87.7	94.7	86.5
96/06/10	78	94.8	85.9	92.7	84.7
96/07/15	114	130.8	118.4	127.9	116.8
96/09/17	90	107.0	96.9	104.7	95.6
96/11/18	110	126.9	114.9	124.1	113.3
97/01/13	108	124.9	113.1	122.2	111.5
97/03/17	102	119.0	107.8	116.4	106.3
97/05/27	88	105.0	95.1	102.7	93.8
97/07/14	124	140.4	127.2	137.3	125.4
97/09/15	118	134.6	121.9	131.7	120.2
97/11/17	110	126.9	114.9	124.1	113.3
98/01/12	110	126.9	114.9	124.1	113.3
98/03/17	104	121.0	109.6	118.3	108.0
98/05/19	117	133.7	121.1	130.7	119.4
98/07/21	121	137.5	124.6	134.5	122.8
98/09/15	260	263.0	238.2	257.2	234.8

Stanton
Zinc Criteria Exceedance

Date	CMC_t Ecorisk Index	CCC_t Ecorisk Index	CMC_d Ecorisk Index	CCC_d Ecorisk Index
94/03/14	0.595	0.657	0.273	0.299
94/04/18	0.081	0.090	NA	NA
94/05/16	0.946	1.044	0.110	0.121
94/06/14	0.184	0.203	0.078	0.086
94/07/18	1.492	1.648	0.147	0.161
94/08/15	0.243	0.268	0.177	0.194
94/09/12	0.072	0.080	NA	NA
94/10/17	0.160	0.177	0.074	0.081
94/12/12	0.254	0.280	0.273	0.299
95/01/17	0.177	0.195	0.087	0.096
95/02/13	0.312	0.345	0.272	0.297
95/03/13	0.198	0.219	0.085	0.093
95/04/17	0.174	0.192	0.086	0.094
95/05/15	0.080	0.088	NA	NA
95/06/19	0.076	0.084	NA	NA
95/07/17	0.328	0.362	0.110	0.121
95/08/14	0.069	0.077	NA	NA
95/09/11	0.075	0.083	NA	NA
95/10/16	0.090	0.099	NA	NA
95/11/13	0.428	0.472	0.386	0.423
95/12/11	0.203	0.224	0.204	0.223
96/01/29	0.618	0.682	0.368	0.403
96/02/12	0.364	0.402	0.287	0.315
96/03/11	0.257	0.284	0.217	0.238
96/04/15	0.268	0.296	0.257	0.281
96/05/13	0.243	0.268	0.291	0.319
96/06/10	0.392	0.433	0.108	0.118
96/07/15	0.158	0.174	0.175	0.192
96/09/17	0.405	0.447	0.096	0.105
96/11/18	0.079	0.087	NA	NA
97/01/13	0.221	0.244	0.209	0.229
97/03/17	0.084	0.093	NA	NA
97/05/27	0.178	0.197	0.183	0.200
97/07/14	0.223	0.246	0.106	0.116
97/09/15	0.087	0.096	0.101	0.111
97/11/17	0.197	0.218	0.110	0.121
98/01/12	0.220	0.243	0.115	0.126
98/03/17	0.260	0.287	0.207	0.227
98/05/19	0.180	0.199	0.158	0.173
98/07/21	0.177	0.196	0.114	0.125
98/09/15	0.051	0.056	0.033	0.036