September 11, 2012

Metropolitan Utilities District of Omaha
Engineering Memorandum No. 7
NPDES Studies
EE&T Project No. 12501

Subject: Florence PWTP – Evaluation of Selected Technologies to Reduce Solids Discharged to the Missouri River

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Introduction

The Florence Potable Water Treatment Plant (PWTP), operated by the Metropolitan Utilities District of Omaha (M.U.D.), is a split-treatment softening facility that currently discharges residuals that are generated during treatment to the Missouri River. This discharge is permitted under NPDES Permit No. NE0000914 which went into effect as of October 1, 2009. As part of this NPDES permit, the Nebraska Department of Environmental Quality (NDEQ) directed M.U.D. to conduct an evaluation of selected technologies to reduce solids discharged to the Missouri River. NDEQ specified that this evaluation shall include:

- Evaluation criteria
- Types of technology available to achieve solids removal
- Relationship between costs and the degree of solids removal
- The total cost of application of technology in relation to the effluent reduction benefits to be achieved from such application
- Non-water quality environmental impacts of solids removal

Each of these objectives will be addressed in the following sections.

Evaluation Criteria

The evaluation criteria used for this study, as outlined in the Study Plan for the Evaluation of Water Quality Impacts from the Discharge of Solids and Solids Reduction Technologies at the Florence PWTP that was submitted to NDEQ in September 2010, are listed below.

- Capital Cost
- Operations and Maintenance Costs
- Required Process Footprints
- Operational Complexity
- Degree of Solids Removal
- Non-water Quality Environmental Impacts of Solids Removal.

Capital costs and operations and maintenance costs were developed using the Minimizing Water Treatment Residual Discharges to Surface Water Decision Support Tool published by the Water Research Foundation (Cornwell *et al.*, 2010). This tool contains a Residuals Treatment Process Sizing and Costing module, which can be used to quickly develop budget-level cost estimates for residuals treatment processes based on plant-specific information, such as solids production rate, desired dewatering schedule, etc. The accuracy of the costing model that this module is based upon was demonstrated previously by Roth *et al.* (2008).

The capital cost, operations and maintenance costs, required process footprints, and degree of solids removal criteria are discussed in the sections Relationship Between Costs and the Degree of Solids Removal and Total Cost of Application of Technology in Relation to the Effluent Reduction Benefits. The operational complexity criterion is discussed in the section Types of Technology Available to Achieve Solids Removal. Non-water quality environmental impacts of solids removal is discussed in its own section.

Types of Technology Available to Achieve Solids Removal

Before evaluating the types of technology available to achieve solids removal at Florence PWTP, it is important to consider the types of solids that are generated at the plant. Solid residuals generated at drinking water treatment plants using a split-treatment softening process generally consist of: a) natural particles present in the raw water removed by the treatment process, b) metal salt precipitates generated by the coagulation process, and c) calcium carbonate and/or magnesium hydroxide particles generated by the lime softening process. Of these, the calcium carbonate/magnesium hydroxide particles generally comprise the largest portion of solids generated, although the final makeup of the sludge depends on site-specific characteristics.

Florence is supplied by the Missouri River, so the solids in the raw water that the plant treats vary considerably, as indicated by raw water turbidity. The minimum, median, and maximum recorded turbidity levels of the raw water treated between January 1, 2007 and February 21, 2010 were 8, 61, and 1,765 ntu, respectively. The raw water is conveyed through 200-ft diameter pre-sedimentation basins before treatment, where a portion of the solids are allowed to settle. These solids are periodically discharged daily back to the river. Because not all solids settle out, treatment requires the use of a coagulant, in the form of aluminum sulfate, at Florence. During the period evaluated for this study, the aluminum sulfate dose fed at the plant ranged from 5.7 to 52.1 mg/L as neat product. Ninety percent of the time the aluminum sulfate dose was 13 mg/L or less.

The suspended solids that are not discharged to the river in the pre-sedimentation basin discharges have to be accounted for in the solids production calculations. Because the data available for Florence is recorded in nephelometric turbidity units (ntu), and not suspended solids, a conversion is needed to estimate the solids that will be coagulated during treatment. The conversion from ntu to mg/L of suspended solids (SS) is not exact and has to be estimated. Typically values of 0.7 to 2.2 mg/L-SS/ntu are used to estimate SS when calculating solids production (Cornwell, 2006). For this study, a conversion rate of 1.5 mg/L/ntu was used for calculations.

Records for effluent turbidity out of the pre-sedimentation basins were not readily available in an electronic format that could be matched to the daily operating data; therefore, to estimate the amount of solids discharged to the river from the pre-sedimentation basins it was necessary to estimate the removal of raw water solids in the pre-sedimentation basins. These estimates were based on data collected from other treatment plants on the Missouri River, where were collected for other treatment plant studies. These data indicated that pre-sedimentation basins achieved 0.5-$\log_{10}$ removal of turbidity, on average, when treating Missouri River water. This removal rate was applied to the Florence raw water data to determine the turbidity in the pre-sedimentation effluent. Figure 1 shows the relationship between raw water turbidity and pre-sedimentation effluent turbidity assumed for this study. For this study, a 0.5-log_{10} removal was applied to the raw water turbidity to for solids production calculations.

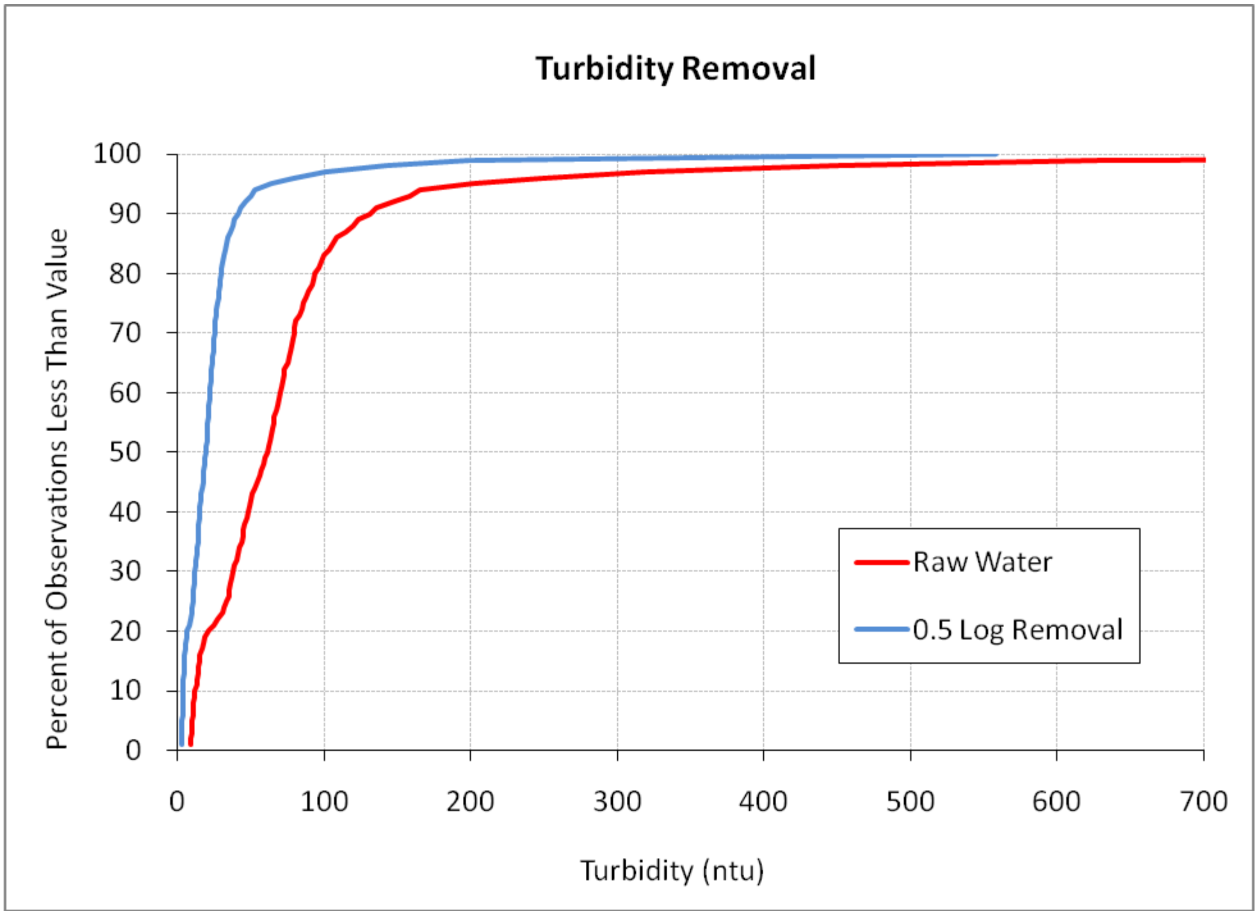

Figure 1: Pecentile distribution of raw water turbidity and estimated, post pre-sedimentation basin blowdown turbidity

Though, turbidity and coagulant do account for a fraction of the total solids production, the majority of solids generated by the plant are softening residuals (primarily calcium carbonate with some magnesium hydroxide). Plant operating records from January 2007 through February 2010 were used to calculate solids production at Florence PWTP. The solids that were produced were broken down into three components: coagulation residuals (aluminum hydroxide), softening residuals (calcium carbonate and magnesium hydroxide), and raw water solids (those solids in the raw water that are removed by the treatment process). Figure 2 shows the solids production during the period studied, by component. During this period, more than 83 percent of the daily solids production at Florence PWTP was attributable to softening residuals, on average.

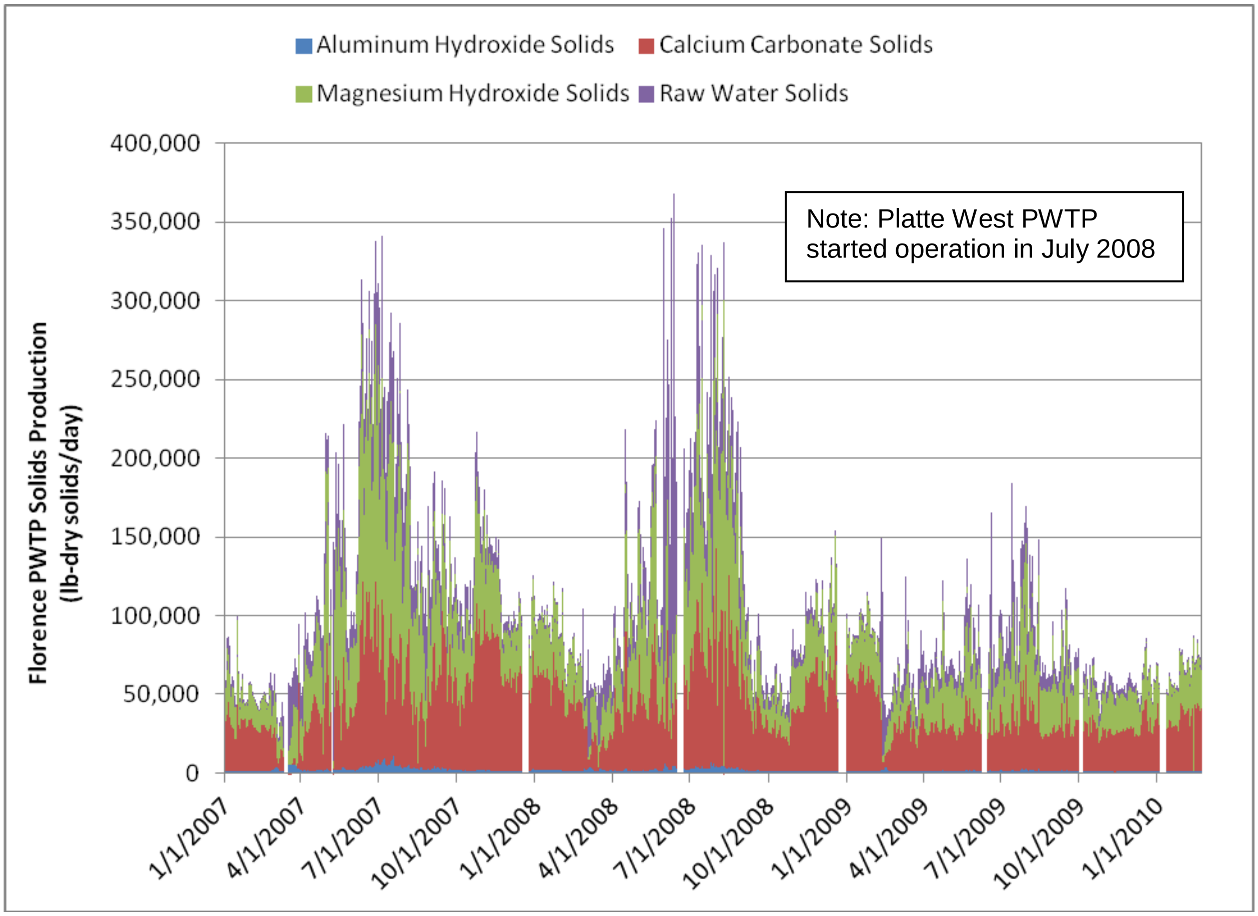

Figure 2. Total solids production at Florence PWTP by component

Since the solids are dominated by softening residuals, certain handling characteristics can be assumed. Because calcium carbonate particles are generally denser and more compact than other types of drinking water treatment residuals, they will thicken and dewater more readily (Cornwell and Roth, 2011).

However, there are also fewer options available to minimize the production of solids at the Florence PWTP and thus, to minimize the discharge of solids to the Missouri River. The production of solids is inherent in the lime softening process; softening is achieved by converting dissolved solids (Ca^{2+} and Mg^{2+}) to suspended solids, which can then be removed from the treated water via settling. The only option available to minimize solids production is to reduce the amount of Ca^{2+} and Mg^{2+} that are removed, which effectively raises the finished water hardness leaving the plant. However, M.U.D. appears to have already optimized their treatment to reduce solids production at the Florence PWTP. Most utilities generally target a finished water hardness of 75 to 150 mg/L as $CaCO_3$ with their softening processes (Randtke, 2011).

During the study period, the median finished water hardness produced at Florence was 194 mg/L as $CaCO_3$, indicating that there is little to no room available for raising the target finished water hardness to further reduce solids.

One common strategy to reduce solids production is to optimize coagulation or switch to alternative coagulants to reduce the amount of chemical precipitate produced by the treatment process. However, as Figure 2 shows, the residuals from the coagulation process comprise only a small portion of the overall solids production at Florence PWTP. Reducing the amount of coagulation residuals produced at the plant would have a negligible effect on solids production for the Florence PWTP.

Another strategy to reduce solids production, which is currently being implemented at the Florence PWTP, is to settle raw water solids before treatment in pre-sedimentation basins to reduce the amount of solid material actually removed by the treatment processes. As discussed previously, data from other plants on the Missouri River show that this achieves a 0.5-$\log_{10}$ removal in raw water solids, as measured by turbidity. However, it may be possible to further increase the amount of solids removed by using an advanced settling technology such as tube settlers or lamella plate settlers.

In order to evaluate the benefit gained from additional pre-sedimentation, the percentage of the total solids production comprised of raw water solids was examined for the peak solids production days during this period. Even though the solids produced at the Florence PWTP are dominated by softening residuals, additional pre-sedimentation could be beneficial if those days of peak solids production were dominated by raw water solids. At first glance, it appears that this may be the case; for the day with the single highest solids production during this period approximately 80 percent of the solids produced at the plant were raw water solids. This might suggest that further removing raw water solids would limit the peak daily solids production at Florence. However, further investigation reveals this not to be the case; when the looking at the top six days of solids production, on three of those days less than 16 percent of the solids production was attributable to raw water solids. Even if pre-sedimentation were enhanced at Florence, there amount of solids produced during peak days would not decrease because some of those peaks are dominated by softening residuals. Further, because the amount of raw water solids in the residuals at Florence is proportional to the amount of solids in the Missouri River, during days of peak raw water solids the river already has high solids content. It is unlikely that discharging large amounts of solids during those periods would impact the river, because of the large amount of solids in the river at that time. Therefore, there appears to be little reason to increase the pre-sedimentation capabilities at the Florence PWTP.

The only other option to minimize solids production at Florence would be to change the primary treatment process to one that produces fewer solids, such as membrane softening. However, such an effort would require essentially re-building the Florence PWTP, and would produce it own residuals (a high-TDS concentrate waste stream) with inherent disposal difficulties. Such an option was not considered feasible for the purposes of this study.

Since options are limited for minimizing the production of solids at Florence, methods to remove solids from the plant's waste streams before they are discharged to the Missouri River must be considered. This involves separating and concentrating the solids from waste streams at the plant (clarifier basin blowdown and spent filter backwash water) and dewatering them sufficiently that they can be trucked off-site. Liquid waste streams would continue to be discharged to the Missouri River, although the amount of solids in those streams would be greatly reduced.

A conceptual design schematic for a drinking water treatment plant residuals treatment system is shown in Figure 3. This schematic is very similar to that used at the Platte West PWTP, which currently treats its residuals due to the lack of a suitable discharge.

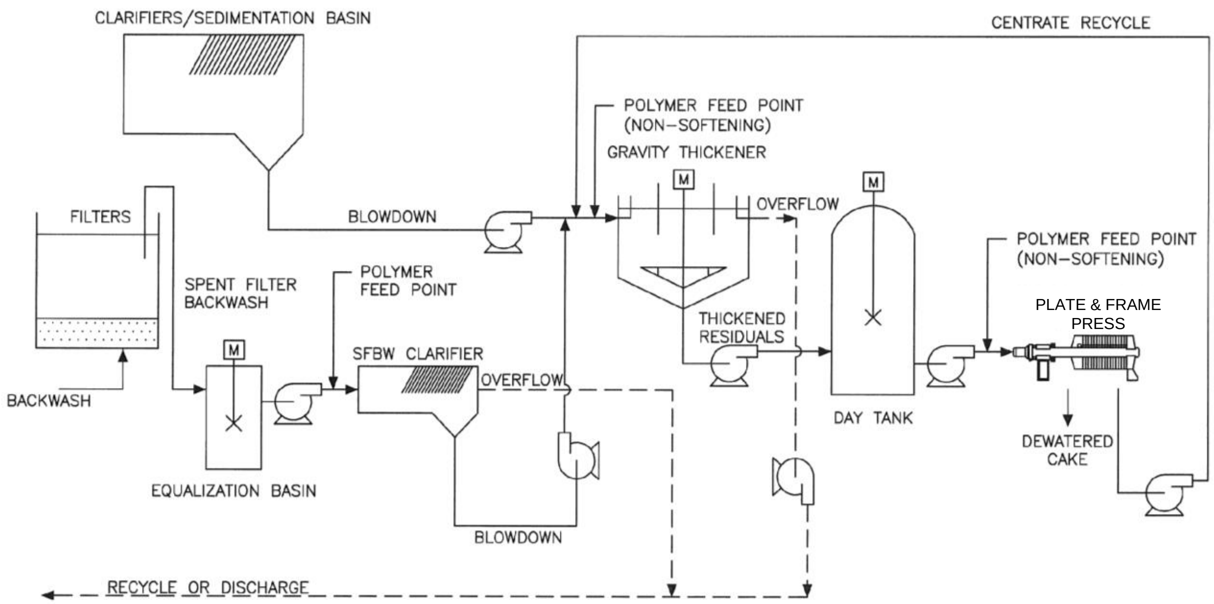

Figure 3: Conceptual design schematic for a typical residuals treatment system

There are three primary treatment steps shown in Figure 3: thickening, dewatering, and spent filter backwash water (SFBW) clarification. The first, thickening, is used to reduce the volume of solids requiring treatment, and increases the solids concentration of the sludge for the downstream dewatering process. Gravitational thickening processes are used almost exclusively in the water industry (Cornwell and Roth, 2011), so no consideration was made to alternate thickening technologies (belt-thickeners, etc.) for the purposes of this study.

Dewatering can be accomplished via mechanical or non-mechanical methods. The most commonly used mechanical dewatering technologies for softening solids are filter presses, such as plate-and-frame presses or diaphragm presses, and centrifuges. Belt filter presses are not recommended for softening sludges based on operator feedback concerning the difficulties in keeping such presses clean. Capital costs for similar-capacity filter presses and centrifuges are generally comparable. Operating costs for filter presses may be higher, as more operator attention is required to make sure that the cake separate from the filter clothes successfully while operating, but maintenance costs for centrifuges may be higher due to the relatively high level of abrasion caused by calcium carbonate particles. Mechanical dewatering processes are commonly preceded by mixed day tanks; the purpose of these tanks is to ensure that a homogeneous sludge is fed to the dewatering process.

The other type of dewatering method used for drinking water treatment plant residuals is non-mechanical dewatering. In this type of process, residuals are loaded into an open bed or lagoon and water is removed from the sludge through draining, decanting, and evaporation. Due to the quantity of sludge produced at softening plants, dewatering lagoons are the most commonly used non-mechanical dewatering process for softening residuals, because they can accommodate relatively high solids loading rates.

SFBW clarification is used to remove solids from the SFBW. Unlike clarifier blowdown, SFBW is relatively low in solids and high in volume. Several high-rate clarification processes have been tested for use in treating SFBW, but because softening residuals are relatively amenable to clarification, a simple gravity clarification process should be adequate for treating SFBW at Florence. Because SFBW is generated at high rates over a short time frame, it is often economical to add equalization basins prior to the SFBW clarification to attenuate the SFBW flows before reaching the clarification step. Solids collected by the SFBW clarification process are typically sent to the thickeners for further treatment.

Relationship between Costs and the Degree of Solids Removal

Degree of solids removal

As discussed above, there are not practical options to further minimize the amount of residuals produced at the Florence PWTP; therefore, any reduction in solids discharged to the Missouri River would be associated with residuals treatment systems installed at Florence. The cost of constructing and operating such systems will depend primarily on the system's size.

Figure 4 presents a percentile distribution of the historical daily solids production at Florence over the period analyzed for this study (January 2007 through February 2010). During this period, the median daily solids production was 85,545 lb-dry solids/day (42.8 tons-dry solids/day) with a maximum daily solids production of 368,318 lb-dry solids/day (184.2 tons-dry/day). For comparison, daily suspended solids data for the Missouri River was obtained from USGS Station 06610000, which is the closest station to the discharge from Florence. Data prior to October 1, 2008 was not available for this station. For the period that was available (October 2008 through February 2010), the median daily solids discharged through Station 06610000 was

34.3×10^6 lb-dry solids/day (17,150 tons-dry solids/day), with a maximum daily solids discharge of 572×10^6 lb-dry solids/day (286,000 tons-dry solids/day). The contribution that the daily solids production would make to the Missouri River solids concentration was calculated based on paired data available during the study period; a percentile plot of this data is shown in Figure 5. This figure assumes all solids generated at Florence on a given day are discharged to the Missouri River.

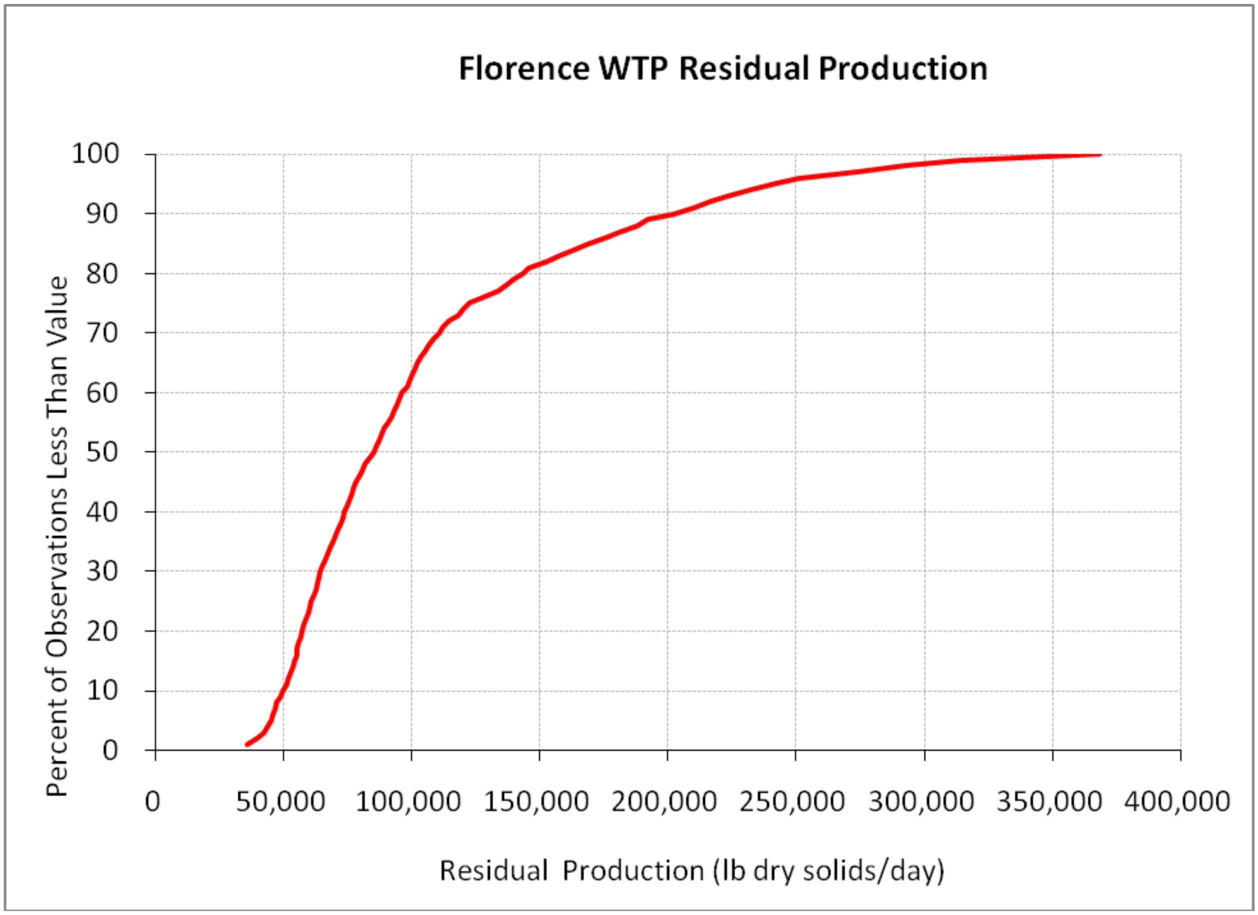

Figure 4: Percentile distribution of the daily calculated solids production at Florence PWTP based on historical data (January 2007 – February 2010)

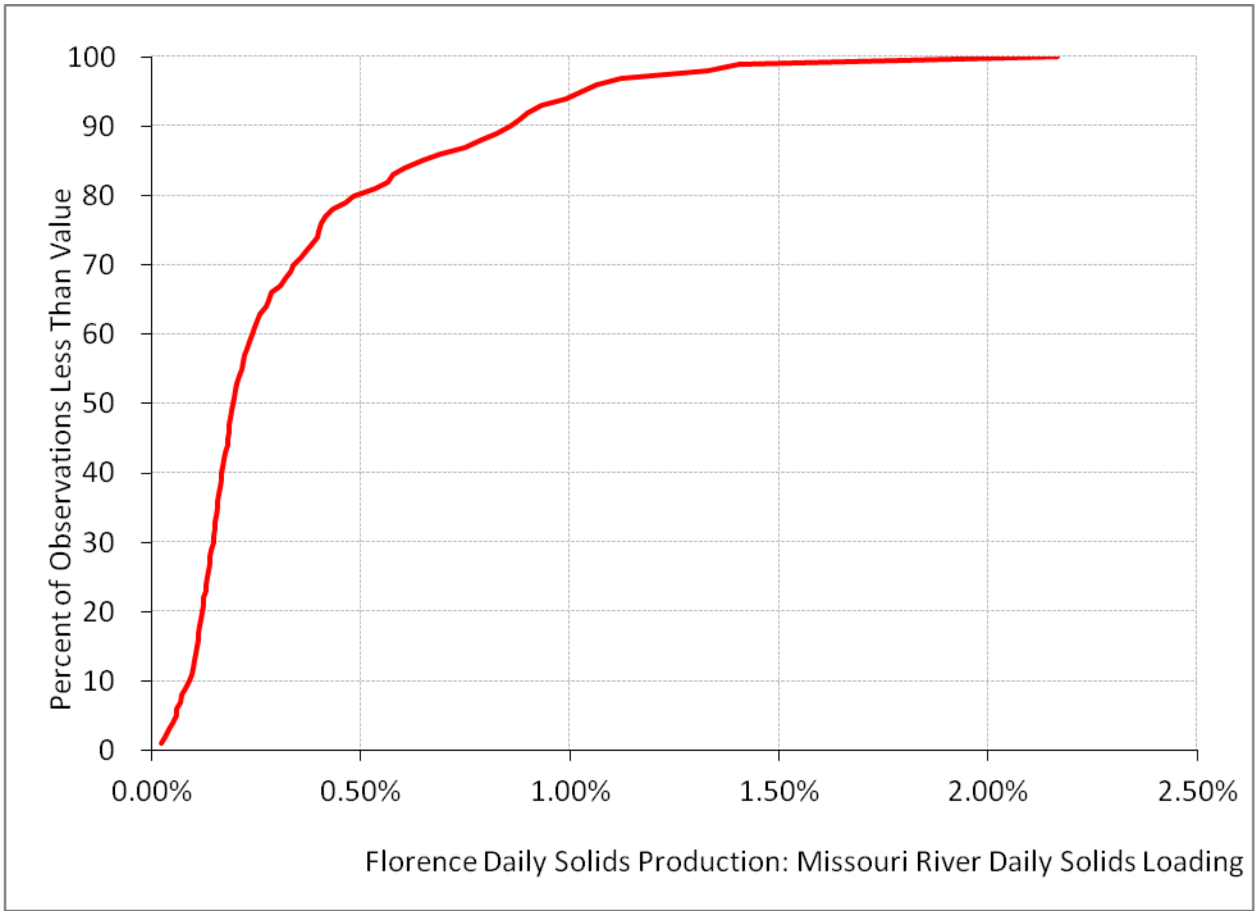

Figure 5: Percentile distribution of the daily calculated solids production at Florence PWTP as a percentage of the total daily solids loading in the Missouri River

As Figure 5 shows, on the maximum day, the solids generate at Florence comprise less than 2.2 percent of the total solids carried by the Missouri River at the location of the discharge. This value decreases significantly as the top values are excluded. A majority of the time Florence would contribute less than 0.3 percent of the total solids in the Missouri River, with a median daily solids contribution of 0.2 percent.

Although the contribution of solids from Florence to the Missouri River is relatively small compared to the amount of solids already present in the river, residuals treatment can be implemented at Florence to reduce the amount of residuals discharged to the river. For the purposes of this study, various levels of treatment were analyzed; cost estimates for systems designed to treat the 50th, 65th, 75th, 90th, and 100th percentile of solids production at Florence were developed using the cost tool described previously. The solids productions corresponding to these percentiles are shown in Table 1.

Table 1: Residual Production Quantities

Percentile	50^{th}	65^{th}	75^{th}	90^{th}	100^{th}
Residual production (lb-dry solids/day)	85,545	102,472	122,584	202,275	368,318

For the purposes of this study, it was assumed that the residuals treatment systems would have a maximum capacity corresponding to the design residuals production, and that any solids produced in excess of that design residuals production would be discharged to the river. For example, if on a given day the solids production was 100,000 lb-dry solids/day, and the system were designed for the 50^{th} percentile, 85,545 lbs of solids would be treated and the remaining 14,455 lbs of solids would be discharged to the Missouri River. In practice the residuals treatment systems would be designed to accommodate some storage of residuals above its design capacity; for example, in the previous example the thickeners might be able to store the extra 14,455 lbs of solids until the dewatering process was able to accommodate the extra solids. However, for the purposes of this study, it is useful to assume the extra solids are discharged to the river to illustrate the relationship between costs and the degree of solids removal.

If residuals treatment systems were to be constructed to treat the daily solids productions shown in Table 1, the resulting solids discharged to the Missouri River would be as shown in Figure 6.

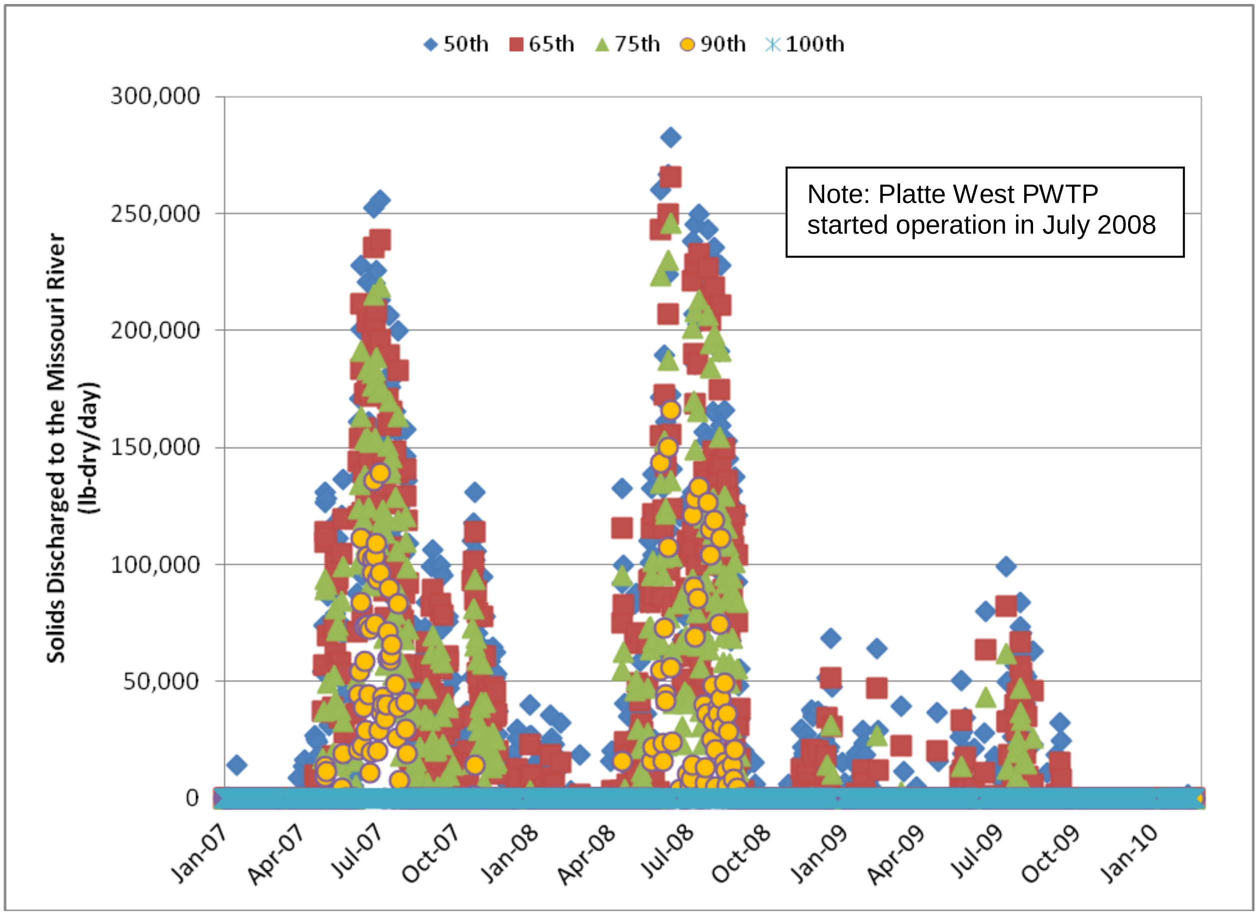

Figure 6. Daily mass of solids discharged to the Missouri River based on the percentile of daily solids production used to size residuals treatment systems

As Figure 5 shows, as the size of the residuals treatment system increases, the number of days that solids are discharged to the river and the mass of solids discharged to the river decreases. Of course, if the system is designed to accommodate the 100th percentile of residuals production, all residuals are treated and on-site and none are discharged to the river.

If this data is analyzed as a percentage of the total solid loading in the Missouri River, as was shown in Figure 5, it can be seen that even a system designed to treat the 50th percentile of daily solids production significantly reduces the amount of solids discharged to the river. This data is shown in Figure 7. Note that there is no percentile distribution shown for discharges over the 90th percentile of solids production. This is because the plant's solids production did not exceed the 90th percentile during the time period when paired data were available (October 2008 through February 2010).

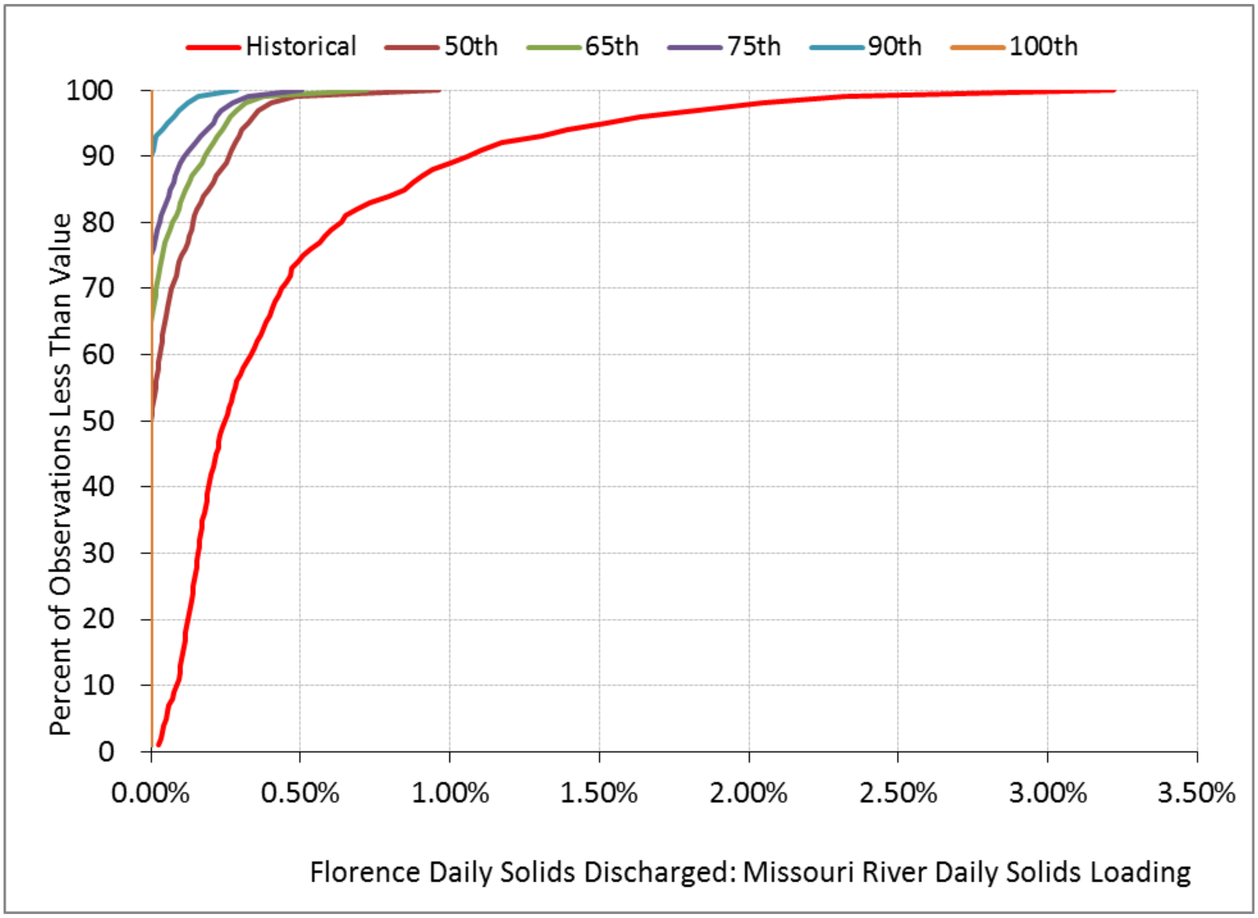

Figure 7: Percentile distribution of the daily solids discharged from Florence PWTP as a percentage of the total daily solids loading in the Missouri River for given levels of residuals treatment

Using the calculated solids production based on the historic operating data from the period analyzed for this study, we can determine the maximum annual solids that would be discharged to the Missouri River. These data are shown in Figure 8. As Figure 8 shows, a residuals treatment system designed to treat the 50^{th} percentile of the daily residuals production at the Florence PWTP would reduce the maximum annual solids discharge from Florence by 60 percent. This is further reduced as the size of the residuals treatment system increases, up to a 93 percent reduction with a system designed to treat the 90^{th} percentile solids production. If the system is sized to treat the 100^{th} percentile, no solids would be discharged to the Missouri River.

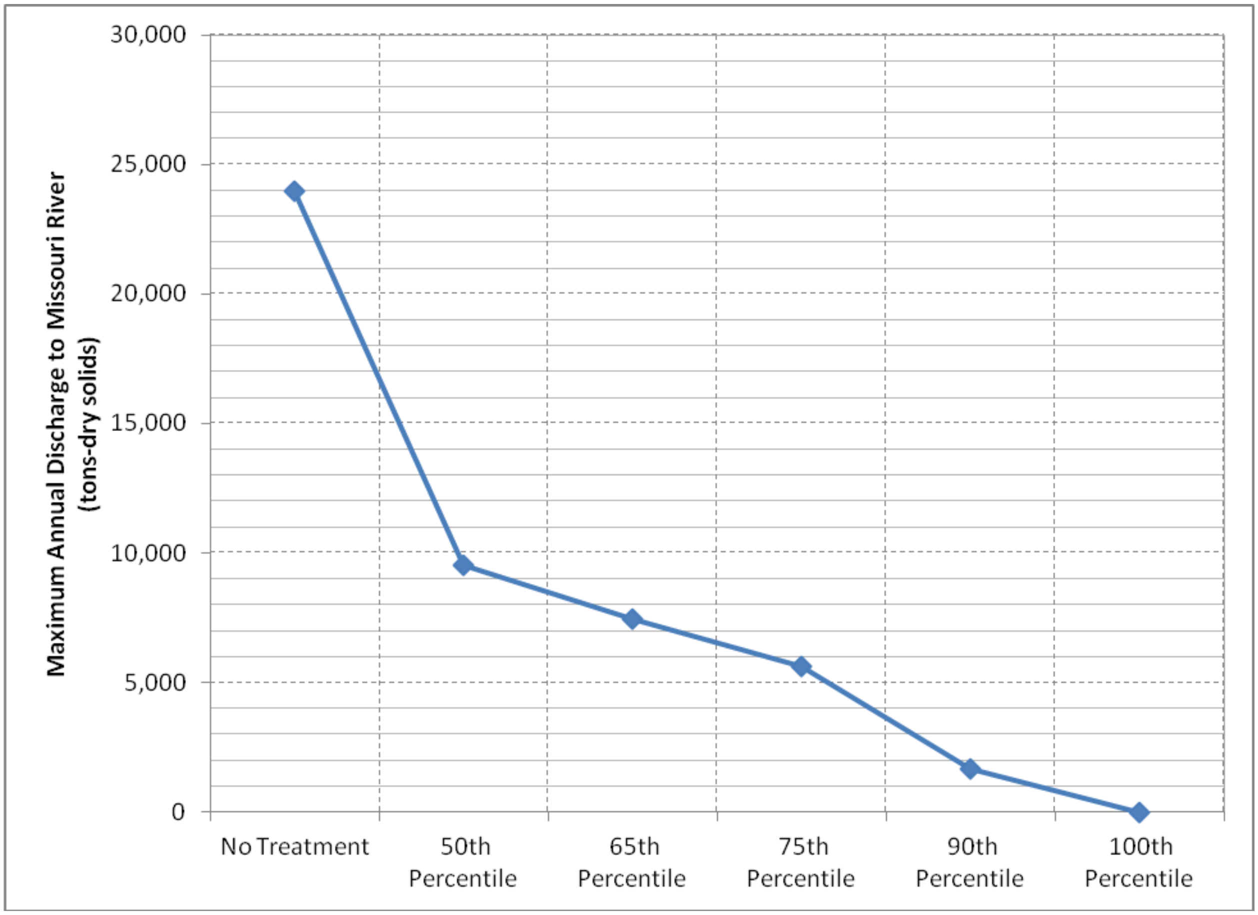

Figure 8: Comparison of maximum annual solids discharge to the Missouri River, for various levels of treatment.

As the above analysis shows, implementing residuals treatment at Florence can significantly reduce the amount of solids discharged from the plant to the Missouri River. The next section will present the total cost of applying residual treatment technologies. While the cost of these technologies can be quantified relative to the degree of solids removal, the effluent reduction benefits to be achieved from such application are unclear, as the amount of solids already in the Missouri River at the discharge significantly outweighs the solids contributed by the plant discharge.

Cost of residuals treatment

As described previously, process sizing and cost estimates were developed using the Residuals Treatment Process Sizing and Costing module in the Minimizing Water Treatment Residual Discharges to Surface Water Decision Support Tool published by the Water Research Foundation (Cornwell *et al.*, 2010).

Sizing of the day tanks, mechanical dewatering (centrifuge or plate and frame press), and thickeners is based primarily on the design solids production rates shown in Table 1. To size the SFBW treatment processes, an operational summary provided by M.U.D. was used. This summary included average filter run times, backwash duration, and normal backwash flow rates, as shown below.

- Worst case scenario would include eight filter backwashes in a single day.
- An hour between backwashes shall be used to develop a worst case backwash frequency.
- 224,000 gallons is representative of a "worst case" backwash volume.
- Using the typical 10 percent recycle rate is acceptable for SFBW treatment sizing.

These guidelines were inputted into the costing tool to assist with SFBW treatment costing with the various treatment scenarios.

The process sizes associated with each design scenario are shown in Table 2. The name, quantity, and size of each major component are outlined in the table. As Table 2 shows, except for SFBW treatment, as the residual production percentile increases the size of the process component increases. SFBW equalization (EQ) storage and treatment remain the same in each scenario as its sizing is based off of the operational parameters shown above.

The previous memorandum for the Platte South PWTP evaluated using a sludge lagoon for emergency storage of residuals in the event a residual process is down for service. Because of the limited space available at the Florence site, and direction from M.U.D., a lagoon was determined not feasible for the emergency storage. Instead, complete redundancy of equipment was incorporated into site layouts and cost estimates. The quantities listed of each basin or dewatering device in Table 2 include the additional redundant unit. Providing full redundancy allows the residuals treatment system to operate as designed when any one unit of each process is down for service or maintenance. An added benefit to full redundancy, when all units are operational, is the ability to treat more residuals than the designed capacity, allowing more flexibility during peak residual production events.

Table 2: Residuals Process Components

Percentile Treated	Required Day Tank Volume (gal)	Day Tank Diameter* (ft)	Day Tanks (Quantity)	Volume Provided (gal)
50	63,086	19	3	95,699
65	75,570	21	3	116,912
75	90,403	23	3	140,235
90	149,174	30	3	238,590
100	271,621	40	3	424,161

Percentile Treated	Required Centrifuge Capacity (lb/hr)	Centrifuges (Quantity)	Centrifuge Size (lb/hr)
50	14,970	4	6,000
65	17,933	4	6,000
75	21,452	3	12,000
90	35,398	4	12,000
100	64,456	7	12,000

Percentile Treated	Required Plate and frame press Capacity (lb/hr)	Plate and frame press (Quantity)	Plate and frame press Size (lb/hr)
50	14,970	4	5,625
65	17,933	4	6,750
75	21,452	5	5,625
90	35,398	7	6,750
100	64,456	11	6,750

Percentile Treated	Thickener Basins (Quantity)	Thickener Basin Diameter (ft)
50	4	72
65	4	78
75	4	86
90	4	110
100	5	128

Percentile Treated	SFBW EQ Tanks* (Quantity)	SFBW EQ Tank Diameter (ft)
All	4	42

Percentile Treated	SFBW Clarifiers* (Quantity)	SFBW Clarifier Diameter (ft)
All	3	43

*Diameters are determined based on a 15-foot side wall height

Along with the process sizing, a conceptual site plan for the residuals treatment infrastructure was developed. The site plan, shown in Figure 9, displays a “paper doll” layout indicating a potential alignment for the residuals treatment systems. Process sizes indicated in the callouts correspond to a system designed to accommodate the 90th percentile solids production.

Figure 9: Conceptual plan for residuals treatment system at Florence

Due to the size and linear nature of the Florence PWTP, it is not possible to co-locate all of the residuals treatment systems in the same area of the plant. Therefore, the SFBW treatment has been located between the pre-sedimentation basins and Basin 6, while the thickening and dewatering facilities have been located south of the pre-sedimentation basins. Because these locations are separated from the existing drain piping, it will be necessary to construct at least two pump stations: one for SFBW and one for blowdown from the primary clarifier basins. Figures 10 through 13 show the potential locations considered for these properties. Based on the latest information that was available, these locations do not appear to conflict with any future treatment upgrade plans for the Florence PWTP.

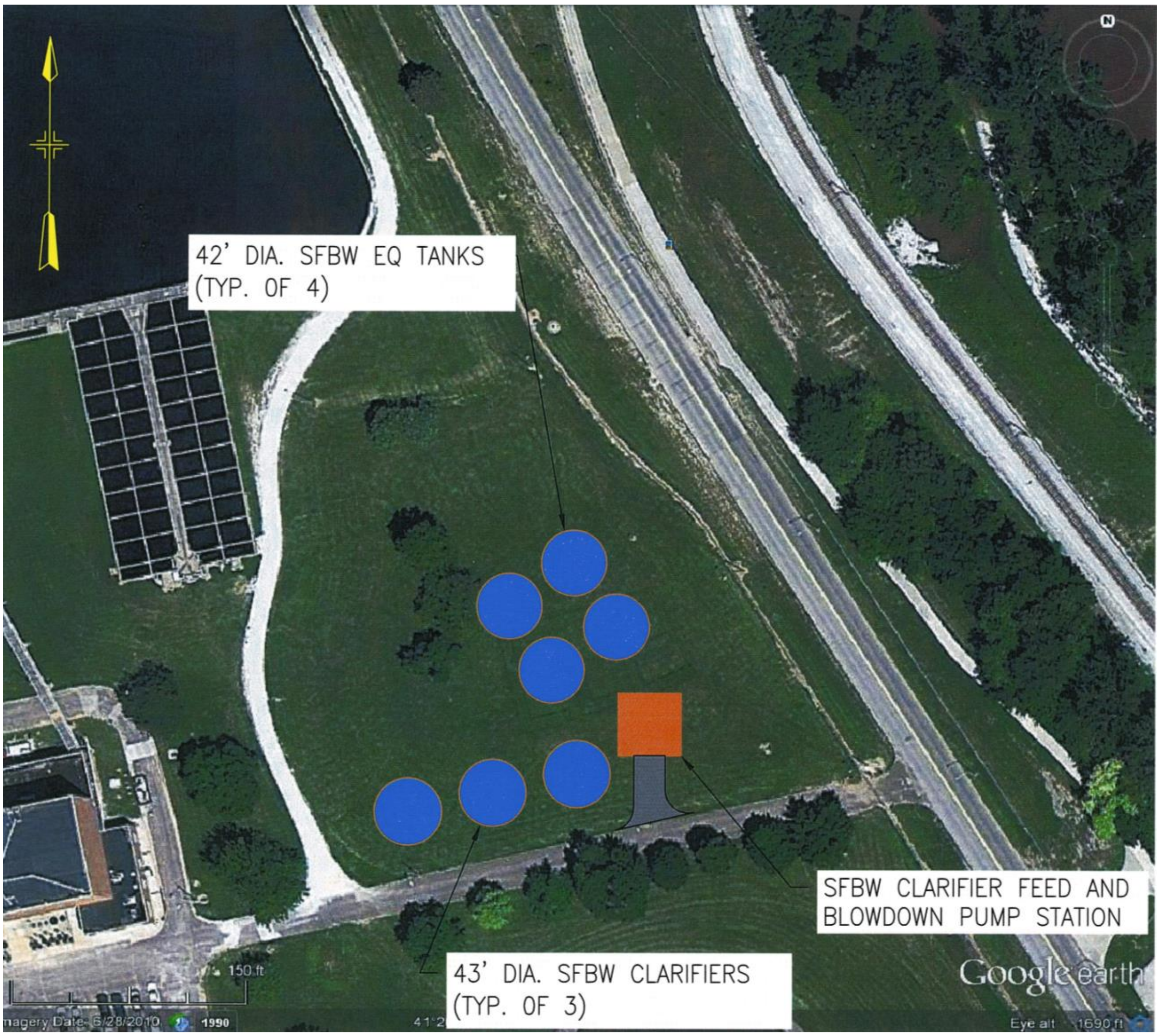

Figure 10. Location of potential SFBW treatment facilities at Florence PWTP

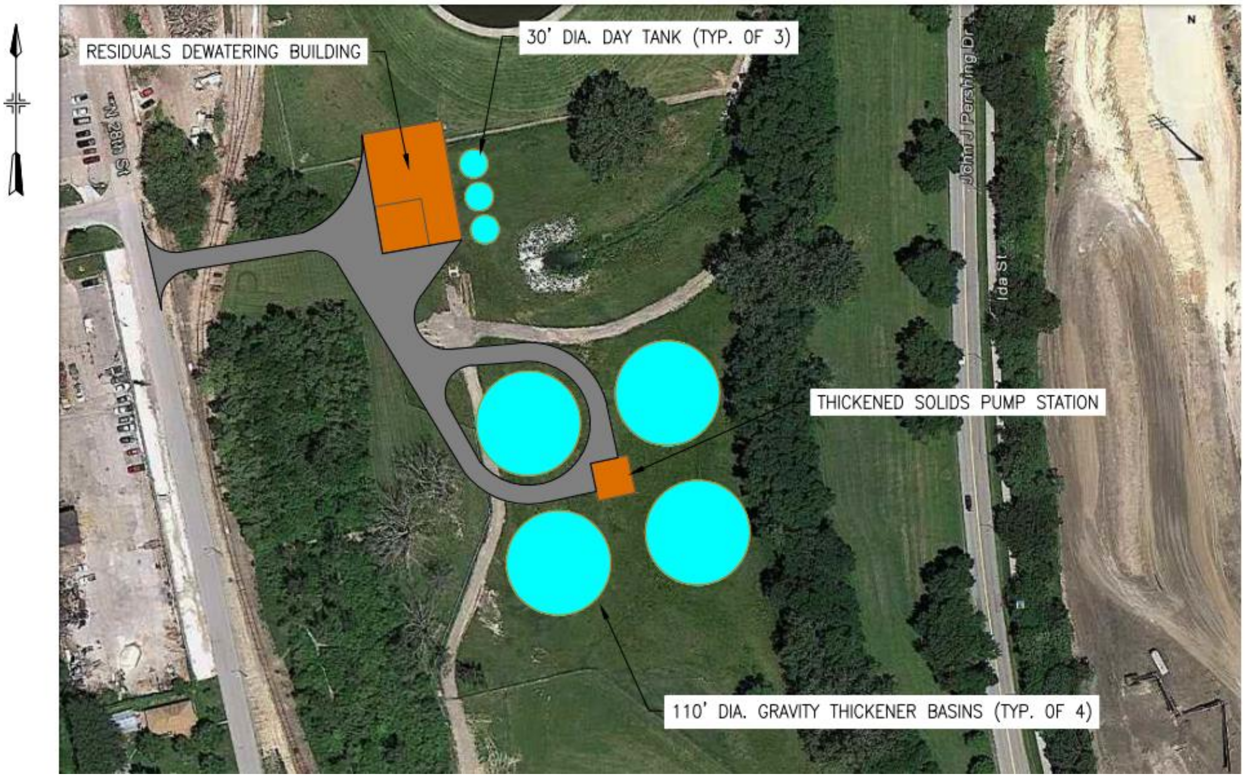

Figure 11. Location of potential residuals thickening and dewatering facilities at Florence PWTP

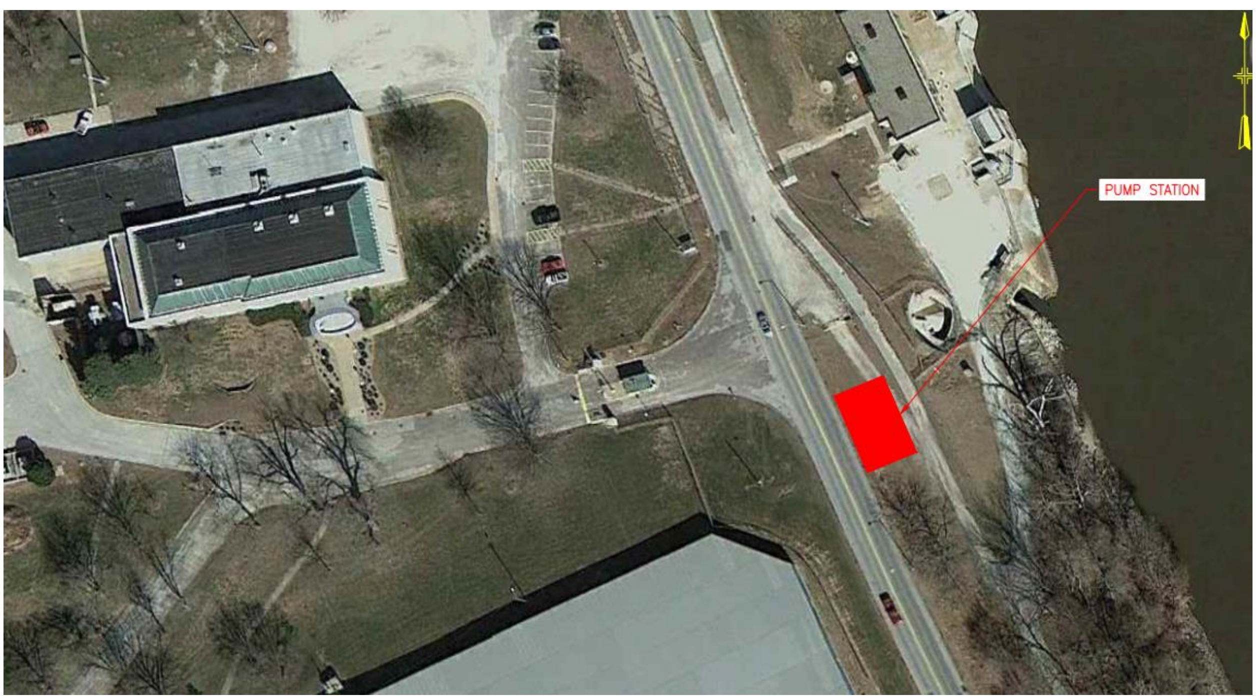

Figure 12. Location of potential SFBW pump station at Florence PWTP

Figure 13. Location of potential clarifier blowdown pump station at Florence PWTP

In addition to the mechanical dewatering systems presented in Table 2, construction of a non-mechanical dewatering system was also considered. As discussed previously, due to the amount of solids produced at Florence, it was assumed that dewatering lagoons would be needed instead of sand drying beds or freeze-thaw beds.

Dewatering lagoons were sized using the procedure described in an AwwaRF report by Vandermeyden and Cornwell (1998). Assuming a drained solids concentration of 20 percent and a loading depth of 6 feet, it would take approximately one year for a lagoon to dry, based on an average annual evaporation of 43.8 inches in the Omaha region (Farnsworth and Thompson, 1982). This would require a minimum of three lagoons (one being loaded, one drying, and one being cleaned) at Florence. Each lagoon would require an area of 874,000 ft^2 (20 acres) using the sizing procedure outlined in the AwwaRF report. As the total required lagoon area would exceed 60 acres, not including support roads, berms, etc., it was decided that this option was not feasible and a cost estimate was not developed.

Total capital costs for the systems indicated in Table 2, as computed by the costing tool, are shown in Table 3 for each residual production percentile analyzed. These costs are shown with individual process costs in Figures 14 and 15, corresponding to systems based on centrifuge dewatering and filter press dewatering, respectively.

Table 3: Residuals treatment costs by treatment scenario

Percentile Treated	Total Capital Costs (Centrifuge)	Total Capital Costs (Plate and frame press)
50	$ 58,500,000	$ 56,460,000
65	$ 59,830,000	$ 61,300,000
75	$ 68,400,000	$ 65,060,000
90	$ 86,470,000	$ 89,410,000
100	$ 131,680,000	$ 127,670,000

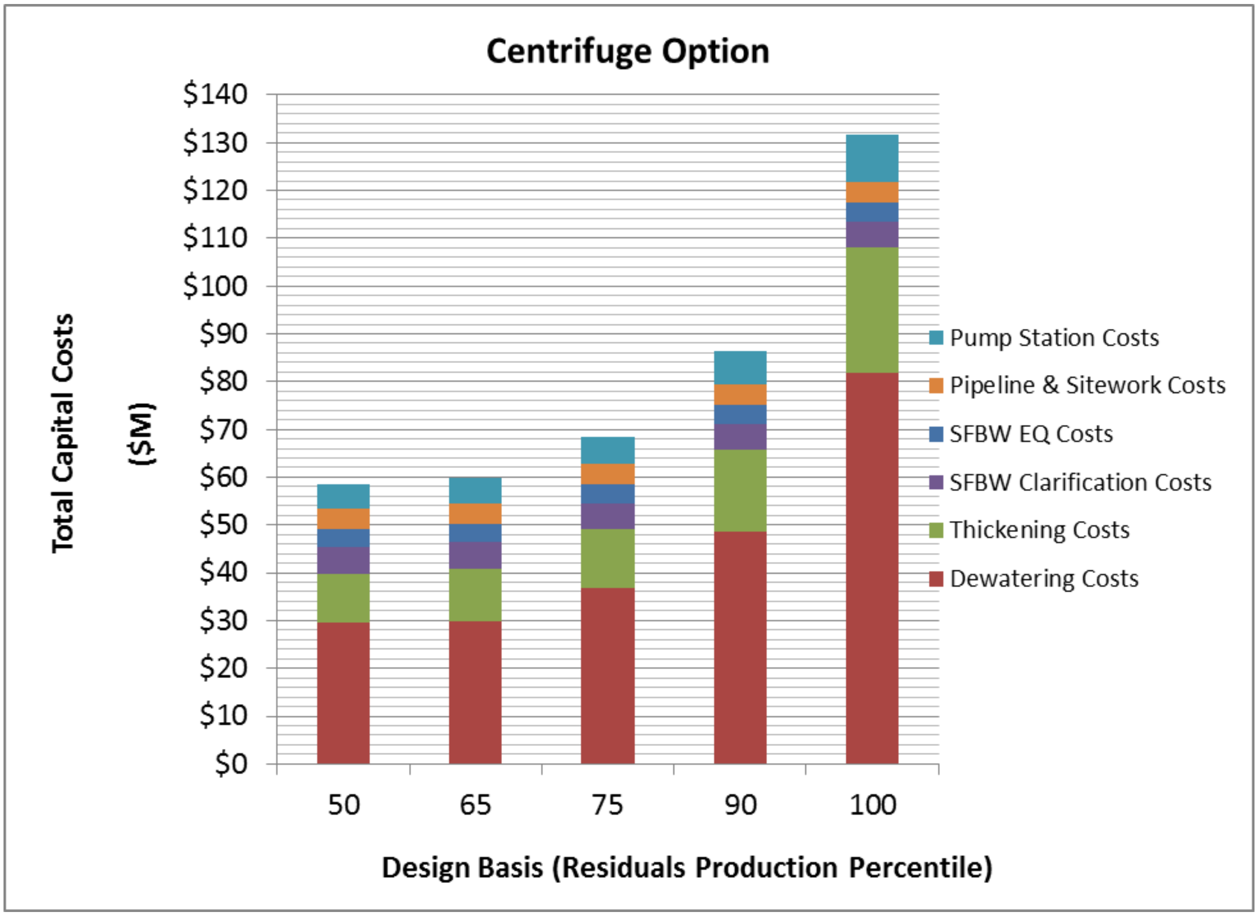

Figure 14: Capital costs by process area (Centrifuge)

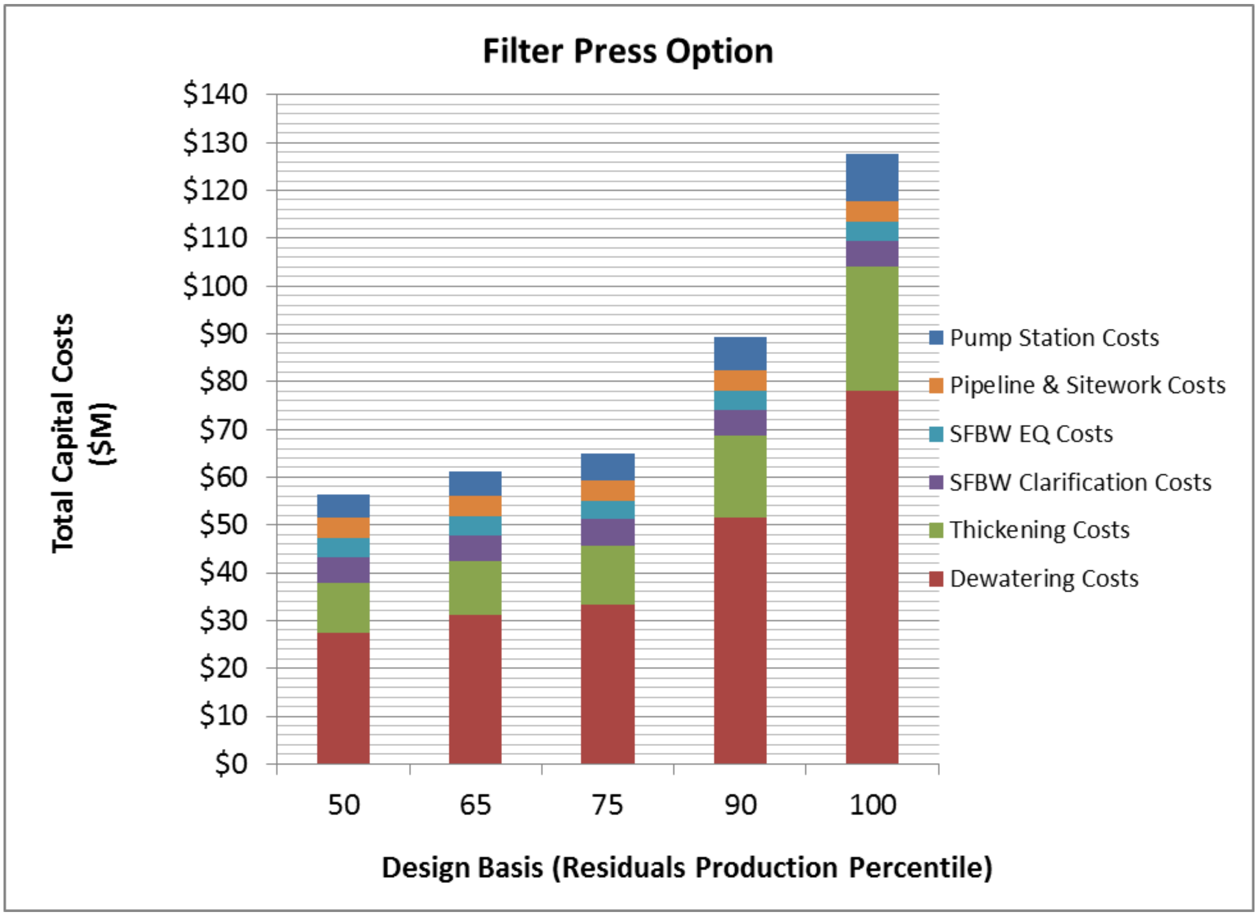

Figure 15: Capital costs by process area (Filter press)

It is clear that the most significant driver of residuals treatment costs is the dewatering system. The costs of the centrifuge system and filter press system are roughly equivalent through each size of treatment used for this study. A conceptual design in greater detail would be required to determine the most cost effective dewatering system for a given treatment size.

In addition to estimating capital costs, the costing tool is configured to also estimate annual operations and maintenance costs. In order to calcualte an annual cost of residuals treatment, the capital costs were annualized based on a 20-year payback and a 5 percent interest rate. These costs are shown in Table 4.

Table 4: Estimated annual cost of residuals treatment by treatment scenario

% Treated	Annualized Capital Costs	Annual O&M Costs	Total Annual Costs
Centrifuge			
50	$ 4,700,000	$ 2,510,000	$ 7,210,000
65	$ 4,810,000	$ 2,690,000	$ 7,500,000
75	$ 5,490,000	$ 3,100,000	$ 8,590,000
90	$ 6,940,000	$ 4,540,000	$ 11,480,000
100	$ 10,570,000	$ 7,340,000	$ 17,910,000
Filter Press			
% Treated	Annualized Capital Costs	Annual O&M Costs	Total Annual Costs
50	$ 4,540,000	$ 2,450,000	$ 6,990,000
65	$ 4,920,000	$ 2,730,000	$ 7,650,000
75	$ 5,230,000	$ 3,020,000	$ 8,250,000
90	$ 7,180,000	$ 4,670,000	$ 11,850,000
100	$ 10,250,000	$ 7,330,000	$ 17,580,000

Except for the scenario where the system is sized for the 100th percentile of the daily solids production, there will be times when Florence will need to discharge to the Missouri River, as shown in Figure 8. Assuming the designed system is adequate at treating only the percentile that the design intended, EE&T has estimated the quantity of residuals expected to be discharged to the Missouri River on a yearly basis. Figure 16 shows the relationship between the size of the treatment system constructed and the anticipated yearly discharges to the river.

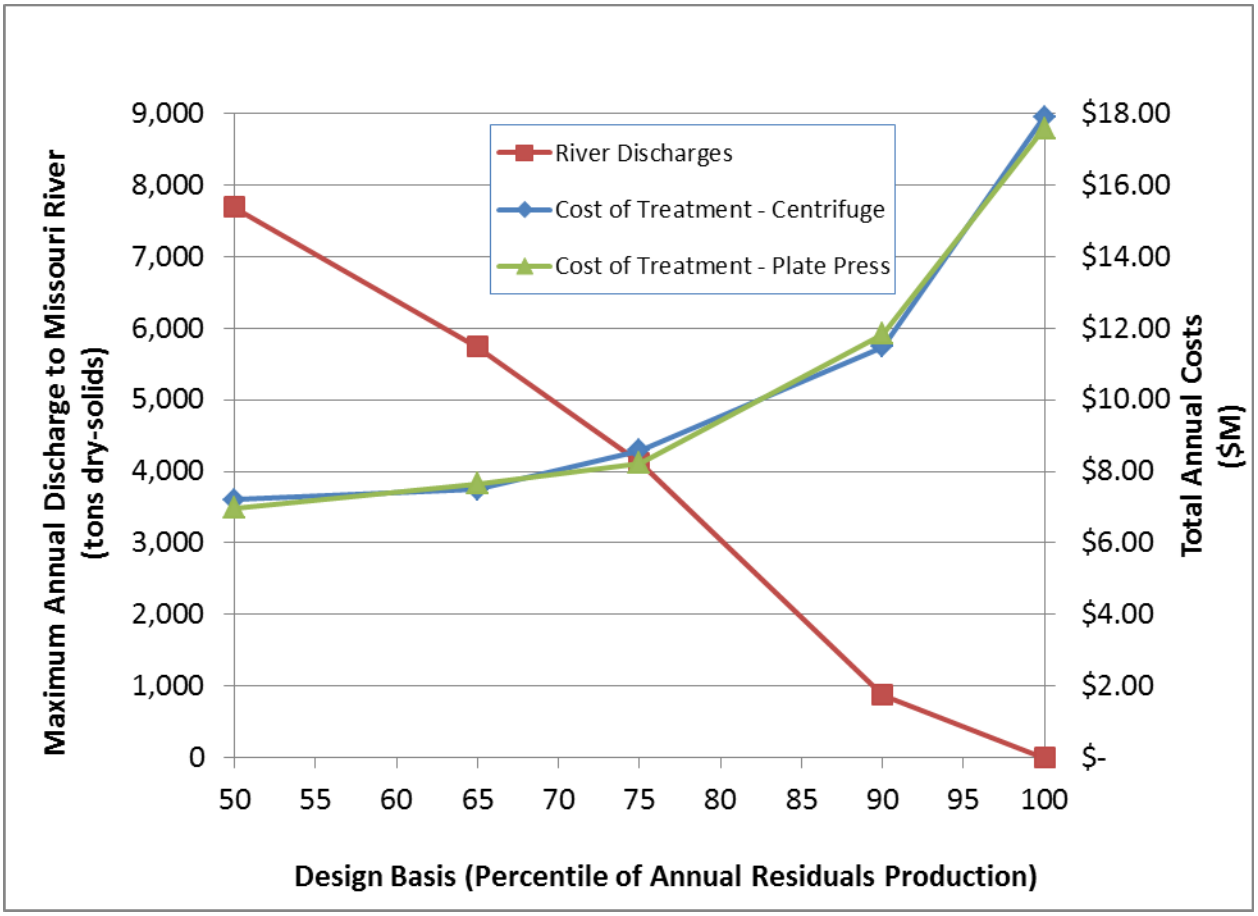

Figure 16: Annual treatment costs compared to maximum annual discharge of solids to the Missouri River

Non-Water Quality Impacts of Solids Removal

There are three primary non-water quality impacts of solids removal. First, because it is relatively energy intensive to dewater and transport drinking water treatment plant residuals, there will be carbon emissions associated with residuals treatment. Second, because the dewatered solids must be removed from the site via trucking, there will be an impact to local roadways from increased truck traffic. Finally, if the residuals were to be disposed via landfill, the consumption of available landfill capacity would be a non-water quality impact.

Calculating carbon emissions for residuals treatment is relatively straightforward. Power use of residuals processes is based on installed horsepower and process runtime. CO_2 emissions due to power usage are estimated to be 7.18×10^{-4} metric tons of CO_2/kWh. Truck emissions are based on an assumed 50 mile trip for disposal and the amount of tonnage carried. Table 5 shows the estimated carbon emissions based on the disposal scenario.

Table 5: Estimated annual carbon emissions associated with residuals treatment at Florence

% Treated	Power Consumption Emissions (metric tons CO_2/year)	Transportation Emissions (metric tons CO_2/year)	Total Annual Carbon Emissions (metric tons CO_2/year)
Centrifuge			
50	1,140	473	1,612
65	1,210	566	1,776
75	1,219	677	1,896
90	1,550	1,118	2,668
100	2,521	2,035	4,557
Filter Press			
% Treated	Power Consumption Emissions (metric tons CO_2/year)	Transportation Emissions (metric tons CO_2/year)	Total Annual Carbon Emissions (metric tons CO_2/year)
50	1,140	473	1,612
65	1,210	566	1,776
75	1,324	677	2,001
90	1,707	1,118	2,825
100	3,221	2,035	5,256

In addition to the emissions shown in Table 5, it should be noted that the facilities required to manage residuals will have their own carbon footprint associated with the resources and energy consumed to manufature and construct those facilities. While estimating this carbon footrpint is beyond the scope of the study, it is important to note that there are impacts beyond those assocaited solely with operation of the resiudals treatment facilities.

As with the carbon emissions, transporation ransporation impacts are also relatively straightforward to evaluate. Each treatment scenario that has been discussed is based on a maximum dewatering rate. Assuming the system is operating at that rate, we can estimate the maximum volume of dewatered cake that will need to be transporated each week. For the purposes of this anlaysis, it was assumed that the dewatered cake would have a final solids concentration of 70 percent, a unit weight of 112 lb/ft^3, and that cake transport would be accomplished using roll-of dumpsters with a capacity of 12 cubic yards (cy). With these assumptions, tranporation impacts will be as shown in Table 6.

Table 6: Estimated increase in truck traffic associated with residuals treatment at Florence

% Treated	Residuals Production (lb/day)	Wet Cake Production (lb/week)	Wet Cake Volume (cy/week)	Trucking Days (days/week)	Number of Trucks per Day
50	85,545	598,815	283	5	5
65	102,472	717,304	339	5	6
75	122,584	858,088	405	5	7
90	202,275	1,415,925	669	5	12
100	368,318	2,578,226	1,218	5	21

There is also an impact associated with disposal of the dewatered residual solids. The most common beneficial reuse option for softening residuals, agricultrual land application, is not anticiapted to be economical because disposal of lime solids from the Platte West PWTP is currently filling the demand for agricultrual lime in the surrounding area. There do not appear to be any other established beneficial resuse options for the softening residuals in the Omaha region. While this does not necessarily preclude beneficial reuse of the solids, it would essentially require M.U.D. to develop a new market for lime solids, which would be a significant and time-consuming enterprise.

Because beneficial reuse does not appear to be an option, it is anticiapted that the solids will be disposed via landfill. As shown in Table 6, it is estimated that 283 to 1,218 cubic yards of material will need to be disposed of per week, depending on the treatment scenario. On an annual basis, this will correspond to 14,710 to 63,335 cubic yards of landfill capacity that will be consumed through the disposal of softening residuals.

Summary

As previous sections have shown, options for reducing the amount of solids discharged to the Missouri River from the Florence PWTP are limited to residuals treatment, as M.U.D. has already optimized operations to reduce solids production. Both mechanical and non-mechanical dewatering technologies were considered; however, non-mechanical dewatering would require over 60 acres of available land for constructing the dewatering lagoons so it was considered not to be feasible for the Florence PWTP. Therefore, costing focused on two mechanical dewatering options: centrifuge dewatering and plate-and-frame filter press dewatering. Between these two options, costs were comparable for each dewatering-capacity scenario. For the purposes of this study they were considered to be equivalent; to determine which mechanical dewatering method was more cost effective would require a more detailed preliminary design effort.

Implementing residuals treatment will reduce the mass of solids discharged to the Missouri River; however, even under current operating conditions the amount of solids contributed by the discharge from the Florence PWTP is negligible compared to the amount of solids already present in the Missouri River. On days of peak solids production, the discharge from the Florence PWTP would comprise less than 2.5 percent of the total solids in the river. The majority of the time, less than 0.3 percent of the solids in the river would be attributable to the discharge from Florence.

While this percentage could be drive lower though residuals treatment, it will come at a significant cost. Even the lowest treatment option considered will have an annualized cost of at least $7.0 million, $2.45 million of which would be annual operations and maintenance costs. To put these amounts in perspective, the current operating budget Florence PWTP is approximately $8 million. Depending on the scenario selected, the cost of reducing the amount of solids discharged to the river ranges from $7.0 million to $17.9 million annually. This means that implementing even partial residuals management at Florence PWTP, even with a reduced treatment schema that would still allow for the discharge of 7,685 dry-tons of solids per year to the Missouri River, would have an annual cost equal to approximately 90 percent of the total annual operating budget at Florence PWTP; the annual cost of treating all the residuals generated at Florence PWTP would be more than double the plant's current operating budget. These increased costs would undoubtedly require significant hikes in water rates.

There are also non-water quality environmental impacts associated with solids removal. The three primary non-water quality environmental impacts are anticipated to be: increased carbon emissions, increased truck traffic to and from the water treatment plant, and use of landfill capacity. These impacts should be considered carefully when determining the feasibility of residuals management at the Florence PWTP.

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March 6, 2013

Metropolitan Utilities District of Omaha
Engineering Memorandum No. 8
NPDES Studies
EE&T Project No. 12501

Subject: Platte South Site Specific Field Studies

The Platte South Potable Water Treatment Plant (PWTP), operated by the Metropolitan Utilities District of Omaha (M.U.D.), is a split-treatment softening facility that currently discharges residuals that are generated during treatment to the Missouri River. This discharge is permitted under NPDES Permit No. NE0000906, which went into effect as of October 1, 2009. As part of this NPDES permit, the Nebraska Department of Environmental Quality (NDEQ) directed M.U.D. to conduct Site Specific Field Studies including Water Column measurements to determine the extent of the discharge plume and the amount of residuals mixing achieved in the mixing zone, suspended solids and sediment evaluations upstream and downstream of the Platte South PWTP, and evaluation of benthic macroinvertebrates upstream and downstream of the Platte South PWTP.

A Study Plan for Evaluation of Water Quality Impacts from the Discharge of Solids and Solids Reduction Technologies at the Platte South PWTP (Study Plan) was submitted to NDEQ in September 2010. Personnel from EE&T, Tennessee Technological University (TTU), M.U.D, and NDEQ met in November 2010 to refine the plan, which was subsequently modified to allow for use of artificial substrates for benthic invertebrate collection. The plan was also modified, due to the historic flooding of the Missouri River in Summer 2011, to extend the permit deadlines in order to delay on-river work until Summer 2012.

Water column and suspended solids samples were collected June 26, 2012. A report detailing the methodology used for the sample collection and analysis, as well as the data collected, has been prepared by TTU and is attached to the memorandum as Attachment A. Artificial substrates were placed on June 26, 2012 for benthic invertebrate accumulation and were subsequently retrieved on August 14, 2012. A report detailing the benthic invertebrate collection and analytical procedures, as well as the data collected, has been prepared by Pennington & Associates (P&A) and is attached to the memorandum as Attachment B.

Water Column and Solids Studies

As described in the Study Plan, seven transects were made of the river to collect water column samples for analysis: two transects upstream of the plant, two transects downstream of the plant, and three transects within the mixing zone downstream of the plant outfall. The transect and sample locations are shown in Figure 1.

Samples were collected at three locations along each transect, as can be seen in Figure 1. Samples were collected at three different depths at each sample location: at 20 percent of the total depth at that location (0.2D), at 50 percent of the total depth at that location (0.5D), and at 80 percent of the total depth at that location (0.8D). Collected water samples were packed in ice and shipped via overnight deliver to TTU's Environmental Analytical Laboratory for analysis. Additional in-situ water quality data was collected with Hydrolab H2O® datasonde at each sample location and depth. The water quality parameters analyzed for this study are shown in Table 1. The sampling methodology is described in detail in Attachment A.

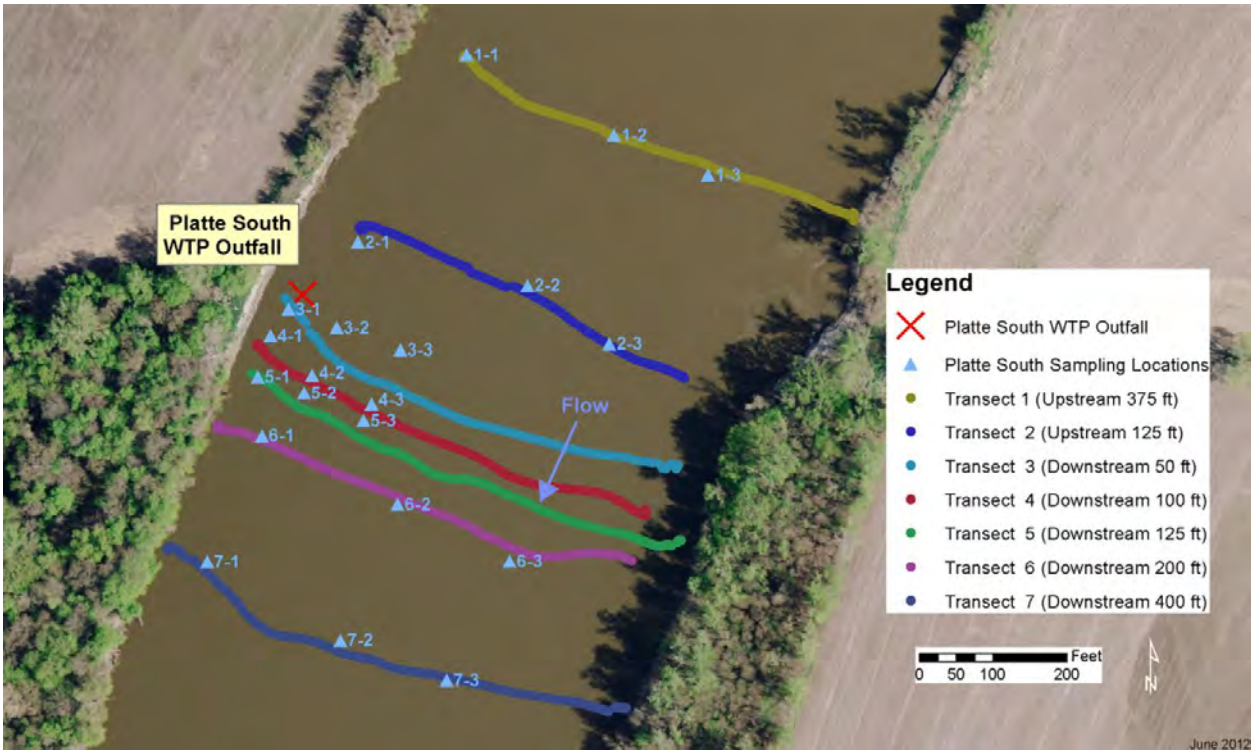

Figure 1. River transect and water column sample locations

Table 1. Water quality parameters analyzed for this study

Parameter	Method	MDL	Analysis Location
Total Suspended Solids (TSS)	SM2540D	2.5 mg/L	TTU
Settable Solids (SS)	ASTM D3977	1mg/L	TTU
Aluminum- Total & Dissolved	EPA 200.7	0.05 mg/L	TTU
Iron – Total & Dissolved	EPA 200.7	0.05 mg/L	TTU
Copper – Total and Dissolved	EPA 200.7	0.007 mg/L	TTU
Manganese – Total and Dissolved	EPA 200.7	0.01 mg/L	TTU
Nickel – Total & Dissolved	EPA 200.7	0.015 mg/L	TTU
Selenium – Total & Dissolved	EPA 200.7	0.05 mg/L	TTU
Zinc – Total & Dissolved	EPA 200.7	0.05 mg/L	TTU
Hardness	SM 2340 B	0.5 mg/L	TTU
pH	Probe	NA	Field
Temperature (T)	Probe	NA	Field
Specific Conductance (EC)	Probe	NA	Field
Dissolved Oxygen (DO)	Probe	0.1 mg/L	Field
Alkalinity	SM2320B	5 mg/L as $CaCO_3$	TTU

The results of the water column and solids studies at Platte South PWTP are presented in full in Attachment A. The following subsections summarize the findings for each of the water quality parameters that were investigated. All discussions of statistical significance are in terms of an 0.05 significance level ($\alpha = 0.05$).

Total Suspended Solids

TSS measurements ranged from a low of 75 mg/L (at 0.5D, 50 feet downstream of the outfall) to a high of 163 mg/L (at 0.2D, 125 feet upstream of the outfall). Statistical analysis indicates that average TSS concentrations 375 feet upstream from the outfall were significantly greater than the concentrations at locations 50 feet, 100 feet, and 200 feet downstream of the outfall. However, there was no significant difference between the average TSS concentrations upstream of the outfall and the average concentration measured 400 feet downstream from the discharge. Based on these data, the discharge from Platte South PWTP does not appear to be significantly increasing TSS in the river.

Settleable Solids

Settleable solids concentrations for all locations were below the detection limit, indicating that the majority of the TSS found were most likely silts, clays, or other fine particles with low settling rates.

Dissolved Oxygen

Measured DO levels ranged from 7.47 mg/L to 11.44 mg/L. There were no significant differences between average DO concentrations at the different sample locations.

pH

There were no statistically significant differences between pH values observed at the different sample locations. Overall, pH values ranged from 8.35 (at 0.8D, 125 feet upstream of the outfall) to 8.58 (at 0.8D, 100 feet downstream of the outfall). All pH measurements were below the 9.0 maximum pH limit specified in the permit.

Temperature

The average water temperature was approximately 25°C. One sampling location, (7-1, the westernmost sample location 400 feet downstream of the outfall) had an average temperature of 22.4°C, approximately 3 degrees cooler than the surrounding sample locations. Although no outfall was noted, this change in temperature may indicate the influent of a new inflow somewhere around that location, downstream of the Platte South PWTP outfall. No other significant variances in temperature were noted.

Specific Conductance

Specific conductance did not vary significantly by location or by depth during the period when measurements were collected. The average specific conductance was approximately 0.87 mS/m.

Hardness

Measured hardness values ranged from 253 mg/L as $CaCO_3$ to 286 mg/L as $CaCO_3$. There were no statistically significant differences between hardness values measured at the different sample locations.

Alkalinity

Corresponding to the hardness measurements, alkalinity ranged from 177 mg/L as $CaCO_3$ to 188 mg/L as $CaCO_3$. Likewise, there were no statistically significant differences between hardness values measured at the different sample locations.

Aluminum

Total aluminum concentrations ranged from a low of 0.338 mg/L (0.8D, 375 feet upstream of the outfall) to a high of 1.197 mg/L (0.5D, 125 feet downstream of the outfall). At all depths, total aluminum concentrations downstream of the outfall were significantly higher than concentrations upstream of the outfall. This result is surprising because, unlike the Florence PWTP, Platte South PWTP uses a ferric-based coagulant and therefore does not contribute significant amounts of aluminum to the river. This is supported by analytical data provided by M.U.D. regarding the metals content of the discharge from the Platte South PWTP discharge; in a recent sample (collected 2/9/2012), the discharge contained an aluminum concentration of only

3.03 μg/L. This is approximately two orders of magnitude less than the background concentration observed during this sampling, which strongly suggests that the Platte South PWTP is not a contributor to the overall aluminum concentration in the Missouri River at the discharge location. In light of this, it is not clear why the sampling indicating an increase in aluminum concentration downstream of the Platte South PWTP discharge.

Aluminum is very insoluble at circumneutral pH; as the river pH was slightly basic, low levels of dissolved aluminum were present in the river. Dissolved aluminum levels ranged from below detection limits to 0.238 mg/L, indicating that the majority of aluminum present was in particulate form.

As described in greater detail in Attachment A, aluminum may be toxic to aquatic life when mobilized in surface water. However, previous toxicity testing of M.U.D.'s Florence PWTP residual solids was conducted by Dr. Dennis George in the mid-1990's. That testing found that growth inhibition of *S. capricornutum* occurred only when the residuals were highly concentrated. Considering the high dilution factor of the river to the discharge flow (>1,000:1), the discharge of residual solids from the Platte South PWTP is not anticipated to significantly inhibit aquatic organisms.

Iron

Measured iron concentrations ranged from 0.292 mg/L to 1.043 mg/L during the period when samples were collected. Iron concentrations increased significantly downstream of the outfall when compared to upstream iron levels. This result is expected, due to the use of a ferric-based coagulant at Platte South PWTP. The highest iron concentrations were measured 125 feet downstream of the outfall; the iron levels at 200 feet and 400 feet downstream of the outfall were significantly less than those at 125 feet downstream of the outfall, but were still significantly higher than the iron levels upstream of the outfall.

Copper

Copper concentrations were less than instrumental detection limits (<0.007 mg/L) in all collected samples.

Manganese

Measured manganese concentrations were relatively low, ranging from 0.027 mg/L to 0.098 mg/L. Although the overall levels were low, the average total manganese concentrations at locations 100 feet, 125 feet, 200 feet, and 400 feet downstream of the outfall were significantly higher than average upstream levels.

Nickel

Nickel concentrations were less than instrumental detection limits (<0.015 mg/L) in all collected samples.

Selenium

Selenium concentrations were less than instrumental detection limits (<0.05 mg/L) in all collected samples.

Zinc

Measured zinc concentrations were low, ranging from <0.006 mg/L to 0.019 mg/L. There were no significant differences between manganese concentrations at different locations.

Summary of Water Column and Solids Measurements

The overall impact of the Platte South PWTP on the Missouri River appears to be relatively minor. The discharge from Platte South PWTP did not appear to significantly increase TSS in the river. However, statistically significant increases in total aluminum, total iron, and total manganese downstream of the outfall from Platte South PWTP were measured. Given that the pH of the river is only slightly basic, the majority of the aluminum and iron are expected to remain in particulate form. That, and the high dilution factor at the discharge, should prevent any inhibitory effect on aquatic life in the water column.

Benthic Study

Benthic macroinvertebrates were collected form the Missouri River using artificial substrate samplers. On June 26, 2012, duplicate sets containing three artificial substrate samplers each were set at three different locations at Platte South PWTP: one location upstream of the plant (PU), one location approximately 125 feet downstream of the outfall (P125D), and one location approximately 600 feet downstream of the outfall (P600D). These locations are shown in Figure 2.

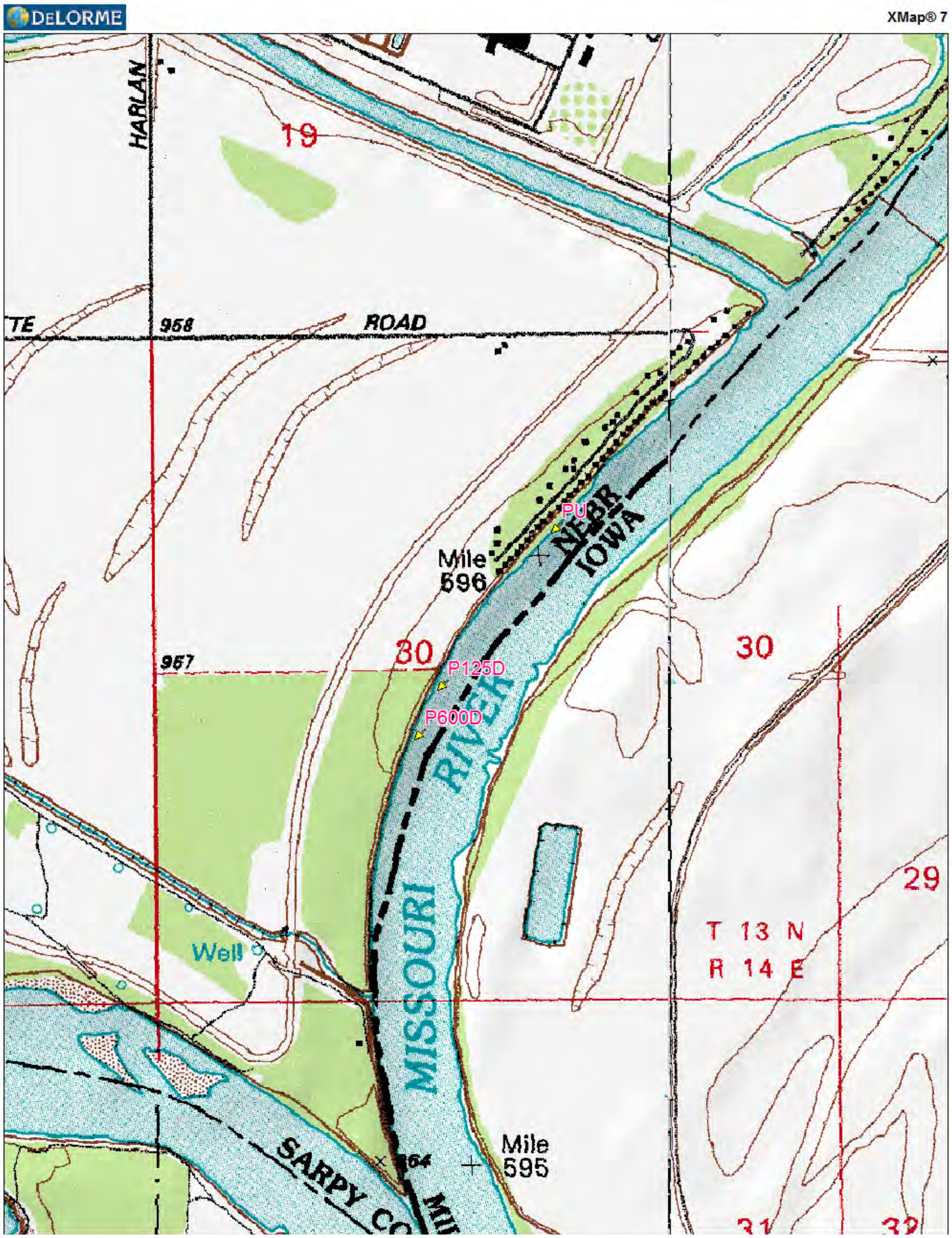

Figure 2. **Benthic Macroinvertebrate Sampling Sites, Platte South PWTP, August, 2012.**

The artificial substrate samplers were retrieved on August 14, 2012, after a 6-week time lapse. At PU, only three of the six samplers were retrieved; five were retrieved from P125D and all six were retrieved from P600D. The samplers were cleaned in the field, and all materials that had accumulated in the sample were transferred to plastic containers, labeled, preserved in formalin, and returned to P&A's laboratory for analysis. In all, 14 of the 18 artificial substrate samplers that had been set were successfully retrieved and analyzed. Details regarding the sample retrieval, collection, and analytical methods can be found in Attachment B.

One of the core benthic macroinvertebrate community metrics is taxa richness, or the total number of distinct taxa. The benthic macroinvertebrate fauna in the vicinity of the Platte South PWTP discharge were represented by a minimum of 27 species upstream (PU), with 33 (P125D) and 60 (P600D) found downstream of the discharges. Statistically, there is no significant difference in taxa richness when comparing upstream to downstream of Platte South PWTP. The discharge of residuals from Platte South PWTP does not appear to have adversely impacted the richness of the benthic macroinvertebrate community in the vicinity of the plant.

A related benthic macroinvertebrate community metric is Ephemeroptera, Plecoptera, and Trichoptera Richness (EPT). This index measures the total number of distinct taxa within the generally pollution sensitive insect orders of EPT, and generally correlates with water quality and habitat stability. Although EPT increased slightly from 11 at PU to 15 at P600D, again there was no significant difference between upstream and downstream EPT values.

In terms of other benthic macroinvertebrate community metrics, there is no change in community health from upstream of Platte South PWTP to downstream of the plant. One measure of evaluating water quality is the Hilsenhoff Biotic Index (HBI), which measures the tolerance of the biotic community to organic enrichment. The State of Nebraska Water Quality Division follows the Hilsenhoff Wisconsin scoring criteria with values less than 3.5 indicating excellent water quality, values of 3.51 to 5 indicating good water quality, 5.01 to 7.5 indicating fair water quality, 7.51 to 8 indicating poor water quality and values greater than 8 would indicate serious water quality problems. The HBI in all locations was "fair", ranging from a low of 5.82 at P600D to a high of 5.99 at PU. Based on HBI, the discharge of residuals from Platte South PWTP is not adversely impacting the Missouri River.

Similarly, when comparing the density of benthic macroinvertebrates between locations density increased downstream of the outfall, from a mean number of 15,677.7 individuals per

0.15m^2 at the upstream location, 20,753.6 per 0.15m^2 and 22,752.7 per 0.15m^2 at P125D and P600D, respectively. However, the difference between densities at each location was not great enough so as to be statistically significant.

Table 2 summarizes the core benthic macroinvertebrate community metrics discussed above. These metrics, along with other statistical measures of the benthic macroinvertebrates at Platte South PWTP and a comparison of the benthic macroinvertebrate communities at Florence PWTP and Platte South PWTP, are discussed in greater detail in Attachment B.

Table 2. Summary of core benthic macroinvertebrate community metrics

Date	Station	Total No. of Taxa	EPT Taxa	HBI	No. of Individuals per 0.15 m^2
8/13/12	PU	27	11	5.99	15,677.7
8/13/12	P125 D	33	14	5.85	20,753.6
8/13/12	P600 D	30	15	5.82	22,752.7

Summary

Based on the water quality data from the water column samples, the discharges of residuals from Platte South PWTP appear to have a minor impact on Missouri River water quality. The discharge from the plant does not appear to significantly increase TSS in the vicinity of the outfall or downstream. Statistically significant increases in total aluminum, total iron, and total manganese were measured downstream of the outfall when compared to upstream levels. However, the overall concentrations of these compounds downstream of the discharge are still relatively low and, given the pH of the Missouri River, are unlikely to inhibit aquatic life in the river.

No significant differences were observed for any of the benthic macroinvertebrate community metrics, including the density of benthic macroinvertebrates. Although not at levels that are statistically significant, most metrics indicated a slight increase in water quality downstream of the Platte South PWTP outfall compared to upstream measurements. Based on these results, the discharge of residuals from Platte South PWTP does not appear to be adversely impacting the Missouri River.

Attachment A

Water Quality Assessment at the Florence and Platte South Potable Water Treatment Plants Discharge

By
Dennis B. George
Dan Dodson
Yvette Clark

The Center for the Management, Utilization, and
Protection of Water Resources,
Tennessee Technological University

Water Quality Assessment at the Florence and Platte South Potable Water Treatment Plants Discharge

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BACKGROUND

The Omaha, NE, Metropolitan Utilities District (M.U.D.) operates the Florence Potable Water Treatment Plant (FWTP) and the Platte South Potable Water Treatment Plant (PSWTP). These plants discharge residuals from the water treatment plants into the Missouri River under NPDES Permit No's. NE0000914 and NE0000906, respectively. The residuals from the FWTP are discharged through Outfalls 001 and 005. Residuals from the PSWTP are discharged through outfall 002. EE&T Inc. contracted with M.U.D. to collect and analyze an adequate number of water and benthic samples to determine the impact (if any) of the discharged solids residuals from FWTP Outfalls 001 and 005 and PSWTP Outfall 002 on water quality and benthic macroinvertebrate communities. To satisfy these requirements Tennessee Technological University's (TTU's) Center for the Management, Utilization, and Protection of Water Resources (CMUPWR), in conjunction with EE&T Inc., collected water samples and performed in situ water column monitoring at the discharge sites June 25-26, 2012. The results of in situ monitoring and laboratory water quality analysis on samples collected at the sites are presented in this report.

The sampling sites are graphically presented in Figures 1 and 2 below. Discharge and gage height during the sampling period are presented in Figures 3 and 4. At the two sampling locations, velocity and streambed morphology data were obtained using the SonTek YSI RiverSurveyor®. Water samples were collected and in situ monitoring was performed at each site that was representative of water quality upstream, within the outfall influence zone and downstream of outfalls.

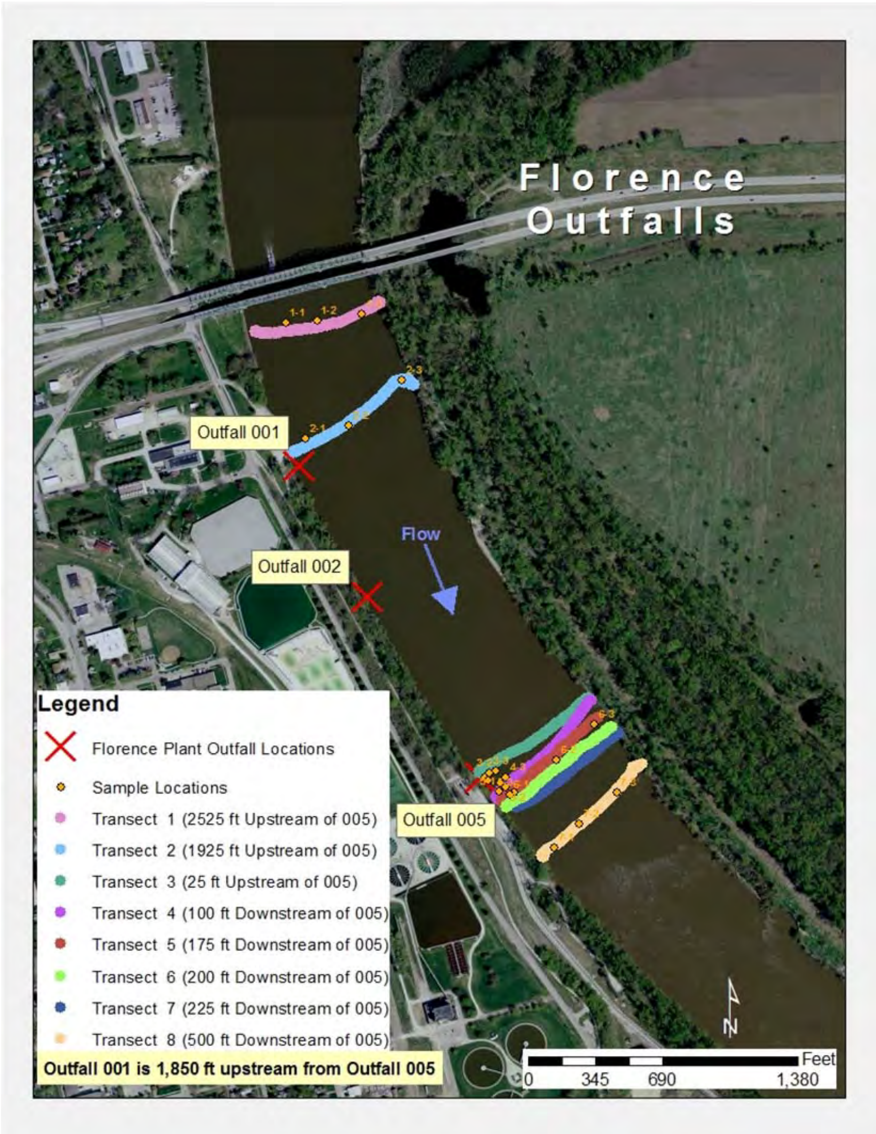


Figure 1. Florence outfalls.

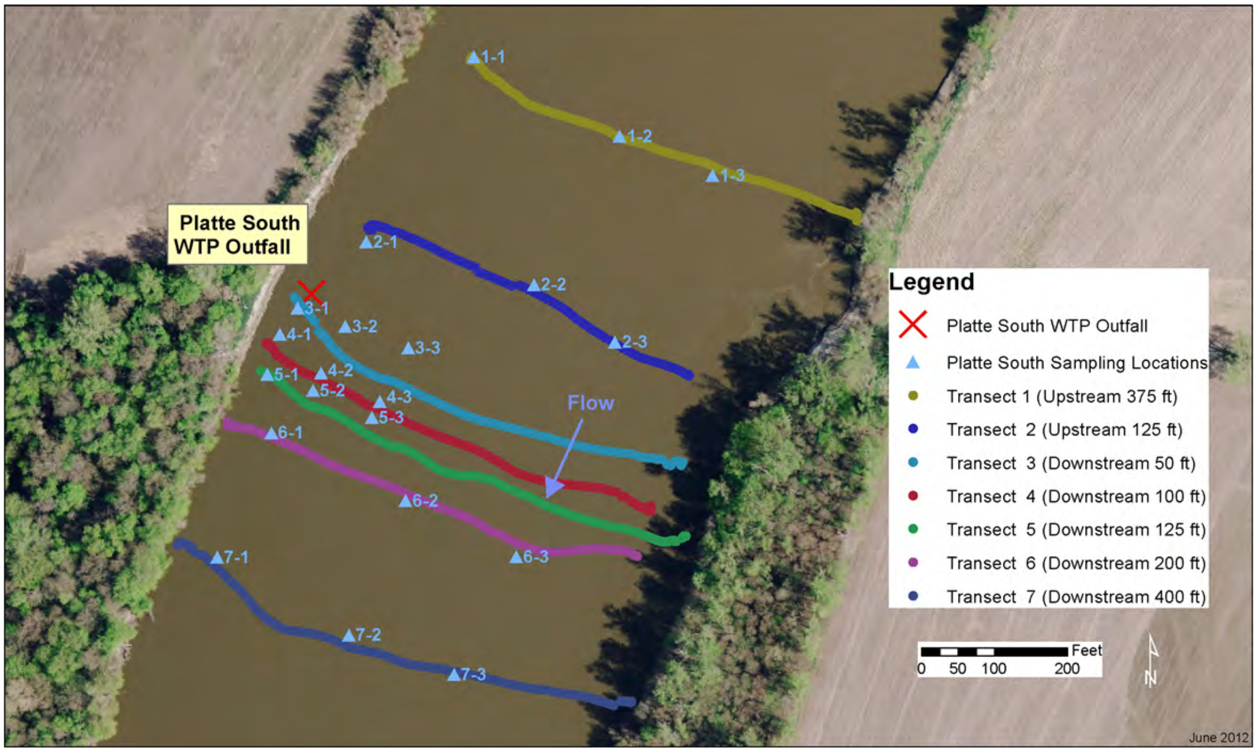


Figure 2. Platte South outfalls.

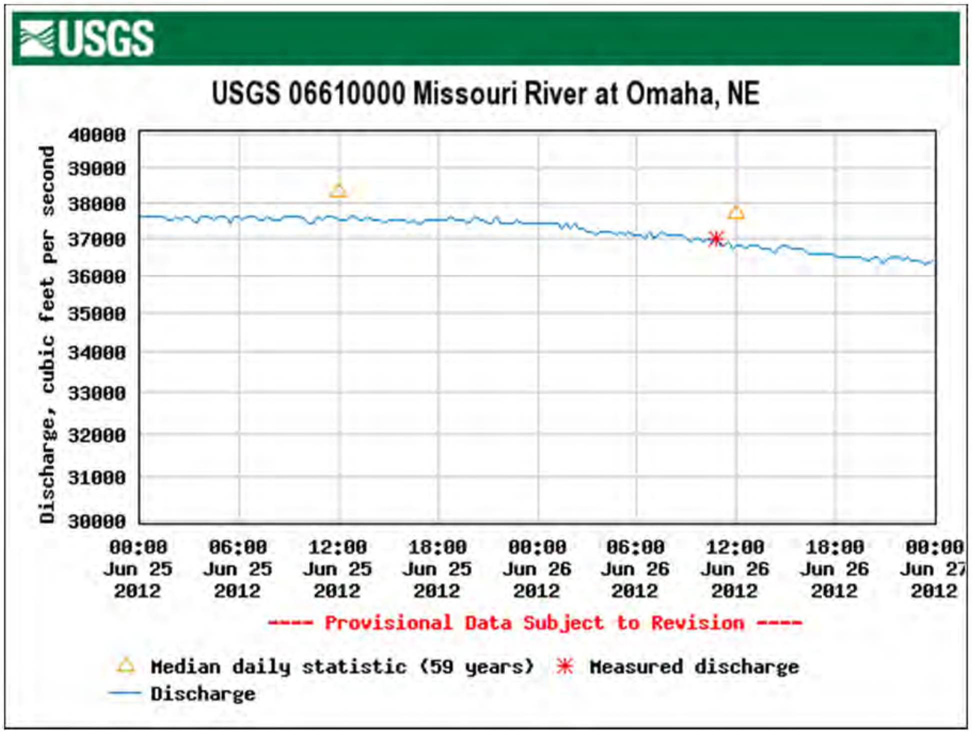


Figure 3. Discharge ft^3/sec.

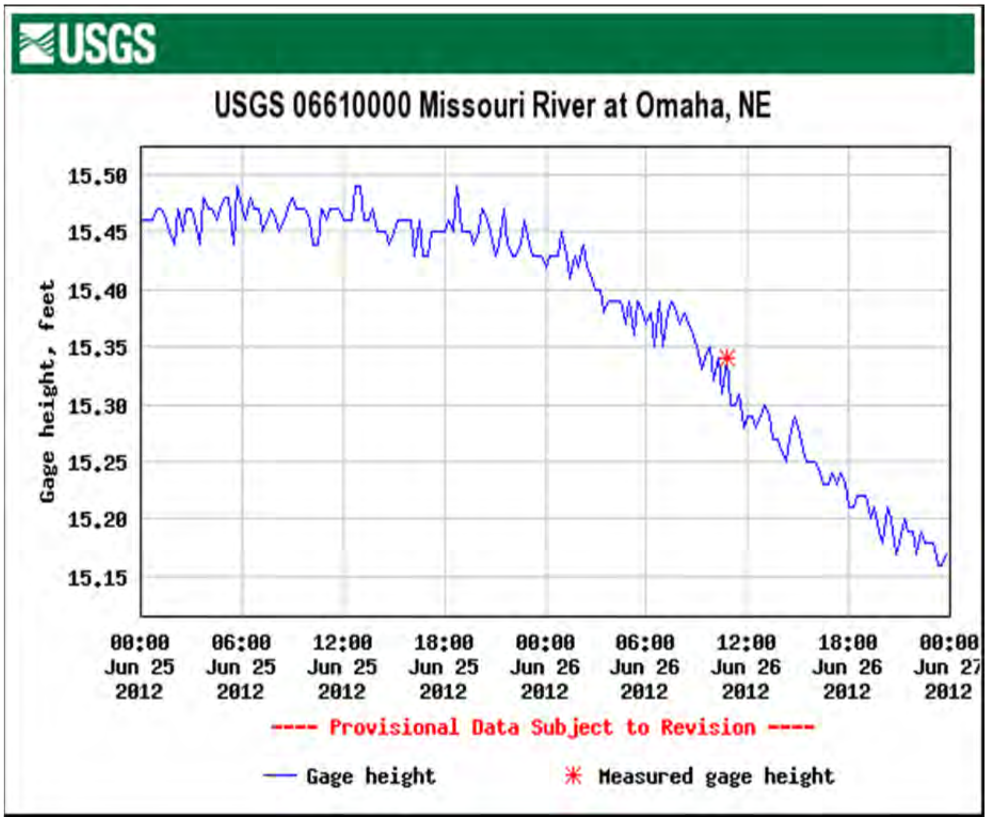


Figure 4. Gage height, ft.

METHODOLOGY

On June 25, 2012, researchers monitored and collected water samples from the Missouri River upstream and downstream from the residual solids discharge Outfall 001 at the FWTP. The monitoring encompassed residual solids discharges from Outfall 002 and Outfall 005. Water samples from the Missouri River were also collected upstream and downstream from the residual solids discharge Outfall 001 at the PSWTP on June 26, 2012. At the FWTP outfall and the PSWTP outfall, seven transects were obtained to define river geomorphology and stream velocity using the SonTek YSI River Surveyor® Acoustic Doppler Profiler (ADP). The locations of the FWTP profiles are represented in Figure 1. The locations of the PSWTP are represented graphically in Figure 2. The SonTek® ADP georeference position was recorded using the Trimble GeoXH GPS system. Water monitoring and sample collection occurred along transects. Streambed morphologies extracted from the SonTek® ADP data are presented in Appendix C for FWPT and PSWTP.

The georeference positions for monitoring and collection of samples were programmed into the Trimble GeoXH GPS system. Grab samples were collected across the width of the upstream and downstream transects. Sample collection points in the outfall influence zone covered approximately one-third of the stream width. Samples were collected by navigating the water craft to a location that corresponded to the reference point stored in the Trimble GeoXH

GPS system. The locations of the sampling positions for the FWTP are shown in Figure 1 and sampling positions for the PSWTP are shown in Figure 2. Once the boat arrived at the desired monitoring position, water samples were collected at three depths (0.8, 0.5 and 0.2) using a modified pull-ring sampler (Wheaton, Model#EW-99152-20). Field duplicates were collected at a 10% level (i.e., every 10th sample). After water was sampled, pH, temperature, dissolved oxygen (DO), and conductivity were collected by deploying a Hydrolab H20® datasonde (HACH) at the location. The Hydrolab H2O® datasonde also records depth so that collected data were obtained at the prescribed depths of 0.2, 0.5, and 0.8. Stream depth at each location was determined using an electronic stream depth finder. Collected water samples were packed in ice and shipped via FedEx courier overnight to TTU's Environmental Analytical Laboratory in the CMUPWR for analysis. All samples were preserved according to EPA criteria and were analyzed for the parameters listed in Table 1 within acceptable time limits.

Table 1. Water quality parameters measured.

Parameter	Method	Analysis Location
Total Suspended Solids (TSS)	SM2540D	TTU
Settable Solids(SS)	ASTM D3977	TTU
Aluminum- Total & Dissolved	EPA 200.7	TTU
Iron – Total & Dissolved	EPA 200.7	TTU
Copper – Total and Dissolved	EPA 200.7	TTU
Manganese – Total and Dissolved	EPA 200.7	TTU
Nickel – Total & Dissolved	EPA 200.7	TTU
Selenium – Total & Dissolved	EPA 200.7	TTU
Zinc – Total & Dissolved	EPA 200.7	TTU
Hardness	SM 2340 B	TTU
Alkalinity	SM2320B	TTU

All the water quality data collected for the FWTP are presented in Appendix A. Similarly, all the water quality data for the PSWTP are presented in Appendix B. All the transect and velocity data are presented in Appendix C for each water treatment plant. Tukey's (SAS, 2012) statistical comparison of water quality parameter mean concentrations was conducted on all data to determine significant differences upstream and downstream of the residual solids discharge Outfall 005 for the FWTP and Outfall 002 for the PSWTP.

RESULTS AND DISCUSSION

Missouri River Hydrology at the FWTP and PSWTP Residual Solids Discharge Outfalls

Velocity and Profile Measurement. At the two sampling locations (FWTP and PSWTP), velocity and streambed morphology data were obtained using the SonTek YSI RiverSurveyor®. This instrumentation belongs to a group of instruments known as acoustic Doppler current profilers (ADCPs). This system is a robust and accurate Acoustic Doppler Profiler Flow Measurement system designed to quickly measure river discharge from a moving vessel. Real-time data collection is accomplished using the Windows XP® compatible RiverSurveryor software program.

An Acoustic Doppler Profiler (ADP) is an instrument that measures the velocity of water using a physical principle called the Doppler shift. The ADP is the principle component of every River-Surveyor system. A SonTek ADP has three transducers mounted in the transducer head of the system. Each of these transducers has a different orientation and generates a narrow beam of sound that is projected through the water. Reflections from particles or "scatterers" (such as suspended sediment, biological matter, or bubbles) in the water column are used to determine the water velocity. The geometric orientation of each of the transducers allows the ADP to calculate the velocity of the water using a Cartesian (XYZ) coordinate system relative to the position and orientation of the instrument. The internal compass and tilt sensor (roll/pitch) used with all RiverSurveyor systems is able to calculate the water velocities in Earth coordinates (East-North-Up or ENU) independent of the system's location. The following describes the ADP sampling strategy:

- An individual measurement of the 3D velocity profile is called a "ping."
- The ADP pings as rapidly as possible (4 to 20 times per second depending upon frequency).
- Pings are averaged over the user-specified averaging interval to produce a mean 3D velocity profile.

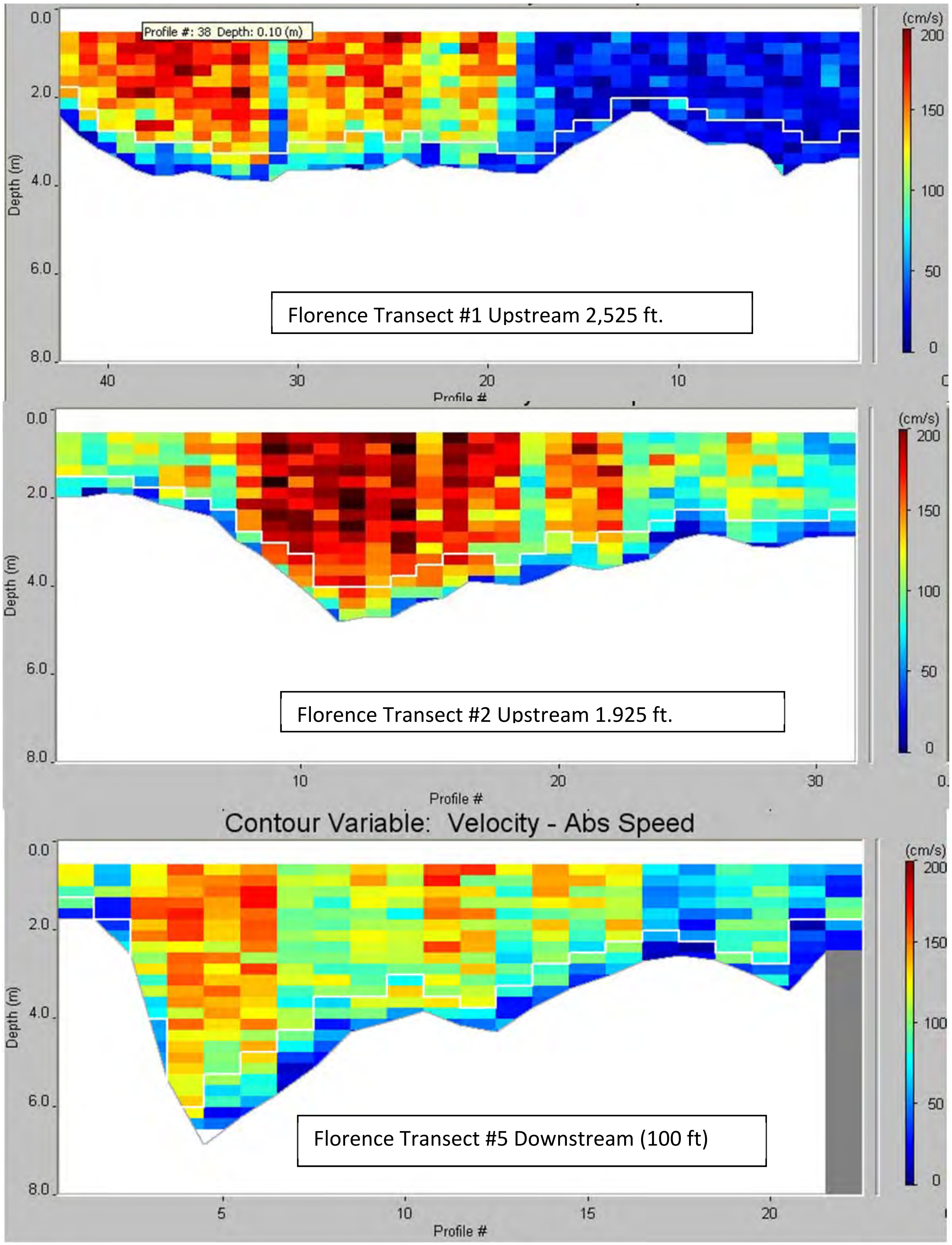
The SonTek River Surveyor is available in frequencies shown in the Table 2. A 1500 kHz instrument was used by TTU.

Table 2. Available SonTek instrument configurations.

ADP Frequency	Maximum	Typical	Blanking	Minimum
	Profiling Range	Resolution		Depth
3.0 MHz	0.6 – 6 m	0.15 – 2 m	0.2 m	10 m
1500 kHz	15-25 m	0.25 - 1.0 m	0.4 m	0.9 m
1000 kHz	25-40 m	0.4 - 2.0 m	0.5 m	1.3 m
500 kHz	0-120 m	1.0 - 5.0 m	1.0 m	3.0 m
250 kHz	20-180 m	1.0 - 10 m	1.5 m	3.5 m

The measurement location is a function of the time at which the return signal is sampled. The time since the pulse was transmitted determines how far the pulse has traveled and specifies the location of the particles that are the source of the reflected signal. By measuring the return signal at different times, the ADP measures the water velocity at different distances from the transducer. The profile of water velocity is divided into range cells, where each cell represents the average of the return signal for a given period. ADPs measure water current velocities along each of the transducer beams and transform these velocities into Cartesian (XYZ) or Earth (ENU) coordinates. The beams are divided into discrete increments or *cells* (also known as *range cells* or *depth cells*) of a specific length. Current profiling can be thought of as dividing a river or stream into several horizontal slices (rows) from top to bottom (columns). The "rows" represent individual cells, and the "columns" represent vertical profiles. Each slice (row of cells) will contain water flowing at a certain velocity. Slices/rows/cells closer to the bottom will tend to flow slower than cells at mid-depth due to friction. The cells at the left and right edges of each row also tend to flow slower than cells in the center of the row. The ADP measures the velocity of the water in each of these cells and produces a velocity profile from the top of the column to the bottom of the column. By moving the ADP from one side of a river to the other, all the adjacent profiles can be added together and the average velocity for all the water in the river can be determined. The cell velocity profiles for representative transects are presented graphically in Figure 5.

Figure 5. Florence transects.



The calculated discharge results and stream width were relatively consistent for the three locations Table 3. Average velocity was significantly higher at the upstream locations since the channel depth was less.

Table 3. FWTP discharge results.

Florence Computed Discharge Results			
Transect #	1	2	5
Width m	216.2	210.6	225.8
Area m^2	741.8	743.1	878.9
Mean Velocity m/s	1.35	1.25	1.06
Discharge m^3/sec	-999.6	-926.45	-934.79
% Measured	70.3	70.2	73.1

Figure 6 shows the typical transects for the Missouri River at the PSWTP residual solids discharge outfalls. In general, the river channel was deeper at the PSWTP (2-4 m) than river channel at the FWTP (2-8 m). This results in lower mean river velocities at the PSWTP (Table 4) than at the FWTP.

Figure 6. Platte transects.

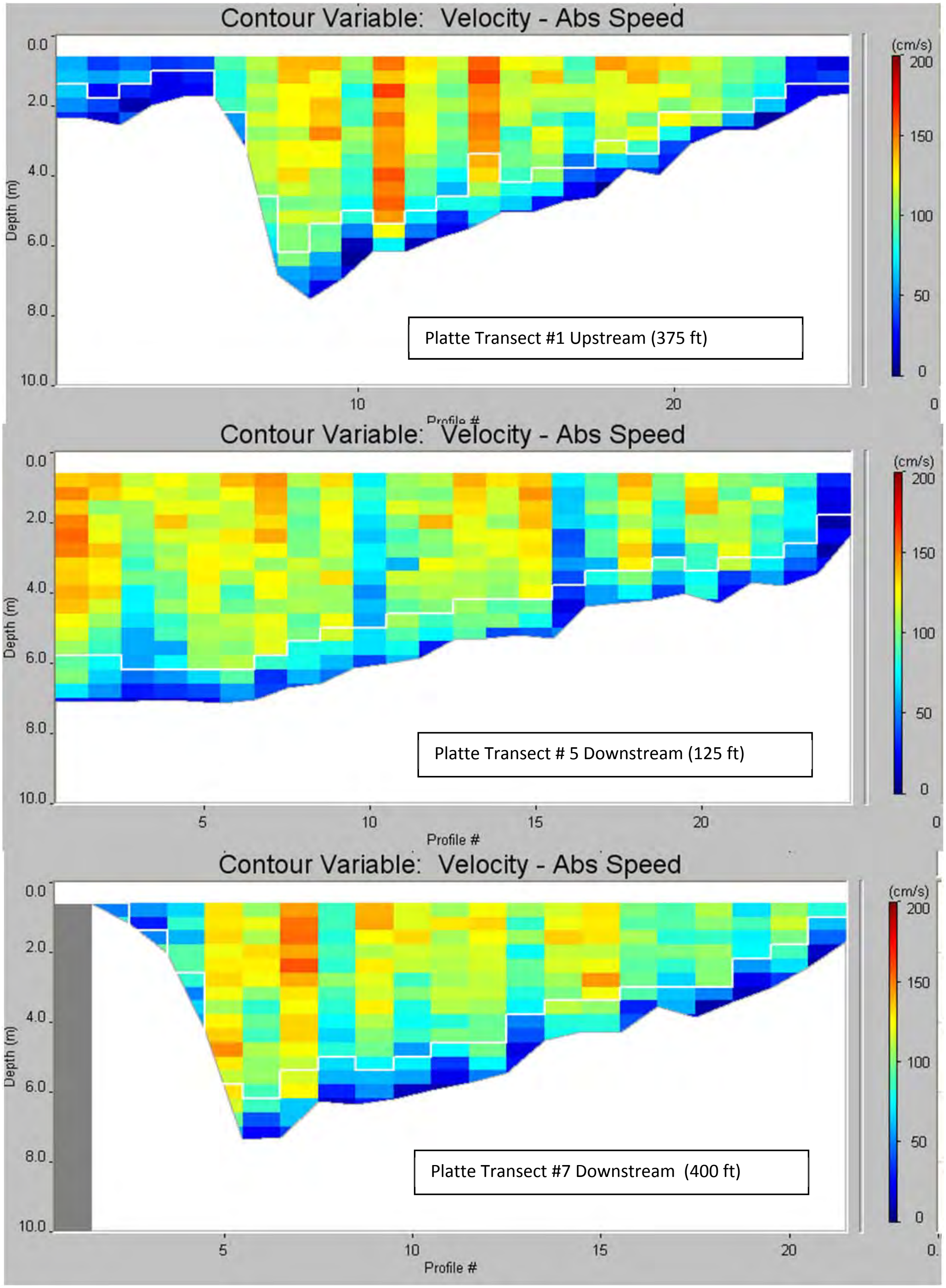


Table 4. Missouri River flow characteristics at the PSWTP residual discharge outfall area.

Computed Discharge Results Platte Transects			
Transect #	#1	#5	#7
Width m	227.1	196.6	198.1
Area m^2	1082.4	857.5	878
Mean Velocity m/sec	0.92	0.98	1.05
Discharge m^3/sec	-992.63	-837.67	-918.51
% Measured	65.2	71	70

Estimating Flow for Non-Gaged Locations (FWTP and the PSWTP). The sampling areas for the two outflow locations were not located at a stream gage. There were gages upstream and downstream from the sample location. Therefore, the flow was estimated using weighted average ratios of gage drainage areas to outfall drainage area (http://ks.water.usgs.gov/pubs/reports/wrir.02-4292.tab03.pdf, 2012).

$$Q_s = \frac{Q_u(DA_d - DA_s) + Q_d(DA_s - DA_u)}{DA_d - DA_u} \qquad (1)$$

Where

Q = Median Flow,

DA = Drainage Area,

s = Segment Ungaged

u = Upstream gaging station, and

d = Downstream gaging station.

Estimated flows at the Florence and Platte outfalls are presented in Table 5.

Table 5. Estimated flows for outfall locations.

Location	June 25, 2012	June 26, 2012
Platte Outfall	37,544 cfs	36,848 cfs
Florence Outfall	37,408 cfs	36,725 cfs

Missouri River Water Quality at the FWTP and PSWTP Residual Solids Discharge Outfalls Area

Florence Water Treatment Plant. Historically, discharging water treatment residuals to surface waters has been commonly practiced as an acceptable disposal method. The M.U.D.'s FWTP is a lime-softening facility. Residual solids from pre-sedimentation basins are continuously pumped to the Missouri River, whereas solids from four 20-million gal (75,700 m^3) sedimentation basins are discharged to the river twice each year. In addition, primary residual solids in the split-treatment reactors are continuously pumped to the river. Also, filter bed backwash water is wasted to the Missouri River. Residual solids from the FWTP are discharged to the Missouri River at three locations (Figure 1). Discharge Outfall 001 is at georeference point 95º 57' 26" W 41º 20' 35" N. Outfall 002 is 95º 57' 22" W 41º 20' 28" N. Outfall 005 is 95º 57' 15" W 41º 20' 19" N. Each outfall was located at the river's right edge, when looking in direction of flow, and near the water surface. The average water temperature was approximately 25^{o}C. The DO levels in the river upstream and downstream of the residual solids discharge outfalls ranged from 7.45 mg/L to 9.48 mg/L. Average DO concentrations for each transect position and depth are presented in Table 6. Upstream monitoring locations are above Outfall 001, and downstream monitoring locations are below Outfall 005. The discharge from Outfall 005 apparently created surface turbulence in the water surface, thereby increasing the reaeration rate at the point that yielded an average DO of 8.25 mg/L, which was significantly ($\alpha = 0.05$) higher than average upstream levels and average DO concentrations obtained 150 ft (46 m) (7.81 mg/L) and 500 ft (152 m) (7.67 mg/L) downstream from Outfall 005. Higher Dos were observed at deeper locations, probably due to cooler water temperatures.

Table 6. Average dissolved oxygen concentration (mg/L) upstream and downstream of FWTP residual solids discharge Outfall 005.

Position	Depth	N	Mean	Std Dev	Minimum	Maximum
Upstream -2,525ft (770m)	0.2	3	7.58	0.16	7.46	7.76
	0.5	3	7.9	0.36	7.52	8.23
	0.8	3	7.89	0.34	7.51	8.16
Upstream -1,925ft (587m)	0.2	3	7.7	0.12	7.56	7.8
	0.5	3	7.69	0.12	7.59	7.83
	0.8	3	7.67	0.08	7.61	7.76
Outfall - 0.0ft (0.0m)	0.2	3	8	0.04	7.97	8.05
	0.5	3	8.53	0.82	8.02	9.48
	0.8	3	8.23	0.29	7.96	8.54
Downstream-50ft (15.2m)	0.2	3	7.93	0.21	7.8	8.17
	0.5	3	8.04	0.22	7.83	8.27
	0.8	3	8.18	0.32	7.85	8.48
Downstream-100ft(30.5 m)	0.2	3	7.81	0.2	7.61	8.01
	0.5	3	8.46	0.57	7.93	9.07
	0.8	3	8.03	0.24	7.8	8.27
Downstream-150ft (61 m)	0.2	3	7.55	0.05	7.5	7.6
	0.5	3	7.86	0.35	7.51	8.2
	0.8	3	8.03	0.46	7.53	8.43
Downstream-500ft (152m)	0.2	3	7.55	0.11	7.45	7.66
	0.5	3	7.76	0.27	7.5	8.03
	0.8	3	7.7	0.11	7.59	7.8

*Outfall 001 is 1,850 ft (564m) upstream from Outfall 005

The drier areas of the Missouri River watershed are located above Omaha, where a greater percentage of the rainfall infiltrates into the calcareous soils and geological formations, and a disproportionately lower amount of rainfall surface runoff occurs compared to runoff amounts observed in the lower portions of the watershed (USAE, 2009). The Missouri River normally has an alkaline pH with values above the FWTP residual solids discharge point, normally ranging from 8 to 9 (USGS, 2010, EPA Storet Data). The river pH values upstream and downstream from the residual solids discharge outfalls ranged from 8.44 SU to 8.60 SU. Differences in pH of less than 0.5 SU are normally insignificant.

With a greater percentage of the Missouri River above Omaha fed from interflow and baseflow through calcareous soils and geological formations, the water of the Missouri River is hard. Hardness values upstream and downstream of the FWTP outfalls ranged from 254 mg $CaCO_3$/L to 302 mg $CaCO_3$/L (Table 7). While the hardness concentration 1,925 ft (587m) upstream (291 mg $CaCO_3$/L) from Outfall 005 was significantly ($\alpha = 0.05$) higher than the average concentration 150 ft downstream (265 mg $CaCO_3$/L) from Outfall 005, there were no significant differences among levels at other distances monitored. Corresponding alkalinity ranged from 179 mg $CaCO_3$/L to 273 mg $CaCO_3$/L (Table 8). Due to the variability of the data, there were no statistically significant ($\alpha = 0.05$) differences in alkalinity concentrations.

Table 7. Average hardness concentrations (mg CaCO3/L) upstream and downstream from the FWTP residual solids discharge Outfall 005.

Position		Depth	N	Mean	Std Dev	Minimum	Maximum
Upstream-2,525ft	(770m)	0.2	4	278	17	261	297
		0.5	3	277	18	261	297
		0.8	3	291	15	274	302
Upstream-1,926ft	(587m)	0.2	4	296	9	287	308
		0.5	3	288	3	284	290
		0.8	3	289	8	281	297
Outfall-0.0ft	(0.0m)	0.2	4	289	4	284	293
		0.5	3	290	1	289	290
		0.8	3	292	2	291	294
Downstream-50ft	(15.2m)	0.2	3	272	23	257	298
		0.5	4	269	19	256	297
		0.8	3	263	5	259	268
Downstream-100ft	(30.5m)	0.2	3	261	1	260	262
		0.5	3	262	5	256	266
		0.8	4	292	68	254	394
Downstream-150ft	(61m)	0.2	3	266	3	262	268
		0.5	3	267	4	262	270
		0.8	4	264	4	259	268
Downstream-500ft	(152m)	0.2	3	273	16	258	290
		0.5	4	265	4	260	269
		0.8	3	269	2	267	271

*Outfall 001 is 1,850 ff (564) upstream from 005

Table 8. Average alkalinity concentrations (mg $CaCO_3$/L) upstream and downstream of FWTP residual solids discharge Outfall 005.

Position	Depth	N	Mean	Std Dev	Minimum	Maximum
Upstream-2,525ft (770m)	0.2	4	185	5	179	190
	0.5	3	187	2	185	189
	0.8	3	186	1	185	187
Upstream-1,925ft (587m)	0.2	4	186	1	184	187
	0.5	3	184	5	179	188
	0.8	3	177	10	165	184
Outfall-0.0ft (0.0m)	0.2	4	183	3	180	186
	0.5	3	185	2	183	186
	0.8	3	184	1	183	184
Downstream-50ft (15.2m)	0.2	3	185	1	184	186
	0.5	4	183	2	182	185
	0.8	3	184	4	179	186
Downstream-100ft (30.5m)	0.2	3	185	1	184	186
	0.5	3	183	2	181	185
	0.8	4	206	45	180	273
Downstream-150ft (61m)	0.2	3	186	3	184	190
	0.5	3	187	2	185	189
	0.8	4	185	2	183	187
Downstream-500ft from	0.2	3	185	3	183	188
	0.5	4	186	1	184	187
	0.8	3	186	2	185	189

*Outfall 001 is 1,850 ft (564m) upstream from outfall 005.

Average total suspended solids (TSS) concentrations upstream and downstream from Outfall 001 are presented in Table 9. TSS values ranged from 31 mg/L (500 ft downstream from Outfall 005 at 0.5 depth) to 269 mg/L (100 ft downstream from Outfall 005 at 0.8 depth). No statistically significant ($\alpha = 0.05$) differences were computed between average TSS levels at different locations. Therefore, no significant increases in average TSS were observed during the discharge of residual solids at the FWTP during the monitoring period. Settleable solids (SS) concentrations were all <1.0 mg/L (detection limit), indicating the bulk of the solids were probably silt, clay particles or other fine particles with low settling rates.

Table 9. Average total suspended solids concentrations (mg/L) upstream and downstream of FWTP residual solids discharge Outfall 005.

Position	Depth	N	Mean	Std Dev	Minimum	Maximum
Upstream-2,525ft (770m)	0.2	4	79	6	70	85
	0.5	3	75	19	53	87
	0.8	3	81	8	73	89
Upstream-1,925ft (587m)	0.2	4	74	6	66	81
	0.5	3	78	11	68	89
	0.8	3	82	14	67	95
Outfall-0.0ft (0.0m)	0.2	4	73	4	70	78
	0.5	3	69	2	67	71
	0.8	3	68	4	65	73
Dwonstream-50ft (15m)	0.2	3	72	5	67	76
	0.5	4	70	4	67	76
	0.8	3	74	5	69	78
Downstream-100ft (30.5m)	0.2	3	71	4	68	76
	0.5	3	78	2	76	79
	0.8	4	127	95	76	269
Downstream-150ft (46m)	0.2	3	80	10	72	92
	0.5	3	82	12	69	91
	0.8	4	82	10	70	93
Downstream-500ft (152m)	0.2	3	76	9	70	86
	0.5	4	69	26	31	87
	0.8	3	80	8	71	86

*Outfall 001 is 1,850 ft (564m) upstream from Outfall 005.

While no significant change in TSS was observed in the Missouri River from the discharge of residual solids, there was a significant difference in the aluminum concentrations (Table 10). The average total aluminum concentration at a distance of 150 ft (46 m) from residual solids Outfall 005 (2.210 mg/L) was significantly different ($\alpha = 0.05$) than the average concentration measured at Outfall 005 (1.468 mg/L). The overall average aluminum concentration (1.938 mg/L) at 2,525 ft (770 m) upstream from Outfall 005 also was significantly greater ($\alpha = 0.05$) than the levels measured at Outfall 005. There were no significant differences ($\alpha = 0.05$) between average aluminum concentration at 2,525 ft (770 m) upstream and 1,925 ft (587 m) upstream of Outfall 005. Adding uncertainty to the issue is the mean aluminum concentrations upstream from the outfall were not significantly different ($\alpha=0.05$) than the mean concentration obtained at position 500 ft (152m) downstream from Outfall 005. It is inconclusive, that the concentration of aluminum at 150 ft and 500 ft (152 m) downstream from

Outfall 005 reflected the contribution of FWTP residual solids introduced at Outfall 005.

Aluminum is amphoteric-soluble in acidic and basic solutions, but very insoluble at circumneutral pH. Since the pH was slightly basic, low levels of dissolved aluminum were present in the river (Table 11). The bulk of the aluminum in the water was in particulate form, which ranged from <0.063 mg/L to 0.288 mg/L.

Table 10. Average total aluminum concentration upstream and downstream from the FWTP residual solids Outfall 005.

Position	Depth	N	Mean	Std Dev	Minimum	Maximum
Upstream-2,525ft (770m)	0.2	4	1.812	0.465	1.300	2.253
	0.5	3	2.026	0.280	1.703	2.196
	0.8	3	2.017	0.173	1.851	2.196
Upstream-1,925ft (587m)	0.2	4	1.898	0.304	1.592	2.186
	0.5	3	1.865	0.188	1.651	2.005
	0.8	3	1.678	0.162	1.567	1.864
Outfall-0.0ft (0.0m)	0.2	4	1.338	0.031	1.300	1.368
	0.5	3	1.583	0.078	1.493	1.630
	0.8	3	1.525	0.081	1.469	1.618
Downstream-50ft (15m)	0.2	3	1.757	0.125	1.641	1.889
	0.5	4	1.742	0.111	1.590	1.853
	0.8	3	1.813	0.108	1.703	1.919
Downstream-100ft (30.5m)	0.2	3	1.710	0.092	1.637	1.814
	0.5	3	1.845	0.024	1.824	1.871
	0.8	4	1.949	0.264	1.712	2.326
Downstream-150ft (46m)	0.2	3	2.208	0.385	1.802	2.569
	0.5	3	2.293	0.314	1.945	2.556
	0.8	4	2.151	0.405	1.781	2.595
Downstream-500ft (152m)	0.2	3	2.100	0.121	1.962	2.185
	0.5	4	1.992	0.150	1.883	2.213
	0.8	3	2.073	0.185	1.906	2.271

Table 11. Average dissolved aluminum (mg/L) upstream and downstream from FWTP residual solids discharge Outfall 005.

Position	Depth	N	Mean	Std Dev	Minimum	Maximum
Upstream-2,525ft (770m)	0.2	4	0.096	0.053	< 0.063	0.156
	0.5	3	0.187	0.027	0.156	0.208
	0.8	3	0.104	0.065	0.031	0.157
Upstream-1,925ft (587m)	0.2	4	0.165	0.045	0.119	0.214
	0.5	3	0.152	0.046	0.107	0.199
	0.8	3	0.163	0.082	0.083	0.246
Outfall-0.0ft (0.0m)	0.2	4	0.203	0.034	0.166	0.248
	0.5	3	0.222	0.018	0.205	0.24
	0.8	3	0.222	0.067	0.154	0.288
Downstream-50ft (15.2m)	0.2	3	0.156	0.054	0.115	0.217
	0.5	4	0.155	0.086	0.078	0.275
	0.8	3	0.125	0.022	0.1	0.141
Downstream-100ft (30m)	0.2	3	0.157	0.014	0.147	0.173
	0.5	3	0.137	0.037	0.114	0.18
	0.8	4	0.162	0.017	0.143	0.182
Downstream-150ft (61m)	0.2	3	0.165	0.016	0.146	0.176
	0.5	3	0.135	0.037	0.103	0.176
	0.8	4	0.131	0.06	0.072	0.209
Downstream-500ft (152m)	0.2	3	0.11	0.076	<0.063	0.183
	0.5	4	<0.063	0.033	<0.063	0.099
	0.8	3	0.082	0.088	<0.063	0.183

**Outfall 001 is 1,850 ft (564) upstream from Outfall 005.*

Aluminum salts can dissociate in water and Al^{+3} bonds with water molecules, hydroxide ions, other inorganic ions, and organic ions or molecules. At pH levels ranging from 4.0 to 8.5, aluminum-phosphate and aluminum-organic complexes are formed that are very insoluble and consequently precipitate from solution (EPA, 1988; Driscoll and Schecker, 1988).

When aluminum is mobilized in surface water, it may be toxic to aquatic life (Burrows, 1977; Schofield and Trojnar, 1980; Freeman and Everhart, 1971, 1973, George et al., 1991). The water hardness and the alkalinity, however, will decrease the toxicity of soluble aluminum on aquatic life (George et al., 1991, 1995). Lime-softening water treatment plants may not adversely aquatic life due to high calcium concentrations and associated high alkalinity.

The mean calcium concentrations upstream and downstream of Outfall 005 are presented in Table 12. While calcium concentrations ranged from 60.162 mg/L to 101.940 mg/L, no statistical differences ($\alpha = 0.05$) were computed between average calcium concentrations throughout the river reach monitored. Aluminum interactions with calcium may reduce the solubility of aluminum in circumneutral and basic solutions (Sposito, 1989). Previous toxicity testing of the M.U.D.'s FWTP residual solids discharged to the Missouri River was conducted by George et al. (1995). Residual solids and associated receiving water were obtained from the FWTP. The residual solids were divided into three parts, and the pH of each aliquot was altered to either an acidic, a circumneutral, or a basic condition. The residual solids were mixed for 24 hrs and filtered with a 0.45μm membrane filter. The extracts were diluted with receiving water at corresponding solids extract pH conditions. The extracts were subjected to a series of bioassays. Growth inhibition of *S. capricornutum* only occurred when the organism were subjected to 50 and 100% of extract solutions at pH 6, and only 100% filter extracts inhibited growth at pH 8.3 (George et al., 1995). With the tremendous dilution factor of the river to discharge flow of more than 1000:1, along with the high calcium and alkalinity concentrations, the solids residual discharge into the river should not significantly inhibit aquatic organisms.

Table 12. Average total calcium concentrations upstream and downstream of the FWTP residual solids Outfall 005.

Position	Depth	N	Mean	Std Dev	Minimum	Maximum
Upstream-2,525ft (770m)	0.2	4	66.582	3.978	62.996	70.517
	0.5	3	66.005	4.386	62.327	70.859
	0.8	3	69.214	4.320	64.267	72.247
Upstream-1,925ft (587m)	0.2	4	69.772	1.448	67.913	71.432
	0.5	3	68.537	0.582	67.897	69.034
	0.8	3	68.265	1.791	66.750	70.242
Outfall-0.0ft (0.0m)	0.2	4	69.142	0.496	68.572	69.757
	0.5	3	68.928	0.711	68.136	69.510
	0.8	3	69.774	1.320	68.524	71.155
Downstream-50ft (15.2m)	0.2	3	64.765	5.899	60.162	71.415
	0.5	4	63.649	4.995	60.634	71.120
	0.8	3	62.146	1.211	60.784	63.102
Downstream-100ft (30.5)	0.2	3	61.861	0.147	61.716	62.009
	0.5	3	61.744	1.138	60.635	62.908
	0.8	4	71.441	20.348	60.338	101.940
Downstream-150ft (61m)	0.2	3	63.049	0.954	61.949	63.650
	0.5	3	62.885	1.115	61.617	63.710
	0.8	4	62.631	1.029	61.585	63.602
Downstream-500ft (152m)	0.2	3	66.051	5.975	61.279	72.752
	0.5	4	62.255	0.994	60.986	63.414
	0.8	3	63.872	0.650	63.359	64.603

*Outfall 001 is 1,850 ft (564m) upstream from Outfall 005.

The chemistry of iron and aluminum in water are similar; however, iron species are less soluble than aluminum species over a wider pH range. Mean iron concentrations are presented in Table 13. Average iron concentrations upstream (> 2.000 mg/L) from Outfall 5 were significantly greater than the average concentration in water samples collected at Outfall 005 (1.464 mg/L to 1.741 mg/L). The upstream iron concentrations were not significantly different ($\alpha = 0.05$) than the mean iron concentrations at 150 ft (61m) and 500 ft (152m) downstream from Outfall 005. Similarly, there were no significant differences ($\alpha = 0.05$) between the mean iron concentrations at Outfall 005, 50 ft (15.2m) and 100 ft (30.5m) downstream. The residual solids discharge may have diluted the iron concentration immediately downstream from the discharge.

Table 13. Average total iron concentrations upstream and downstream from the FWTP residual solids Outfall 005.

Position	Depth	N	Mean	Std Dev	Minimum	Maximum
Upstream-2,525ft (770m)	0.2	4	2.184	0.404	1.599	2.497
	0.5	3	2.038	0.513	1.464	2.452
	0.8	3	2.272	0.299	1.940	2.521
Upstream-1,925ft (587m)	0.2	4	2.098	0.345	1.741	2.432
	0.5	3	2.073	0.233	1.824	2.285
	0.8	3	1.896	0.174	1.768	2.094
Outfall-0.0ft (0.0m)	0.2	4	1.464	0.028	1.433	1.500
	0.5	3	1.741	0.057	1.675	1.774
	0.8	3	1.695	0.097	1.594	1.788
Downstream-50ft (15.2m)	0.2	3	1.680	0.128	1.555	1.811
	0.5	4	1.658	0.128	1.529	1.830
	0.8	3	1.622	0.083	1.554	1.714
Downstream-100ft (30.5m)	0.2	3	1.545	0.090	1.469	1.645
	0.5	3	1.631	0.029	1.597	1.649
	0.8	4	1.726	0.180	1.585	1.987
Downstream-150ft (61m)	0.2	3	2.004	0.423	1.554	2.394
	0.5	3	2.111	0.315	1.767	2.385
	0.8	4	1.999	0.404	1.622	2.440
Downstream-500ft (152m)	0.2	3	2.004	0.267	1.754	2.285
	0.5	4	2.033	0.217	1.796	2.322
	0.8	3	2.089	0.297	1.824	2.410

The average magnesium concentrations at Outfall 005 (28.307 mg/L to 28.683 mg/L) were significantly higher than levels measured at 150 ft (46 m) and 500 ft (152 m) downstream from Outfall 005 (Table 14). There were no significant differences between average magnesium concentrations at Outfall 005 and upstream levels, which were greater than 27 mg/L. Similar to observations with iron, the residual solids discharge may have diluted the magnesium levels in the plume from Outfall 005.

Table 14. Average total magnesium concentrations upstream and downstream of FWTP residual solids discharge Outfall 005.

Position	Depth	N	Mean	Std Dev	Minimum	Maximum
Upstream-2,525ft (770m)	0.2	4	27.154	1.801	25.235	29.310
	0.5	3	27.112	1.874	25.516	29.175
	0.8	3	28.536	0.994	27.458	29.417
Upstream-1,925ft (587m)	0.2	4	29.466	1.407	28.523	31.561
	0.5	3	28.331	0.419	27.893	28.728
	0.8	3	28.692	0.839	27.770	29.409
Outfall-0.0ft (0.0m)	0.2	4	28.307	0.573	27.486	28.817
	0.5	3	28.533	0.260	28.289	28.807
	0.8	3	28.683	0.772	27.795	29.197
Downstream-50ft (15m)	0.2	3	26.865	2.032	25.378	29.180
	0.5	4	26.815	1.566	25.334	29.017
	0.8	3	26.229	0.558	25.794	26.859
Downstream-100ft (30.5m)	0.2	3	25.861	0.234	25.602	26.057
	0.5	2	25.894	0.684	25.410	26.377
	0.8	4	27.642	4.208	25.163	33.941
Downstream-150ft (46m)	0.2	3	26.386	0.264	26.083	26.564
	0.5	3	26.621	0.452	26.242	27.121
	0.8	4	26.091	0.514	25.357	26.522
Downstream-500ft (152m)	0.2	3	26.338	0.925	25.434	27.283
	0.5	4	26.484	0.352	26.151	26.956
	0.8	3	26.474	0.103	26.372	26.578

Manganese concentrations were relatively low, ranging from 0.128 mg/L to 0.186 mg/L Table 15. No significant differences ($\alpha = 0.05$) between manganese concentrations at various positions upstream and downstream of Outfall 005 were computed. Similarly, average zinc concentrations were low (Table 16.) Statistical comparison of data between different positions upstream and downstream of Outfall 005 indicated no significant differences ($\alpha = 0.05$) between average zinc concentrations. Trace metals such as copper (Table A.5), nickel (Table A.9) and selenium (Table A.10) were less than instrumental detection limits.

Table 15. Average total manganese concentrations upstream and downstream of FWTP solids residuals discharge Outfall 005.

Position	Depth	N	Mean	Std Dev	Minimum	Maximum
Upstream-2,525ft (770m)	0.2	4	0.166	0.023	0.134	0.186
	0.5	3	0.158	0.024	0.131	0.176
	0.8	3	0.172	0.012	0.159	0.181
Upstream-1,925ft (587m)	0.2	4	0.163	0.016	0.146	0.177
	0.5	3	0.161	0.009	0.150	0.167
	0.8	3	0.153	0.011	0.142	0.164
Outfall-0.0ft (0.0m)	0.2	4	0.132	0.003	0.129	0.136
	0.5	3	0.148	0.001	0.147	0.149
	0.8	3	0.147	0.006	0.141	0.153
Downstream-50ft (15.2m)	0.2	3	0.141	0.011	0.132	0.154
	0.5	4	0.140	0.011	0.130	0.156
	0.8	3	0.137	0.005	0.132	0.141
Downstream-100ft (30.5m)	0.2	3	0.133	0.005	0.128	0.138
	0.5	3	0.138	0.001	0.137	0.139
	0.8	4	0.145	0.015	0.134	0.168
Downstream-150ft (61m)	0.2	3	0.155	0.019	0.134	0.171
	0.5	3	0.160	0.017	0.141	0.174
	0.8	4	0.154	0.021	0.134	0.177
Downstream-500ft (152m)	0.2	3	0.155	0.009	0.145	0.162
	0.5	4	0.153	0.008	0.147	0.165
	0.8	3	0.156	0.009	0.148	0.166

Table 16. Average total zinc concentrations upstream and downstream of FTWP solids residual discharge Outfall 005.

Position	Depth	N	Mean	Std Dev	Minimum	Maximum
Upstream-2,525ft (770m)	0.2	4	0.012	0.003	0.010	0.016
	0.5	3	0.010	0.003	0.008	0.013
	0.8	3	0.011	0.001	0.011	0.012
Ustream-1,925ft (587m)	0.2	4	0.016	0.010	0.008	0.031
	0.5	3	0.009	0.001	0.009	0.010
	0.8	3	0.009	0.002	0.007	0.010
Outfall-0.0ft (0.0m)	0.2	4	0.007	0.003	<0.006	0.009
	0.5	3	0.008	0.002	0.006	0.010
	0.8	3	0.007	0.000	0.007	0.007
Downstream-50ft (15.2m)	0.2	3	0.011	0.003	0.008	0.013
	0.5	4	0.010	0.002	0.007	0.012
	0.8	3	0.011	0.001	0.010	0.012
Downstream-100ft (30.5m)	0.2	3	0.011	0.001	0.010	0.012
	0.5	3	0.011	0.001	0.010	0.012
	0.8	4	0.011	0.002	0.010	0.014
Downstream-150ft (61m)	0.2	3	0.016	0.003	0.014	0.019
	0.5	3	0.013	0.002	0.011	0.015
	0.8	4	0.011	0.002	0.009	0.014
Downstream-500ft (152m)	0.2	3	0.011	0.004	0.007	0.014
	0.5	4	0.005	0.005	<0.006	0.012
	0.8	3	0.007	0.006	<0.006	0.014

Platte South Water Treatment Plant. The PSWTP is a lime-softening facility that uses iron or aluminum salts as the primary coagulant. Upstream from the PSWTP and downstream from the FWTP, a major subwatershed flows into the Missouri River (Figure 7). This additional flow affected water quality immediately upstream for the PSWTP residual solids discharge.

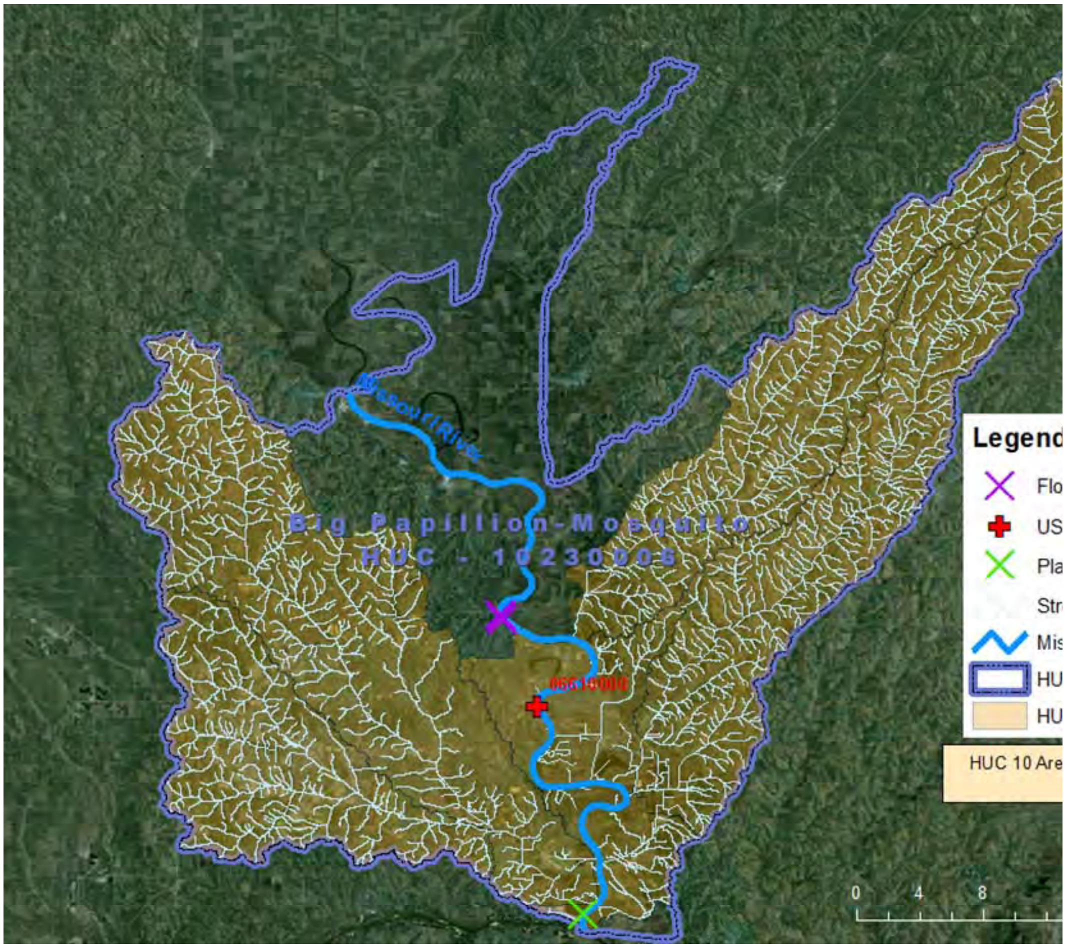


Figure 7. Subwatershed drainage area flowing into the Missouri River upstream of the PSWTP residual solids outfall.

Figure 2 shows the locations upstream and downstream from the PSWTP residual solids discharge point, Outfall 002, where river transects and water quality data were obtained. Outfall 002 was located near the river edge at georeferenced coordinates 476,601.28ft N, 2,775,327.96 ft. E. Residual solids were discharged beneath the water surface. DO levels varied from 7.47 mg/L to 11.44 mg/L. Average TSS concentrations at each location are presented in Table 17. These values represent the average TSS concentrations obtained in water samples collected along each transect width and depth. TSS concentrations ranged from 75 mg/L to 163 mg/L. Statistical analysis of the data indicated that average TSS concentrations at 375 ft upstream from the discharge point (94-141 mg/L) were significantly ($\alpha = 0.05$) greater than the downstream concentrations at 50 ft (88 -92 mg/L), 100 ft (92-109 mg/L) and 200 ft (87-100 mg/L). The average TSS concentrations upstream from the discharge were not significantly different ($\alpha = 0.05$) than the average concentration measured at 400 ft downstream from the discharge. Statistical analysis of the data also showed that at each depth there was no significant difference (α = 0.05) in average TSS between locations. Therefore, no significant increases in average TSS were observed during the discharge of residual solids at the PSWTP during the monitoring period.

Table 17. Average total suspended solids at each location and depth related to the PSWTP solids residual discharge.

Position	Depth	N	Mean	Std Dev	Minimum	Maximum
Upstream (375ft/144m)	0.2	4	141	30	99	169
	0.5	3	94	9	88	104
	0.8	3	114	32	94	151
Upstream (125ft/38m)	0.2	3	122	36	95	163
	0.5	4	95	5	91	102
	0.8	3	98	1	97	99
Downstream-50ft(15m)	0.2	3	92	5	88	97
	0.5	3	88	14	75	103
	0.8	4	90	4	84	93
Downstream-100ft(30.5m)	0.2	4	109	21	90	138
	0.5	3	92	6	85	97
	0.8	3	94	6	88	100
Downstream-125ft(38m)	0.2	3	90	6	85	96
	0.5	4	90	4	84	93
	0.8	3	94	5	90	99
Downstream-200ft(61m)	0.2	3	87	9	82	97
	0.5	3	100	9	90	108
	0.8	4	97	6	90	104
Downstream-400ft(122m)	0.2	3	106	39	82	151
	0.5	4	90	7	83	100
	0.8	2	97	11	89	105

The chemical composition of the TSS, however, did vary significantly (α = 0.05) from upstream to downstream. Aluminum, which is commonly used as a coagulant in water treatment to remove colloidal solids, may be present in residual solids that are discharged to surface waters. Downstream from the PSWTP, discharged outfall aluminum concentrations were significantly (α = 0.05) higher than upstream levels (Table 18). Similarly, for each specific water depth upstream, average aluminum concentrations were significantly (α = 0.05) less than concentrations measured downstream from Outfall 002. Aluminum is amphoteric-soluble in acidic and basic solutions, but very insoluble at circumneutral pH. Table 19 presents the mean pH values upstream and downstream of the PSWTP outfall. In general, the pH of the river was approximately 8.5, which was within the historic pH range of the river and was less than the acceptable level of 9.0 that was stated in the PSWTP's NPDES discharge permit. Since the pH was slightly basic, low levels of dissolved aluminum were present in the river (Table 20). Aluminum salts can dissociate in water and Al^{+3} bonds with water molecules, hydroxide ions, other inorganic ions and organic ions, or molecules. At pH levels ranging from 4.0 to 8.5, aluminum-phosphate and aluminum-organic complexes are formed that are very insoluble and consequently precipitate from solution (EPA, 1988; Driscoll and Schecker, 1988).

Table 18. Average total aluminum concentrations upstream and downstream from the PSWTP solids residual discharge outfall into the Missouri River.

Pos	Depth	N	Mean	Std Dev	Minimum	Maximum
Upstream (375ft/144m)	0.2	4	0.450	0.048	0.396	0.509
	0.5	3	0.422	0.049	0.384	0.477
	0.8	3	0.392	0.052	0.338	0.441
Upstream (125ft/38m)	0.2	3	0.428	0.048	0.393	0.483
	0.5	4	0.430	0.055	0.385	0.501
	0.8	3	0.481	0.030	0.459	0.515
Downstream-50ft(15m)	0.2	3	0.498	0.077	0.446	0.587
	0.5	3	0.511	0.083	0.422	0.585
	0.8	4	0.567	0.067	0.513	0.657
Downstream-100ft(30.5m)	0.2	4	0.853	0.212	0.653	1.040
	0.5	3	0.742	0.249	0.555	1.025
	0.8	3	0.770	0.292	0.575	1.106
Downstream-125ft(38m)	0.2	3	1.085	0.035	1.051	1.120
	0.5	4	1.134	0.044	1.094	1.197
	0.8	3	1.089	0.041	1.044	1.123
Downstream-200ft(61m)	0.2	3	0.904	0.213	0.674	1.095
	0.5	3	0.986	0.223	0.729	1.117
	0.8	4	0.746	0.152	0.626	0.963
Downstream-400ft(122m)	0.2	3	0.664	0.008	0.659	0.673
	0.5	4	0.733	0.097	0.610	0.817
	0.8	2	0.576	0.045	0.544	0.608

Table 19. Average pH values in the Missouri River upstream and downstream from PSWTP residuals discharge outfall.

Pos	Depth	N	Mean	Std Dev	Minimum	Maximum
Upstream (375ft/144m)	0.2	3	8.47	0.03	8.44	8.50
	0.5	3	8.44	0.04	8.41	8.48
	0.8	3	8.39	0.04	8.36	8.43
Upstream (125ft/38m)	0.2	3	8.48	0.01	8.47	8.49
	0.5	3	8.43	0.04	8.41	8.48
	0.8	3	8.42	0.06	8.35	8.45
Downstream-50ft(15m)	0.2	3	8.50	0.03	8.47	8.52
	0.5	3	8.45	0.03	8.42	8.48
	0.8	3	8.43	0.03	8.41	8.47
Downstream-100ft(30.5m)	0.2	3	8.53	0.01	8.52	8.53
	0.5	3	8.49	0.06	8.43	8.55
	0.8	3	8.50	0.07	8.45	8.58
Downstream-125ft(38m)	0.2	3	8.53	0.01	8.53	8.54
	0.5	3	8.51	0.01	8.50	8.52
	0.8	3	8.47	0.02	8.45	8.48
Downstream-200ft(61m)	0.2	3	8.55	0.01	8.54	8.56
	0.5	3	8.52	0.02	8.50	8.54
	0.8	3	8.48	0.01	8.48	8.49
Downstream-400ft(122m)	0.2	3	8.56	0.01	8.55	8.57
	0.5	3	8.53	0.02	8.51	8.55
	0.8	2	8.50	0.02	8.48	8.51

Table 20. Mean dissolved aluminum concentrations upstream and downstream of the PSWTP residual solids discharge outfall.

Pos	Depth	N	Mean	Std Dev	Minimum	Maximum
Upstream (375ft/144m)	0.2	4	0.120	0.022	0.100	0.152
	0.5	3	0.077	0.043	0.031	0.117
	0.8	3	0.061	0.051	0.031	0.120
Upstream (125ft/38m)	0.2	3	0.171	0.059	0.118	0.234
	0.5	4	0.118	0.055	0.065	0.181
	0.8	3	0.116	0.088	0.031	0.207
Downstream-50ft(15m)	0.2	3	0.097	0.030	0.067	0.126
	0.5	3	0.113	0.072	0.031	0.163
	0.8	4	0.124	0.078	0.031	0.204
Downstream-100ft(30.5m)	0.2	4	0.059	0.037	0.031	0.108
	0.5	3	0.073	0.046	0.031	0.123
	0.8	3	0.044	0.023	0.031	0.070
Downstream-125ft(38m)	0.2	3	0.074	0.046	0.031	0.123
	0.5	4	0.042	0.022	0.031	0.075
	0.8	3	0.055	0.042	0.031	0.104
Downstream-200ft(61m)	0.2	3	0.049	0.031	0.031	0.085
	0.5	3	0.046	0.027	0.031	0.077
	0.8	4	0.095	0.043	0.031	0.122
Downstream-400ft(122m)	0.2	3	0.138	0.011	0.128	0.150
	0.5	4	0.149	0.016	0.137	0.172
	0.8	2	0.119	0.016	0.107	0.130

As mentioned in the FWTP discussion (Page 21), when aluminum is mobilized in surface water, it may be toxic to aquatic life (Burrows, 1977; Schofield and Trojnar, 1980; Freeman and Everhart, 1971,1973; George et al., 1991). The water hardness and the alkalinity, however, will decrease the toxicity of soluble aluminum on aquatic life (George et al., 1991,1995). Lime-softening water treatment plants may not adversely aquatic life due to high calcium concentrations and associated high alkalinity.

The mean calcium concentrations present in the Missouri River upstream and downstream of the PSWTP solids residuals discharge outfall are provided in Table 21. In general, there were no significant differences ($\alpha = 0.05$) in average calcium concentrations between any of the upstream or downstream locations. Aluminum interactions with calcium may reduce the solubility of aluminum in circumneutral and basic solutions (Sposito, 1989). The Missouri River mean alkalinity levels upstream and downstream of the PSWTP outfall ranged from 177 to 188 mg $CaCO_3$/L (Table 22). As previously mentioned, previous toxicity testing of the M.U.D.'s FWTP showed growth inhibition of *S. capricornutum* only in 50 and 100% of extract solutions obtained from the plant's solids residual at pH 6.0 (George et al., 1995). With the tremendous estimated dilution factor of the river to residual solids discharge flow of greater than 13,000:1, along with the high calcium and alkalinity concentrations, the solids residual discharge into the river should not significantly inhibit aquatic organisms at a pH range from 8.0 to 9.0.

Table 21. Average total calcium concentrations in the Missouri River upstream and downstream of PSWTP solids residual outfall.

Pos	Depth	N	Mean	Std Dev	Minimum	Maximum
Upstream (375ft/144m)	0.2	4	62.033	1.796	59.530	63.435
	0.5	3	62.534	1.612	60.706	63.750
	0.8	3	61.657	0.913	60.735	62.561
Upstream (125ft/38m)	0.2	3	61.591	1.691	59.710	62.984
	0.5	4	62.094	1.063	60.530	62.907
	0.8	3	61.658	0.944	60.977	62.736
Downstream-50ft(15m)	0.2	3	63.058	1.906	61.081	64.884
	0.5	3	62.584	2.862	59.332	64.720
	0.8	4	64.509	0.953	63.531	65.682
Downstream-100ft(30.5m)	0.2	4	63.177	2.189	60.832	66.063
	0.5	3	64.080	2.418	61.380	66.045
	0.8	3	62.867	1.489	61.151	63.820
Downstream-125ft(38m)	0.2	3	63.251	3.951	59.973	67.638
	0.5	4	64.258	2.063	62.742	67.298
	0.8	3	63.489	2.597	61.658	66.461
Downstream-200ft(61m)	0.2	3	66.424	2.523	63.757	68.772
	0.5	3	65.831	2.818	63.039	68.675
	0.8	4	63.504	1.188	62.140	64.631
Downstream-400ft(122m)	0.2	3	62.071	0.461	61.539	62.350
	0.5	4	62.221	0.879	61.149	63.031
	0.8	2	61.958	1.312	61.030	62.885

Table 22. Mean total alkalinity (as mg $CaCO_3$/L) concentrations upstream and downstream of the PSWTP solids residual outfall.

Pos	Depth	N	Mean	Std Dev	Minimum	Maximum
Upstream (375ft/144m)	0.2	4	183	1	182	184
	0.5	3	183	1	182	184
	0.8	3	181	2	180	183
Upstream (125ft/38m)	0.2	3	182	2	181	184
	0.5	4	181	1	179	182
	0.8	3	182	2	180	183
Downstream-50ft(15m)	0.2	3	184	2	182	186
	0.5	3	183	1	182	184
	0.8	4	183	2	181	185
Downstream-100ft(30.5m)	0.2	4	182	4	178	187
	0.5	3	183	1	183	184
	0.8	3	183	2	182	185
Downstream-125ft(38m)	0.2	3	183	2	181	184
	0.5	4	183	2	181	184
	0.8	3	186	2	184	188
Downstream-200ft(61m)	0.2	3	181	1	180	182
	0.5	3	181	4	177	184
	0.8	4	182	2	180	184
Downstream-400ft(122m)	0.2	3	183	2	181	185
	0.5	4	183	2	180	185
	0.8	3	181	1	180	182

The chemistry of iron and aluminum in water are similar; however, iron species are less soluble than aluminum species over a wider pH range. Table 23 provides the mean total iron, Fe, concentrations upstream and downstream of the PSWTP outfall. As observed with aluminum, the average total iron concentrations in the Missouri River significantly ($\alpha = 0.05$) increased up to 125 ft (38 m) downstream of the PSWTP outfall at all depths. Average iron concentration at 200 ft (61 m) and 400 ft (122 m),while significantly ($\alpha = 0.05$) less than the mean values at 125 ft (38 m), were significantly higher than mean iron concentration upstream of the outfall.

Table 23. Average total iron concentrations upstream and downstream from the PSWTP solids residual outfall.

Pos	Depth	N	Mean	Std Dev	Minimum	Maximum
Upstream (375ft/144m)	0.2	4	0.396	0.063	0.325	0.465
	0.5	3	0.381	0.031	0.345	0.403
	0.8	3	0.328	0.027	0.311	0.359
Upstream (125ft/38m)	0.2	3	0.386	0.051	0.354	0.445
	0.5	4	0.367	0.071	0.292	0.462
	0.8	3	0.385	0.043	0.342	0.427
Downstream-50ft(15m)	0.2	3	0.438	0.048	0.396	0.491
	0.5	3	0.450	0.050	0.396	0.493
	0.8	4	0.505	0.069	0.444	0.599
Downstream-100ft(30.5m)	0.2	4	0.738	0.214	0.532	0.929
	0.5	3	0.611	0.258	0.406	0.900
	0.8	3	0.640	0.275	0.480	0.957
Downstream-125ft(38m)	0.2	3	0.974	0.010	0.967	0.986
	0.5	4	1.013	0.074	0.932	1.093
	0.8	3	0.994	0.032	0.966	1.028
Downstream-200ft(61m)	0.2	3	0.796	0.220	0.561	0.996
	0.5	3	0.900	0.247	0.615	1.043
	0.8	4	0.670	0.141	0.555	0.871
Downstream-400ft(122m)	0.2	3	0.612	0.014	0.603	0.628
	0.5	4	0.674	0.105	0.537	0.783
	0.8	2	0.560	0.037	0.533	0.586

While manganese concentrations were relatively low, ranging from 0.027 mg/L to 0.101 mg/L, downstream average total manganese concentrations at locations 100 ft (31 m), 125 ft (38 m), 200 ft (61 m), and 400 ft (122 m) also were significantly higher than average upstream levels (Table 24). With respect to depth, upstream average concentrations were significantly (α = 0.05) less than average concentrations at 100 ft (31 m), 125 ft (38 m), 200 ft (61 m) downstream from the outfall.

Table 24. Average total manganese concentrations upstream and downstream of PSWTP solids residual outfall.

Pos	Depth	N	Mean	Std Dev	Minimum	Maximum
Upstream (375ft/144m)	0.2	4	0.035	0.006	0.028	0.041
	0.5	3	0.034	0.002	0.031	0.035
	0.8	3	0.030	0.002	0.028	0.032
Upstream (125ft/38m)	0.2	3	0.035	0.004	0.032	0.039
	0.5	4	0.033	0.006	0.027	0.041
	0.8	3	0.034	0.003	0.031	0.037
Downstream-50ft(15m)	0.2	3	0.043	0.009	0.037	0.053
	0.5	3	0.045	0.008	0.039	0.054
	0.8	4	0.049	0.010	0.038	0.061
Downstream-100ft(30.5m)	0.2	4	0.072	0.016	0.056	0.086
	0.5	3	0.063	0.020	0.047	0.085
	0.8	3	0.064	0.019	0.052	0.086
Downstream-125ft(38m)	0.2	3	0.091	0.001	0.090	0.092
	0.5	4	0.095	0.006	0.089	0.101
	0.8	3	0.093	0.003	0.090	0.096
Downstream-200ft(61m)	0.2	3	0.078	0.019	0.058	0.095
	0.5	3	0.086	0.019	0.064	0.098
	0.8	4	0.062	0.018	0.046	0.085
Downstream-400ft(122m)	0.2	3	0.050	0.003	0.047	0.053
	0.5	4	0.056	0.008	0.046	0.063
	0.8	2	0.047	0.004	0.044	0.049

Upstream average magnesium concentrations, however, were only significantly less than the average magnesium concentration at 200 ft (61 m) downstream from outfall (Table 25). Magnesium levels ranged from 24.599 mg/L to 28.073 mg/L. Magnesium salts precipitated out of the drinking water during the lime-softening process and then were reintroduced to the Missouri River with the residuals discharge. Other metals such as copper, nickel, selenium were not present above detection limits (Table B.5, Table B.9, Table B.10).

Table 25. Average total magnesium concentrations in the Missouri River upstream and downstream of PSWTP solids residual outfall.

Pos	Depth	N	Mean	Std Dev	Minimum	Maximum
Upstream (375ft/144m)	0.2	4	25.956	1.327	24.599	27.778
	0.5	3	25.727	0.266	25.445	25.974
	0.8	3	25.519	0.016	25.503	25.534
Upstream (125ft/38m)	0.2	3	25.679	0.528	25.209	26.250
	0.5	4	25.774	0.610	25.076	26.394
	0.8	3	26.356	0.767	25.632	27.160
Downstream-50ft(15m)	0.2	3	26.548	0.552	26.034	27.131
	0.5	3	26.205	0.415	25.780	26.609
	0.8	4	26.477	0.416	26.086	26.969
Downstream-100ft(30.5m)	0.2	4	26.237	1.048	25.148	27.639
	0.5	3	26.167	0.457	25.651	26.520
	0.8	3	25.955	0.024	25.928	25.970
Downstream-125ft(38m)	0.2	3	26.164	1.250	25.308	27.599
	0.5	4	26.654	1.086	25.402	28.041
	0.8	3	25.992	0.899	25.397	27.026
Downstream-200ft(61m)	0.2	3	27.616	0.581	26.962	28.073
	0.5	3	27.154	0.095	27.096	27.263
	0.8	4	26.384	0.629	25.712	27.017
Downstream-400ft(122m)	0.2	3	25.656	0.492	25.225	26.192
	0.5	4	25.670	0.198	25.434	25.914
	0.8	2	25.630	0.021	25.615	25.645

CONCLUSION

The investigation of the Missouri River water quality upstream and downstream of the residual solids outfalls from the FWTP and the PSWTP was to determine if the residual solids discharged by either facility impacted the water quality of the Missouri River. Data analysis indicated that the solids discharge at both facilities did not significantly affect the TSS concentrations in the river. The chemical composition of the solids, i.e., aluminum and iron, at the PSWTP apparently increased downstream from the residual solids discharge due to the introduction of solids mass from the facility. However, the calcium and pH levels of the Missouri River should prevent any inhibitory effect by aluminum on aquatic life in the water column. Trace metals such as copper, nickel, and selenium were measured at detection limits and, therefore, pose no concern.

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APPENDIX A

FLORENCE WATER TREATMENT PLANT

MISSOURI RIVER WATER QUALITY DATA

Table A.1. Sonde data Florence Water Treatment Plant, Metropolitan Utility District, Omaha, NE.

Location From Reference Discharge	Transect No.	Position along Transect	Depth (Fraction of Total Depth)	Specific Conductance (mS/m)	Dissolved O_2 (mg/L)	pH (SU)	Temperature (^oC)
Upstream (2,525 ft)	1	1	.2	0.876	7.53	8.5	25.13
Upstream (2,525 ft)	1	1	.5	0.876	8.23	8.48	25.12
Upstream (2,525 ft)	1	1	.8	0.876	8.16	8.47	25.12
Upstream (2,525 ft)	1	2	.2	0.869	7.46	8.49	25.17
Upstream (2,525 ft)	1	2	.5	0.869	7.52	8.47	25.17
Upstream (2,525 ft)	1	2	.8	0.868	7.51	8.44	25.17
Upstream (2,525 ft)	1	3	.2	0.865	7.76	8.49	25.24
Upstream (2,525 ft)	1	3	.5	0.865	7.95	8.47	25.23
Upstream (2,525 ft)	1	3	.8	0.865	8	8.45	25.23
Upstream (1,925 ft)	2	1	.2	0.877	7.8	8.49	25.16
Upstream (1,925 ft)	2	1	.5	0.877	7.83	8.47	25.17
Upstream (1,925 ft)	2	1	.8	0.877	7.76	8.46	25.16
Upstream (1,925 ft)	2	2	.2	0.872	7.74	8.47	25.18
Upstream (1,925 ft)	2	2	.5	0.87	7.59	8.48	25.25
Upstream (1,925 ft)	2	2	.8	0.87	7.65	8.46	25.25
Upstream (1,925 ft)	2	3	.2	0.863	7.56	8.5	25.49
Upstream (1,925 ft)	2	3	.5	0.863	7.66	8.5	25.48
Upstream (1,925 ft)	2	3	.8	0.863	7.61	8.48	25.5
Outfall 005	3	1	.2	0.875	7.97	8.55	25.55
Outfall 005	3	1	.5	0.875	8.1	8.53	25.55
Outfall 005	3	1	.8	0.875	8.18	8.5	25.55
Outfall 005	3	2	.2	0.874	7.98	8.57	25.56
Outfall 005	3	2	.5	0.874	8.02	8.52	25.56
Outfall 005	3	2	.8	0.875	7.96	8.5	25.56
Outfall 005	3	3	.2	0.874	8.05	8.56	25.56
Outfall 005	3	3	.5	0.874	9.48	8.5	25.56
Outfall 005	3	3	.8	0.874	8.54	8.48	25.56
Downstream (50 ft)	4	1	.2	0.875	7.81	8.57	25.48
Downstream (50 ft)	4	1	.5	0.875	7.83	8.55	25.49
Downstream (50 ft)	4	1	.8	0.875	7.85	8.52	25.49
Downstream (50 ft)	4	2	.2	0.874	8.17	8.56	25.5
Downstream (50 ft)	4	2	.5	0.875	8.27	8.55	25.5

Downstream (50 ft)	4	2	08	0.874	8.2	8.5	25.49
Downstream (50 ft)	4	3	.2	0.874	7.8	8.55	25.49
Downstream (50 ft)	4	3	.5	0.874	8.02	8.53	25.49
Downstream (50 ft)	4	3	.8	0.874	8.48	8.5	25.5
Downstream (100 ft)	5	1	.2	0.874	7.61	8.57	25.42
Downstream (100 ft)	5	1	.5	0.874	9.07	8.53	25.41
Downstream (100 ft)	5	1	.8	0.871	8.03	8.6	25.44
Downstream (100 ft)	5	2	.2	0.874	7.81	8.54	25.42
Downstream (100 ft)	5	2	.5	0.874	7.93	8.53	25.42
Downstream (100 ft)	5	2	.8	0.875	7.8	8.47	25.42
Downstream (100 ft)	5	3	.2	0.874	8.01	8.55	25.44
Downstream (100 ft)	5	3	.5	0.874	8.37	8.52	25.43
Downstream (100 ft)	5	3	.8	0.874	8.27	8.5	25.43
Downstream (150 ft)	6	1	.2	0.874	7.55	8.53	25.35
Downstream (150 ft)	6	1	.5	0.875	7.86	8.52	25.34
Downstream (150 ft)	6	1	.8	0.875	8.43	8.48	25.35
Downstream (150 ft)	6	2	.2	0.866	7.6	8.51	25.38
Downstream (150 ft)	6	2	.5	0.866	7.51	8.5	25.38
Downstream (150 ft)	6	2	.8	0.866	7.53	8.47	25.38
Downstream (150 ft)	6	3	.2	0.862	7.5	8.51	25.55
Downstream (150 ft)	6	3	.5	0.862	8.2	8.49	25.54
Downstream (150 ft)	6	3	.8	0.862	8.12	8.48	25.53
Downstream (500 ft)	7	1	.2	0.875	7.66	8.55	25.34
Downstream (500 ft)	7	1	.5	0.875	7.74	8.52	25.32
Downstream (500 ft)	7	1	.8	0.875	7.71	8.51	25.32
Downstream (500 ft)	7	2	.2	0.87	7.45	8.51	25.31
Downstream (500 ft)	7	2	.5	0.87	7.5	8.5	25.31
Downstream (500 ft)	7	2	.8	0.87	7.59	8.47	25.31
Downstream (500 ft)	7	3	.2	0.863	7.55	8.5	25.43
Downstream (500 ft)	7	3	.5	0.783	8.03	8.48	25.81
Downstream (500 ft)	7	3	.8	0.863	7.8	8.45	25.45

Table A.2. Total suspended solids, alkalinity, hardness and settable solids data Florence Water Treatment Plant, Metropolitan Utility District, Omaha, NE.

Location From Reference Discharge	Transect No#	Position along Transect	Depth (Fraction of Total Depth)	Alkalinity (mg/L $CaCO_3$)	Hardness (mg/L $CaCO_3$)	Settable Solids (mg/L)	TSS (mg/L)
Upstream (2,525 ft)	1	1	.2	179	261	< 1	70
Upstream (2,525 ft)	1	1	.5	185	261	< 1	53
Upstream (2,525 ft)	1	1	.8	185	274	< 1	73
Upstream (2,525 ft)	1	2	.2	183	266	< 1	80
Upstream (2,525 ft)	1	2	.5	186	272	< 1	85
Upstream (2,525 ft)	1	2	.8	185	296	< 1	82
Upstream (2,525 ft)	1	3	.2	187	288	< 1	81
Upstream (2,525 ft)	1	3	.5	189	297	< 1	87
Upstream (2,525 ft)	1	3	.8	187	302	< 1	89
Upstream (1,925 ft)	2	1	.2	186	294	< 1	72
Upstream (1,925 ft)	2	1	.5	186	289	< 1	68
Upstream (1,925 ft)	2	1	.8	165	297	< 1	67
Upstream (1,925 ft)	2	2	.2	184	308	< 1	76
Upstream (1,925 ft)	2	2	.5	179	284	< 1	78
Upstream (1,925 ft)	2	2	.8	182	288	< 1	83
Upstream (1,925 ft)	2	3	.2	187	293	< 1	81
Upstream (1,925 ft)	2	3	.5	188	290	< 1	89
Upstream (1,925 ft)	2	3	.8	184	281	< 1	95
Outfall 005	3	1	.2	185	293	< 1	74
Outfall 005	3	1	.5	186	290	< 1	71
Outfall 005	3	1	.8	183	294	< 1	73
Outfall 005	3	2	.2	180	290	< 1	70
Outfall 005	3	2	.5	186	290	< 1	67
Outfall 005	3	2	.8	184	291	< 1	65
Outfall 005	3	3	.2	180	290	< 1	70
Outfall 005	3	3	.5	183	289	< 1	68
Outfall 005	3	3	.8	184	292	< 1	67
Downstream (50 ft)	4	1	.2	185	298	< 1	74
Downstream (50 ft)	4	1	.5	182	297	< 1	70
Downstream (50 ft)	4	1	.8	186	268	< 1	69
Downstream (50 ft)	4	2	.2	184	257	< 1	67
Downstream (50 ft)	4	2	.5	185	263	< 1	68
Downstream (50 ft)	4	2	08	179	262	< 1	74
Downstream (50 ft)	4	3	.2	186	261	< 1	76
Downstream (50 ft)	4	3	.5	182	256	< 1	76
Downstream (50 ft)	4	3	.8	186	259	< 1	78

Downstream (100 ft)	5	1	.2	184	260	< 1	76
Downstream (100 ft)	5	1	.5	184	263	< 1	76
Downstream (100 ft)	5	1	.8	273	394	< 1	269
Downstream (100 ft)	5	2	.2	184	261	< 1	70
Downstream (100 ft)	5	2	.5	185	266	< 1	79
Downstream (100 ft)	5	2	.8	186	262	< 1	79
Downstream (100 ft)	5	3	.2	186	262	< 1	68
Downstream (100 ft)	5	3	.5	181	256	< 1	79
Downstream (100 ft)	5	3	.8	180	254	< 1	83
Downstream (150 ft)	6	1	.2	184	262	< 1	72
Downstream (150 ft)	6	1	.5	185	262	< 1	69
Downstream (150 ft)	6	1	.8	185	261	< 1	70
Downstream (150 ft)	6	2	.2	185	268	< 1	77
Downstream (150 ft)	6	2	.5	186	268	< 1	86
Downstream (150 ft)	6	2	.8	187	268	< 1	87
Downstream (150 ft)	6	3	.2	190	268	< 1	92
Downstream (150 ft)	6	3	.5	189	270	< 1	91
Downstream (150 ft)	6	3	.8	183	267	< 1	93
Downstream (500 ft)	7	1	.2	183	258	< 1	70
Downstream (500 ft)	7	1	.5	186	269	< 1	76
Downstream (500 ft)	7	1	.8	185	271	< 1	71
Downstream (500 ft)	7	2	.2	185	272	< 1	71
Downstream (500 ft)	7	2	.5	184	264	< 1	82
Downstream (500 ft)	7	2	.8	185	268	< 1	86
Downstream (500 ft)	7	3	.2	188	290	< 1	86
Downstream (500 ft)	7	3	.5	187	265	< 1	87
Downstream (500 ft)	7	3	.8	189	267	< 1	84

Table A.3 Aluminum data Florence Water Treatment Plant, Metropolitan Utility District, Omaha, NE.

Location From Reference Discharge	Transect No.	Position along Transect	Parameter	Results (mg/L)
Upstream (2,525 ft)	1	1	Al Total	1.539
	1	1	Al Total	1.409
	1	1	Al Total	1.929
	1	2	Al Total	2.174
	1	2	Al Total	2.062
	1	2	Al Total	1.972
	1	3	Al Total	2.083
	1	3	Al Total	2.185
	1	3	Al Total	2.178
	1	3	Al Total	2.196
Upstream (1,925 ft)	2	1	Al Total	1.682
	2	1	Al Total	1.592
	2	1	Al Total	1.651
	2	1	Al Total	1.603
	2	2	Al Total	2.131
	2	2	Al Total	1.94
	2	2	Al Total	1.864
	2	3	Al Total	2.186
	2	3	Al Total	2.005
	2	3	Al Total	1.567
Outfall 005	3	1	Al Total	1.357
	3	1	Al Total	1.325
	3	1	Al Total	1.63
	3	1	Al Total	1.618
	3	2	Al Total	1.368
	3	2	Al Total	1.493
	3	2	Al Total	1.488
	3	3	Al Total	1.3
	3	3	Al Total	1.627
	3	3	Al Total	1.469
Downstream (50 ft)	4	1	Al Total	1.641
	4	1	Al Total	1.59
	4	1	Al Total	1.853
	4	1	Al Total	1.919
	4	2	Al Total	1.889
	4	2	Al Total	1.784
	4	2	Al Total	1.703
	4	3	Al Total	1.741
	4	3	Al Total	1.741
	4	3	Al Total	1.818
Downstream (100 ft)	5	1	Al Total	1.637
	5	1	Al Total	1.824
	5	1	Al Total	2.326
	5	2	Al Total	1.68
	5	2	Al Total	1.84
	5	2	Al Total	1.851
	5	2	Al Total	1.712
	5	3	Al Total	1.814
	5	3	Al Total	1.871

	5	3	Al Total	1.905
Downstream (150 ft)	6	1	Al Total	1.802
	6	1	Al Total	1.945
	6	1	Al Total	1.834
	6	1	Al Total	1.781
	6	2	Al Total	2.253
	6	2	Al Total	2.378
	6	2	Al Total	2.392
	6	3	Al Total	2.569
	6	3	Al Total	2.556
	6	3	Al Total	2.595
Downstream (500 ft)	7	1	Al Total	1.962
	7	1	Al Total	1.946
	7	1	Al Total	2.041
	7	2	Al Total	2.154
	7	2	Al Total	1.883
	7	2	Al Total	1.925
	7	2	Al Total	1.906
	7	3	Al Total	2.185
	7	3	Al Total	2.213
	7	3	Al Total	2.271
Upstream (2,525 ft)	1	1	Al Dissolved	0.116
	1	1	Al Dissolved	0.156
	1	1	Al Dissolved	0.157
	1	2	Al Dissolved	<0.063
	1	2	Al Dissolved	0.196
	1	2	Al Dissolved	0.123
	1	3	Al Dissolved	0.082
	1	3	Al Dissolved	0.156
	1	3	Al Dissolved	0.208
	1	3	Al Dissolved	<0.063
Upstream (1,925 ft)	2	1	Al Dissolved	0.191
	2	1	Al Dissolved	0.135
	2	1	Al Dissolved	0.199
	2	1	Al Dissolved	0.083
	2	2	Al Dissolved	0.119
	2	2	Al Dissolved	0.107
	2	2	Al Dissolved	0.159
	2	3	Al Dissolved	0.214
	2	3	Al Dissolved	0.151
	2	3	Al Dissolved	0.246
Outfall 005	3	1	Al Dissolved	0.202
	3	1	Al Dissolved	0.248
	3	1	Al Dissolved	0.22
	3	1	Al Dissolved	0.154
	3	2	Al Dissolved	0.166
	3	2	Al Dissolved	0.205
	3	2	Al Dissolved	0.225
	3	3	Al Dissolved	0.195
	3	3	Al Dissolved	0.24
	3	3	Al Dissolved	0.288
Downstream (50 ft)	4	1	Al Dissolved	0.217
	4	1	Al Dissolved	0.275
	4	1	Al Dissolved	0.111

	4	1	Al Dissolved	0.141
	4	2	Al Dissolved	0.115
	4	2	Al Dissolved	0.157
	4	2	Al Dissolved	0.133
	4	3	Al Dissolved	0.137
	4	3	Al Dissolved	0.078
	4	3	Al Dissolved	0.1
Downstream (100 ft)	5	1	Al Dissolved	0.147
	5	1	Al Dissolved	0.117
	5	1	Al Dissolved	0.182
	5	2	Al Dissolved	0.152
	5	2	Al Dissolved	0.114
	5	2	Al Dissolved	0.143
	5	2	Al Dissolved	0.167
	5	3	Al Dissolved	0.173
	5	3	Al Dissolved	0.18
	5	3	Al Dissolved	0.156
Downstream (150 ft)	6	1	Al Dissolved	0.176
	6	1	Al Dissolved	0.103
	6	1	Al Dissolved	0.099
	6	1	Al Dissolved	0.145
	6	2	Al Dissolved	0.146
	6	2	Al Dissolved	0.126
	6	2	Al Dissolved	0.209
	6	3	Al Dissolved	0.172
	6	3	Al Dissolved	0.176
	6	3	Al Dissolved	0.072
Downstream (500 ft)	7	1	Al Dissolved	0.183
	7	1	Al Dissolved	0.099
	7	1	Al Dissolved	0.183
	7	2	Al Dissolved	0.116
	7	2	Al Dissolved	<0.063
	7	2	Al Dissolved	<0.063
	7	2	Al Dissolved	<0.063
	7	3	Al Dissolved	<0.063
	7	3	Al Dissolved	0.072
	7	3	Al Dissolved	<0.063

Table A.4. Calcium data Florence Water Treatment Plant, Metropolitan Utility District, Omaha, NE.

Location From Reference Discharge	Transverse No.	Position along Transect	Parameter	Results (mg/L)
Upstream (2,525 ft)	1	1	Ca Total	62.996
	1	1	Ca Total	62.327
	1	1	Ca Total	64.267
	1	2	Ca Total	63.321
	1	2	Ca Total	64.829
	1	2	Ca Total	71.127
	1	3	Ca Total	69.495
	1	3	Ca Total	70.517
	1	3	Ca Total	70.859
	1	3	Ca Total	72.247
Upstream (1,925 ft)	2	1	Ca Total	70.044
	2	1	Ca Total	67.913
	2	1	Ca Total	69.034
	2	1	Ca Total	70.242
	2	2	Ca Total	71.432
	2	2	Ca Total	67.897
	2	2	Ca Total	67.802
	2	3	Ca Total	69.698
	2	3	Ca Total	68.68
	2	3	Ca Total	66.75
Outfall 005	3	1	Ca Total	69.757
	3	1	Ca Total	68.572
	3	1	Ca Total	69.138
	3	1	Ca Total	69.643
	3	2	Ca Total	68.986
	3	2	Ca Total	69.51
	3	2	Ca Total	68.524
	3	3	Ca Total	69.251
	3	3	Ca Total	68.136
	3	3	Ca Total	71.155
Downstream (50 ft)	4	1	Ca Total	71.415
	4	1	Ca Total	71.12
	4	1	Ca Total	61.36
	4	1	Ca Total	63.102
	4	2	Ca Total	60.162
	4	2	Ca Total	61.482
	4	2	Ca Total	62.553
	4	3	Ca Total	62.718
	4	3	Ca Total	60.634
	4	3	Ca Total	60.784
Downstream (100 ft)	5	1	Ca Total	61.857
	5	1	Ca Total	61.688
	5	1	Ca Total	101.949
	5	2	Ca Total	61.716
	5	2	Ca Total	62.908
	5	2	Ca Total	62.266
	5	2	Ca Total	61.221

	5	3	Ca Total	62.009
	5	3	Ca Total	60.635
	5	3	Ca Total	60.338
Downstream (150 ft)	6	1	Ca Total	61.949
	6	1	Ca Total	61.617
	6	1	Ca Total	61.585
	6	1	Ca Total	61.914
	6	2	Ca Total	63.65
	6	2	Ca Total	63.71
	6	2	Ca Total	63.423
	6	3	Ca Total	63.548
	6	3	Ca Total	63.329
	6	3	Ca Total	63.602
Downstream (500 ft)	7	1	Ca Total	61.279
	7	1	Ca Total	63.414
	7	1	Ca Total	64.603
	7	2	Ca Total	64.122
	7	2	Ca Total	62.257
	7	2	Ca Total	60.986
	7	2	Ca Total	63.654
	7	3	Ca Total	72.752
	7	3	Ca Total	62.364
	7	3	Ca Total	63.359
Upstream (2,525 ft)	1	1	Ca Dissolved	64.605
	1	1	Ca Dissolved	74.708
	1	1	Ca Dissolved	66.291
	1	2	Ca Dissolved	66.459
	1	2	Ca Dissolved	100.093
	1	2	Ca Dissolved	64.638
	1	3	Ca Dissolved	67.36
	1	3	Ca Dissolved	67.768
	1	3	Ca Dissolved	66.436
	1	3	Ca Dissolved	73.712
Upstream (1,925 ft)	2	1	Ca Dissolved	66.267
	2	1	Ca Dissolved	64.775
	2	1	Ca Dissolved	64.586
	2	1	Ca Dissolved	64.374
	2	2	Ca Dissolved	64.389
	2	2	Ca Dissolved	66.041
	2	2	Ca Dissolved	69.167
	2	3	Ca Dissolved	68.621
	2	3	Ca Dissolved	68.565
	2	3	Ca Dissolved	70.4
Outfall 005	3	1	Ca Dissolved	65.559
	3	1	Ca Dissolved	65.946
	3	1	Ca Dissolved	66.377
	3	1	Ca Dissolved	66.197
	3	2	Ca Dissolved	66.341
	3	2	Ca Dissolved	68.071
	3	2	Ca Dissolved	68.316
	3	3	Ca Dissolved	66.502
	3	3	Ca Dissolved	67.949
	3	3	Ca Dissolved	68.153
Downstream (50 ft)	4	1	Ca Dissolved	66.746

	4	1	Ca Dissolved	67.656
	4	1	Ca Dissolved	63.792
	4	1	Ca Dissolved	65.168
	4	2	Ca Dissolved	64.181
	4	2	Ca Dissolved	66.732
	4	2	Ca Dissolved	63.891
	4	3	Ca Dissolved	62.477
	4	3	Ca Dissolved	63.376
	4	3	Ca Dissolved	63.039
Downstream (100 ft)	5	1	Ca Dissolved	62.293
	5	1	Ca Dissolved	64.225
	5	1	Ca Dissolved	48.435
	5	2	Ca Dissolved	61.846
	5	2	Ca Dissolved	63.692
	5	2	Ca Dissolved	65.378
	5	2	Ca Dissolved	63.807
	5	3	Ca Dissolved	65.789
	5	3	Ca Dissolved	61.98
	5	3	Ca Dissolved	64.353
Downstream (150 ft)	6	1	Ca Dissolved	64.318
	6	1	Ca Dissolved	61.46
	6	1	Ca Dissolved	63.491
	6	1	Ca Dissolved	63.023
	6	2	Ca Dissolved	61.897
	6	2	Ca Dissolved	65.005
	6	2	Ca Dissolved	62.241
	6	3	Ca Dissolved	64.826
	6	3	Ca Dissolved	66.612
	6	3	Ca Dissolved	64.05
Downstream (500 ft)	7	1	Ca Dissolved	64.331
	7	1	Ca Dissolved	63.825
	7	1	Ca Dissolved	62.817
	7	2	Ca Dissolved	64.012
	7	2	Ca Dissolved	61.67
	7	2	Ca Dissolved	59.77
	7	2	Ca Dissolved	60.629
	7	3	Ca Dissolved	62.65
	7	3	Ca Dissolved	62.518
	7	3	Ca Dissolved	62.175

Table A.5. Copper data Florence Water Treatment Plant, Metropolitan Utility District, Omaha, NE.

Location From Reference Discharge	**Transverse No.**	**Position along Transect**	**Parameter**	**Results (mg/L)**
Upstream (2,525 ft)	1	1	Cu Total	<0.008
	1	1	Cu Total	0.008
	1	1	Cu Total	<0.008
	1	2	Cu Total	<0.008
	1	2	Cu Total	<0.008
	1	2	Cu Total	<0.008
	1	3	Cu Total	<0.008
	1	3	Cu Total	<0.008
	1	3	Cu Total	<0.008
	1	3	Cu Total	<0.008
Upstream (1,925 ft)	2	1	Cu Total	<0.008
	2	1	Cu Total	<0.008
	2	1	Cu Total	<0.008
	2	1	Cu Total	<0.008
	2	2	Cu Total	<0.008
	2	2	Cu Total	<0.008
	2	2	Cu Total	<0.008
	2	3	Cu Total	<0.008
	2	3	Cu Total	<0.008
	2	3	Cu Total	<0.008
Outfall 005	3	1	Cu Total	<0.008
	3	1	Cu Total	<0.008
	3	1	Cu Total	<0.008
	3	1	Cu Total	<0.008
	3	2	Cu Total	<0.008
	3	2	Cu Total	<0.008
	3	2	Cu Total	<0.008
	3	3	Cu Total	<0.008
	3	3	Cu Total	<0.008
	3	3	Cu Total	<0.008
Downstream (50 ft)	4	1	Cu Total	<0.008
	4	1	Cu Total	<0.008
	4	1	Cu Total	<0.008
	4	1	Cu Total	<0.008
	4	2	Cu Total	<0.008
	4	2	Cu Total	<0.008
	4	2	Cu Total	<0.008
	4	3	Cu Total	<0.008
	4	3	Cu Total	<0.008
	4	3	Cu Total	0.008
Downstream (100 ft)	5	1	Cu Total	<0.008
	5	1	Cu Total	<0.008
	5	1	Cu Total	<0.008
	5	2	Cu Total	<0.008
	5	2	Cu Total	<0.008
	5	2	Cu Total	0.008
	5	2	Cu Total	<0.008
	5	3	Cu Total	<0.008
	5	3	Cu Total	<0.008

	5	3	Cu Total	<0.008
Downstream (150 ft)	6	1	Cu Total	<0.008
	6	1	Cu Total	<0.008
	6	1	Cu Total	<0.008
	6	1	Cu Total	<0.008
	6	2	Cu Total	0.008
	6	2	Cu Total	<0.008
	6	2	Cu Total	<0.008
	6	3	Cu Total	0.008
	6	3	Cu Total	0.008
	6	3	Cu Total	<0.008
Downstream (500 ft)	7	1	Cu Total	<0.008
	7	1	Cu Total	0.009
	7	1	Cu Total	<0.008
	7	2	Cu Total	0.012
	7	2	Cu Total	<0.008
	7	2	Cu Total	<0.008
	7	2	Cu Total	<0.008
	7	3	Cu Total	<0.008
	7	3	Cu Total	<0.008
	7	3	Cu Total	<0.008
Upstream (2,525 ft)	1	1	Cu Dissolved	<0.008
	1	1	Cu Dissolved	<0.008
	1	1	Cu Dissolved	<0.008
	1	2	Cu Dissolved	<0.008
	1	2	Cu Dissolved	<0.008
	1	2	Cu Dissolved	<0.008
	1	3	Cu Dissolved	<0.008
	1	3	Cu Dissolved	<0.008
	1	3	Cu Dissolved	<0.008
	1	3	Cu Dissolved	<0.008
Upstream (1,925 ft)	2	1	Cu Dissolved	<0.008
	2	1	Cu Dissolved	<0.008
	2	1	Cu Dissolved	<0.008
	2	1	Cu Dissolved	<0.008
	2	2	Cu Dissolved	<0.008
	2	2	Cu Dissolved	<0.008
	2	2	Cu Dissolved	<0.008
	2	3	Cu Dissolved	<0.008
	2	3	Cu Dissolved	<0.008
	2	3	Cu Dissolved	<0.008
Outfall 005	3	1	Cu Dissolved	<0.008
	3	1	Cu Dissolved	<0.008
	3	1	Cu Dissolved	<0.008
	3	1	Cu Dissolved	<0.008
	3	2	Cu Dissolved	<0.008
	3	2	Cu Dissolved	<0.008
	3	2	Cu Dissolved	<0.008
	3	3	Cu Dissolved	<0.008
	3	3	Cu Dissolved	<0.008
	3	3	Cu Dissolved	<0.008
Downstream (50 ft)	4	1	Cu Dissolved	<0.008
	4	1	Cu Dissolved	<0.008
	4	1	Cu Dissolved	<0.008

	4	1	Cu Dissolved	<0.008
	4	2	Cu Dissolved	<0.008
	4	2	Cu Dissolved	<0.008
	4	2	Cu Dissolved	<0.008
	4	3	Cu Dissolved	<0.008
	4	3	Cu Dissolved	<0.008
	4	3	Cu Dissolved	<0.008
Downstream (100 ft)	5	1	Cu Dissolved	<0.008
	5	1	Cu Dissolved	<0.008
	5	1	Cu Dissolved	<0.008
	5	2	Cu Dissolved	<0.008
	5	2	Cu Dissolved	<0.008
	5	2	Cu Dissolved	<0.008
	5	2	Cu Dissolved	<0.008
	5	3	Cu Dissolved	<0.008
	5	3	Cu Dissolved	<0.008
	5	3	Cu Dissolved	<0.008
Downstream (150 ft)	6	1	Cu Dissolved	<0.008
	6	1	Cu Dissolved	<0.008
	6	1	Cu Dissolved	<0.008
	6	1	Cu Dissolved	<0.008
	6	2	Cu Dissolved	<0.008
	6	2	Cu Dissolved	<0.008
	6	2	Cu Dissolved	<0.008
	6	3	Cu Dissolved	<0.008
	6	3	Cu Dissolved	<0.008
	6	3	Cu Dissolved	<0.008
Downstream (500 ft)	7	1	Cu Dissolved	<0.008
	7	1	Cu Dissolved	<0.008
	7	1	Cu Dissolved	<0.008
	7	2	Cu Dissolved	<0.008
	7	2	Cu Dissolved	<0.008
	7	2	Cu Dissolved	<0.008
	7	2	Cu Dissolved	<0.008
	7	3	Cu Dissolved	<0.008
	7	3	Cu Dissolved	<0.008
	7	3	Cu Dissolved	<0.008

Table A.6. Iron data Florence Water Treatment Plant, Metropolitan Utility District, Omaha, NE.

Location From Reference Discharge	Transverse No.	Position along Transect	Parameter	Results (mg/L)
Upstream (2,525 ft)	1	1	Fe Total	1.599
	1	1	Fe Total	1.464
	1	1	Fe Total	1.94
	1	2	Fe Total	2.238
	1	2	Fe Total	2.197
	1	2	Fe Total	2.354
	1	3	Fe Total	2.401
	1	3	Fe Total	2.497
	1	3	Fe Total	2.452
	1	3	Fe Total	2.521
Upstream (1,925 ft)	2	1	Fe Total	1.865
	2	1	Fe Total	1.741
	2	1	Fe Total	1.824
	2	1	Fe Total	1.825
	2	2	Fe Total	2.352
	2	2	Fe Total	2.11
	2	2	Fe Total	2.094
	2	3	Fe Total	2.432
	2	3	Fe Total	2.285
	2	3	Fe Total	1.768
Outfall 005	3	1	Fe Total	1.469
	3	1	Fe Total	1.433
	3	1	Fe Total	1.774
	3	1	Fe Total	1.788
	3	2	Fe Total	1.5
	3	2	Fe Total	1.675
	3	2	Fe Total	1.594
	3	3	Fe Total	1.454
	3	3	Fe Total	1.773
	3	3	Fe Total	1.704
Downstream (50 ft)	4	1	Fe Total	1.811
	4	1	Fe Total	1.83
	4	1	Fe Total	1.666
	4	1	Fe Total	1.714
	4	2	Fe Total	1.673
	4	2	Fe Total	1.608
	4	2	Fe Total	1.554
	4	3	Fe Total	1.555
	4	3	Fe Total	1.529
	4	3	Fe Total	1.597
Downstream (100 ft)	5	1	Fe Total	1.469
	5	1	Fe Total	1.597
	5	1	Fe Total	1.987
	5	2	Fe Total	1.521
	5	2	Fe Total	1.647
	5	2	Fe Total	1.633
	5	2	Fe Total	1.585

	5	3	Fe Total	1.645
	5	3	Fe Total	1.649
	5	3	Fe Total	1.697
Downstream (150 ft)	6	1	Fe Total	1.554
	6	1	Fe Total	1.767
	6	1	Fe Total	1.692
	6	1	Fe Total	1.622
	6	2	Fe Total	2.065
	6	2	Fe Total	2.18
	6	2	Fe Total	2.243
	6	3	Fe Total	2.394
	6	3	Fe Total	2.385
	6	3	Fe Total	2.44
Downstream (500 ft)	7	1	Fe Total	1.754
	7	1	Fe Total	1.796
	7	1	Fe Total	1.824
	7	2	Fe Total	1.973
	7	2	Fe Total	2.004
	7	2	Fe Total	2.01
	7	2	Fe Total	2.033
	7	3	Fe Total	2.285
	7	3	Fe Total	2.322
	7	3	Fe Total	2.41
Upstream (2,525 ft)	1	1	Fe Dissolved	<0.063
	1	1	Fe Dissolved	<0.063
	1	1	Fe Dissolved	<0.063
	1	2	Fe Dissolved	<0.063
	1	2	Fe Dissolved	<0.063
	1	2	Fe Dissolved	<0.063
	1	3	Fe Dissolved	<0.063
	1	3	Fe Dissolved	<0.063
	1	3	Fe Dissolved	<0.063
	1	3	Fe Dissolved	<0.063
Upstream (1,925 ft)	2	1	Fe Dissolved	<0.063
	2	1	Fe Dissolved	<0.063
	2	1	Fe Dissolved	<0.063
	2	1	Fe Dissolved	<0.063
	2	2	Fe Dissolved	<0.063
	2	2	Fe Dissolved	<0.063
	2	2	Fe Dissolved	<0.063
	2	3	Fe Dissolved	<0.063
	2	3	Fe Dissolved	<0.063
	2	3	Fe Dissolved	<0.063
Outfall 005	3	1	Fe Dissolved	<0.063
	3	1	Fe Dissolved	<0.063
	3	1	Fe Dissolved	<0.063
	3	1	Fe Dissolved	<0.063
	3	2	Fe Dissolved	<0.063
	3	2	Fe Dissolved	<0.063
	3	2	Fe Dissolved	<0.063
	3	3	Fe Dissolved	<0.063
	3	3	Fe Dissolved	<0.063
	3	3	Fe Dissolved	<0.063
Downstream (50 ft)	4	1	Fe Dissolved	<0.063

	4	1	Fe Dissolved	<0.063
	4	1	Fe Dissolved	<0.063
	4	1	Fe Dissolved	<0.063
	4	2	Fe Dissolved	<0.063
	4	2	Fe Dissolved	<0.063
	4	2	Fe Dissolved	<0.063
	4	3	Fe Dissolved	<0.063
	4	3	Fe Dissolved	<0.063
	4	3	Fe Dissolved	<0.063
Downstream (100 ft)	5	1	Fe Dissolved	<0.063
	5	1	Fe Dissolved	<0.063
	5	1	Fe Dissolved	<0.063
	5	2	Fe Dissolved	<0.063
	5	2	Fe Dissolved	<0.063
	5	2	Fe Dissolved	<0.063
	5	2	Fe Dissolved	<0.063
	5	3	Fe Dissolved	<0.063
	5	3	Fe Dissolved	<0.063
	5	3	Fe Dissolved	<0.063
Downstream (150 ft)	6	1	Fe Dissolved	<0.063
	6	1	Fe Dissolved	<0.063
	6	1	Fe Dissolved	<0.063
	6	1	Fe Dissolved	<0.063
	6	2	Fe Dissolved	<0.063
	6	2	Fe Dissolved	<0.063
	6	2	Fe Dissolved	<0.063
	6	3	Fe Dissolved	<0.063
	6	3	Fe Dissolved	<0.063
	6	3	Fe Dissolved	<0.063
Downstream (500 ft)	7	1	Fe Dissolved	<0.063
	7	1	Fe Dissolved	<0.063
	7	1	Fe Dissolved	<0.063
	7	2	Fe Dissolved	<0.063
	7	2	Fe Dissolved	<0.063
	7	2	Fe Dissolved	<0.063
	7	2	Fe Dissolved	<0.063
	7	3	Fe Dissolved	<0.063
	7	3	Fe Dissolved	<0.063
	7	3	Fe Dissolved	<0.063

Table A.7. Magnesium data Florence Water Treatment Plant, Metropolitan Utility District, Omaha, NE.

Location From Reference Discharge	Transverse No.	Position along Transect	Parameter	Results (mg/L)
Upstream (2,525 ft)	1	1	Mg Total	25.235
	1	1	Mg Total	25.516
	1	1	Mg Total	27.458
	1	2	Mg Total	26.208
	1	2	Mg Total	26.644
	1	2	Mg Total	28.732
	1	3	Mg Total	27.864
	1	3	Mg Total	29.31
	1	3	Mg Total	29.175
	1	3	Mg Total	29.417
Upstream (1,925 ft)	2	1	Mg Total	28.914
	2	1	Mg Total	28.523
	2	1	Mg Total	28.373
	2	1	Mg Total	29.409
	2	2	Mg Total	31.561
	2	2	Mg Total	27.893
	2	2	Mg Total	28.898
	2	3	Mg Total	28.867
	2	3	Mg Total	28.728
	2	3	Mg Total	27.77
Outfall 005	3	1	Mg Total	28.817
	3	1	Mg Total	27.486
	3	1	Mg Total	28.504
	3	1	Mg Total	29.197
	3	2	Mg Total	28.489
	3	2	Mg Total	28.289
	3	2	Mg Total	29.057
	3	3	Mg Total	28.436
	3	3	Mg Total	28.807
	3	3	Mg Total	27.795
Downstream (50 ft)	4	1	Mg Total	29.18
	4	1	Mg Total	29.017
	4	1	Mg Total	26.282
	4	1	Mg Total	26.859
	4	2	Mg Total	26.036
	4	2	Mg Total	26.627
	4	2	Mg Total	25.794
	4	3	Mg Total	25.378
	4	3	Mg Total	25.334
	4	3	Mg Total	26.035
Downstream (100 ft)	5	1	Mg Total	25.602
	5	1	Mg Total	26.579
	5	1	Mg Total	33.941
	5	2	Mg Total	25.924
	5	2	Mg Total	26.377
	5	2	Mg Total	25.756
	5	2	Mg Total	25.709
	5	3	Mg Total	26.057
	5	3	Mg Total	25.41

	5	3	Mg Total	25.163
Downstream (150 ft)	6	1	Mg Total	26.083
	6	1	Mg Total	26.242
	6	1	Mg Total	26.136
	6	1	Mg Total	25.357
	6	2	Mg Total	26.564
	6	2	Mg Total	26.501
	6	2	Mg Total	26.522
	6	3	Mg Total	26.511
	6	3	Mg Total	27.121
	6	3	Mg Total	26.348
Downstream (500 ft)	7	1	Mg Total	25.434
	7	1	Mg Total	26.956
	7	1	Mg Total	26.578
	7	2	Mg Total	27.283
	7	2	Mg Total	26.294
	7	2	Mg Total	26.151
	7	2	Mg Total	26.472
	7	3	Mg Total	26.296
	7	3	Mg Total	26.536
	7	3	Mg Total	26.372
Upstream (2,525 ft)	1	1	Mg Dissolved	27.478
	1	1	Mg Dissolved	30.127
	1	1	Mg Dissolved	28.015
	1	2	Mg Dissolved	27.407
	1	2	Mg Dissolved	27.511
	1	2	Mg Dissolved	26.688
	1	3	Mg Dissolved	27.445
	1	3	Mg Dissolved	28.516
	1	3	Mg Dissolved	27.672
	1	3	Mg Dissolved	29.614
Upstream (1,925 ft)	2	1	Mg Dissolved	26.962
	2	1	Mg Dissolved	26.596
	2	1	Mg Dissolved	28.817
	2	1	Mg Dissolved	26.329
	2	2	Mg Dissolved	27.444
	2	2	Mg Dissolved	27.172
	2	2	Mg Dissolved	28.741
	2	3	Mg Dissolved	27.924
	2	3	Mg Dissolved	28.246
	2	3	Mg Dissolved	28.605
Outfall 005	3	1	Mg Dissolved	27.275
	3	1	Mg Dissolved	28.625
	3	1	Mg Dissolved	28.131
	3	1	Mg Dissolved	27.75
	3	2	Mg Dissolved	27.433
	3	2	Mg Dissolved	29.205
	3	2	Mg Dissolved	27.804
	3	3	Mg Dissolved	27.991
	3	3	Mg Dissolved	28.945
	3	3	Mg Dissolved	29.586
Downstream (50 ft)	4	1	Mg Dissolved	28.982
	4	1	Mg Dissolved	28.496
	4	1	Mg Dissolved	26.588

	4	1	Mg Dissolved	26.407
	4	2	Mg Dissolved	26.406
	4	2	Mg Dissolved	26.018
	4	2	Mg Dissolved	26.114
	4	3	Mg Dissolved	25.768
	4	3	Mg Dissolved	26.386
	4	3	Mg Dissolved	27.191
Downstream (100 ft)	5	1	Mg Dissolved	26.479
	5	1	Mg Dissolved	26.699
	5	1	Mg Dissolved	32.214
	5	2	Mg Dissolved	25.382
	5	2	Mg Dissolved	26.257
	5	2	Mg Dissolved	26.404
	5	2	Mg Dissolved	26.146
	5	3	Mg Dissolved	25.831
	5	3	Mg Dissolved	25.833
	5	3	Mg Dissolved	26.203
Downstream (150 ft)	6	1	Mg Dissolved	26.882
	6	1	Mg Dissolved	25.178
	6	1	Mg Dissolved	26.039
	6	1	Mg Dissolved	26
	6	2	Mg Dissolved	25.521
	6	2	Mg Dissolved	25.126
	6	2	Mg Dissolved	25.814
	6	3	Mg Dissolved	26.06
	6	3	Mg Dissolved	26.122
	6	3	Mg Dissolved	25.079
Downstream (500 ft)	7	1	Mg Dissolved	26.948
	7	1	Mg Dissolved	25.925
	7	1	Mg Dissolved	27.129
	7	2	Mg Dissolved	26.187
	7	2	Mg Dissolved	28.128
	7	2	Mg Dissolved	25.644
	7	2	Mg Dissolved	26.893
	7	3	Mg Dissolved	26.824
	7	3	Mg Dissolved	26.44
	7	3	Mg Dissolved	26.758

Table A.8. Manganese data Florence Water Treatment Plant, Metropolitan Utility District, Omaha, NE.

Location From Reference Discharge	Transverse No.	Position along Transect	Parameter	Results (mg/L)
Upstream (2,525 ft)				
	1	1	Mn Total	0.134
	1	1	Mn Total	0.131
	1	1	Mn Total	0.159
	1	2	Mn Total	0.17
	1	2	Mn Total	0.168
	1	2	Mn Total	0.176
	1	3	Mn Total	0.175
	1	3	Mn Total	0.186
	1	3	Mn Total	0.176
	1	3	Mn Total	0.181
Upstream (1,925 ft)				
	2	1	Mn Total	0.152
	2	1	Mn Total	0.146
	2	1	Mn Total	0.15
	2	1	Mn Total	0.152
	2	2	Mn Total	0.177
	2	2	Mn Total	0.165
	2	2	Mn Total	0.164
	2	3	Mn Total	0.177
	2	3	Mn Total	0.167
	2	3	Mn Total	0.142
Outfall 005				
	3	1	Mn Total	0.134
	3	1	Mn Total	0.13
	3	1	Mn Total	0.149
	3	1	Mn Total	0.153
	3	2	Mn Total	0.136
	3	2	Mn Total	0.147
	3	2	Mn Total	0.141
	3	3	Mn Total	0.129
	3	3	Mn Total	0.148
	3	3	Mn Total	0.146
Downstream (50 ft)				
	4	1	Mn Total	0.154
	4	1	Mn Total	0.156
	4	1	Mn Total	0.138
	4	1	Mn Total	0.141
	4	2	Mn Total	0.138
	4	2	Mn Total	0.136
	4	2	Mn Total	0.132
	4	3	Mn Total	0.132
	4	3	Mn Total	0.13
	4	3	Mn Total	0.137
Downstream (100 ft)				
	5	1	Mn Total	0.128

	5	1	Mn Total	0.137
	5	1	Mn Total	0.168
	5	2	Mn Total	0.132
	5	2	Mn Total	0.139
	5	2	Mn Total	0.139
	5	2	Mn Total	0.134
	5	3	Mn Total	0.138
	5	3	Mn Total	0.138
	5	3	Mn Total	0.14
Downstream (150 ft)				
	6	1	Mn Total	0.134
	6	1	Mn Total	0.141
	6	1	Mn Total	0.139
	6	1	Mn Total	0.134
	6	2	Mn Total	0.16
	6	2	Mn Total	0.165
	6	2	Mn Total	0.166
	6	3	Mn Total	0.171
	6	3	Mn Total	0.174
	6	3	Mn Total	0.177
Downstream (500 ft)				
	7	1	Mn Total	0.145
	7	1	Mn Total	0.147
	7	1	Mn Total	0.148
	7	2	Mn Total	0.158
	7	2	Mn Total	0.15
	7	2	Mn Total	0.151
	7	2	Mn Total	0.153
	7	3	Mn Total	0.162
	7	3	Mn Total	0.165
	7	3	Mn Total	0.166
Upstream (2,525 ft)				
	1	1	Mn Dissolved	<0.006
	1	1	Mn Dissolved	<0.006
	1	1	Mn Dissolved	<0.006
	1	2	Mn Dissolved	<0.006
	1	2	Mn Dissolved	<0.006
	1	2	Mn Dissolved	<0.006
	1	3	Mn Dissolved	<0.006
	1	3	Mn Dissolved	<0.006
	1	3	Mn Dissolved	<0.006
	1	3	Mn Dissolved	<0.006
Upstream (1,925 ft)				
	2	1	Mn Dissolved	<0.006
	2	1	Mn Dissolved	<0.006
	2	1	Mn Dissolved	<0.006
	2	1	Mn Dissolved	<0.006
	2	2	Mn Dissolved	<0.006
	2	2	Mn Dissolved	<0.006
	2	2	Mn Dissolved	<0.006
	2	3	Mn Dissolved	<0.006
	2	3	Mn Dissolved	<0.006

	2	3	Mn Dissolved	<0.006
Outfall 005				
	3	1	Mn Dissolved	<0.006
	3	1	Mn Dissolved	<0.006
	3	1	Mn Dissolved	<0.006
	3	1	Mn Dissolved	<0.006
	3	2	Mn Dissolved	<0.006
	3	2	Mn Dissolved	<0.006
	3	2	Mn Dissolved	<0.006
	3	3	Mn Dissolved	<0.006
	3	3	Mn Dissolved	<0.006
	3	3	Mn Dissolved	<0.006
Downstream (50 ft)				
	4	1	Mn Dissolved	<0.006
	4	1	Mn Dissolved	<0.006
	4	1	Mn Dissolved	<0.006
	4	1	Mn Dissolved	<0.006
	4	2	Mn Dissolved	<0.006
	4	2	Mn Dissolved	<0.006
	4	2	Mn Dissolved	<0.006
	4	3	Mn Dissolved	<0.006
	4	3	Mn Dissolved	<0.006
	4	3	Mn Dissolved	<0.006
Downstream (100 ft)				
	5	1	Mn Dissolved	<0.006
	5	1	Mn Dissolved	<0.006
	5	1	Mn Dissolved	<0.006
	5	2	Mn Dissolved	<0.006
	5	2	Mn Dissolved	<0.006
	5	2	Mn Dissolved	<0.006
	5	2	Mn Dissolved	<0.006
	5	3	Mn Dissolved	<0.006
	5	3	Mn Dissolved	<0.006
	5	3	Mn Dissolved	<0.006
Downstream (150 ft)				
	6	1	Mn Dissolved	<0.006
	6	1	Mn Dissolved	<0.006
	6	1	Mn Dissolved	<0.006
	6	1	Mn Dissolved	<0.006
	6	2	Mn Dissolved	<0.006
	6	2	Mn Dissolved	<0.006
	6	2	Mn Dissolved	<0.006
	6	3	Mn Dissolved	<0.006
	6	3	Mn Dissolved	<0.006
	6	3	Mn Dissolved	<0.006
Downstream (500 ft)				
	7	1	Mn Dissolved	<0.006
	7	1	Mn Dissolved	<0.006
	7	1	Mn Dissolved	<0.006
	7	2	Mn Dissolved	<0.006
	7	2	Mn Dissolved	<0.006
	7	2	Mn Dissolved	<0.006

	7	2	Mn Dissolved	<0.006
	7	3	Mn Dissolved	<0.006
	7	3	Mn Dissolved	<0.006
Upstream (2,525 ft)	7	3	Mn Dissolved	<0.006

Table A.9. Nickel data Florence Water Treatment Plant, Metropolitan Utility District, Omaha, NE.

Location From Reference Discharge	Transverse No.	Position along Transect	Parameter	Results (mg/L)
Upstream (2,525 ft)	1	1	Ni Total	<0.019
	1	1	Ni Total	<0.019
	1	1	Ni Total	<0.019
	1	2	Ni Total	<0.019
	1	2	Ni Total	<0.019
	1	2	Ni Total	<0.019
	1	3	Ni Total	<0.019
	1	3	Ni Total	<0.019
	1	3	Ni Total	<0.019
	1	3	Ni Total	<0.019
Upstream (1,925 ft)	2	1	Ni Total	<0.019
	2	1	Ni Total	<0.019
	2	1	Ni Total	<0.019
	2	1	Ni Total	<0.019
	2	2	Ni Total	<0.019
	2	2	Ni Total	<0.019
	2	2	Ni Total	<0.019
	2	3	Ni Total	<0.019
	2	3	Ni Total	<0.019
	2	3	Ni Total	<0.019
Outfall 005	3	1	Ni Total	<0.019
	3	1	Ni Total	<0.019
	3	1	Ni Total	<0.019
	3	1	Ni Total	<0.019
	3	2	Ni Total	<0.019
	3	2	Ni Total	<0.019
	3	2	Ni Total	<0.019
	3	3	Ni Total	<0.019
	3	3	Ni Total	<0.019
	3	3	Ni Total	<0.019
Downstream (50 ft)	4	1	Ni Total	<0.019
	4	1	Ni Total	<0.019
	4	1	Ni Total	<0.019
	4	1	Ni Total	<0.019
	4	2	Ni Total	<0.019
	4	2	Ni Total	<0.019
	4	2	Ni Total	<0.019
	4	3	Ni Total	<0.019
	4	3	Ni Total	<0.019
	4	3	Ni Total	<0.019
Downstream (100 ft)	5	1	Ni Total	<0.019
	5	1	Ni Total	<0.019
	5	1	Ni Total	<0.019
	5	2	Ni Total	<0.019
	5	2	Ni Total	<0.019
	5	2	Ni Total	<0.019
	5	2	Ni Total	<0.019
	5	3	Ni Total	<0.019
	5	3	Ni Total	<0.019

	5	3	Ni Total	<0.019
Downstream (150 ft)	6	1	Ni Total	<0.019
	6	1	Ni Total	<0.019
	6	1	Ni Total	<0.019
	6	1	Ni Total	<0.019
	6	2	Ni Total	<0.019
	6	2	Ni Total	<0.019
	6	2	Ni Total	<0.019
	6	3	Ni Total	<0.019
	6	3	Ni Total	<0.019
	6	3	Ni Total	<0.019
Downstream (500 ft)	7	1	Ni Total	<0.019
	7	1	Ni Total	<0.019
	7	1	Ni Total	<0.019
	7	2	Ni Total	<0.019
	7	2	Ni Total	<0.019
	7	2	Ni Total	<0.019
	7	2	Ni Total	<0.019
	7	3	Ni Total	<0.019
	7	3	Ni Total	<0.019
	7	3	Ni Total	<0.019
Upstream 001 (675ft)	1	1	Ni Dissolved	<0.019
	1	1	Ni Dissolved	<0.019
	1	1	Ni Dissolved	<0.019
	1	2	Ni Dissolved	<0.019
	1	2	Ni Dissolved	<0.019
	1	2	Ni Dissolved	<0.019
	1	3	Ni Dissolved	<0.019
	1	3	Ni Dissolved	<0.019
	1	3	Ni Dissolved	<0.019
	1	3	Ni Dissolved	<0.019
Upstream (1,925 ft)	2	1	Ni Dissolved	<0.019
	2	1	Ni Dissolved	<0.019
	2	1	Ni Dissolved	<0.019
	2	1	Ni Dissolved	<0.019
	2	2	Ni Dissolved	<0.019
	2	2	Ni Dissolved	<0.019
	2	2	Ni Dissolved	<0.019
	2	3	Ni Dissolved	<0.019
	2	3	Ni Dissolved	<0.019
	2	3	Ni Dissolved	<0.019
Outfall 005	3	1	Ni Dissolved	<0.019
	3	1	Ni Dissolved	<0.019
	3	1	Ni Dissolved	<0.019
	3	1	Ni Dissolved	<0.019
	3	2	Ni Dissolved	<0.019
	3	2	Ni Dissolved	<0.019
	3	2	Ni Dissolved	<0.019
	3	3	Ni Dissolved	<0.019
	3	3	Ni Dissolved	<0.019
	3	3	Ni Dissolved	<0.019
Downstream (50 ft)	4	1	Ni Dissolved	<0.019
	4	1	Ni Dissolved	<0.019
	4	1	Ni Dissolved	<0.019

	4	1	Ni Dissolved	<0.019
	4	2	Ni Dissolved	<0.019
	4	2	Ni Dissolved	<0.019
	4	2	Ni Dissolved	<0.019
	4	3	Ni Dissolved	<0.019
	4	3	Ni Dissolved	<0.019
	4	3	Ni Dissolved	<0.019
Downstream (100 ft)	5	1	Ni Dissolved	<0.019
	5	1	Ni Dissolved	<0.019
	5	1	Ni Dissolved	<0.019
	5	2	Ni Dissolved	<0.019
	5	2	Ni Dissolved	<0.019
	5	2	Ni Dissolved	<0.019
	5	2	Ni Dissolved	<0.019
	5	3	Ni Dissolved	<0.019
	5	3	Ni Dissolved	<0.019
	5	3	Ni Dissolved	<0.019
Downstream (150 ft)	6	1	Ni Dissolved	<0.019
	6	1	Ni Dissolved	<0.019
	6	1	Ni Dissolved	<0.019
	6	1	Ni Dissolved	<0.019
	6	2	Ni Dissolved	<0.019
	6	2	Ni Dissolved	<0.019
	6	2	Ni Dissolved	<0.019
	6	3	Ni Dissolved	<0.019
	6	3	Ni Dissolved	<0.019
	6	3	Ni Dissolved	<0.019
Downstream (500 ft)	7	1	Ni Dissolved	<0.019
	7	1	Ni Dissolved	<0.019
	7	1	Ni Dissolved	<0.019
	7	2	Ni Dissolved	<0.019
	7	2	Ni Dissolved	<0.019
	7	2	Ni Dissolved	<0.019
	7	2	Ni Dissolved	<0.019
	7	3	Ni Dissolved	<0.019
	7	3	Ni Dissolved	<0.019
	7	3	Ni Dissolved	<0.019

Table A.10. Selenium data Florence Water Treatment Plant, Metropolitan Utility District, Omaha, NE.

Location From Reference Discharge	Transverse No.	Position along Transect	Parameter	Results (mg/L)
Upstream (2,525 ft)	1	1	Se Total	<0.063
	1	1	Se Total	<0.063
	1	1	Se Total	<0.063
	1	2	Se Total	<0.063
	1	2	Se Total	<0.063
	1	2	Se Total	<0.063
	1	3	Se Total	<0.063
	1	3	Se Total	<0.063
	1	3	Se Total	<0.063
	1	3	Se Total	<0.063
Upstream (1,925 ft)	2	1	Se Total	<0.063
	2	1	Se Total	<0.063
	2	1	Se Total	<0.063
	2	1	Se Total	<0.063
	2	2	Se Total	<0.063
	2	2	Se Total	<0.063
	2	2	Se Total	<0.063
	2	3	Se Total	<0.063
	2	3	Se Total	<0.063
	2	3	Se Total	<0.063
Outfall 005	3	1	Se Total	<0.063
	3	1	Se Total	<0.063
	3	1	Se Total	<0.063
	3	1	Se Total	<0.063
	3	2	Se Total	<0.063
	3	2	Se Total	<0.063
	3	2	Se Total	<0.063
	3	3	Se Total	<0.063
	3	3	Se Total	<0.063
	3	3	Se Total	<0.063
Downstream (50 ft)	4	1	Se Total	<0.063
	4	1	Se Total	<0.063
	4	1	Se Total	<0.063
	4	1	Se Total	<0.063
	4	2	Se Total	<0.063
	4	2	Se Total	<0.063
	4	2	Se Total	<0.063
	4	3	Se Total	<0.063
	4	3	Se Total	<0.063
	4	3	Se Total	<0.063
Downstream (100 ft)	5	1	Se Total	<0.063
	5	1	Se Total	<0.063
	5	1	Se Total	<0.063
	5	2	Se Total	<0.063
	5	2	Se Total	<0.063
	5	2	Se Total	<0.063
	5	2	Se Total	<0.063
	5	3	Se Total	<0.063
	5	3	Se Total	<0.063

	5	3	Se Total	<0.063
Downstream (150 ft)	6	1	Se Total	<0.063
	6	1	Se Total	<0.063
	6	1	Se Total	<0.063
	6	1	Se Total	<0.063
	6	2	Se Total	<0.063
	6	2	Se Total	<0.063
	6	2	Se Total	<0.063
	6	3	Se Total	<0.063
	6	3	Se Total	<0.063
	6	3	Se Total	<0.063
Downstream (500 ft)	7	1	Se Total	<0.063
	7	1	Se Total	<0.063
	7	1	Se Total	<0.063
	7	2	Se Total	<0.063
	7	2	Se Total	<0.063
	7	2	Se Total	<0.063
	7	2	Se Total	<0.063
	7	3	Se Total	<0.063
	7	3	Se Total	<0.063
	7	3	Se Total	<0.063
Upstream (2,525 ft)	1	1	Se Dissolved	<0.063
	1	1	Se Dissolved	<0.063
	1	1	Se Dissolved	<0.063
	1	2	Se Dissolved	<0.063
	1	2	Se Dissolved	<0.063
	1	2	Se Dissolved	<0.063
	1	3	Se Dissolved	<0.063
	1	3	Se Dissolved	<0.063
	1	3	Se Dissolved	<0.063
	1	3	Se Dissolved	<0.063
Upstream (1,925 ft)	2	1	Se Dissolved	<0.063
	2	1	Se Dissolved	<0.063
	2	1	Se Dissolved	<0.063
	2	1	Se Dissolved	<0.063
	2	2	Se Dissolved	<0.063
	2	2	Se Dissolved	<0.063
	2	2	Se Dissolved	<0.063
	2	3	Se Dissolved	<0.063
	2	3	Se Dissolved	<0.063
	2	3	Se Dissolved	<0.063
Outfall 005	3	1	Se Dissolved	<0.063
	3	1	Se Dissolved	<0.063
	3	1	Se Dissolved	<0.063
	3	1	Se Dissolved	<0.063
	3	2	Se Dissolved	<0.063
	3	2	Se Dissolved	<0.063
	3	2	Se Dissolved	<0.063
	3	3	Se Dissolved	<0.063
	3	3	Se Dissolved	<0.063
	3	3	Se Dissolved	<0.063
Downstream (50 ft)	4	1	Se Dissolved	<0.063
	4	1	Se Dissolved	<0.063
	4	1	Se Dissolved	<0.063

	4	1	Se Dissolved	<0.063
	4	2	Se Dissolved	<0.063
	4	2	Se Dissolved	<0.063
	4	2	Se Dissolved	<0.063
	4	3	Se Dissolved	<0.063
	4	3	Se Dissolved	<0.063
	4	3	Se Dissolved	<0.063
Downstream (100 ft)	5	1	Se Dissolved	<0.063
	5	1	Se Dissolved	<0.063
	5	1	Se Dissolved	<0.063
	5	2	Se Dissolved	<0.063
	5	2	Se Dissolved	<0.063
	5	2	Se Dissolved	<0.063
	5	2	Se Dissolved	<0.063
	5	3	Se Dissolved	<0.063
	5	3	Se Dissolved	<0.063
	5	3	Se Dissolved	<0.063
Downstream (150 ft)	6	1	Se Dissolved	<0.063
	6	1	Se Dissolved	<0.063
	6	1	Se Dissolved	<0.063
	6	1	Se Dissolved	<0.063
	6	2	Se Dissolved	<0.063
	6	2	Se Dissolved	<0.063
	6	2	Se Dissolved	<0.063
	6	3	Se Dissolved	<0.063
	6	3	Se Dissolved	<0.063
	6	3	Se Dissolved	<0.063
Downstream (500 ft)	7	1	Se Dissolved	<0.063
	7	1	Se Dissolved	<0.063
	7	1	Se Dissolved	<0.063
	7	2	Se Dissolved	<0.063
	7	2	Se Dissolved	<0.063
	7	2	Se Dissolved	<0.063
	7	2	Se Dissolved	<0.063
	7	3	Se Dissolved	<0.063
	7	3	Se Dissolved	<0.063
	7	3	Se Dissolved	<0.063

Table A.11. Zinc data Florence Water Treatment Plant, Metropolitan Utility District, Omaha, NE.

Location From Reference Discharge	Transverse No.	Position along Transect	Parameter	Results (mg/L)
Upstream- (2,525ft)	1	1	Zn Total	0.011
	1	1	Zn Total	0.008
	1	1	Zn Total	0.011
	1	2	Zn Total	0.01
	1	2	Zn Total	0.009
	1	2	Zn Total	0.011
	1	3	Zn Total	0.016
	1	3	Zn Total	0.011
	1	3	Zn Total	0.013
	1	3	Zn Total	0.012
Upstream (1,925ft)	2	1	Zn Total	0.011
	2	1	Zn Total	0.008
	2	1	Zn Total	0.009
	2	1	Zn Total	0.01
	2	2	Zn Total	0.012
	2	2	Zn Total	0.009
	2	2	Zn Total	0.01
	2	3	Zn Total	0.031
	2	3	Zn Total	0.01
	2	3	Zn Total	0.007
OUTFALL 005	3	1	Zn Total	0.009
	3	1	Zn Total	<0.006
	3	1	Zn Total	0.006
	3	1	Zn Total	0.007
	3	2	Zn Total	0.007
	3	2	Zn Total	0.009
	3	2	Zn Total	0.007
	3	3	Zn Total	0.008
	3	3	Zn Total	0.01
	3	3	Zn Total	0.007
Downstream (50ft)	4	1	Zn Total	0.008
	4	1	Zn Total	0.007
	4	1	Zn Total	0.009
	4	1	Zn Total	0.012
	4	2	Zn Total	0.012
	4	2	Zn Total	0.012
	4	2	Zn Total	0.01
	4	3	Zn Total	0.013
	4	3	Zn Total	0.01
	4	3	Zn Total	0.011
Downstream (100 ft)	5	1	Zn Total	0.011
	5	1	Zn Total	0.01
	5	1	Zn Total	0.014
	5	2	Zn Total	0.01
	5	2	Zn Total	0.012
	5	2	Zn Total	0.011
	5	2	Zn Total	0.01
	5	3	Zn Total	0.012
	5	3	Zn Total	0.01

	5	3	Zn Total	0.01
Downstream (150 ft)	6	1	Zn Total	0.015
	6	1	Zn Total	0.011
	6	1	Zn Total	0.009
	6	1	Zn Total	0.01
	6	2	Zn Total	0.014
	6	2	Zn Total	0.012
	6	2	Zn Total	0.014
	6	3	Zn Total	0.019
	6	3	Zn Total	0.015
	6	3	Zn Total	0.012
Downstream (500 ft)	7	1	Zn Total	0.013
	7	1	Zn Total	0.012
	7	1	Zn Total	0.014
	7	2	Zn Total	0.014
	7	2	Zn Total	<0.006
	7	2	Zn Total	<0.006
	7	2	Zn Total	<0.006
	7	3	Zn Total	0.007
	7	3	Zn Total	<0.006
	7	3	Zn Total	<0.006
Upstream (2,525ft)	1	1	Zn Dissolved	<0.006
	1	1	Zn Dissolved	<0.006
	1	1	Zn Dissolved	<0.006
	1	2	Zn Dissolved	<0.006
	1	2	Zn Dissolved	<0.006
	1	2	Zn Dissolved	<0.006
	1	3	Zn Dissolved	<0.006
	1	3	Zn Dissolved	<0.006
	1	3	Zn Dissolved	<0.006
	1	3	Zn Dissolved	<0.006
Upstream (1,925 ft)	2	1	Zn Dissolved	<0.006
	2	1	Zn Dissolved	0.007
	2	1	Zn Dissolved	<0.006
	2	1	Zn Dissolved	<0.006
	2	2	Zn Dissolved	<0.006
	2	2	Zn Dissolved	<0.006
	2	2	Zn Dissolved	<0.006
	2	3	Zn Dissolved	0.009
	2	3	Zn Dissolved	<0.006
	2	3	Zn Dissolved	<0.006
Outfall 005	3	1	Zn Dissolved	<0.006
	3	1	Zn Dissolved	<0.006
	3	1	Zn Dissolved	<0.006
	3	1	Zn Dissolved	<0.006
	3	2	Zn Dissolved	<0.006
	3	2	Zn Dissolved	<0.006
	3	2	Zn Dissolved	<0.006
	3	3	Zn Dissolved	<0.006
	3	3	Zn Dissolved	<0.006
	3	3	Zn Dissolved	<0.006
Downstream (50 ft)	4	1	Zn Dissolved	<0.006
	4	1	Zn Dissolved	<0.006
	4	1	Zn Dissolved	<0.006

	4	1	Zn Dissolved	<0.006
	4	2	Zn Dissolved	0.064
	4	2	Zn Dissolved	<0.006
	4	2	Zn Dissolved	<0.006
	4	3	Zn Dissolved	<0.006
	4	3	Zn Dissolved	<0.006
	4	3	Zn Dissolved	<0.006
Downstream (100 ft)	5	1	Zn Dissolved	<0.006
	5	1	Zn Dissolved	<0.006
	5	1	Zn Dissolved	<0.006
	5	2	Zn Dissolved	<0.006
	5	2	Zn Dissolved	<0.006
	5	2	Zn Dissolved	<0.006
	5	2	Zn Dissolved	<0.006
	5	3	Zn Dissolved	<0.006
	5	3	Zn Dissolved	<0.006
	5	3	Zn Dissolved	<0.006
Downstream (150 ft)	6	1	Zn Dissolved	<0.006
	6	1	Zn Dissolved	<0.006
	6	1	Zn Dissolved	<0.006
	6	1	Zn Dissolved	<0.006
	6	2	Zn Dissolved	<0.006
	6	2	Zn Dissolved	<0.006
	6	2	Zn Dissolved	<0.006
	6	3	Zn Dissolved	<0.006
	6	3	Zn Dissolved	<0.006
	6	3	Zn Dissolved	<0.006
Downstream (500 ft)	7	1	Zn Dissolved	<0.006
	7	1	Zn Dissolved	<0.006
	7	1	Zn Dissolved	<0.006
	7	2	Zn Dissolved	<0.006
	7	2	Zn Dissolved	<0.006
	7	2	Zn Dissolved	<0.006
	7	2	Zn Dissolved	<0.006
	7	3	Zn Dissolved	<0.006
	7	3	Zn Dissolved	<0.006
	7	3	Zn Dissolved	<0.006

APPENDIX B

PLATTE SOUTH WATER TREATMENT PLANT

MISSOURI RIVER WATER QUALITY

Table B.1. Sonde data Platte South Water Treatment Plant, Metropolitan Utility District, Omaha, NE.

Location From Reference Discharge	Transect No#	Position along Transect	Depth (Fraction of Total Depth)	Specific Conductance (mS/m)	Dissolved O_2 (mg/L)	pH (SU)	Temp (^oC)
Upstream (375 ft)	1	1	.2	0.869	7.62	8.44	25.31
Upstream (375 ft)	1	1	.5	0.869	7.82	8.41	25.29
Upstream (375 ft)	1	1	.8	0.869	7.98	8.36	25.3
Upstream (375 ft)	1	2	.2	0.867	7.71	8.47	25.4
Upstream (375 ft)	1	2	.5	0.867	7.85	8.44	25.39
Upstream (375 ft)	1	2	.8	0.867	8.28	8.37	25.39
Upstream (375 ft)	1	3	.2	0.865	7.54	8.5	25.42
Upstream (375 ft)	1	3	.8	0.866	7.95	8.43	25.41
Upstream (125 ft)	2	1	.2	0.869	8.53	8.47	25.29
Upstream (125 ft)	2	1	.5	0.869	9.53	8.41	25.27
Upstream (125 ft)	2	1	.8	0.871	8.43	8.45	25.15
Upstream (125 ft)	2	2	.2	0.866	7.54	8.49	25.42
Upstream (125 ft)	2	2	.5	0.866	7.56	8.48	25.42
Upstream (125 ft)	2	2	.8	0.866	7.49	8.45	25.42
Upstream (125 ft)	2	3	.2	0.865	7.7	8.47	25.42
Upstream (125 ft)	2	3	.5	0.865	8.08	8.41	25.41
Upstream (125 ft)	2	3	.8	0.846	8.19	8.35	25.23
Downstream (50 ft)	3	1	.2	0.875	7.58	8.47	24.88
Downstream (50 ft)	3	1	.5	0.875	7.75	8.42	24.88
Downstream (50 ft)	3	1	.8	0.826	8.74	8.42	24.81
Downstream (50 ft)	3	2	.2	0.867	7.47	8.5	25.36
Downstream (50 ft)	3	2	.5	0.867	7.54	8.48	25.35
Downstream (50 ft)	3	2	.8	0.868	7.62	8.41	25.35
Downstream (50 ft)	3	3	.2	0.912	8.67	8.52	22.8
Downstream (50 ft)	3	3	.5	0.913	9.86	8.46	22.68
Downstream (50 ft)	3	3	.8	0.98	11.44	8.47	18.5
Downstream (100 ft)	4	1	.2	0.866	7.82	8.53	25.32
Downstream (100 ft)	4	1	.5	0.865	7.95	8.55	25.32
Downstream (100 ft)	4	1	.8	0.864	9.59	8.58	25.32
Downstream (100 ft)	4	2	.2	0.867	8.37	8.53	25.4
Downstream (100 ft)	4	2	.5	0.804	8.77	8.43	24.28
Downstream (100 ft)	4	2	.8	0.867	9.74	8.45	25.36

Downstream (100 ft)	4	3	.2	0.865	7.49	8.52	25.52
Downstream (100 ft)	4	3	.5	0.865	7.69	8.48	25.5
Downstream (100 ft)	4	3	.8	0.867	8.31	8.47	25.34
Downstream (125 ft)	5	1	.2	0.868	7.75	8.53	25.41
Downstream (125 ft)	5	1	.5	0.868	7.72	8.51	25.41
Downstream (125 ft)	5	1	.8	0.868	7.75	8.48	25.39
Downstream (125 ft)	5	2	.2	0.879	8.01	8.53	24.77
Downstream (125 ft)	5	2	.5	0.879	8.57	8.5	24.75
Downstream (125 ft)	5	2	.8	0.879	8.76	8.45	24.78
Downstream (125 ft)	5	3	.2	0.866	8.45	8.54	25.54
Downstream (125 ft)	5	3	.5	0.866	8.72	8.52	25.52
Downstream (125 ft)	5	3	.8	0.866	8.76	8.48	25.51
Downstream (200 ft)	6	1	.2	0.866	7.91	8.55	25.53
Downstream (200 ft)	6	1	.5	0.867	7.91	8.5	25.52
Downstream (200 ft)	6	1	.8	0.867	8.51	8.48	25.51
Downstream (200 ft)	6	2	.2	0.864	7.71	8.56	25.65
Downstream (200 ft)	6	2	.5	0.864	7.87	8.54	25.65
Downstream (200 ft)	6	2	.8	0.864	7.91	8.49	25.63
Downstream (200 ft)	6	3	.2	0.867	7.99	8.54	25.49
Downstream (200 ft)	6	3	.5	0.867	8.01	8.51	25.49
Downstream (200 ft)	6	3	.8	0.868	8.1	8.48	25.5
Downstream (400 ft)	7	1	.2	0.929	9.35	8.55	22.05
Downstream (400 ft)	7	1	.5	0.918	9.29	8.51	22.66
Downstream (400 ft)	7	1	.8	0.922	10.04	8.51	22.57
Downstream (400 ft)	7	2	.2	0.867	7.84	8.55	25.52
Downstream (400 ft)	7	2	.5	0.867	7.81	8.53	25.53
Downstream (400 ft)	7	2	.8	0.867	8.05	8.48	25.52
Downstream (400 ft)	7	3	.2	0.865	7.9	8.57	25.64
Downstream (400 ft)	7	3	.5	0.866	8	8.55	25.64
Downstream (400 ft)	7	3	.8	0.865	8	8.5	25.64

Table B. 2. Solids, alkalinity, and hardness data Platte South Water Treatment Plant, Metropolitan Utility District, Omaha, NE.

Location From Reference Discharge	Transect No	Position along Transect	Depth (Fraction of Total Depth)	Alkalinity (mg/L $CaCO_3$)	Hardness (mg/L $CaCO_3$)	Settable Solids (mg/L)	TSS (mg/L)
Upstream (375 ft)	1	1	.2	182	261	< 1	99
Upstream (375 ft)	1	1	.5	184	256	< 1	104
Upstream (375 ft)	1	1	.8	183	259	< 1	94
Upstream (375 ft)	1	2	.2	182	272	< 1	169
Upstream (375 ft)	1	2	.5	183	265	< 1	88
Upstream (375 ft)	1	2	.8	181	257	< 1	98
Upstream (375 ft)	1	3	.2	184	264	< 1	142
Upstream (375 ft)	1	3	.8	180	261	< 1	151
Upstream (125 ft)	2	1	.2	182	263	< 1	95
Upstream (125 ft)	2	1	.5	181	261	< 1	93
Upstream (125 ft)	2	1	.8	183	262	< 1	98
Upstream (125 ft)	2	2	.2	181	263	< 1	108
Upstream (125 ft)	2	2	.5	179	254	< 1	102
Upstream (125 ft)	2	2	.8	180	265	< 1	99
Upstream (125 ft)	2	3	.2	184	253	< 1	163
Upstream (125 ft)	2	3	.5	182	264	< 1	91
Upstream (125 ft)	2	3	.8	183	260	< 1	97
Downstream (50 ft)	3	1	.2	186	267	< 1	97
Downstream (50 ft)	3	1	.5	182	267	< 1	103
Downstream (50 ft)	3	1	.8	185	266	< 1	93
Downstream (50 ft)	3	2	.2	183	260	< 1	91
Downstream (50 ft)	3	2	.5	184	254	< 1	75
Downstream (50 ft)	3	2	.8	182	268	< 1	89
Downstream (50 ft)	3	3	.2	182	274	< 1	88
Downstream (50 ft)	3	3	.5	184	271	< 1	87
Downstream (50 ft)	3	3	.8	185	273	< 1	92
Downstream (100 ft)	4	1	.2	187	279	< 1	105
Downstream (100 ft)	4	1	.5	183	274	< 1	94
Downstream (100 ft)	4	1	.8	182	260	< 1	95
Downstream (100 ft)	4	2	.2	180	255	< 1	101
Downstream (100 ft)	4	2	.5	184	270	< 1	97
Downstream (100 ft)	4	2	.8	185	266	< 1	100
Downstream (100 ft)	4	3	.2	178	266	< 1	90
Downstream (100 ft)	4	3	.5	183	259	< 1	85
Downstream (100 ft)	4	3	.8	183	266	< 1	88
Downstream (125 ft)	5	1	.2	183	261	< 1	96

Downstream (125 ft)	5	1	.5	184	268	< 1	93
Downstream (125 ft)	5	1	.8	188	259	< 1	90
Downstream (125 ft)	5	2	.2	184	254	< 1	85
Downstream (125 ft)	5	2	.5	181	266	< 1	84
Downstream (125 ft)	5	2	.8	184	261	< 1	93
Downstream (125 ft)	5	3	.2	181	283	< 1	88
Downstream (125 ft)	5	3	.5	181	284	< 1	91
Downstream (125 ft)	5	3	.8	187	277	< 1	99
Downstream (200 ft)	6	1	.2	180	286	< 1	82
Downstream (200 ft)	6	1	.5	177	276	< 1	90
Downstream (200 ft)	6	1	.8	180	262	< 1	90
Downstream (200 ft)	6	2	.2	182	270	< 1	82
Downstream (200 ft)	6	2	.5	184	284	< 1	108
Downstream (200 ft)	6	2	.8	183	272	< 1	97
Downstream (200 ft)	6	3	.2	182	282	< 1	97
Downstream (200 ft)	6	3	.5	181	268	< 1	101
Downstream (200 ft)	6	3	.8	184	272	< 1	104
Downstream (400 ft)	7	1	.2	181	259	< 1	84
Downstream (400 ft)	7	1	.5	182	258	< 1	86
Downstream (400 ft)	7	1	.8	180	258	< 1	89
Downstream (400 ft)	7	2	.2	182	260	< 1	82
Downstream (400 ft)	7	2	.5	180	264	< 1	83
Downstream (400 ft)	7	2	.8	182	263	< 1	105
Downstream (400 ft)	7	3	.2	185	264	< 1	151
Downstream (400 ft)	7	3	.5	185	259	< 1	100
Downstream (400 ft)	7	3	.8	182	266	< 1	86

Table B.3. Aluminum data, Platte South Water Treatment Plant, Metropolitan Utility District, Omaha, NE.

Location From Reference Discharge	Transverse No.	Position along Transect	Parameter	Results (mg/L)
Upstream (375 ft)	1	1	Al Total	0.464
	1	1	Al Total	0.396
	1	1	Al Total	0.384
	1	1	Al Total	0.338
	1	2	Al Total	0.509
	1	2	Al Total	0.477
	1	2	Al Total	0.441
	1	3	Al Total	0.429
	1	2	Al Total	0.406
	1	3	Al Total	0.398
Upstream (125 ft)	2	1	Al Total	0.393
	2	1	Al Total	0.446
	2	1	Al Total	0.385
	2	1	Al Total	0.47
	2	2	Al Total	0.408
	2	2	Al Total	0.388
	2	2	Al Total	0.459
	2	3	Al Total	0.483
	2	3	Al Total	0.501
	2	3	Al Total	0.515
Downstream (50 ft)	3	1	Al Total	0.446
	3	1	Al Total	0.422
	3	1	Al Total	0.513
	3	2	Al Total	0.462
	3	2	Al Total	0.526
	3	2	Al Total	0.518
	3	2	Al Total	0.579
	3	3	Al Total	0.587
	3	3	Al Total	0.585
	3	3	Al Total	0.657
Downstream (100 ft)	4	1	Al Total	0.687
	4	1	Al Total	0.646
	4	1	Al Total	0.628
	4	2	Al Total	0.653
	4	2	Al Total	0.555
	4	2	Al Total	0.575
	4	3	Al Total	1.04
	4	3	Al Total	1.032
	4	3	Al Total	1.025

	4	3	Al Total	1.106
Downstream (125 ft)	5	1	Al Total	1.083
	5	1	Al Total	1.128
	5	1	Al Total	1.117
	5	1	Al Total	1.123
	5	2	Al Total	1.12
	5	2	Al Total	1.094
	5	2	Al Total	1.044
	5	3	Al Total	1.051
	5	3	Al Total	1.197
	5	3	Al Total	1.101
Downstream (200 ft)	6	1	Al Total	1.095
	6	1	Al Total	1.112
	6	1	Al Total	0.963
	6	2	Al Total	0.942
	6	2	Al Total	1.117
	6	2	Al Total	0.734
	6	3	Al Total	0.674
	6	3	Al Total	0.729
	6	3	Al Total	0.661
	6	3	Al Total	0.626
Downstream (400 ft)	7	1	Al Total	0.673
	7	1	Al Total	0.702
	7	1	Al Total	0.608
	7	2	Al Total	0.659
	7	2	Al Total	0.61
	7	2	Al Total	0.544
	7	3	Al Total	0.659
	7	3	Al Total	0.817
	7	3	Al Total	0.804
	7	3	Al Total	0.683
Upstream (375 ft)	1	1	Al Dissolved	0.112
	1	1	Al Dissolved	0.115
	1	1	Al Dissolved	0.117
	1	1	Al Dissolved	0.12
	1	2	Al Dissolved	0.1
	1	2	Al Dissolved	0.082
	1	2	Al Dissolved	<0.063
	1	3	Al Dissolved	0.152
	1	2	Al Dissolved	<0.063
	1	3	Al Dissolved	<0.063
Upstream (125 ft)	2	1	Al Dissolved	0.118
	2	1	Al Dissolved	0.065

	2	1	Al Dissolved	0.147
	2	1	Al Dissolved	0.109
	2	2	Al Dissolved	0.162
	2	2	Al Dissolved	0.078
	2	2	Al Dissolved	<0.063
	2	3	Al Dissolved	0.234
	2	3	Al Dissolved	0.181
	2	3	Al Dissolved	0.207
Downstream (50 ft)	3	1	Al Dissolved	0.099
	3	1	Al Dissolved	0.163
	3	1	Al Dissolved	0.17
	3	2	Al Dissolved	0.126
	3	2	Al Dissolved	0.145
	3	2	Al Dissolved	0.204
	3	2	Al Dissolved	0.089
	3	3	Al Dissolved	0.067
	3	3	Al Dissolved	<0.063
	3	3	Al Dissolved	<0.063
Downstream (100 ft)	4	1	Al Dissolved	0.108
	4	1	Al Dissolved	0.123
	4	1	Al Dissolved	<0.063
	4	2	Al Dissolved	0.065
	4	2	Al Dissolved	0.066
	4	2	Al Dissolved	0.07
	4	3	Al Dissolved	<0.063
	4	3	Al Dissolved	<0.063
	4	3	Al Dissolved	<0.063
	4	3	Al Dissolved	<0.063
Downstream (125 ft)	5	1	Al Dissolved	0.123
	5	1	Al Dissolved	<0.063
	5	1	Al Dissolved	<0.063
	5	1	Al Dissolved	0.104
	5	2	Al Dissolved	<0.063
	5	2	Al Dissolved	0.075
	5	2	Al Dissolved	<0.063
	5	3	Al Dissolved	0.068
	5	3	Al Dissolved	<0.063
	5	3	Al Dissolved	<0.063
Downstream (200 ft)	6	1	Al Dissolved	<0.063
	6	1	Al Dissolved	0.077
	6	1	Al Dissolved	<0.063
	6	2	Al Dissolved	<0.063
	6	2	Al Dissolved	<0.063

	6	2	Al Dissolved	0.122
	6	3	Al Dissolved	0.085
	6	3	Al Dissolved	<0.063
	6	3	Al Dissolved	0.119
	6	3	Al Dissolved	0.108
Downstream (400 ft)	7	1	Al Dissolved	0.128
	7	1	Al Dissolved	0.138
	7	1	Al Dissolved	0.13
	7	2	Al Dissolved	0.15
	7	2	Al Dissolved	0.15
	7	2	Al Dissolved	0.107
	7	3	Al Dissolved	0.135
	7	3	Al Dissolved	0.137
	7	3	Al Dissolved	0.172
	7	3	Al Dissolved	0.102

Table B.4. Calcium data , Platte South Water Treatment Plant, Metropolitan Utility District, Omaha, NE.

Location From Reference Discharge	Transverse No.	Position along Transect	Parameter	Results (mg/L)
Upstream (375 ft)	1	1	Ca Total	61.936
	1	1	Ca Total	59.53
	1	1	Ca Total	60.706
	1	1	Ca Total	61.676
	1	2	Ca Total	63.231
	1	2	Ca Total	63.75
	1	2	Ca Total	60.735
	1	3	Ca Total	63.435
	1	2	Ca Total	63.147
	1	3	Ca Total	62.561
Upstream (125 ft)	2	1	Ca Total	62.984
	2	1	Ca Total	62.429
	2	1	Ca Total	62.907
	2	1	Ca Total	62.736
	2	2	Ca Total	62.078
	2	2	Ca Total	60.53
	2	2	Ca Total	61.262
	2	3	Ca Total	59.71
	2	3	Ca Total	62.51
	2	3	Ca Total	60.977
Downstream (50 ft)	3	1	Ca Total	63.21
	3	1	Ca Total	63.699
	3	1	Ca Total	63.531
	3	2	Ca Total	61.081
	3	2	Ca Total	59.332
	3	2	Ca Total	63.98
	3	2	Ca Total	65.682
	3	3	Ca Total	64.884
	3	3	Ca Total	64.72
	3	3	Ca Total	64.841
Downstream (100 ft)	4	1	Ca Total	66.063
	4	1	Ca Total	66.045
	4	1	Ca Total	61.151
	4	2	Ca Total	60.832
	4	2	Ca Total	64.814
	4	2	Ca Total	63.63
	4	3	Ca Total	63.355
	4	3	Ca Total	62.457
	4	3	Ca Total	61.38
	4	3	Ca Total	63.82

Downstream (125 ft)	5	1	Ca Total	62.142
	5	1	Ca Total	63.308
	5	1	Ca Total	63.685
	5	1	Ca Total	61.658
	5	2	Ca Total	59.973
	5	2	Ca Total	62.742
	5	2	Ca Total	62.348
	5	3	Ca Total	67.638
	5	3	Ca Total	67.298
	5	3	Ca Total	66.461
Downstream (200 ft)	6	1	Ca Total	68.772
	6	1	Ca Total	65.78
	6	1	Ca Total	62.14
	6	2	Ca Total	63.757
	6	2	Ca Total	68.675
	6	2	Ca Total	64.356
	6	3	Ca Total	66.744
	6	3	Ca Total	63.039
	6	3	Ca Total	64.631
	6	3	Ca Total	62.888
Downstream (400 ft)	7	1	Ca Total	61.539
	7	1	Ca Total	61.149
	7	1	Ca Total	61.03
	7	2	Ca Total	62.325
	7	2	Ca Total	63.031
	7	2	Ca Total	62.885
	7	3	Ca Total	62.35
	7	3	Ca Total	61.863
	7	3	Ca Total	62.84
	7	3	Ca Total	63.061
Upstream (375 ft)	1	1	Ca Dissolved	59.894
	1	1	Ca Dissolved	61.606
	1	1	Ca Dissolved	61.602
	1	1	Ca Dissolved	60.683
	1	2	Ca Dissolved	61.996
	1	2	Ca Dissolved	61.97
	1	2	Ca Dissolved	63.811
	1	3	Ca Dissolved	59.412
	1	2	Ca Dissolved	60.543
	1	3	Ca Dissolved	60.589
Upstream (125 ft)	2	1	Ca Dissolved	61.555
	2	1	Ca Dissolved	68.473
	2	1	Ca Dissolved	60.535

	2	1	Ca Dissolved	60.761
	2	2	Ca Dissolved	62.37
	2	2	Ca Dissolved	60.73
	2	2	Ca Dissolved	61.571
	2	3	Ca Dissolved	66.698
	2	3	Ca Dissolved	70.837
	2	3	Ca Dissolved	69.451
Downstream (50 ft)	3	1	Ca Dissolved	67.478
	3	1	Ca Dissolved	71.437
	3	1	Ca Dissolved	71.413
	3	2	Ca Dissolved	69.537
	3	2	Ca Dissolved	65.956
	3	2	Ca Dissolved	67.866
	3	2	Ca Dissolved	64.336
	3	3	Ca Dissolved	61.148
	3	3	Ca Dissolved	63.536
	3	3	Ca Dissolved	62.105
Downstream (100 ft)	4	1	Ca Dissolved	63.741
	4	1	Ca Dissolved	62.775
	4	1	Ca Dissolved	61.703
	4	2	Ca Dissolved	62.738
	4	2	Ca Dissolved	62.967
	4	2	Ca Dissolved	63.183
	4	3	Ca Dissolved	61.995
	4	3	Ca Dissolved	62.895
	4	3	Ca Dissolved	61.752
	4	3	Ca Dissolved	62.599
Downstream (125 ft)	5	1	Ca Dissolved	62.269
	5	1	Ca Dissolved	62.072
	5	1	Ca Dissolved	62.513
	5	1	Ca Dissolved	61.542
	5	2	Ca Dissolved	65.716
	5	2	Ca Dissolved	61.08
	5	2	Ca Dissolved	62.649
	5	3	Ca Dissolved	62.065
	5	3	Ca Dissolved	61.289
	5	3	Ca Dissolved	60.325
Downstream (200 ft)	6	1	Ca Dissolved	61.922
	6	1	Ca Dissolved	62.157
	6	1	Ca Dissolved	62.407
	6	2	Ca Dissolved	62.289
	6	2	Ca Dissolved	60.464
	6	2	Ca Dissolved	61.936

	6	3	Ca Dissolved	62.62
	6	3	Ca Dissolved	61.923
	6	3	Ca Dissolved	61.277
	6	3	Ca Dissolved	61.447
Downstream (400 ft)	7	1	Ca Dissolved	60.815
	7	1	Ca Dissolved	61.792
	7	1	Ca Dissolved	60.781
	7	2	Ca Dissolved	60.745
	7	2	Ca Dissolved	60.881
	7	2	Ca Dissolved	61.056
	7	3	Ca Dissolved	61.854
	7	3	Ca Dissolved	63.023
	7	3	Ca Dissolved	62.319
	7	3	Ca Dissolved	62.66

Table B.5. Copper data , Platte South Water Treatment Plant, Metropolitan Utility District, Omaha, NE.

Location From Reference Discharge	Transverse No.	Position along Transect	Parameter	Results (mg/L)
Upstream (375 ft)	1	1	Cu Total	<0.008
	1	1	Cu Total	<0.008
	1	1	Cu Total	<0.008
	1	1	Cu Total	<0.008
	1	2	Cu Total	<0.008
	1	2	Cu Total	<0.008
	1	2	Cu Total	<0.008
	1	3	Cu Total	<0.008
	1	2	Cu Total	<0.008
	1	3	Cu Total	<0.008
Upstream (125 ft)	2	1	Cu Total	<0.008
	2	1	Cu Total	<0.008
	2	1	Cu Total	<0.008
	2	1	Cu Total	<0.008
	2	2	Cu Total	<0.008
	2	2	Cu Total	<0.008
	2	2	Cu Total	<0.008
	2	3	Cu Total	<0.008
	2	3	Cu Total	<0.008
	2	3	Cu Total	<0.008
Downstream (50 ft)	3	1	Cu Total	<0.008
	3	1	Cu Total	<0.008
	3	1	Cu Total	<0.008
	3	2	Cu Total	<0.008
	3	2	Cu Total	<0.008
	3	2	Cu Total	<0.008
	3	2	Cu Total	<0.008
	3	3	Cu Total	<0.008
	3	3	Cu Total	<0.008
	3	3	Cu Total	<0.008
Downstream (100 ft)	4	1	Cu Total	<0.008
	4	1	Cu Total	<0.008
	4	1	Cu Total	<0.008
	4	2	Cu Total	<0.008
	4	2	Cu Total	<0.008
	4	2	Cu Total	<0.008
	4	3	Cu Total	<0.008
	4	3	Cu Total	<0.008
	4	3	Cu Total	<0.008
	4	3	Cu Total	<0.008

Downstream (125 ft)	5	1	Cu Total	<0.008
	5	1	Cu Total	<0.008
	5	1	Cu Total	<0.008
	5	1	Cu Total	<0.008
	5	2	Cu Total	<0.008
	5	2	Cu Total	<0.008
	5	2	Cu Total	<0.008
	5	3	Cu Total	<0.008
	5	3	Cu Total	<0.008
	5	3	Cu Total	<0.008
Downstream (200 ft)	6	1	Cu Total	<0.008
	6	1	Cu Total	<0.008
	6	1	Cu Total	<0.008
	6	2	Cu Total	<0.008
	6	2	Cu Total	<0.008
	6	2	Cu Total	0.015
	6	3	Cu Total	<0.008
	6	3	Cu Total	<0.008
	6	3	Cu Total	<0.008
	6	3	Cu Total	<0.008
Downstream (400 ft)	7	1	Cu Total	<0.008
	7	1	Cu Total	<0.008
	7	1	Cu Total	<0.008
	7	2	Cu Total	<0.008
	7	2	Cu Total	<0.008
	7	2	Cu Total	<0.008
	7	3	Cu Total	<0.008
	7	3	Cu Total	<0.008
	7	3	Cu Total	<0.008
	7	3	Cu Total	<0.008
Upstream (375 ft)	1	1	Cu Dissolved	<0.008
	1	1	Cu Dissolved	<0.008
	1	1	Cu Dissolved	<0.008
	1	1	Cu Dissolved	<0.008
	1	2	Cu Dissolved	<0.008
	1	2	Cu Dissolved	<0.008
	1	2	Cu Dissolved	<0.008
	1	3	Cu Dissolved	<0.008
	1	2	Cu Dissolved	<0.008
	1	3	Cu Dissolved	<0.008
Upstream (125 ft)	2	1	Cu Dissolved	<0.008
	2	1	Cu Dissolved	<0.008
	2	1	Cu Dissolved	<0.008

	2	1	Cu Dissolved	<0.008
	2	2	Cu Dissolved	<0.008
	2	2	Cu Dissolved	<0.008
	2	2	Cu Dissolved	<0.008
	2	3	Cu Dissolved	<0.008
	2	3	Cu Dissolved	<0.008
	2	3	Cu Dissolved	<0.008
Downstream (50 ft)	3	1	Cu Dissolved	<0.008
	3	1	Cu Dissolved	<0.008
	3	1	Cu Dissolved	<0.008
	3	2	Cu Dissolved	<0.008
	3	2	Cu Dissolved	<0.008
	3	2	Cu Dissolved	<0.008
	3	2	Cu Dissolved	<0.008
	3	3	Cu Dissolved	<0.008
	3	3	Cu Dissolved	<0.008
	3	3	Cu Dissolved	<0.008
Downstream (100 ft)	4	1	Cu Dissolved	<0.008
	4	1	Cu Dissolved	<0.008
	4	1	Cu Dissolved	<0.008
	4	2	Cu Dissolved	<0.008
	4	2	Cu Dissolved	<0.008
	4	2	Cu Dissolved	<0.008
	4	3	Cu Dissolved	<0.008
	4	3	Cu Dissolved	<0.008
	4	3	Cu Dissolved	<0.008
	4	3	Cu Dissolved	<0.008
Downstream (125 ft)	5	1	Cu Dissolved	<0.008
	5	1	Cu Dissolved	<0.008
	5	1	Cu Dissolved	<0.008
	5	1	Cu Dissolved	<0.008
	5	2	Cu Dissolved	<0.008
	5	2	Cu Dissolved	<0.008
	5	2	Cu Dissolved	<0.008
	5	3	Cu Dissolved	<0.008
	5	3	Cu Dissolved	<0.008
	5	3	Cu Dissolved	<0.008
Downstream (200 ft)	6	1	Cu Dissolved	<0.008
	6	1	Cu Dissolved	<0.008
	6	1	Cu Dissolved	<0.008
	6	2	Cu Dissolved	<0.008
	6	2	Cu Dissolved	<0.008
	6	2	Cu Dissolved	<0.008

	6	3	Cu Dissolved	<0.008
	6	3	Cu Dissolved	<0.008
	6	3	Cu Dissolved	<0.008
	6	3	Cu Dissolved	<0.008
Downstream (400 ft)	7	1	Cu Dissolved	<0.008
	7	1	Cu Dissolved	<0.008
	7	1	Cu Dissolved	<0.008
	7	2	Cu Dissolved	<0.008
	7	2	Cu Dissolved	<0.008
	7	2	Cu Dissolved	<0.008
	7	3	Cu Dissolved	<0.008
	7	3	Cu Dissolved	<0.008
	7	3	Cu Dissolved	<0.008
	7	3	Cu Dissolved	<0.008

Table B.6. Iron data, Platte South Water Treatment Plant, Metropolitan Utility District, Omaha, NE.

Location From Reference Discharge	Transverse No.	Position along Transect	Parameter	Results (mg/L)
Upstream (375 ft)	1	1	Fe Total	0.428
	1	1	Fe Total	0.366
	1	1	Fe Total	0.345
	1	1	Fe Total	0.311
	1	2	Fe Total	0.465
	1	2	Fe Total	0.403
	1	2	Fe Total	0.359
	1	3	Fe Total	0.325
	1	2	Fe Total	0.395
	1	3	Fe Total	0.313
Upstream (125 ft)	2	1	Fe Total	0.358
	2	1	Fe Total	0.366
	2	1	Fe Total	0.292
	2	1	Fe Total	0.386
	2	2	Fe Total	0.354
	2	2	Fe Total	0.347
	2	2	Fe Total	0.342
	2	3	Fe Total	0.445
	2	3	Fe Total	0.462
	2	3	Fe Total	0.427
Downstream (50 ft)	3	1	Fe Total	0.396
	3	1	Fe Total	0.396
	3	1	Fe Total	0.444
	3	2	Fe Total	0.428
	3	2	Fe Total	0.462
	3	2	Fe Total	0.463
	3	2	Fe Total	0.515
	3	3	Fe Total	0.491
	3	3	Fe Total	0.493
	3	3	Fe Total	0.599
Downstream (100 ft)	4	1	Fe Total	0.574
	4	1	Fe Total	0.526
	4	1	Fe Total	0.48
	4	2	Fe Total	0.532
	4	2	Fe Total	0.406
	4	2	Fe Total	0.482
	4	3	Fe Total	0.929
	4	3	Fe Total	0.915
	4	3	Fe Total	0.9
	4	3	Fe Total	0.957

Downstream (125 ft)	5	1	Fe Total	0.967
	5	1	Fe Total	1.054
	5	1	Fe Total	0.973
	5	1	Fe Total	0.966
	5	2	Fe Total	0.986
	5	2	Fe Total	0.932
	5	2	Fe Total	0.987
	5	3	Fe Total	0.969
	5	3	Fe Total	1.093
	5	3	Fe Total	1.028
Downstream (200 ft)	6	1	Fe Total	0.996
	6	1	Fe Total	1.043
	6	1	Fe Total	0.871
	6	2	Fe Total	0.832
	6	2	Fe Total	1.043
	6	2	Fe Total	0.661
	6	3	Fe Total	0.561
	6	3	Fe Total	0.615
	6	3	Fe Total	0.592
	6	3	Fe Total	0.555
Downstream (400 ft)	7	1	Fe Total	0.628
	7	1	Fe Total	0.654
	7	1	Fe Total	0.586
	7	2	Fe Total	0.603
	7	2	Fe Total	0.537
	7	2	Fe Total	0.533
	7	3	Fe Total	0.606
	7	3	Fe Total	0.783
	7	3	Fe Total	0.722
	7	3	Fe Total	0.581
Upstream (375 ft)	1	1	Fe Dissolved	<0.063
	1	1	Fe Dissolved	<0.063
	1	1	Fe Dissolved	<0.063
	1	1	Fe Dissolved	<0.063
	1	2	Fe Dissolved	<0.063
	1	2	Fe Dissolved	<0.063
	1	2	Fe Dissolved	<0.063
	1	3	Fe Dissolved	<0.063
	1	2	Fe Dissolved	<0.063
	1	3	Fe Dissolved	<0.063
Upstream (125 ft)	2	1	Fe Dissolved	<0.063
	2	1	Fe Dissolved	<0.063
	2	1	Fe Dissolved	<0.063

	2	1	Fe Dissolved	<0.063
	2	2	Fe Dissolved	<0.063
	2	2	Fe Dissolved	<0.063
	2	2	Fe Dissolved	<0.063
	2	3	Fe Dissolved	<0.063
	2	3	Fe Dissolved	<0.063
	2	3	Fe Dissolved	<0.063
Downstream (50 ft)	3	1	Fe Dissolved	<0.063
	3	1	Fe Dissolved	<0.063
	3	1	Fe Dissolved	<0.063
	3	2	Fe Dissolved	<0.063
	3	2	Fe Dissolved	<0.063
	3	2	Fe Dissolved	<0.063
	3	2	Fe Dissolved	<0.063
	3	3	Fe Dissolved	<0.063
	3	3	Fe Dissolved	<0.063
	3	3	Fe Dissolved	<0.063
Downstream (100 ft)	4	1	Fe Dissolved	<0.063
	4	1	Fe Dissolved	<0.063
	4	1	Fe Dissolved	<0.063
	4	2	Fe Dissolved	<0.063
	4	2	Fe Dissolved	<0.063
	4	2	Fe Dissolved	<0.063
	4	3	Fe Dissolved	<0.063
	4	3	Fe Dissolved	<0.063
	4	3	Fe Dissolved	<0.063
	4	3	Fe Dissolved	<0.063
Downstream (125 ft)	5	1	Fe Dissolved	<0.063
	5	1	Fe Dissolved	<0.063
	5	1	Fe Dissolved	<0.063
	5	1	Fe Dissolved	<0.063
	5	2	Fe Dissolved	<0.063
	5	2	Fe Dissolved	<0.063
	5	2	Fe Dissolved	<0.063
	5	3	Fe Dissolved	<0.063
	5	3	Fe Dissolved	<0.063
	5	3	Fe Dissolved	<0.063
Downstream (200 ft)	6	1	Fe Dissolved	<0.063
	6	1	Fe Dissolved	<0.063
	6	1	Fe Dissolved	<0.063
	6	2	Fe Dissolved	<0.063
	6	2	Fe Dissolved	<0.063
	6	2	Fe Dissolved	<0.063

	6	3	Fe Dissolved	<0.063
	6	3	Fe Dissolved	<0.063
	6	3	Fe Dissolved	<0.063
	6	3	Fe Dissolved	<0.063
Downstream (400 ft)	7	1	Fe Dissolved	<0.063
	7	1	Fe Dissolved	<0.063
	7	1	Fe Dissolved	<0.063
	7	2	Fe Dissolved	<0.063
	7	2	Fe Dissolved	<0.063
	7	2	Fe Dissolved	<0.063
	7	3	Fe Dissolved	<0.063
	7	3	Fe Dissolved	<0.063
	7	3	Fe Dissolved	<0.063
	7	3	Fe Dissolved	<0.063

Table B.7. Magnesium data, Platte South Water Treatment Plant, Metropolitan Utility District, Omaha, NE.

Location From Reference Discharge	Transverse No.	Position along Transect	Parameter	Results (mg/L)
Upstream (375 ft)	1	1	Mg Total	25.806
	1	1	Mg Total	24.599
	1	1	Mg Total	25.445
	1	1	Mg Total	25.519
	1	2	Mg Total	27.778
	1	2	Mg Total	25.762
	1	2	Mg Total	25.503
	1	3	Mg Total	25.642
	1	2	Mg Total	25.974
	1	3	Mg Total	25.534
Upstream (125 ft)	2	1	Mg Total	25.579
	2	1	Mg Total	25.465
	2	1	Mg Total	26.394
	2	1	Mg Total	25.632
	2	2	Mg Total	26.25
	2	2	Mg Total	25.076
	2	2	Mg Total	27.16
	2	3	Mg Total	25.209
	2	3	Mg Total	26.16
	2	3	Mg Total	26.275
Downstream (50 ft)	3	1	Mg Total	26.48
	3	1	Mg Total	26.225
	3	1	Mg Total	26.086
	3	2	Mg Total	26.034
	3	2	Mg Total	25.78
	3	2	Mg Total	26.182
	3	2	Mg Total	26.669
	3	3	Mg Total	27.131
	3	3	Mg Total	26.609
	3	3	Mg Total	26.969
Downstream (100 ft)	4	1	Mg Total	27.639
	4	1	Mg Total	26.52
	4	1	Mg Total	25.97
	4	2	Mg Total	25.148
	4	2	Mg Total	26.331
	4	2	Mg Total	25.968
	4	3	Mg Total	26.299
	4	3	Mg Total	25.863
	4	3	Mg Total	25.651

	4	3	Mg Total	25.928
Downstream (125 ft)	5	1	Mg Total	25.585
	5	1	Mg Total	26.721
	5	1	Mg Total	25.402
	5	1	Mg Total	25.397
	5	2	Mg Total	25.308
	5	2	Mg Total	26.453
	5	2	Mg Total	25.552
	5	3	Mg Total	27.599
	5	3	Mg Total	28.041
	5	3	Mg Total	27.026
Downstream (200 ft)	6	1	Mg Total	27.813
	6	1	Mg Total	27.096
	6	1	Mg Total	25.995
	6	2	Mg Total	26.962
	6	2	Mg Total	27.263
	6	2	Mg Total	27.017
	6	3	Mg Total	28.073
	6	3	Mg Total	27.102
	6	3	Mg Total	26.813
	6	3	Mg Total	25.712
Downstream (400 ft)	7	1	Mg Total	25.551
	7	1	Mg Total	25.629
	7	1	Mg Total	25.615
	7	2	Mg Total	25.225
	7	2	Mg Total	25.914
	7	2	Mg Total	25.645
	7	3	Mg Total	26.192
	7	3	Mg Total	25.434
	7	3	Mg Total	25.701
	7	3	Mg Total	26.42
Upstream (375 ft)	1	1	Mg Dissolved	25.112
	1	1	Mg Dissolved	25.609
	1	1	Mg Dissolved	26.383
	1	1	Mg Dissolved	24.975
	1	2	Mg Dissolved	26.924
	1	2	Mg Dissolved	27.321
	1	2	Mg Dissolved	26.354
	1	3	Mg Dissolved	26.502
	1	2	Mg Dissolved	24.149
	1	3	Mg Dissolved	26.293
Upstream (125 ft)	2	1	Mg Dissolved	24.805
	2	1	Mg Dissolved	25.136

	2	1	Mg Dissolved	28.55
	2	1	Mg Dissolved	25.829
	2	2	Mg Dissolved	26.171
	2	2	Mg Dissolved	25.887
	2	2	Mg Dissolved	25.681
	2	3	Mg Dissolved	29.119
	2	3	Mg Dissolved	27.699
	2	3	Mg Dissolved	29.035
Downstream (50 ft)	3	1	Mg Dissolved	26.383
	3	1	Mg Dissolved	25.967
	3	1	Mg Dissolved	28.607
	3	2	Mg Dissolved	28.702
	3	2	Mg Dissolved	27.851
	3	2	Mg Dissolved	27.626
	3	2	Mg Dissolved	27.212
	3	3	Mg Dissolved	26.663
	3	3	Mg Dissolved	26.759
	3	3	Mg Dissolved	26.803
Downstream (100 ft)	4	1	Mg Dissolved	26.266
	4	1	Mg Dissolved	28.423
	4	1	Mg Dissolved	25.562
	4	2	Mg Dissolved	27.269
	4	2	Mg Dissolved	26.041
	4	2	Mg Dissolved	27.123
	4	3	Mg Dissolved	26.195
	4	3	Mg Dissolved	26.634
	4	3	Mg Dissolved	25.785
	4	3	Mg Dissolved	25.76
Downstream (125 ft)	5	1	Mg Dissolved	26.094
	5	1	Mg Dissolved	25.312
	5	1	Mg Dissolved	26.28
	5	1	Mg Dissolved	26.471
	5	2	Mg Dissolved	24.693
	5	2	Mg Dissolved	26.154
	5	2	Mg Dissolved	25.639
	5	3	Mg Dissolved	26.068
	5	3	Mg Dissolved	25.396
	5	3	Mg Dissolved	25.978
Downstream (200 ft)	6	1	Mg Dissolved	25.853
	6	1	Mg Dissolved	26.324
	6	1	Mg Dissolved	26.206
	6	2	Mg Dissolved	25.887
	6	2	Mg Dissolved	26.067

	6	2	Mg Dissolved	26.591
	6	3	Mg Dissolved	25.837
	6	3	Mg Dissolved	25.977
	6	3	Mg Dissolved	25.913
	6	3	Mg Dissolved	26.567
Downstream (400 ft)	7	1	Mg Dissolved	25.803
	7	1	Mg Dissolved	25.354
	7	1	Mg Dissolved	25.457
	7	2	Mg Dissolved	26.357
	7	2	Mg Dissolved	26.249
	7	2	Mg Dissolved	25.876
	7	3	Mg Dissolved	26.406
	7	3	Mg Dissolved	26.516
	7	3	Mg Dissolved	26.097
	7	3	Mg Dissolved	26.299

Table B.8. Manganese data, Platte South Water Treatment Plant, Metropolitan Utility District, Omaha, NE.

Location From Reference Discharge	Transverse No.	Position along Transect	Parameter	Results (mg/L)
Upstream (375 ft)	1	1	Mn Total	0.039
	1	1	Mn Total	0.033
	1	1	Mn Total	0.031
	1	1	Mn Total	0.029
	1	2	Mn Total	0.041
	1	2	Mn Total	0.035
	1	2	Mn Total	0.032
	1	3	Mn Total	0.028
	1	2	Mn Total	0.035
	1	3	Mn Total	0.028
Upstream (125 ft)	2	1	Mn Total	0.033
	2	1	Mn Total	0.033
	2	1	Mn Total	0.027
	2	1	Mn Total	0.035
	2	2	Mn Total	0.032
	2	2	Mn Total	0.031
	2	2	Mn Total	0.031
	2	3	Mn Total	0.039
	2	3	Mn Total	0.041
	2	3	Mn Total	0.037
Downstream (50 ft)	3	1	Mn Total	0.037
	3	1	Mn Total	0.039
	3	1	Mn Total	0.043
	3	2	Mn Total	0.04
	3	2	Mn Total	0.041
	3	2	Mn Total	0.038
	3	2	Mn Total	0.054
	3	3	Mn Total	0.053
	3	3	Mn Total	0.054
	3	3	Mn Total	0.061
Downstream (100 ft)	4	1	Mn Total	0.061
	4	1	Mn Total	0.056
	4	1	Mn Total	0.054
	4	2	Mn Total	0.056
	4	2	Mn Total	0.047
	4	2	Mn Total	0.052
	4	3	Mn Total	0.086
	4	3	Mn Total	0.085
	4	3	Mn Total	0.085

	4	3	Mn Total	0.086
Downstream (125 ft)	5	1	Mn Total	0.09
	5	1	Mn Total	0.097
	5	1	Mn Total	0.091
	5	1	Mn Total	0.09
	5	2	Mn Total	0.092
	5	2	Mn Total	0.089
	5	2	Mn Total	0.092
	5	3	Mn Total	0.091
	5	3	Mn Total	0.101
	5	3	Mn Total	0.096
Downstream (200 ft)	6	1	Mn Total	0.095
	6	1	Mn Total	0.098
	6	1	Mn Total	0.085
	6	2	Mn Total	0.08
	6	2	Mn Total	0.097
	6	2	Mn Total	0.067
	6	3	Mn Total	0.058
	6	3	Mn Total	0.064
	6	3	Mn Total	0.048
	6	3	Mn Total	0.046
Downstream (400 ft)	7	1	Mn Total	0.053
	7	1	Mn Total	0.054
	7	1	Mn Total	0.049
	7	2	Mn Total	0.049
	7	2	Mn Total	0.046
	7	2	Mn Total	0.044
	7	3	Mn Total	0.047
	7	3	Mn Total	0.063
	7	3	Mn Total	0.06
	7	3	Mn Total	0.048
Upstream (375 ft)	1	1	Mn Dissolved	<0.006
	1	1	Mn Dissolved	<0.006
	1	1	Mn Dissolved	<0.006
	1	1	Mn Dissolved	<0.006
	1	2	Mn Dissolved	<0.006
	1	2	Mn Dissolved	<0.006
	1	2	Mn Dissolved	<0.006
	1	3	Mn Dissolved	<0.006
	1	2	Mn Dissolved	<0.006
	1	3	Mn Dissolved	<0.006
Upstream (125 ft)	2	1	Mn Dissolved	<0.006
	2	1	Mn Dissolved	<0.006

	2	1	Mn Dissolved	<0.006
	2	1	Mn Dissolved	<0.006
	2	2	Mn Dissolved	<0.006
	2	2	Mn Dissolved	<0.006
	2	2	Mn Dissolved	<0.006
	2	3	Mn Dissolved	<0.006
	2	3	Mn Dissolved	<0.006
	2	3	Mn Dissolved	<0.006
Downstream (50 ft)	3	1	Mn Dissolved	<0.006
	3	1	Mn Dissolved	<0.006
	3	1	Mn Dissolved	<0.006
	3	2	Mn Dissolved	<0.006
	3	2	Mn Dissolved	<0.006
	3	2	Mn Dissolved	<0.006
	3	2	Mn Dissolved	<0.006
	3	3	Mn Dissolved	<0.006
	3	3	Mn Dissolved	<0.006
	3	3	Mn Dissolved	<0.006
Downstream (100 ft)	4	1	Mn Dissolved	<0.006
	4	1	Mn Dissolved	<0.006
	4	1	Mn Dissolved	<0.006
	4	2	Mn Dissolved	<0.006
	4	2	Mn Dissolved	<0.006
	4	2	Mn Dissolved	<0.006
	4	3	Mn Dissolved	<0.006
	4	3	Mn Dissolved	<0.006
	4	3	Mn Dissolved	<0.006
	4	3	Mn Dissolved	<0.006
Downstream (125 ft)	5	1	Mn Dissolved	<0.006
	5	1	Mn Dissolved	<0.006
	5	1	Mn Dissolved	<0.006
	5	1	Mn Dissolved	<0.006
	5	2	Mn Dissolved	<0.006
	5	2	Mn Dissolved	<0.006
	5	2	Mn Dissolved	<0.006
	5	3	Mn Dissolved	<0.006
	5	3	Mn Dissolved	<0.006
	5	3	Mn Dissolved	<0.006
Downstream (200 ft)	6	1	Mn Dissolved	<0.006
	6	1	Mn Dissolved	<0.006
	6	1	Mn Dissolved	<0.006
	6	2	Mn Dissolved	<0.006
	6	2	Mn Dissolved	<0.006

	6	2	Mn Dissolved	<0.006
	6	3	Mn Dissolved	<0.006
	6	3	Mn Dissolved	<0.006
	6	3	Mn Dissolved	<0.006
	6	3	Mn Dissolved	<0.006
Downstream (400 ft)	7	1	Mn Dissolved	<0.006
	7	1	Mn Dissolved	<0.006
	7	1	Mn Dissolved	<0.006
	7	2	Mn Dissolved	<0.006
	7	2	Mn Dissolved	<0.006
	7	2	Mn Dissolved	<0.006
	7	3	Mn Dissolved	<0.006
	7	3	Mn Dissolved	<0.006
	7	3	Mn Dissolved	<0.006
	7	3	Mn Dissolved	<0.006

Table B.9. Nickel data, Platte South Water Treatment Plant, Metropolitan Utility District, Omaha, NE.

Location From Reference Discharge	Transverse No.	Position along Transect	Parameter	Results (mg/L)
Upstream (375 ft)	1	1	Ni Total	<0.019
	1	1	Ni Total	<0.019
	1	1	Ni Total	<0.019
	1	1	Ni Total	<0.019
	1	2	Ni Total	<0.019
	1	2	Ni Total	<0.019
	1	2	Ni Total	<0.019
	1	3	Ni Total	<0.019
	1	2	Ni Total	<0.019
	1	3	Ni Total	<0.019
Upstream (125 ft)	2	1	Ni Total	<0.019
	2	1	Ni Total	<0.019
	2	1	Ni Total	<0.019
	2	1	Ni Total	<0.019
	2	2	Ni Total	<0.019
	2	2	Ni Total	<0.019
	2	2	Ni Total	<0.019
	2	3	Ni Total	<0.019
	2	3	Ni Total	<0.019
	2	3	Ni Total	<0.019
Downstream (50 ft)	3	1	Ni Total	<0.019
	3	1	Ni Total	<0.019
	3	1	Ni Total	<0.019
	3	2	Ni Total	<0.019
	3	2	Ni Total	<0.019
	3	2	Ni Total	<0.019
	3	2	Ni Total	<0.019
	3	3	Ni Total	<0.019
	3	3	Ni Total	<0.019
	3	3	Ni Total	<0.019
Downstream (100 ft)	4	1	Ni Total	<0.019
	4	1	Ni Total	<0.019
	4	1	Ni Total	<0.019
	4	2	Ni Total	<0.019
	4	2	Ni Total	<0.019
	4	2	Ni Total	<0.019
	4	3	Ni Total	<0.019
	4	3	Ni Total	<0.019
	4	3	Ni Total	<0.019
	4	3	Ni Total	<0.019

Downstream (125 ft)	5	1	Ni Total	<0.019
	5	1	Ni Total	<0.019
	5	1	Ni Total	<0.019
	5	1	Ni Total	<0.019
	5	2	Ni Total	<0.019
	5	2	Ni Total	<0.019
	5	2	Ni Total	<0.019
	5	3	Ni Total	<0.019
	5	3	Ni Total	<0.019
	5	3	Ni Total	<0.019
Downstream (200 ft)	6	1	Ni Total	<0.019
	6	1	Ni Total	<0.019
	6	1	Ni Total	<0.019
	6	2	Ni Total	<0.019
	6	2	Ni Total	<0.019
	6	2	Ni Total	<0.019
	6	3	Ni Total	<0.019
	6	3	Ni Total	<0.019
	6	3	Ni Total	<0.019
	6	3	Ni Total	<0.019
Downstream (400 ft)	7	1	Ni Total	<0.019
	7	1	Ni Total	<0.019
	7	1	Ni Total	<0.019
	7	2	Ni Total	<0.019
	7	2	Ni Total	<0.019
	7	2	Ni Total	<0.019
	7	3	Ni Total	<0.019
	7	3	Ni Total	<0.019
	7	3	Ni Total	<0.019
	7	3	Ni Total	<0.019
Upstream (375 ft)	1	1	Ni Dissolved	<0.019
	1	1	Ni Dissolved	<0.019
	1	1	Ni Dissolved	<0.019
	1	1	Ni Dissolved	<0.019
	1	2	Ni Dissolved	<0.019
	1	2	Ni Dissolved	<0.019
	1	2	Ni Dissolved	<0.019
	1	3	Ni Dissolved	<0.019
	1	2	Ni Dissolved	<0.019
	1	3	Ni Dissolved	<0.019
Upstream (125 ft)	2	1	Ni Dissolved	<0.019
	2	1	Ni Dissolved	<0.019
	2	1	Ni Dissolved	<0.019

	2	1	Ni Dissolved	<0.019
	2	2	Ni Dissolved	<0.019
	2	2	Ni Dissolved	<0.019
	2	2	Ni Dissolved	<0.019
	2	3	Ni Dissolved	<0.019
	2	3	Ni Dissolved	<0.019
	2	3	Ni Dissolved	<0.019
Downstream (50 ft)	3	1	Ni Dissolved	<0.019
	3	1	Ni Dissolved	<0.019
	3	1	Ni Dissolved	<0.019
	3	2	Ni Dissolved	<0.019
	3	2	Ni Dissolved	<0.019
	3	2	Ni Dissolved	<0.019
	3	2	Ni Dissolved	<0.019
	3	3	Ni Dissolved	<0.019
	3	3	Ni Dissolved	<0.019
	3	3	Ni Dissolved	<0.019
Downstream (100 ft)	4	1	Ni Dissolved	<0.019
	4	1	Ni Dissolved	<0.019
	4	1	Ni Dissolved	<0.019
	4	2	Ni Dissolved	<0.019
	4	2	Ni Dissolved	<0.019
	4	2	Ni Dissolved	<0.019
	4	3	Ni Dissolved	<0.019
	4	3	Ni Dissolved	<0.019
	4	3	Ni Dissolved	<0.019
	4	3	Ni Dissolved	<0.019
Downstream (125 ft)	5	1	Ni Dissolved	<0.019
	5	1	Ni Dissolved	<0.019
	5	1	Ni Dissolved	<0.019
	5	1	Ni Dissolved	<0.019
	5	2	Ni Dissolved	<0.019
	5	2	Ni Dissolved	<0.019
	5	2	Ni Dissolved	<0.019
	5	3	Ni Dissolved	<0.019
	5	3	Ni Dissolved	<0.019
	5	3	Ni Dissolved	<0.019
Downstream (200 ft)	6	1	Ni Dissolved	<0.019
	6	1	Ni Dissolved	<0.019
	6	1	Ni Dissolved	<0.019
	6	2	Ni Dissolved	<0.019
	6	2	Ni Dissolved	<0.019
	6	2	Ni Dissolved	<0.019

	6	3	Ni Dissolved	<0.019
	6	3	Ni Dissolved	<0.019
	6	3	Ni Dissolved	<0.019
	6	3	Ni Dissolved	<0.019
Downstream (400 ft)	7	1	Ni Dissolved	<0.019
	7	1	Ni Dissolved	<0.019
	7	1	Ni Dissolved	<0.019
	7	2	Ni Dissolved	<0.019
	7	2	Ni Dissolved	<0.019
	7	2	Ni Dissolved	<0.019
	7	3	Ni Dissolved	<0.019
	7	3	Ni Dissolved	<0.019
	7	3	Ni Dissolved	<0.019
	7	3	Ni Dissolved	<0.019

Table B.10. Selenium data, Platte South Water Treatment Plant, Metropolitan Utility District, Omaha, NE.

Location From Reference Discharge	Transverse No.	Position along Transect	Parameter	Results (mg/L)
Upstream (375 ft)	1	1	Se Total	<0.063
	1	1	Se Total	<0.063
	1	1	Se Total	<0.063
	1	1	Se Total	<0.063
	1	2	Se Total	<0.063
	1	2	Se Total	<0.063
	1	2	Se Total	<0.063
	1	3	Se Total	<0.063
	1	2	Se Total	<0.063
	1	3	Se Total	<0.063
Upstream (125 ft)	2	1	Se Total	<0.063
	2	1	Se Total	<0.063
	2	1	Se Total	<0.063
	2	1	Se Total	<0.063
	2	2	Se Total	<0.063
	2	2	Se Total	<0.063
	2	2	Se Total	<0.063
	2	3	Se Total	<0.063
	2	3	Se Total	<0.063
	2	3	Se Total	<0.063
Downstream (50 ft)	3	1	Se Total	<0.063
	3	1	Se Total	<0.063
	3	1	Se Total	<0.063
	3	2	Se Total	<0.063
	3	2	Se Total	<0.063
	3	2	Se Total	<0.063
	3	2	Se Total	<0.063
	3	3	Se Total	<0.063
	3	3	Se Total	<0.063
	3	3	Se Total	<0.063
Downstream (100 ft)	4	1	Se Total	<0.063
	4	1	Se Total	<0.063
	4	1	Se Total	<0.063
	4	2	Se Total	<0.063
	4	2	Se Total	<0.063
	4	2	Se Total	<0.063
	4	3	Se Total	<0.063
	4	3	Se Total	<0.063
	4	3	Se Total	<0.063

	4	3	Se Total	<0.063
Downstream (125 ft)	5	1	Se Total	<0.063
	5	1	Se Total	<0.063
	5	1	Se Total	<0.063
	5	1	Se Total	<0.063
	5	2	Se Total	<0.063
	5	2	Se Total	<0.063
	5	2	Se Total	<0.063
	5	3	Se Total	<0.063
	5	3	Se Total	<0.063
	5	3	Se Total	<0.063
Downstream (200 ft)	6	1	Se Total	<0.063
	6	1	Se Total	<0.063
	6	1	Se Total	<0.063
	6	2	Se Total	<0.063
	6	2	Se Total	<0.063
	6	2	Se Total	<0.063
	6	3	Se Total	<0.063
	6	3	Se Total	<0.063
	6	3	Se Total	<0.063
	6	3	Se Total	<0.063
Downstream (400 ft)	7	1	Se Total	<0.063
	7	1	Se Total	<0.063
	7	1	Se Total	<0.063
	7	2	Se Total	<0.063
	7	2	Se Total	<0.063
	7	2	Se Total	<0.063
	7	3	Se Total	<0.063
	7	3	Se Total	<0.063
	7	3	Se Total	<0.063
	7	3	Se Total	<0.063
Upstream (375 ft)	1	1	Se Dissolved	<0.063
Upstream (375 ft)	1	1	Se Dissolved	<0.063
	1	1	Se Dissolved	<0.063
	1	1	Se Dissolved	<0.063
	1	2	Se Dissolved	<0.063
	1	2	Se Dissolved	<0.063
	1	2	Se Dissolved	<0.063
	1	3	Se Dissolved	<0.063
	1	2	Se Dissolved	<0.063
	1	3	Se Dissolved	<0.063
Upstream (125 ft)	2	1	Se Dissolved	<0.063
	2	1	Se Dissolved	<0.063

	2	1	Se Dissolved	<0.063
	2	1	Se Dissolved	<0.063
	2	2	Se Dissolved	<0.063
	2	2	Se Dissolved	<0.063
	2	2	Se Dissolved	<0.063
	2	3	Se Dissolved	<0.063
	2	3	Se Dissolved	<0.063
	2	3	Se Dissolved	<0.063
Downstream (50 ft)	3	1	Se Dissolved	<0.063
	3	1	Se Dissolved	<0.063
	3	1	Se Dissolved	<0.063
	3	2	Se Dissolved	<0.063
	3	2	Se Dissolved	<0.063
	3	2	Se Dissolved	<0.063
	3	2	Se Dissolved	<0.063
	3	3	Se Dissolved	<0.063
	3	3	Se Dissolved	<0.063
	3	3	Se Dissolved	<0.063
Downstream (100 ft)	4	1	Se Dissolved	<0.063
	4	1	Se Dissolved	<0.063
	4	1	Se Dissolved	<0.063
	4	2	Se Dissolved	<0.063
	4	2	Se Dissolved	<0.063
	4	2	Se Dissolved	<0.063
	4	3	Se Dissolved	<0.063
	4	3	Se Dissolved	<0.063
	4	3	Se Dissolved	<0.063
	4	3	Se Dissolved	<0.063
Downstream (125 ft)	5	1	Se Dissolved	<0.063
	5	1	Se Dissolved	<0.063
	5	1	Se Dissolved	<0.063
	5	1	Se Dissolved	<0.063
	5	2	Se Dissolved	<0.063
	5	2	Se Dissolved	<0.063
	5	2	Se Dissolved	<0.063
	5	3	Se Dissolved	<0.063
	5	3	Se Dissolved	<0.063
	5	3	Se Dissolved	<0.063
Downstream (200 ft)	6	1	Se Dissolved	<0.063
	6	1	Se Dissolved	<0.063
	6	1	Se Dissolved	<0.063
	6	2	Se Dissolved	<0.063
	6	2	Se Dissolved	<0.063

	6	2	Se Dissolved	<0.063
	6	3	Se Dissolved	<0.063
	6	3	Se Dissolved	<0.063
	6	3	Se Dissolved	<0.063
	6	3	Se Dissolved	<0.063
Downstream (400 ft)	7	1	Se Dissolved	<0.063
	7	1	Se Dissolved	<0.063
	7	1	Se Dissolved	<0.063
	7	2	Se Dissolved	<0.063
	7	2	Se Dissolved	<0.063
	7	2	Se Dissolved	<0.063
	7	3	Se Dissolved	<0.063
	7	3	Se Dissolved	<0.063
	7	3	Se Dissolved	<0.063
	7	3	Se Dissolved	<0.063

Table B.11. Zinc data, Platte South Water Treatment Plant, Metropolitan Utility District, Omaha, NE.

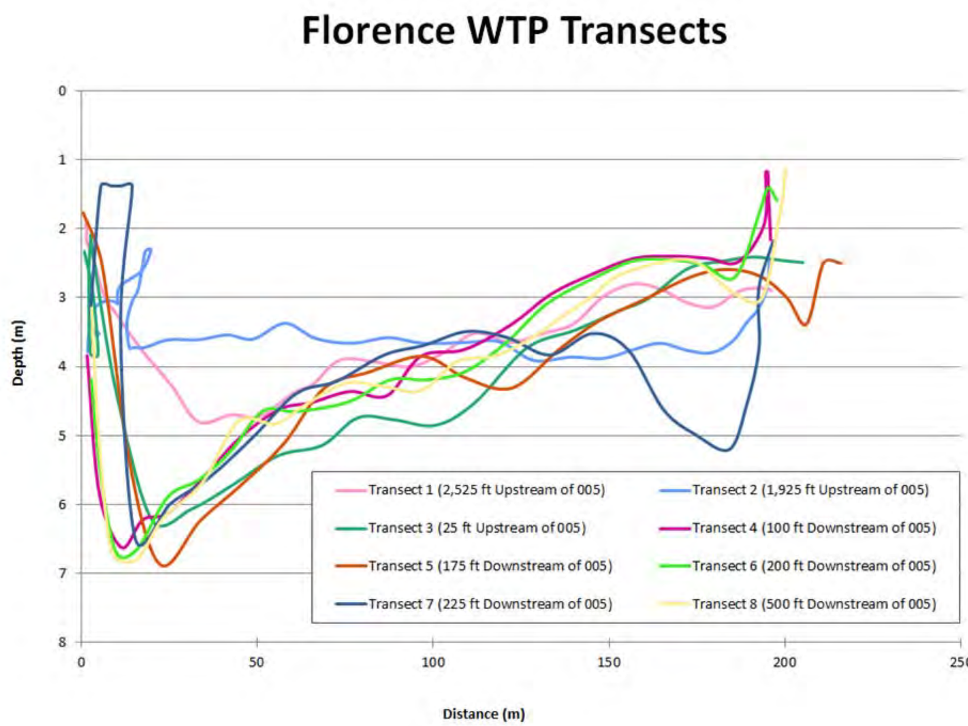
Location From Reference Discharge	Transverse No.	Position along Transect	Parameter	Results (mg/L)
Upstream (375 ft)	1	1	Zn Total	<0.006
	1	1	Zn Total	<0.006
	1	1	Zn Total	<0.006
	1	1	Zn Total	<0.006
	1	2	Zn Total	<0.006
	1	2	Zn Total	<0.006
	1	2	Zn Total	<0.006
	1	3	Zn Total	<0.006
	1	2	Zn Total	<0.006
	1	3	Zn Total	<0.006
Upstream (125 ft)	2	1	Zn Total	<0.006
	2	1	Zn Total	<0.006
	2	1	Zn Total	<0.006
	2	1	Zn Total	<0.006
	2	2	Zn Total	<0.006
	2	2	Zn Total	<0.006
	2	2	Zn Total	<0.006
	2	3	Zn Total	<0.006
	2	3	Zn Total	<0.006
	2	3	Zn Total	<0.006
Downstream (50 ft)	3	1	Zn Total	<0.006
	3	1	Zn Total	<0.006
	3	1	Zn Total	<0.006
	3	2	Zn Total	<0.006
	3	2	Zn Total	<0.006
	3	2	Zn Total	<0.006
	3	2	Zn Total	0.008
	3	3	Zn Total	0.008
	3	3	Zn Total	<0.006
	3	3	Zn Total	0.007
Downstream (100 ft)	4	1	Zn Total	0.01
	4	1	Zn Total	0.009
	4	1	Zn Total	0.008
	4	2	Zn Total	0.011
	4	2	Zn Total	0.008
	4	2	Zn Total	0.009
	4	3	Zn Total	0.009
	4	3	Zn Total	0.01
	4	3	Zn Total	0.01
	4	3	Zn Total	0.01

Downstream (125 ft)	5	1	Zn Total	0.009
	5	1	Zn Total	0.017
	5	1	Zn Total	0.01
	5	1	Zn Total	0.015
	5	2	Zn Total	0.011
	5	2	Zn Total	0.012
	5	2	Zn Total	0.01
	5	3	Zn Total	0.013
	5	3	Zn Total	0.012
	5	3	Zn Total	0.01
Downstream (200 ft)	6	1	Zn Total	0.011
	6	1	Zn Total	0.01
	6	1	Zn Total	0.009
	6	2	Zn Total	0.009
	6	2	Zn Total	0.011
	6	2	Zn Total	0.007
	6	3	Zn Total	0.007
	6	3	Zn Total	0.009
	6	3	Zn Total	<0.006
	6	3	Zn Total	<0.006
Downstream (400 ft)	7	1	Zn Total	<0.006
	7	1	Zn Total	<0.006
	7	1	Zn Total	<0.006
	7	2	Zn Total	<0.006
	7	2	Zn Total	<0.006
	7	2	Zn Total	<0.006
	7	3	Zn Total	<0.006
	7	3	Zn Total	<0.006
	7	3	Zn Total	<0.006
	7	3	Zn Total	<0.006
Upstream (375 ft)	1	1	Zn Dissolved	<0.006
	1	1	Zn Dissolved	<0.006
	1	1	Zn Dissolved	<0.006
	1	1	Zn Dissolved	<0.006
	1	2	Zn Dissolved	<0.006
	1	2	Zn Dissolved	<0.006
	1	2	Zn Dissolved	<0.006
	1	3	Zn Dissolved	<0.006
	1	2	Zn Dissolved	<0.006
	1	3	Zn Dissolved	<0.006
Upstream (125 ft)	2	1	Zn Dissolved	<0.006
	2	1	Zn Dissolved	<0.006
	2	1	Zn Dissolved	<0.006

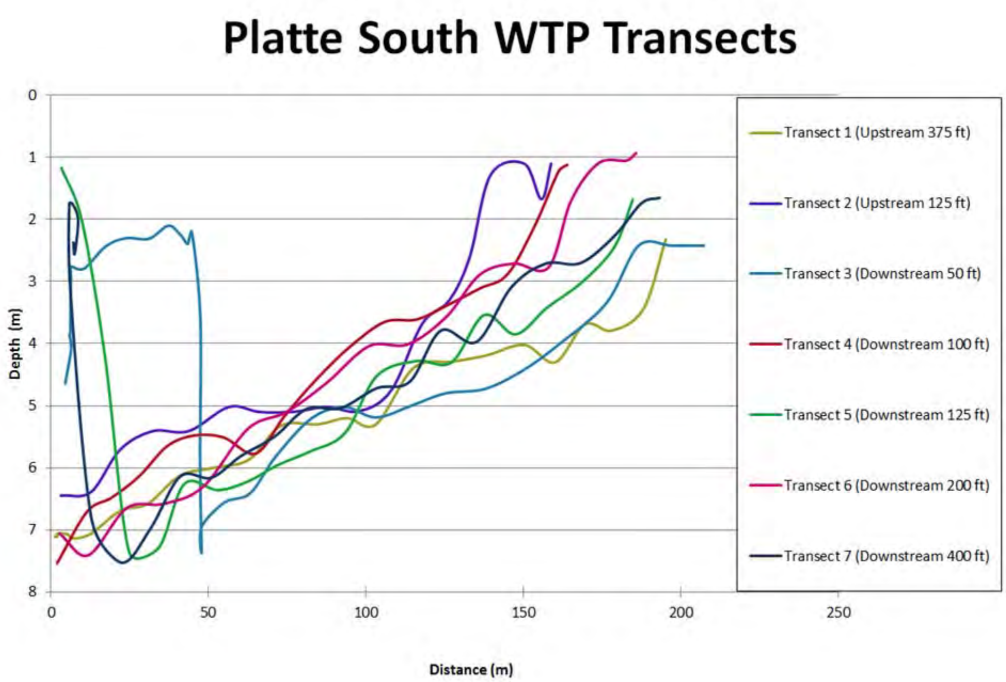
	2	1	Zn Dissolved	<0.006
	2	2	Zn Dissolved	<0.006
	2	2	Zn Dissolved	<0.006
	2	2	Zn Dissolved	<0.006
	2	3	Zn Dissolved	<0.006
	2	3	Zn Dissolved	<0.006
	2	3	Zn Dissolved	<0.006
Downstream (50 ft)	3	1	Zn Dissolved	<0.006
	3	1	Zn Dissolved	<0.006
	3	1	Zn Dissolved	<0.006
	3	2	Zn Dissolved	<0.006
	3	2	Zn Dissolved	<0.006
	3	2	Zn Dissolved	<0.006
	3	2	Zn Dissolved	<0.006
	3	3	Zn Dissolved	<0.006
	3	3	Zn Dissolved	<0.006
	3	3	Zn Dissolved	<0.006
Downstream (100 ft)	4	1	Zn Dissolved	<0.006
	4	1	Zn Dissolved	<0.006
	4	1	Zn Dissolved	<0.006
	4	2	Zn Dissolved	<0.006
	4	2	Zn Dissolved	<0.006
	4	2	Zn Dissolved	<0.006
	4	3	Zn Dissolved	<0.006
	4	3	Zn Dissolved	<0.006
	4	3	Zn Dissolved	<0.006
	4	3	Zn Dissolved	<0.006
Downstream (125 ft)	5	1	Zn Dissolved	<0.006
	5	1	Zn Dissolved	<0.006
	5	1	Zn Dissolved	<0.006
	5	1	Zn Dissolved	<0.006
	5	2	Zn Dissolved	<0.006
	5	2	Zn Dissolved	<0.006
	5	2	Zn Dissolved	<0.006
	5	3	Zn Dissolved	<0.006
	5	3	Zn Dissolved	<0.006
	5	3	Zn Dissolved	<0.006
Downstream (200 ft)	6	1	Zn Dissolved	<0.006
	6	1	Zn Dissolved	<0.006
	6	1	Zn Dissolved	<0.006
	6	2	Zn Dissolved	<0.006
	6	2	Zn Dissolved	<0.006
	6	2	Zn Dissolved	<0.006

	6	3	Zn Dissolved	<0.006
	6	3	Zn Dissolved	<0.006
	6	3	Zn Dissolved	0.007
	6	3	Zn Dissolved	0.012
Downstream (400 ft)	7	1	Zn Dissolved	0.008
	7	1	Zn Dissolved	0.007
	7	1	Zn Dissolved	0.01
	7	2	Zn Dissolved	0.007
	7	2	Zn Dissolved	0.008
	7	2	Zn Dissolved	0.01
	7	3	Zn Dissolved	0.007
	7	3	Zn Dissolved	0.011
	7	3	Zn Dissolved	<0.006
	7	3	Zn Dissolved	0.007

APPENDIX C



Florence WTP Transects
Depth (m)
Distance (m)
Transect 1 (2,525 ft Upstream of 005)
Transect 2 (1,925 ft Upstream of 005)
Transect 3 (25 ft Upstream of 005)
Transect 4 (100 ft Downstream of 005)
Transect 5 (175 ft Downstream of 005)
Transect 6 (200 ft Downstream of 005)
Transect 7 (225 ft Downstream of 005)
Transect 8 (500 ft Downstream of 005)



Platte South WTP Transects
Depth (m)
Distance (m)
Transect 1 (Upstream 375 ft)
Transect 2 (Upstream 125 ft)
Transect 3 (Downstream 50 ft)
Transect 4 (Downstream 100 ft)
Transect 5 (Downstream 125 ft)
Transect 6 (Downstream 200 ft)
Transect 7 (Downstream 400 ft)

Attachment B

Benthic Macroinvertebrate Community Analyses
Missouri River in the Vicinity of the Florence and Platte South
Potable Water Treatment Plants
Omaha, Nebraska

By
Pennington and Associates, Inc.
Cookeville, Tennessee

BENTHIC MACROINVERTEBRATE COMMUNITY ANALYSES
MISSOURI RIVER IN THE VICINITY OF THE FLORENCE AND PLATTE SOUTH POTABLE WATER TREATMENT PLANTS
OMAHA, NEBRASKA

PREPARED FOR

EE & T, INC.
NEWPORT NEWS, VIRGINIA

AUGUST 2012

PREPARED BY

PENNINGTON AND ASSOCIATES, INC.
COOKEVILLE, TENNESSEE

EXECUTIVE SUMMARY

Benthic macroinvertebrates were collected from the Missouri River in the vicinity of the Florence Potable Water Treatment Plant's (PWTP) and Platte South PWTP for the Omaha Nebraska Municipal Utility District. One location was established upstream and two downstream (125' and 600') of the permitted discharges. At each of the six locations, six artificial substrate samplers were placed on June 25 and 26 and retrieved on August 13 and 14, 2012. Analyses of the substrate samplers included taxa richness, density, EPT taxa, Hilsenhoff Biotic Index, species diversity, evenness, Jaccard's Coefficient and percent similarity. A minimum of 57 species was found on the substrates with the net-spinning caddisfly *Potamyia flava* and the midge *Rheotanytarsus exiguus gp.* dominant. The most significant differences included a statistically measurable drop in density from the upstream substrates to the downstream substrates below the Florence PWTP discharges and significantly higher numbers of taxa at Platt South when compared to the Florence locations.

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INTRODUCTION

Pennington and Associates, Inc. was contracted in May 2012 by EE & T, Inc. to conduct benthic macroinvertebrate surveys in the Missouri River using artificial substrate samplers in the vicinity of the Florence PWTP outfalls (NPDES Permit No. NE0000914) and the Platte South PWTP outfall (NPDES Permit No. NE0000906). The two facilities are operated by Omaha's Metropolitan Utilities District (M.U.D.). The artificial substrate samplers were placed on June 25, 2012 at the Florence PWTP and retrieved on August 13, 2012. At the Platte South locations the artificial substrate samplers (Photo 1) were placed on June 26 and retrieved on August 14, 2012. The approximate 6 week duration allowed for maximum colonization (Photo 2 and 3) of the substrates by benthic macroinvertebrates that exist in the river.

Attention is normally focused on the benthic macroinvertebrate community because it is more indicative of the relative health of the aquatic ecosystem. Macroinvertebrates are found in all habitats, are less mobile than some other groups of aquatic organisms such as fish, and most species of macroinvertebrates have relatively long periods of development in the aquatic environment. It is because of these factors that macroinvertebrate species can be used to indicate deleterious events that may occur in an aquatic environment over a period of time (OEPA 1987).

LOCATIONS

The locations selected for benthic macroinvertebrate community analyses in the Missouri River for the Florence PWTP and the Platte South PWTP are shown in Figures 1 and 2 and described as follows:

F 600 D – Approximately 600 feet downstream of Florence PWTP most downstream discharge, approximately 50 feet off right descending bank.

F 125 D – Approximately 125 feet downstream of Florence PWTP most downstream discharge, approximately 50 feet off right descending bank.

F U – Approximately 50 feet off right descending bank just upstream of Florence PWTP discharges.

P 600 D – Approximately 600 feet downstream of Platte South PWTP discharge, approximately 50 feet off right descending bank.

P 125 D - Approximately 125 feet downstream of Platte South PWTP discharge, approximately 50 feet off right descending bank.

PU – Just upstream of Platte South PWTP discharge at approximately 50 feet off right descending bank.

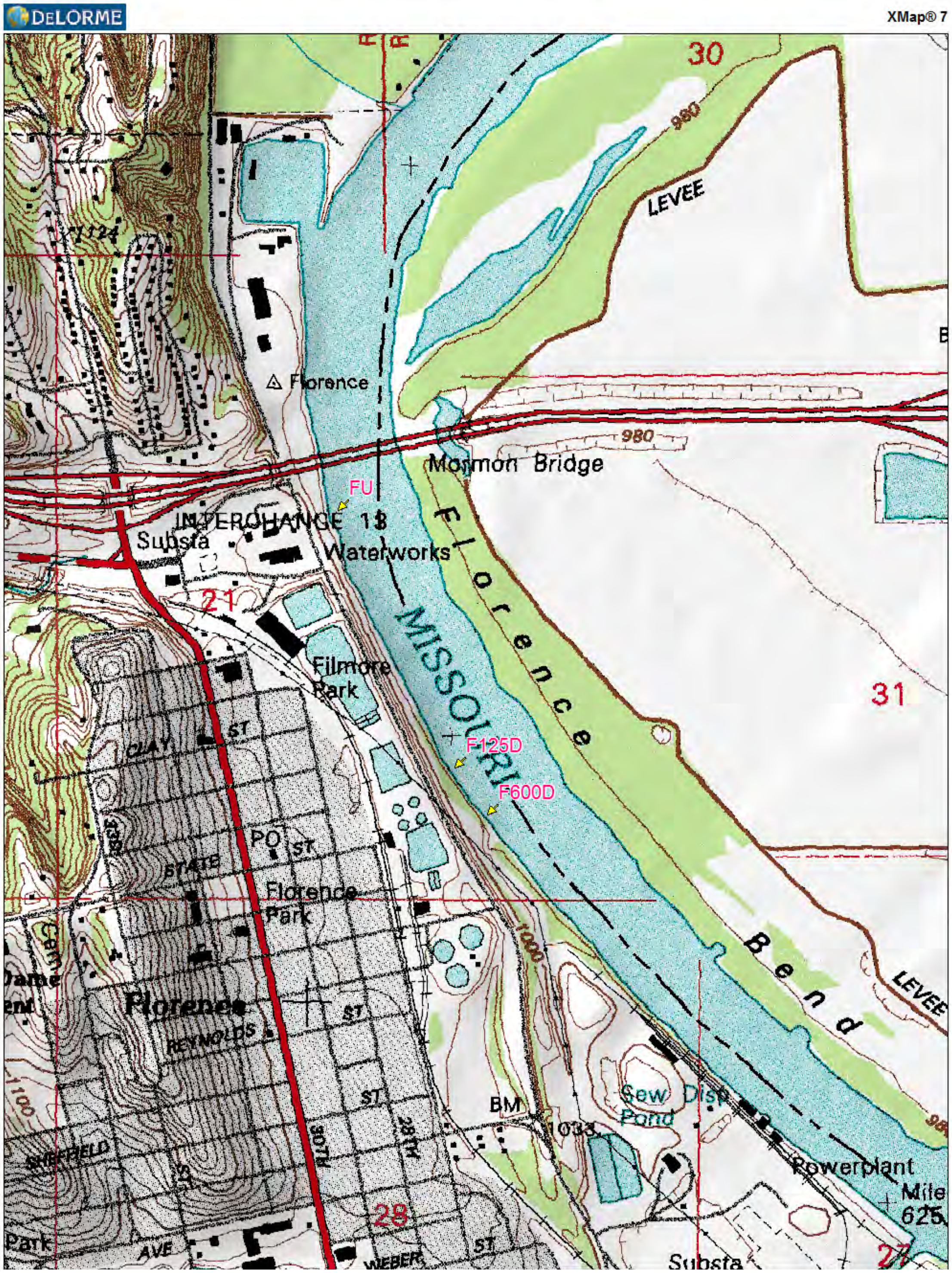

Figure 1. Benthic Macroinvertebrate Sampling Sites, Florence PWTP, August, 2012.

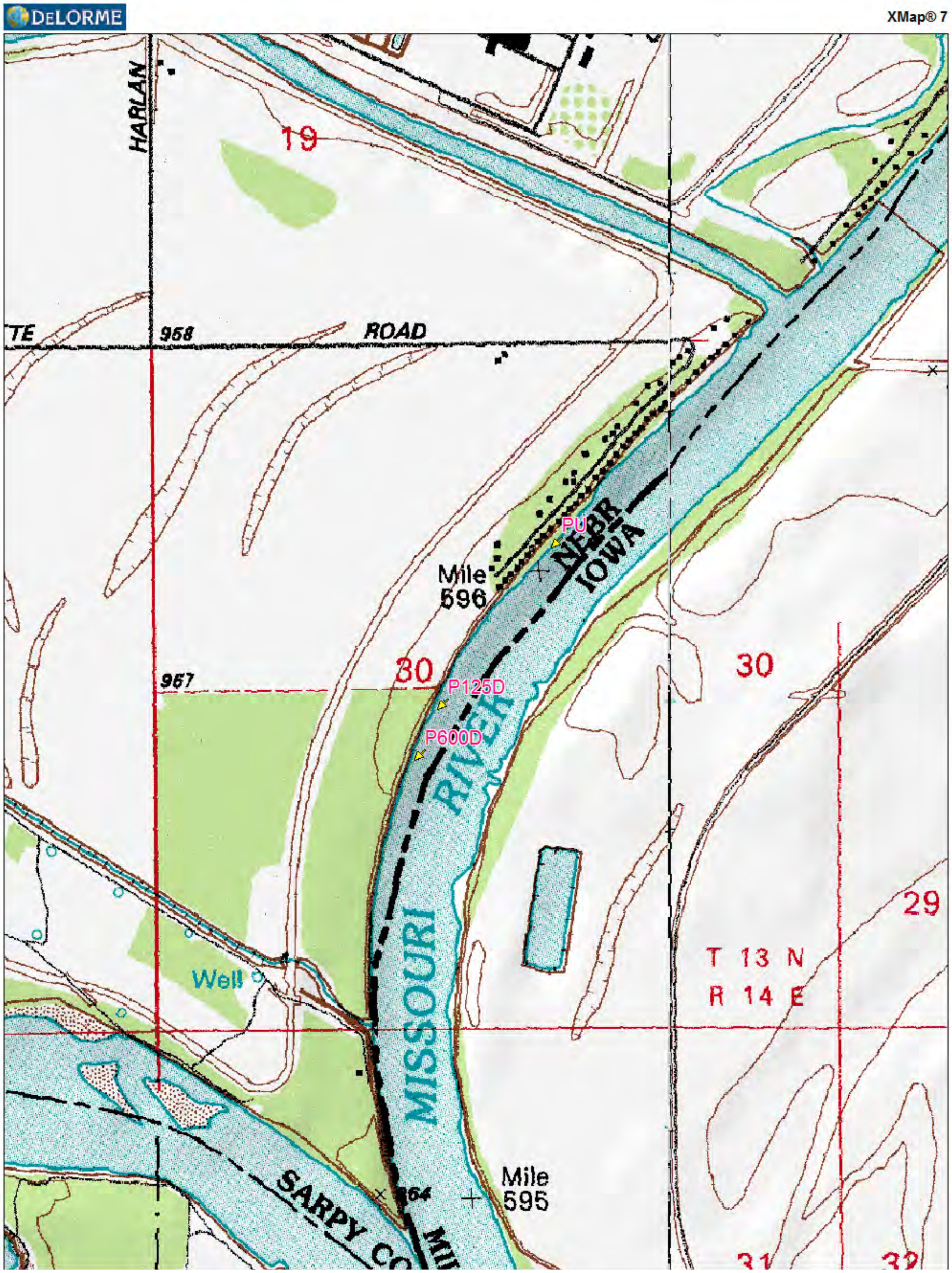

Figure 2. Benthic Macroinvertebrate Sampling Sites, Platte South PWTP, August, 2012.

Photo 1. Artificial substrate sampler prior to placement, June 25, 2012.

Photo 2. Artificial substrate sampler approximately 6 weeks after placement, August 13, 2012.

Photo 3. Individual artificial substrate approximately 6 weeks after placement, August 13, 2012.

MATERIALS AND METHODS

Collection Methods

Benthic macroinvertebrates were collected from the Missouri River using artificial substrate samplers (concrete forms in baskets) (Merritt et al. 2008). The substrate samplers were placed on June 25 and 26 retrieved on August 13 and 14, 2012. At the six sites, duplicate sets of three artificial substrate samplers were placed in the river for a total of 36. As stipulated in the work plan a minimum of one set of three from each location was to be processed. The artificial substrate samplers were constructed of 1" welded wire, based on the design of the barbecue basket sampler (Mason et al. 1967; Merritt et al. 2008). They were 11" (length) X 7" (diameter) (28 X 18 cm). Substrates were constructed by filling 7 ounce paper cups with concrete. After the mixture hardened the paper was removed to expose the hard surface and the substrates were seasoned in water. Ten concrete substrates were placed in each basket. The surface area of each substrate was approximately 150 cm^2 (10 x .015m^2 = 0.15m^2/Basket).

The artificial substrate samplers were attached to the riverbank with a plastic coated steel cable to reduce oxidation and breakage. Survey tape was used to mark bank locations. After a 6-week time lapse, each sampler was retrieved from the river by lifting the cable and placing a 250-micron net under it below the water surface to capture any animals dislodged when the substrates broke the surface. The substrates were removed from the baskets and cleaned in the field. All materials (detritus, organisms, etc.) were transferred to plastic containers, labeled, preserved in formalin and returned to the laboratory for analyses. All 18 substrates were retrieved in the vicinity of the Florence PWTP discharge. At the Platte South location 3 substrates were found upstream, 5 from 125 feet downstream and 6 from the 600 feet downstream location.

Laboratory Methods

In the laboratory, all benthic samples were washed in a 250-micron mesh sieve, manually separated from the detritus using a stereomicroscope, and preserved in 70-80% ethanol. If sub-sampling of large numbers of certain groups was required a Water's (1969) sub-sampling device was used. Identifications were made with a stereomicroscope (0.8X to 4X). Chironomids were cleared for 24 hours in cold 10% KOH and temporary mounts were made in glycerine. Slide mounts of chironomids, oligochaetes, small crustaceans, and others were identified with a compound microscope (4X to 40X). Once identified, the animals were returned to 80% ethanol. Permanent mounts were made with CMC-10 and euperol (Pennak 1989). Identifications were made to the lowest practical taxonomic level (species or genus) using taxonomic keys listed in Pennington & Associates, Inc. Standard Operating Procedures, Benthic Macroinvertebrates (2006).

COMMUNITY STRUCTURE MEASURES

Core benthic macroinvertebrate community metrics were calculated for each location and include:

1. **Taxa Richness (TR)** – Total number of distinct taxa. In general, increasing taxa richness reflects increasing water quality, habitat diversity and habitat suitability (KDOW 2002).

2. **Ephemeroptera, Plecoptera, and Trichoptera Richness (EPT)** – Total number of distinct taxa within the generally pollution sensitive insect orders of EPT. This index value will usually increase with increasing water quality, habitat diversity and habitat stability (Plafkin et al. 1989).

3. **Hilsenhoff Biotic Index (HBI)** – The Biotic Index was originally developed by Hilsenhoff (1982) as a rapid method for evaluating water quality in Wisconsin streams by

summarizing the overall pollution tolerance of a benthic arthropod community with a single value from 0-5. Hilsenhoff (1987) later refined the index and expanded the scale from 0-10. The biotic index is an average of tolerance values, and measures saprobity (pertaining to tolerance of organic enrichment) and to some extent tropism. Range of the index ranges from 0 (no apparent organic pollution) to 10 (severe organic pollution). An increasing Biotic Index value indicates decreasing water quality. The formula for the Biotic Index is as follows:

$$HBI = \sum \frac{x_i t_i}{n}$$

Where: x_i = number of individuals within a taxon
t_i = tolerance value of a taxon
n = total number of individuals in the sample

According to Hilsenhoff (1987) the calculated Biotic Index values for Wisconsin streams reflect the following:

Biotic Index	**Water Quality**	**Degree of Organic Pollution**
0.00 - 3.50	Excellent	No apparent organic pollution
3.51 - 4.50	Very Good	Possibly slight organic pollution
4.51 - 5.50	Good	Some organic pollution
5.51 - 6.50	Fair	Fairly significant organic pollution
6.51 - 7.50	Fairly Poor	Significant organic pollution
7.51 - 8.50	Poor	Very significant organic pollution
8.51 - 10.00	Very Poor	Severe organic pollution

The State of Nebraska Water Quality Division (1997) follows the Hilsenhoff (1987) Wisconsin scoring criteria with values less than 3.5 indicating excellent water quality, values of 3.51 to 5 indicating good water quality, 5.01 to 7.5 indicating fair water quality, 7.51 to 8 indicating poor water quality and values greater than 8 would indicate serious water quality problems.

Brower and Zar (1984) provide a detailed discussion of a variety of techniques for measuring community structure. The use of diversity indices is based upon the observation that normally undisturbed environments support communities with large numbers of species having no individuals present in overwhelming abundance. If the species of a disturbed community are ranked by numerical abundance, there may be relatively few species with large numbers of individuals. Mean diversity is affected by both "richness" of species (or abundance of different species) and by the distribution of individuals among the species. High species diversity indicates a highly complex community.

Species diversity was estimated using Shannon's Index of Diversity (H):

$$H = -\sum p_i \log p_i$$

where p_i is the proportion of the total number of individuals occurring in species i ($p_i = n_i/N$), N is the total number of individuals in all species.

Diversity indices take into account both the species richness and the evenness of the individuals' distribution among the species. Separate measures of these two components of diversity are often desirable. Species richness can be expressed simply as the number of species in the community. Evenness may be expressed by considering how close a set of observed species abundance are to those from an aggregation of species having maximum possible diversity for a given N and S (Brower and Zar 1984).

Evenness is calculated as follows:

$$\text{Pielou } J' = H/H_{max}$$

where H is calculated diversity and H_{max} is maximum possible diversity.

Community similarity between sites is measured by Jaccards Coefficient, Percent Similarity and Bray-Curtis Percent Dissimilarity.

$$\text{Jaccards Coefficient} = \frac{C}{S_1 + S_2 - C}$$

where S = Species in each community (S_1 is reference Community)

and C = Species common to both communities

Percent Similarity, for a two-community comparison, is calculated as follows: The number of individuals in each species is calculated as a fractional portion of the total community. The value for species i in community 1 is compared to the value for species i in community 2. The lower of the two is tabulated. This procedure is followed for each species. The tabulated list (of the lower of each pair of values) is summed. The sum is defined as the Percent Similarity of the two communities.

Bray-Curtis Percent Dissimilarity (PD) is based on species abundance compared between any two communities. The index is expressed as

$$PD = 1 - PS/100$$

where PS = Percent similarity. Boyle et al. (1990) indicated the index was insensitive to low and moderate level structural changes.

Cluster analysis sorts sampling units into groups based on the overall resemblance to each other (Ludwig and Reynolds 1988). By using the PD, sampling units are sorted to permit grouping. The cluster analysis combines the distances between sampling units into a matrix table, and two strategies of clustering are used to calculate a distance for N-1 cycles (N=number of sampling units). The cluster analysis is interpreted graphically on a dendrogram to relate the similar communities (Eckblad 1989, Ludwig and Reynolds 1988).

Community indices were calculated at log base 2 where applicable using the software package ECOL ANAL (Eckbland 1989). Statistical analyses, using the software package Number Cruncher Statistical Systems, were used to compare the number of taxa and the relative numbers between each location.

Statistical Evaluation

Sampling efficiency of the field techniques was calculated via a statistical analysis of the quantitative samples. The mean number of organisms per sample, the standard deviation, the standard error, and the sampling precision of the mean were calculated for the benthic samples from each station (Elliot 1977). The sampling precision is the primary parameter evaluated and represents the percentage of the actual mean of the population within which the sample mean lies and indicates how accurately the macroinvertebrate community was sampled. According to Elliot (1977), a sampling precision of 20% (80% confidence) or less is usually acceptable in biological studies. The sampling precision (D) is the ratio of the standard error to the arithmetic mean:

$$D = (S.E./Mean)\ 100$$

Since six artificial substrate samples were taken in each area (5 at Platte South 125' downstream and 3 at Platte South upstream), some of the population estimates may not be sampled with 80%

or greater confidence. As stated by Elliot (1977), the simplest solution to this problem is to take many samples (over 50 samples), but this is not usually an acceptable allocation of resources.

An analysis of variance (F test) was used to compare the stations using the number of organisms and species per sample. According to Sokal and Rohlf (1981), analysis of variance is a technique in statistics where the total variation in a set of data is partitioned into components associated with possible sources of variability. The relative importance of the different sources is then assessed by F-tests between each component of variation and the "error" variation. If the calculated F-value is greater than the tabular F-value at the 0.05 level of significance, then a difference between data sets is greater than the variation within a data set. Following the approach of Chew (1977), mean separation tests were applied to separate and rank the mean values of each data set developed from benthic enumeration.

RESULTS AND DISCUSSION

A summary of the benthic macroinvertebrate communities including species, tolerance values, functional feeding groups and habit at each of the six locations in the Missouri River is presented in Table 1. All data for each individual substrate is found in Table 1A in the Appendix. Summaries of Benthic Macroinvertebrate Community Indices are presented in Table 2. Graphic examples of community clusters are found in Figures 3 and 4. Statistical comparisons of the locations based on density are found in Tables 3, 4 and 5 while similar comparisons based on number of species are found in Tables 6, 7 and 8.

Benthic macroinvertebrate populations found in the vicinity of Florence PWTP and Platte South PWTP on the artificial substrates consisted of a minimum of 57 species, 41 families and 18 orders (Table 1). Most of the species taken (40) were aquatic insects. The dominant groups at all locations were net-spinning caddisflies, especially *Potamyia flava,* and midges belonging to the *Rheotanytarsus exiguus* group. *Potamyia flava* is a species common to the upper Mississippi River where larvae built nets in high concentrations on rocks in sandy, silt-free bottom materials exposed to current (Wiggins 1996). Larvae of midges belonging to the *Rheotanytarsus exiguus* group are basically filter-feeders and strain organic debris from passing water with strands of salivary secretions strung between arms of their cases (Simpson and Bode 1980). Larvae belonging to the group are dominant in aquatic systems with moderate flows and high amounts of suspended organic particulates.

FLORENCE PWTP

The benthic macroinvertebrate fauna in the vicinity of the Florence PWTP discharge were represented by a minimum of 25 species upstream (FU), with 27 (F125D) and 23 (F600D) found downstream of the discharges (Table 1). *Potamyia flava* (33.0% at FU, 36.7% at F125D and 35.8% at F600D) and *Rheotanytarsus exiguus gp*. (11.9% at FU, 19.6% at F125D and 17.7% at F600D) were dominant on all of the substrates. When compared statistically (Table 6) the differences between mean number of taxa upstream to downstream were not significant at the 0.05 confidence level. In terms of density (mean number per $0.15m^2$), the upstream location had a mean number of 20904.5 individuals per $0.15m^2$ while F125D had $10570.7/0.15m^2$ and F600D had $9470.5/0.15m^2$, a statistically measurable drop in density from upstream to downstream with no significant differences in the two downstream locations (Table 3). The Hilsenhoff's Biotic

Index values for all locations are indicative of “Fair” water quality with “fairly significant organic pollution” (Table 2). The diversity values may also indicate some organic pollution at all locations (Weber 1973). In terms of species shared (Jaccard’s Coefficient), the locations were 0.524 to 0.581 comparable or shared slightly more than ½ their species between sites (Table 2). When a density component was added (percent similarity, Table 2) the two downstream locations were 92.5% comparable while the upstream (FU) location was slightly less comparable, (85.1% to F125D and 81.4% to F600D).

PLATTE SOUTH PWTP

The benthic macroinvertebrate community upstream and downstream of the Platte South PWTP was represented by a minimum of 27 species upstream (PU), 33 just downstream (P125D) and 30 species 600 feet downstream of the discharge (Table 1). The benthic macroinvertebrate populations at all three locations were dominated by individuals belonging to the *Rheotanytarsus exiguus* gp (59.2% at PU, 52.0% at P125D and 48.2% at P600D). The caddisfly *Potamyia flava* and immature hydropsychids were also abundant on the substrates at the two downstream locations. A statistical comparison of the mean number of taxa (Table 7) found no differences between the three locations. In terms of density, the upstream (PU) location had a mean number of 15677.7 individuals per $0.15m^2$ while the two downstream locations ($20753.6/015m^2$ at P125D and $22752.7/0.15m^2$ at P600D) showed an increase in populations density (Table 1). When compared statistically (Table 4) the increase in density was not significant at the 0.05 confidence level. As found at the Florence sites, the Hilsenhoff Biotic Index values calculated from the Platte South substrates yielded a benthic macroinvertebrate fauna representative of “Fair” water quality conditions (Table 2). In terms of species shared (Jaccard’s Coefficient) values ranged from 0.542 to 0.634 with the higher values indicating greater similarity. The two downstream locations (P125D and P600D) had the highest percent similarity (88.4%) while the upstream site (PU) and the most downstream site (P600D) were the least similar (71.4%).

ALL SITES

A comparison of both the Florence PWTP and Platte South PWTP locations using mean number of taxa per substrate shown in Table 8 has the Platte South substrates with significant higher numbers of taxa than the Florence PWTP locations. A similar comparison using mean number of individuals per substrate (Table 5) has the downstream Platte South and the Florence PWTP upstream location (FU) with significantly higher numbers of individuals than the Florence PWTP downstream sites (F125D and F600D). Cluster analyses of the substrates using species shared as shown in Figure 3 has the Platte South locations and Florence locations forming separate and distinct clusters. Similar clusters were found when a density component was added (Figure 4).

Table 1. Benthic Macroinvertebrates Collected from the Missouri River, Omaha, Nebraska on August 13 and 14, 2012.

				Florence 600' Downstream	Florence 125' Downstream	Florence Upstream	Platte S. 600' Downstream	[a]Platte S. 125' Downstream	[b] Platte S. Upstream
				Total	**Total**	**Total**	**Total**	**Total**	**Total**
PLATYHELMINTHES									
Turbellaria									
Tricladida									
Dugesiidae									
Girardia (Dugesia) tigrina	**8**	**CG**	**SP**	1698	796	2287	1044	2024	2463
NEMERTEA					1				
MOLLUSCA									
Bivalvia									
Veneroida									
Sphaeriidae						81			
Musculium transversum	**8**	**CF**	**BU**		1	217	386	164	21
Pisidium sp.	**7**	**CF**	**BU**		1				
Gastropoda									
Basommatophora									
Ancylidae									
Ferrissia rivularis	**8**	**SC**	**CN**					1	
Physidae									
Physella sp.	**9**	**SC**	**SP**					80	
ANNELIDA									
Oligochaeta									
Tubificida									
Naididae								160	200
Nais barbata	**8**	**CG**	**CN**				80		
Nais behningi	**6**	**CG**	**CN**			130	180	740	1020
Nais pardalis	**8**	**CG**	**CN**				80		80
Nais sp.	**9**	**CG**	**BU**					60	
Pristina sp.	**4**	**CG**	**CN**						60
ARTHROPODA									
Arachnoidea									
Acariformes				350	560		240	460	240
Crustacea									
Copepoda									
Cyclopoida						40			
Ostracoda					20				
Cladocera									
Sidaidae									

Table 1. Benthic Macroinvertebrates Collected from the Missouri River, Omaha, Nebraska on August 13 and 14, 2012.

				Florence 600' Downstream	Florence 125' Downstream	Florence Upstream	Platte S. 600' Downstream	[a]Platte S. 125' Downstream	[b] Platte S. Upstream
				Total	Total	Total	Total	Total	Total
Sida crystillina								240	
Amphipoda									
Crangonyctidae									
Crangonyx sp.	2	CG	SW		80				
Decapoda									
Cambaridae									
Orconectes sp.	8	SC	SP					1	
Insecta									
Ephemeroptera									
Baetidae	4	CG	SP	1460	1772	2241	1000	420	
Baetis sp.	5	CG	SP				921		
Labiobaetis longipalpus				1426	1460	9732	2604	1196	161
Caenidae								480	60
Americaenis ridens	7	CG	SP	240	100	321	720	201	140
Caenis sp.	7	CG	SP				40	321	
Heptageniidae				470	263	360	400	740	80
Heptagenia sp.	4	SC	CN					1	
Maccaffertium mexicanum	5	SC	CN					3	80
Maccaffertium sp.	3	SC	CN	100	2	240	261	740	
Isonychiidae									
Isonychia sp.	2	CG	SW	1		711	172	174	1
Leptophlebiidae	2	CG					160	80	
Odonata									
Coenagrionidae	9	PR	CB						
Argia sp.	8	PR	CB						21
Enallagma sp.	9	PR	CB		50				
Libellulidae	9	PR	SP						
Neurocordulia molesta	4	PR	SP					1	
Plecoptera									
Perlidae									
Acroneuria sp.	1	PR	CN		1				
Megaloptera									
Corydalidae	4	PR	CB						
Corydalus cornutus	4	PR	CB	1			1	1	1
Trichoptera									
Brachycentridae									
Brachycentrus sp.	3	CG	SP			1			
Hydropsychidae	5	CF	CN	20363	23268	41433	24368	14321	2900

Table 1. Benthic Macroinvertebrates Collected from the Missouri River, Omaha, Nebraska on August 13 and 14, 2012.

				Florence 600' Downstream	Florence 125' Downstream	Florence Upstream	Platte S. 600' Downstream	[a]Platte S. 125' Downstream	[b] Platte S. Upstream
				Total	**Total**	**Total**	**Total**	**Total**	**Total**
Cheumatopsyche sp.	**5**	**CF**	**CN**	90	70	650	322	480	422
Hydropsyche cf. bidens	**5**	**CF**	**CN**	40	120	400	300		61
Hydropsyche orris	**8**	**CF**	**CN**	4002	3645	13421	6446	2845	641
Hydropsyche simulians	**4**	**CF**	**CN**	1426	2248	1596	2629	1189	501
Hydropsyche sp.	**5**	**CF**	**CN**	60	80			160	
Potamyia flava	**6**	**CF**	**CN**	12312	12556	30613	17868	15489	3188
Hydroptilidae	**4**	**SC**	**cn**	50	80	560	480		20
Hydroptila sp.	**6**	**SC**	**CN**	250					
Mayatrichia sp.	**6**	**SC**	**CN**	430	350	1121	2020	1000	1142
Leptoceridae	**4**	**CG**	**CN**		320	100	80		
Ceraclea sp.	**4**	**CG**	**CB**				40		
Mystacides sp.				120					
Oecetis sp.	**3**	**PR**	**SP**		50				
Polycentropodidae					80				
Cyrnellus fraternus				22	40				
Neureclipsis sp.	**6**	**FC**	**CN**	75	6		43	4	2
Coleoptera									
Elmidae									
Stenelmis sp.	**5**	**SC**	**CN**	50	1	60			
Diptera									
Ceratopogonidae				80					
Chironomidae									
Conchapelopia sp.	**6**	**PR**	**SP**	2	401	1090	2103	1221	402
Corynoneura sp.	**3**	**CG**	**SP**					80	
Cryptochironomus sp.	**8**	**PR**	**SP**					100	60
Glyptotendipes sp.	**10**	**CF**	**BU**				400		20
Nanocladius distinctus	**2**	**CG**	**SP**			60	80	220	260
Paratendipes albimanus	**6**	**CG**	**SP**			80			
Polypedilum flavum (convictum)	**4**	**SH**	**SP**	750	1241	1760	2921	1802	781
Polypedilum halterale gp.	**7**	**SH**	**SP**				220		
Rheotanytarsus exiguus gp.	**6**	**FC**	**CN**	10043	12420	14981	65827	53968	27843
Tanytarsus sp.	**6**	**CF**	**CB**	610	1180	601	1520	1860	4000
Empididae	**8**	**CG**	**SP**	1					62
Hemerodromia sp.	**6**	**PR**	**CN**	221	161	500	560	741	100
Simuliidae									
Simulium sp.	**6**	**FC**	**CN**	80		40			
TOTAL NO. OF ORGANISMS				**56823**	**63424**	**125427**	**136516**	**103768**	**47033**

Table 1. Benthic Macroinvertebrates Collected from the Missouri River, Omaha, Nebraska on August 13 and 14, 2012.

	Florence 600' Downstream	Florence 125' Downstream	Florence Upstream	Platte S. 600' Downstream	[a]Platte S. 125' Downstream	[b] Platte S. Upstream
	Total	**Total**	**Total**	**Total**	**Total**	**Total**
AVERAGE NO. PER 0.15 M^2	**9470.5**	**10570.7**	**20904.5**	**22752.7**	**20753.6**	**15677.7**
[C]TOTAL NO. OF TAXA	**23**	**27**	**25**	**30**	**33**	**27**
[C]EPT TAXA	**14**	**13**	**12**	**15**	**14**	**11**

[a] Five baskets retrieved.
[b] Three baskets retrieved.
[c] Families represented by species or genera (or a lower taxonomic unit) not included in the taxa count.

Table 2. Benthic Macroinvertebrate Community Analyses.

Date	Station	No. of Taxa	HBI	No. of Individuals per 0.15 m^2	Shannon Diversity (H')	Pielou (J')
8/13/12	F 600 D	23	5.69	9470.5	2.81	0.57
8/13/12	F 125 D	27	5.57	10570.7	2.79	0.55
8/13/12	FU	25	5.77	20904.5	2.86	0.58
8/14/12	P 600 D	30	5.82	22752.7	2.62	0.51
8/14/12	P 125 D	33	5.85	20753.6	2.57	0.49
8/14/12	PU	27	5.99	15677.7	2.42	0.48

Jaccards Coefficient

STATION	F 600 D	F 125 D	FU	P 600 D	P 125 D	PU
F 600 D	1	0.585	0.564	0.535	0.458	0.537
F 125 D	0.585	1	0.524	0.5	0.404	0.435
FU	0.564	0.524	1	0.585	0.438	0.512
P 600 D	0.535	0.5	0.585	1	0.542	0.634
P 125 D	0.458	0.404	0.438	0.542	1	0.578
PU	0.537	0.435	0.512	0.634	0.578	1

more similar   least similar

Percent similarity

STATION	F 600 D	F 125 D	FU	P 600 D	P 125 D	PU
F 600 D	100	92.5	85.1	63.6	59.1	41
F 125 D	92.5	100	81.4	66.2	61.2	42.6
FU	85.1	81.4	100	58.4	53.6	34.7
P 600 D	63.6	66.2	58.4	100	88.4	71.4
P 125 D	59.1	61.2	53.6	88.4	100	77.8
PU	41	42.6	34.7	71.4	77.8	100

highest similarity

Table 3. Statistical Comparison of Community Structure (Florence PWTP) Using Mean Number of Organisms per Artificial Substrate Sample (0.15m^2).

Date	Station	No. of Samples	Mean	Standard Deviation	Standard Error	Precision of the Sampling Mean
8/13/2012	F600D	6	9470.5	3726.26	1525.32	16.11%
8/13/2012	F125D	6	10570.7	2857.87	1166.72	11.04%
8/13/2012	FU	6	20904.5	8204.33	3349.03	16.02%

F - ratio = 8.01

Duncan's Multiple Range Test

F U	F 125D	F 600D
20904.5	10570.7	9470.5

(F U 20904.5 underlined alone; F 125D 10570.7 and F 600D 9470.5 underlined together)

Means comparable at the 0.05 confidence levels are underlined.

Table 4. Statistical Comparison of Community Structure (Platte South PWTP) Using Mean Number of Organisms per Artificial Substrate Sample (0.15m^2).

Date	Station	No. of Samples	Mean	Standard Deviation	Standard Error	Precision of the Sampling Mean
8/14/2012	P 600 D	6	22752.7	8512.29	3475.13	15.27%
8/14/2012	P125 D	5	20753.6	6154.03	2752.17	13.26%
8/14/2012	PU	3	15677.7	6784.81	3917.21	24.99%

F - ratio = 0.91

Duncan's Multiple Range Test

P 600 D	P125 D	PU
22752.7	Downstream 20753.6	15677.7

Means comparable at the 0.05 confidence levels are underlined.

Table 5. Statistical Comparison of Community Structure (All Sites) Using Mean Number of Organisms per Artificial Substrate Sample ($0.15m^2$).

Date	Station	No. of Samples	Mean	Standard Deviation	Standard Error	Precision of the Sampling Mean
8/13/2012	F600D	6	9470.5	3726.26	1525.32	16.11%
8/13/2012	F125D	6	10570.7	2857.87	1166.72	11.04%
8/13/2012	FU	6	20904.5	8204.33	3349.03	16.02%
8/14/2012	P 600 D	6	22752.7	8512.29	3475.13	15.27%
8/14/2012	P125 D	5	20753.6	6154.03	2752.17	13.26%
8/14/2012	PU	3	15677.7	6784.81	3917.21	24.99%

F - ratio = 4.69

P600D	FU	P125D	PU	F125D	F600D
22752.7	20904.5	20753.6	15677.7	10570.7	9470.5

Means comparable at the 0.05 confidence levels are underlined.

Table 6. Statistical Comparison of Community Structure (Florence PWTP) Using Mean Number of Taxa per Artificial Substrate Sample (0.15m²).

Date	Station	No. of Samples	Mean	Standard Deviation	Standard Error	Precision of the Sampling Mean
8/13/2012	F600D	6	15.83	1.17	0.48	0.03%
8/13/2012	F125D	6	16.83	0.41	0.17	0.09%
8/13/2012	FU	6	17.5	1.76	0.72	4.10%

F - ratio = 2.73

Duncan's Multiple Range Test

FU	F125D	F600D
17.5	16.83	15.83

Means comparable at the 0.05 confidence levels are underlined.

Table 7. Statistical Comparison of Community Structure (Platte South PWTP) Using Mean Number of Taxa per Artificial Substrate Sample ($0.15m^2$).

Date	Station	No. of Samples	Mean	Standard Deviation	Standard Error	Precision of the Sampling Mean
8/14/2012	P 600 D	6	21	2.83	1.15	5.50%
8/14/2012	P125 D	5	21.4	3.13	1.4	6.54%
8/14/2012	PU	3	22	1.73	1	4.54%

F - ratio = 0.13

Duncan's Multiple Range Test

PU	P125 D	P 600 D
22	21.4	21

Means comparable at the 0.05 confidence levels are underlined.

Table 8. Statistical Comparison of Community Structure (All Sites) Using Mean Number of Taxa per Artificial Substrate Sample ($0.15 m^2$).

Date	Station	No. of Samples	Mean	Standard Deviation	Standard Error	Precision of the Sampling Mean
8/13/2012	F600D	6	15.83	1.17	0.48	0.03%
8/13/2012	F125D	6	16.83	0.41	0.17	0.09%
8/13/2012	FU	6	17.5	1.76	0.72	4.10%
8/14/2012	P600D	6	21	2.83	1.15	5.50%
8/14/2012	P125D	5	21.4	3.13	1.4	6.54%
8/14/2012	PU	3	22	1.73	1	4.54%

F - ratio = 8.62

PU	P125D	P600D	FU	F125D	F600D
22	21.4	21	17.5	16.83	15.83

(Underlined groups: PU, P125D, P600D; FU, F125D, F600D)

Means comparable at the 0.05 confidence levels are underlined.

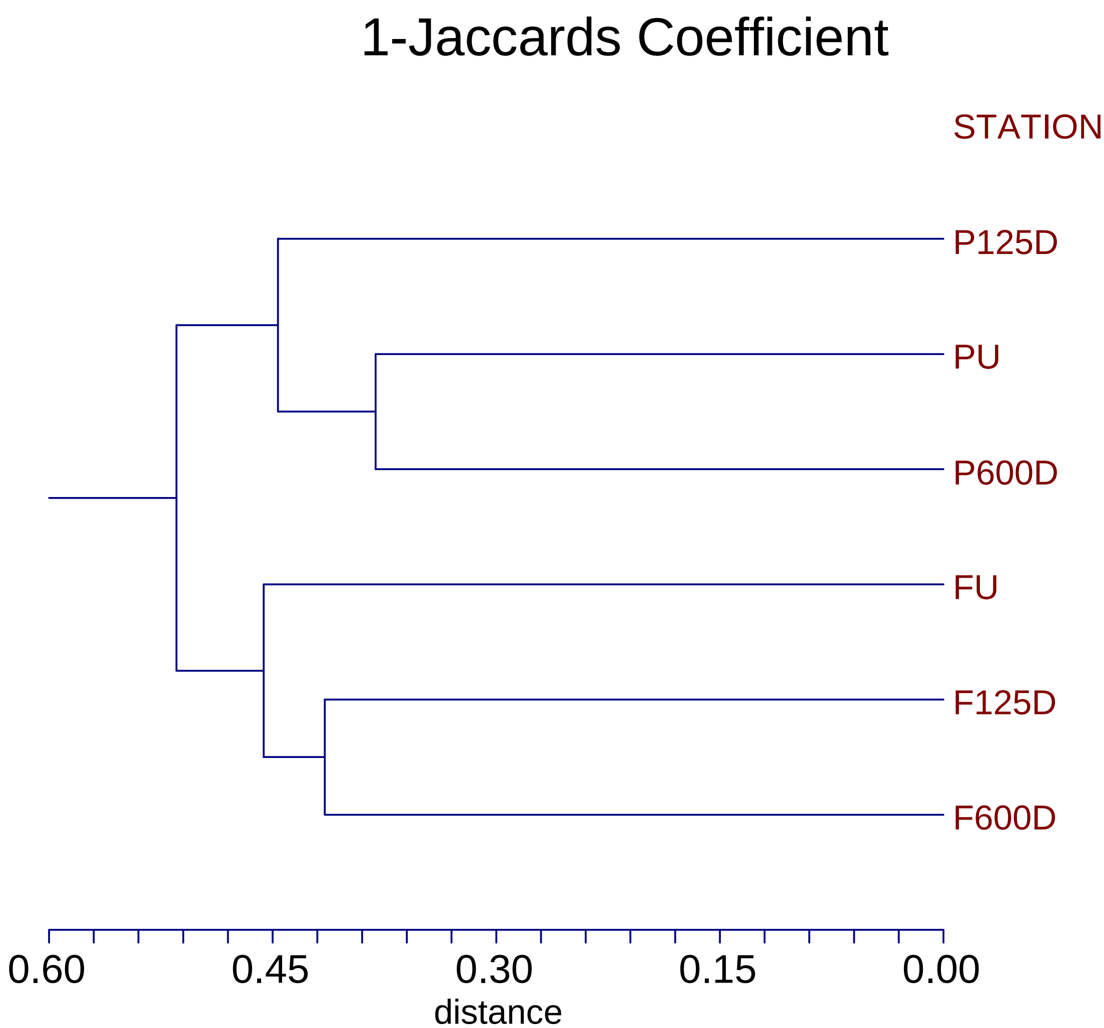

Figure 3. Cluster analyses of artificial substrate samples based on 1-Jaccard's Coefficient (b=0.25).

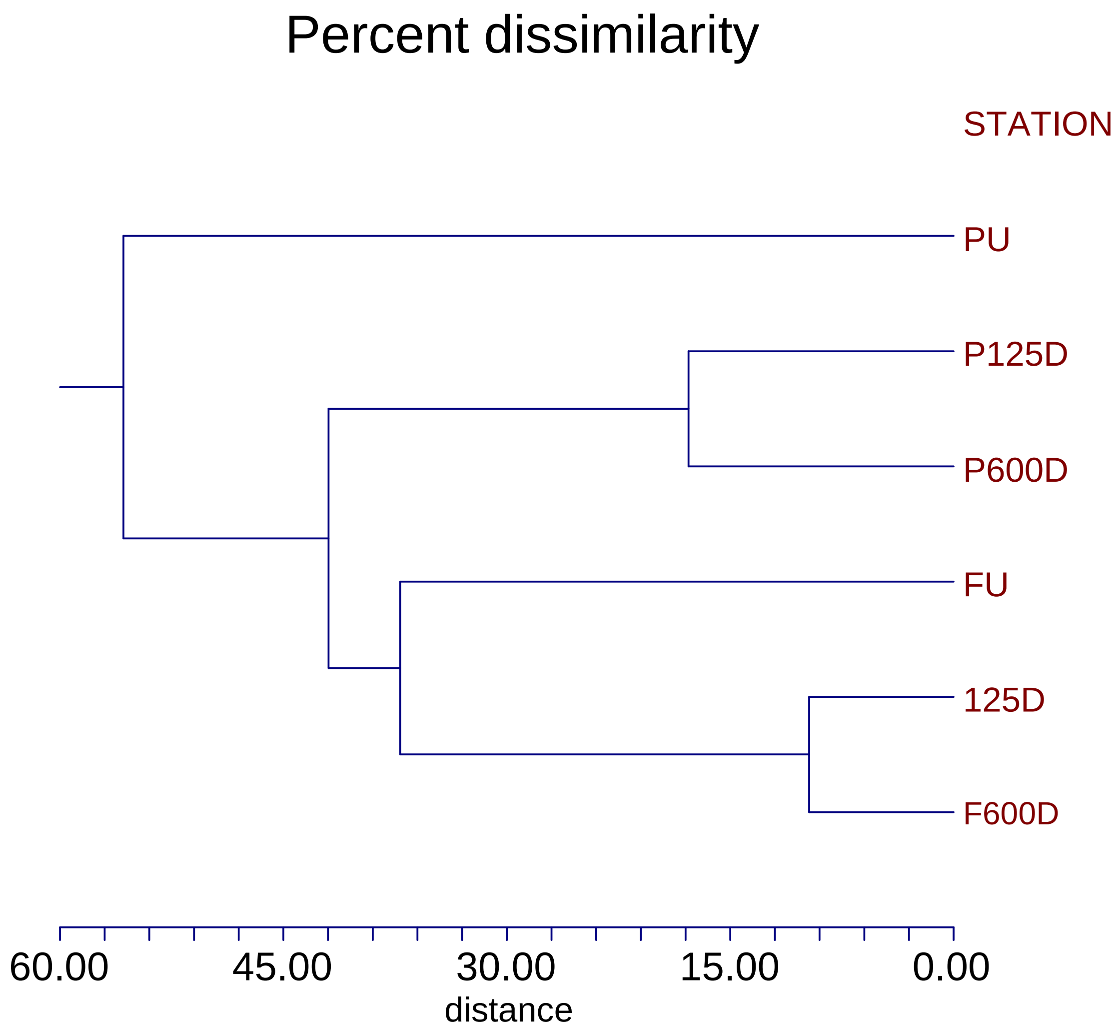

Figure 4. Cluster analyses of artificial substrate samples based on Percent Dissimilarity (b=0.25).

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APPENDIX

Table 1A. Benthic Macroinvertebrate Data, Artificial Substrates, August 13 and 14, 2012.

SPECIES	T.V.	F.F.G.	Habit	Florence 600' Downstream						
				B1	B2	B3	B4	B5	B6	Total
PLATYHELMINTHES										
Turbellaria										
Tricladida										
Dugesiidae										
Girardia (Dugesia) tigrina	8	CG	SP	551	81	281	182	241	362	1698
NEMERTEA										
MOLLUSCA										
Bivalvia										
Veneroida										
Sphaeriidae										
Musculium transversum	8	CF	BU							
Pisidium sp.	7	CF	BU							
Gastropoda										
Basommatophora										
Ancylidae										
Ferrissia rivularis	8	SC	CN							
Physidae										
Physella sp.	9	SC	SP							
ANNELIDA										
Oligochaeta										
Tubificida										
Naididae										
Nais barbata	8	CG	CN							
Nais behningi	6	CG	CN							
Nais pardalis	8	CG	CN							
Nais sp.	9	CG	BU							
Pristina sp.	4	CG	CN							
ARTHROPODA										
Arachnoidea										
Acariformes				150	60		60		80	350
Crustacea										
Copepoda										
Cyclopoida										
Ostracoda										
Cladocera										
Sidaidae										
Sida crystillina										
Amphipoda										
Crangonyctidae										
Crangonyx sp.	2	CG	SW							
Decapoda										
Cambaridae										
Orconectes sp.	8	SC	SP							
Insecta										

Table 1A. Benthic Macroinvertebrate Data, Artificial Substrates, August 13 and 14, 2012.

SPECIES	T.V.	F.F.G.	Habit	Florence 600' Downstream						
				B1	B2	B3	B4	B5	B6	Total
Ephemeroptera										
Baetidae	4	CG	SP	250	160	200	210	640		1460
Baetis sp.	5	CG	SP							
Labiobaetis longipalpus				202	104	40	32	321	727	1426
Caenidae										
Americaenis ridens	7	CG	SP					160	80	240
Caenis sp.	7	CG	SP							
Heptageniidae				250	20			80	120	470
Heptagenia sp.	4	SC	CN							
Maccaffertium mexicanum	5	SC	CN							
Maccaffertium sp.	3	SC	CN			100				100
Isonychiidae										
Isonychia sp.	2	CG	SW					1		1
Leptophlebiidae	2	CG								
Odonata										
Coenagrionidae	9	PR	CB							
Argia sp.	8	PR	CB							
Enallagma sp.	9	PR	CB							
Libellulidae	9	PR	SP							
Neurocordulia molesta	4	PR	SP							
Plecoptera										
Perlidae										
Acroneuria sp.	1	PR	CN							
Megaloptera										
Corydalidae	4	PR	CB							
Corydalus cornutus	4	PR	CB				1			1
Trichoptera										
Brachycentridae										
Brachycentrus sp.	3	CG	SP							
Hydropsychidae	5	CF	CN	3300	2420	1640	1921	6160	4922	20363
Cheumatopsyche sp.	5	CF	CN	50	40					90
Hydropsyche cf. bidens	5	CF	CN			40				40
Hydropsyche orris	8	CF	CN	1253	883	321	482	421	642	4002
Hydropsyche simulians	4	CF	CN	302	140	60	121	481	322	1426
Hydropsyche sp.	5	CF	CN			60				60
Potamyia flava	6	CF	CN	3902	983	1681	1023	2881	1842	12312
Hydroptilidae	4	SC	cn			20	30			50
Hydroptila sp.	6	SC	CN	250						250
Mayatrichia sp.	6	SC	CN				30	400		430
Leptoceridae	4	CG	CN							
Ceraclea sp.	4	CG	CB							
Mystacides sp.					80	40				120
Oecetis sp.	3	PR	SP							
Polycentropodidae										
Cyrnellus fraternus					22					22

Table 1A. Benthic Macroinvertebrate Data, Artificial Substrates, August 13 and 14, 2012.

SPECIES	T.V.	F.F.G.	Habit	Florence 600' Downstream						
				B1	B2	B3	B4	B5	B6	Total
Neureclipsis sp.	6	FC	CN	52		21	2			75
Coleoptera										
Elmidae										
Stenelmis sp.	5	SC	CN	50						50
Diptera										
Ceratopogonidae								80		80
Chironomidae										
Conchapelopia sp.	6	PR	SP						2	2
Corynoneura sp.	3	CG	SP							
Cryptochironomus sp.	8	PR	SP							
Glyptotendipes sp.	10	CF	BU							
Nanocladius distinctus	2	CG	SP							
Paratendipes albimanus	6	CG	SP							
Polypedilum flavum (convictum)	4	SH	SP	200	120	80	30	160	160	750
Polypedilum halterale gp.	7	SH	SP							
Rheotanytarsus exiguus gp.	6	FC	CN	1900	1282	2461	840	1680	1880	10043
Tanytarsus sp.	6	CF	CB	150	20	160		240	40	610
Empididae	8	CG	SP				1			1
Hemerodromia sp.	6	PR	CN	100		20	60		41	221
Simuliidae										
Simulium sp.	6	FC	CN					80		80
TOTAL NO. OF ORGANISMS				**12912**	**6415**	**7225**	**5025**	**14026**	**11220**	**56823**
TOTAL NO. OF TAXA				**17**	**15**	**17**	**16**	**16**	**14**	**31**
EPT TAXA										**19**
HBI										**5.69**

Table 1A. Benthic Macroinvertebrate Data, Artificial Substrates, August 13 and 14, 2012.

SPECIES	T.V.	F.F.G.	Habit	Florence 125' Downstream						
				B1	B2	B3	B4	B5	B6	Total
PLATYHELMINTHES										
Turbellaria										
Tricladida										
Dugesiidae										
Girardia (Dugesia) tigrina	8	CG	SP		52	481	81	81	101	796
NEMERTEA				1						1
MOLLUSCA										
Bivalvia										
Veneroida										
Sphaeriidae										
Musculium transversum	8	CF	BU		1					1
Pisidium sp.	7	CF	BU	1						1
Gastropoda										
Basommatophora										
Ancylidae										
Ferrissia rivularis	8	SC	CN							
Physidae										
Physella sp.	9	SC	SP							
ANNELIDA										
Oligochaeta										
Tubificida										
Naididae										
Nais barbata	8	CG	CN							
Nais behningi	6	CG	CN							
Nais pardalis	8	CG	CN							
Nais sp.	9	CG	BU							
Pristina sp.	4	CG	CN							
ARTHROPODA										
Arachnoidea										
Acariformes				280		80		100	100	560
Crustacea										
Copepoda										
Cyclopoida										
Ostracoda								20		20
Cladocera										
Sidaidae										
Sida crystillina										
Amphipoda										
Crangonyctidae										
Crangonyx sp.	2	CG	SW				80			80
Decapoda										
Cambaridae										
Orconectes sp.	8	SC	SP							
Insecta										
Ephemeroptera										

Table 1A. Benthic Macroinvertebrate Data, Artificial Substrates, August 13 and 14, 2012.

SPECIES	T.V.	F.F.G.	Habit	Florence 125' Downstream						
				B1	B2	B3	B4	B5	B6	Total
Baetidae	4	CG	SP	201	500	480	160	81	350	1772
Baetis sp.	5	CG	SP							
Labiobaetis longipalpus				122	200	481	82	62	513	1460
Caenidae										
Americaenis ridens	7	CG	SP		50				50	100
Caenis sp.	7	CG	SP							
Heptageniidae						80	80		103	263
Heptagenia sp.	4	SC	CN							
Maccaffertium mexicanum	5	SC	CN							
Maccaffertium sp.	3	SC	CN			1		1		2
Isonychiidae										
Isonychia sp.	2	CG	SW							
Leptophlebiidae	2	CG								
Odonata										
Coenagrionidae	9	PR	CB							
Argia sp.	8	PR	CB							
Enallagma sp.	9	PR	CB		50					50
Libellulidae	9	PR	SP							
Neurocordulia molesta	4	PR	SP							
Plecoptera										
Perlidae										
Acroneuria sp.	1	PR	CN				1			1
Megaloptera										
Corydalidae	4	PR	CB							
Corydalus cornutus	4	PR	CB							
Trichoptera										
Brachycentridae										
Brachycentrus sp.	3	CG	SP							
Hydropsychidae	5	CF	CN	4562	3201	4880	3440	2985	4200	23268
Cheumatopsyche sp.	5	CF	CN		50			20		70
Hydropsyche cf. bidens	5	CF	CN			80		40		120
Hydropsyche orris	8	CF	CN	681	500	881	640	542	401	3645
Hydropsyche simulians	4	CF	CN	483	51	801	320	241	352	2248
Hydropsyche sp.	5	CF	CN				80			80
Potamyia flava	6	CF	CN	1521	2604	2400	2641	540	2850	12556
Hydroptilidae	4	SC	cn			80				80
Hydroptila sp.	6	SC	CN							
Mayatrichia sp.	6	SC	CN	200	150					350
Leptoceridae	4	CG	CN				80	140	100	320
Ceraclea sp.	4	CG	CB							
Mystacides sp.										
Oecetis sp.	3	PR	SP						50	50
Polycentropodidae							80			80
Cyrnellus fraternus				40						40
Neureclipsis sp.	6	FC	CN	1		1	1	2	1	6
Coleoptera										

Table 1A. Benthic Macroinvertebrate Data, Artificial Substrates, August 13 and 14, 2012.

SPECIES	T.V.	F.F.G.	Habit	Florence 125' Downstream						
				B1	**B2**	**B3**	**B4**	**B5**	**B6**	**Total**
Elmidae										
Stenelmis sp.	**5**	**SC**	**CN**						1	1
Diptera										
Ceratopogonidae										
Chironomidae										
Conchapelopia sp.	**6**	**PR**	**SP**		350	1			50	401
Corynoneura sp.	**3**	**CG**	**SP**							
Cryptochironomus sp.	**8**	**PR**	**SP**							
Glyptotendipes sp.	**10**	**CF**	**BU**							
Nanocladius distinctus	**2**	**CG**	**SP**							
Paratendipes albimanus	**6**	**CG**	**SP**							
Polypedilum flavum (convictum)	**4**	**SH**	**SP**	40	200	320	240	41	400	1241
Polypedilum halterale gp.	**7**	**SH**	**SP**							
Rheotanytarsus exiguus gp.	**6**	**FC**	**CN**	1720	2750	3200	3600		1150	12420
Tanytarsus sp.	**6**	**CF**	**CB**	40	300	80	80	680		1180
Empididae	**8**	**CG**	**SP**							
Hemerodromia sp.	**6**	**PR**	**CN**	41	100			20		161
Simuliidae										
Simulium sp.	**6**	**FC**	**CN**							
TOTAL NO. OF ORGANISMS				**9934**	**11109**	**14327**	**11686**	**5596**	**10772**	**63424**
TOTAL NO. OF TAXA				**16**	**17**	**17**	**17**	**17**	**17**	**34**
EPT TAXA										**20**
HBI										**5.57**

Table 1A. Benthic Macroinvertebrate Data, Artificial Substrates, August 13 and 14, 2012.

SPECIES	T.V.	F.F.G.	Habit	Florence Upstream						
				B1	B2	B3	B4	B5	B6	Total
PLATYHELMINTHES										
Turbellaria										
Tricladida										
Dugesiidae										
Girardia (Dugesia) tigrina	8	CG	SP	401	801	322	362	321	80	2287
NEMERTEA										
MOLLUSCA										
Bivalvia										
Veneroida										
Sphaeriidae					81					81
Musculium transversum	8	CF	BU	53			2	161	1	217
Pisidium sp.	7	CF	BU							
Gastropoda										
Basommatophora										
Ancylidae										
Ferrissia rivularis	8	SC	CN							
Physidae										
Physella sp.	9	SC	SP							
ANNELIDA										
Oligochaeta										
Tubificida										
Naididae										
Nais barbata	8	CG	CN							
Nais behningi	6	CG	CN	50					80	130
Nais pardalis	8	CG	CN							
Nais sp.	9	CG	BU							
Pristina sp.	4	CG	CN							
ARTHROPODA										
Arachnoidea										
Acariformes										
Crustacea										
Copepoda										
Cyclopoida						40				40
Ostracoda										
Cladocera										
Sidaidae										
Sida crystillina										
Amphipoda										
Crangonyctidae										
Crangonyx sp.	2	CG	SW							
Decapoda										
Cambaridae										
Orconectes sp.	8	SC	SP							
Insecta										
Ephemeroptera										

Table 1A. Benthic Macroinvertebrate Data, Artificial Substrates, August 13 and 14, 2012.

SPECIES	T.V.	F.F.G.	Habit	Florence Upstream						
				B1	B2	B3	B4	B5	B6	Total
Baetidae	4	CG	SP	400		760	120		961	2241
Baetis sp.	5	CG	SP							
Labiobaetis longipalpus				353	1285	765	846	5281	1202	9732
Caenidae										
Americaenis ridens	7	CG	SP					321		321
Caenis sp.	7	CG	SP							
Heptageniidae					80		120	160		360
Heptagenia sp.	4	SC	CN							
Maccaffertium mexicanum	5	SC	CN							
Maccaffertium sp.	3	SC	CN		80			160		240
Isonychiidae										
Isonychia sp.	2	CG	SW		161	2	66	321	161	711
Leptophlebiidae	2	CG								
Odonata										
Coenagrionidae	9	PR	CB							
Argia sp.	8	PR	CB							
Enallagma sp.	9	PR	CB							
Libellulidae	9	PR	SP							
Neurocordulia molesta	4	PR	SP							
Plecoptera										
Perlidae										
Acroneuria sp.	1	PR	CN							
Megaloptera										
Corydalidae	4	PR	CB							
Corydalus cornutus	4	PR	CB							
Trichoptera										
Brachycentridae										
Brachycentrus sp.	3	CG	SP		1					1
Hydropsychidae	5	CF	CN	5650	8480	5361	4981	8320	8641	41433
Cheumatopsyche sp.	5	CF	CN	50	160		120	160	160	650
Hydropsyche cf. bidens	5	CF	CN		80			320		400
Hydropsyche orris	8	CF	CN	1255	2000	1523	1441	2881	4321	13421
Hydropsyche simulians	4	CF	CN	50	241	202	60	481	562	1596
Hydropsyche sp.	5	CF	CN							
Potamyia flava	6	CF	CN	2704	5521	4241	2225	10721	5201	30613
Hydroptilidae	4	SC	cn		240			320		560
Hydroptila sp.	6	SC	CN							
Mayatrichia sp.	6	SC	CN		240	200	120	160	401	1121
Leptoceridae	4	CG	CN	100						100
Ceraclea sp.	4	CG	CB							
Mystacides sp.										
Oecetis sp.	3	PR	SP							
Polycentropodidae										
Cyrnellus fraternus										
Neureclipsis sp.	6	FC	CN							
Coleoptera										

Table 1A. Benthic Macroinvertebrate Data, Artificial Substrates, August 13 and 14, 2012.

SPECIES	T.V.	F.F.G.	Habit	Florence Upstream						
				B1	B2	B3	B4	B5	B6	Total
Elmidae										
Stenelmis sp.	5	SC	CN				60			60
Diptera										
Ceratopogonidae										
Chironomidae										
Conchapelopia sp.	6	PR	SP	50	240	80	240	480		1090
Corynoneura sp.	3	CG	SP							
Cryptochironomus sp.	8	PR	SP							
Glyptotendipes sp.	10	CF	BU							
Nanocladius distinctus	2	CG	SP				60			60
Paratendipes albimanus	6	CG	SP		80					80
Polypedilum flavum (convictum)	4	SH	SP	200	400	480	360	160	160	1760
Polypedilum halterale gp.	7	SH	SP							
Rheotanytarsus exiguus gp.	6	FC	CN	2800	2160	2401	1140	3680	2800	14981
Tanytarsus sp.	6	CF	CB	100	80	41	300		80	601
Empididae	8	CG	SP							
Hemerodromia sp.	6	PR	CN	100		80		160	160	500
Simuliidae										
Simulium sp.	6	FC	CN			40				40
TOTAL NO. OF ORGANISMS				**14316**	**22411**	**16538**	**12623**	**34568**	**24971**	**125427**
TOTAL NO. OF TAXA				**16**	**20**	**16**	**18**	**19**	**16**	**30**
EPT TAXA										**16**
HBI										**5.77**

Table 1A. Benthic Macroinvertebrate Data, Artificial Substrates, August 13 and 14, 2012.

SPECIES	T.V.	F.F.G.	Habit	Platte South 600' Downstream						
				B1	B2	B3	B4	B5	B6	Total
PLATYHELMINTHES										
Turbellaria										
Tricladida										
Dugesiidae										
Girardia (Dugesia) tigrina	8	CG	SP	400	161	1	481	1		1044
NEMERTEA										
MOLLUSCA										
Bivalvia										
Veneroida										
Sphaeriidae										
Musculium transversum	8	CF	BU	1		82	241	61	1	386
Pisidium sp.	7	CF	BU							
Gastropoda										
Basommatophora										
Ancylidae										
Ferrissia rivularis	8	SC	CN							
Physidae										
Physella sp.	9	SC	SP							
ANNELIDA										
Oligochaeta										
Tubificida										
Naididae										
Nais barbata	8	CG	CN				80			80
Nais behningi	6	CG	CN			80			100	180
Nais pardalis	8	CG	CN				80			80
Nais sp.	9	CG	BU							
Pristina sp.	4	CG	CN							
ARTHROPODA										
Arachnoidea										
Acariformes				100		80		60		240
Crustacea										
Copepoda										
Cyclopoida										
Ostracoda										
Cladocera										
Sidaidae										
Sida crystillina										
Amphipoda										
Crangonyctidae										
Crangonyx sp.	2	CG	SW							
Decapoda										
Cambaridae										
Orconectes sp.	8	SC	SP							
Insecta										

Table 1A. Benthic Macroinvertebrate Data, Artificial Substrates, August 13 and 14, 2012.

SPECIES	T.V.	F.F.G.	Habit	Platte South 600' Downstream						
				B1	B2	B3	B4	B5	B6	Total
Ephemeroptera										
Baetidae	4	CG	SP	200		400			400	1000
Baetis sp.	5	CG	SP	600			321			921
Labiobaetis longipalpus				1	363	805	321	609	505	2604
Caenidae										
Americaenis ridens	7	CG	SP	100	40	240	80	60	200	720
Caenis sp.	7	CG	SP		40					40
Heptageniidae						320	80			400
Heptagenia sp.	4	SC	CN							
Maccaffertium mexicanum	5	SC	CN							
Maccaffertium sp.	3	SC	CN		200	1		60		261
Isonychiidae										
Isonychia sp.	2	CG	SW	1	1	3	1	64	102	172
Leptophlebiidae	2	CG			80		80			160
Odonata										
Coenagrionidae	9	PR	CB							
Argia sp.	8	PR	CB							
Enallagma sp.	9	PR	CB							
Libellulidae	9	PR	SP							
Neurocordulia molesta	4	PR	SP							
Plecoptera										
Perlidae										
Acroneuria sp.	1	PR	CN							
Megaloptera										
Corydalidae	4	PR	CB							
Corydalus cornutus	4	PR	CB					1		1
Trichoptera										
Brachycentridae										
Brachycentrus sp.	3	CG	SP							
Hydropsychidae	5	CF	CN	4500	2800	6401	2160	3005	5502	24368
Cheumatopsyche sp.	5	CF	CN	100	40	80	1	1	100	322
Hydropsyche cf. bidens	5	CF	CN	100	200					300
Hydropsyche orris	8	CF	CN	1401	721	1361	160	603	2200	6446
Hydropsyche simulians	4	CF	CN	501	321	962		241	604	2629
Hydropsyche sp.	5	CF	CN							
Potamyia flava	6	CF	CN	4001	1401	4641	1681	1143	5001	17868
Hydroptilidae	4	SC	cn	400	80					480
Hydroptila sp.	6	SC	CN							
Mayatrichia sp.	6	SC	CN	200	240	720	80	180	600	2020
Leptoceridae	4	CG	CN				80			80
Ceraclea sp.	4	CG	CB		40					40
Mystacides sp.										
Oecetis sp.	3	PR	SP							
Polycentropodidae										
Cyrnellus fraternus										

Table 1A. Benthic Macroinvertebrate Data, Artificial Substrates, August 13 and 14, 2012.

SPECIES	T.V.	F.F.G.	Habit	Platte South 600' Downstream						
				B1	B2	B3	B4	B5	B6	Total
Neureclipsis sp.	6	FC	CN		40	2	1			43
Coleoptera										
Elmidae										
Stenelmis sp.	5	SC	CN							
Diptera										
Ceratopogonidae										
Chironomidae										
Conchapelopia sp.	6	PR	SP	500	202	400	640	61	300	2103
Corynoneura sp.	3	CG	SP							
Cryptochironomus sp.	8	PR	SP							
Glyptotendipes sp.	10	CF	BU				400			400
Nanocladius distinctus	2	CG	SP			80				80
Paratendipes albimanus	6	CG	SP							
Polypedilum flavum (convictum)	4	SH	SP	900	241	800	160	120	700	2921
Polypedilum halterale gp.	7	SH	SP	100	40		80			220
Rheotanytarsus exiguus gp.	6	FC	CN	12000	7400	13200	11520	5705	16002	65827
Tanytarsus sp.	6	CF	CB	200	200		800	120	200	1520
Empididae	8	CG	SP							
Hemerodromia sp.	6	PR	CN	100	40	240	80		100	560
Simuliidae										
Simulium sp.	6	FC	CN							
TOTAL NO. OF ORGANISMS				**26406**	**14891**	**30899**	**19608**	**12095**	**32617**	**136516**
TOTAL NO. OF TAXA				**22**	**23**	**22**	**24**	**18**	**17**	**35**
EPT TAXA										**20**
HBI										**5.82**

Table 1A. Benthic Macroinvertebrate Data, Artificial Substrates, August 13 and 14, 2012.

SPECIES	T.V.	F.F.G.	Habit	Platte South 125' Downstream					
				B1	B2	B3	B5	B6	Total
PLATYHELMINTHES									
Turbellaria									
Tricladida									
Dugesiidae									
Girardia (Dugesia) tigrina	8	CG	SP	541	321	241	600	321	2024
NEMERTEA									
MOLLUSCA									
Bivalvia									
Veneroida									
Sphaeriidae									
Musculium transversum	8	CF	BU	62			102		164
Pisidium sp.	7	CF	BU						
Gastropoda									
Basommatophora									
Ancylidae									
Ferrissia rivularis	8	SC	CN			1			1
Physidae									
Physella sp.	9	SC	SP			80			80
ANNELIDA									
Oligochaeta									
Tubificida									
Naididae								160	160
Nais barbata	8	CG	CN						
Nais behningi	6	CG	CN	240		320	100	80	740
Nais pardalis	8	CG	CN						
Nais sp.	9	CG	BU	60					60
Pristina sp.	4	CG	CN						
ARTHROPODA									
Arachnoidea									
Acariformes				120	80	80	100	80	460
Crustacea									
Copepoda									
Cyclopoida									
Ostracoda									
Cladocera									
Sidaidae									
Sida crystillina						240			240
Amphipoda									
Crangonyctidae									
Crangonyx sp.	2	CG	SW						
Decapoda									
Cambaridae									
Orconectes sp.	8	SC	SP			1			1
Insecta									
Ephemeroptera									

Table 1A. Benthic Macroinvertebrate Data, Artificial Substrates, August 13 and 14, 2012.

SPECIES	T.V.	F.F.G.	Habit	Platte South 125' Downstream					
				B1	B2	B3	B5	B6	Total
Baetidae	4	CG	SP				100	320	420
Baetis sp.	5	CG	SP						
Labiobaetis longipalpus				301	5		407	483	1196
Caenidae					80	400			480
Americaenis ridens	7	CG	SP	121				80	201
Caenis sp.	7	CG	SP			321			321
Heptageniidae				60			200	480	740
Heptagenia sp.	4	SC	CN					1	1
Maccaffertium mexicanum	5	SC	CN			1		2	3
Maccaffertium sp.	3	SC	CN		80	320	100	240	740
Isonychiidae									
Isonychia sp.	2	CG	SW	1	4	1	4	164	174
Leptophlebiidae	2	CG				80			80
Odonata									
Coenagrionidae	9	PR	CB						
Argia sp.	8	PR	CB						
Enallagma sp.	9	PR	CB						
Libellulidae	9	PR	SP						
Neurocordulia molesta	4	PR	SP			1			1
Plecoptera									
Perlidae									
Acroneuria sp.	1	PR	CN						
Megaloptera									
Corydalidae	4	PR	CB						
Corydalus cornutus	4	PR	CB				1		1
Trichoptera									
Brachycentridae									
Brachycentrus sp.	3	CG	SP						
Hydropsychidae	5	CF	CN	3420	2561	320	3300	4720	14321
Cheumatopsyche sp.	5	CF	CN		160			320	480
Hydropsyche cf. bidens	5	CF	CN						
Hydropsyche orris	8	CF	CN	721	721		601	802	2845
Hydropsyche simulians	4	CF	CN	781	2		5	401	1189
Hydropsyche sp.	5	CF	CN		160				160
Potamyia flava	6	CF	CN	2521	3840	321	3605	5202	15489
Hydroptilidae	4	SC	cn						
Hydroptila sp.	6	SC	CN						
Mayatrichia sp.	6	SC	CN	300		80	300	320	1000
Leptoceridae	4	CG	CN						
Ceraclea sp.	4	CG	CB						
Mystacides sp.									
Oecetis sp.	3	PR	SP						
Polycentropodidae									
Cyrnellus fraternus									
Neureclipsis sp.	6	FC	CN	1	2			1	4
Coleoptera									

Table 1A. Benthic Macroinvertebrate Data, Artificial Substrates, August 13 and 14, 2012.

SPECIES	T.V.	F.F.G.	Habit	Platte South 125' Downstream					
				B1	B2	B3	B5	B6	Total
Elmidae									
Stenelmis sp.	5	SC	CN						
Diptera									
Ceratopogonidae									
Chironomidae									
Conchapelopia sp.	6	PR	SP	120	81	160	300	560	1221
Corynoneura sp.	3	CG	SP					80	80
Cryptochironomus sp.	8	PR	SP				100		100
Glyptotendipes sp.	10	CF	BU						
Nanocladius distinctus	2	CG	SP	60		80		80	220
Paratendipes albimanus	6	CG	SP						
Polypedilum flavum (convictum)	4	SH	SP	180	561	80	501	480	1802
Polypedilum halterale gp.	7	SH	SP						
Rheotanytarsus exiguus gp.	6	FC	CN	8160	10962	10240	9805	14801	53968
Tanytarsus sp.	6	CF	CB	180	240	1120		320	1860
Empididae	8	CG	SP						
Hemerodromia sp.	6	PR	CN		80	81	100	480	741
Simuliidae									
Simulium sp.	6	FC	CN						
TOTAL NO. OF ORGANISMS				**17950**	**19940**	**14569**	**20331**	**30978**	**103768**
TOTAL NO. OF TAXA				**20**	**18**	**23**	**20**	**26**	**39**
EPT TAXA									**19**
HBI									**5.85**

Table 1A. Benthic Macroinvertebrate Data, Artificial Substrates, August 13 and 14, 2012.

SPECIES	T.V.	F.F.G.	Habit	Platte South Upstream			
				B2	B3	B4	Total
PLATYHELMINTHES							
Turbellaria							
Tricladida							
Dugesiidae							
Girardia (Dugesia) tigrina	8	CG	SP	21	1601	841	2463
NEMERTEA							
MOLLUSCA							
Bivalvia							
Veneroida							
Sphaeriidae							
Musculium transversum	8	CF	BU	20		1	21
Pisidium sp.	7	CF	BU				
Gastropoda							
Basommatophora							
Ancylidae							
Ferrissia rivularis	8	SC	CN				
Physidae							
Physella sp.	9	SC	SP				
ANNELIDA							
Oligochaeta							
Tubificida							
Naididae				40	160		200
Nais barbata	8	CG	CN				
Nais behningi	6	CG	CN	120	480	420	1020
Nais pardalis	8	CG	CN		80		80
Nais sp.	9	CG	BU				
Pristina sp.	4	CG	CN			60	60
ARTHROPODA							
Arachnoidea							
Acariformes						240	240
Crustacea							
Copepoda							
Cyclopoida							
Ostracoda							
Cladocera							
Sidaidae							
Sida crystillina							
Amphipoda							
Crangonyctidae							
Crangonyx sp.	2	CG	SW				
Decapoda							
Cambaridae							
Orconectes sp.	8	SC	SP				
Insecta							
Ephemeroptera							

Table 1A. Benthic Macroinvertebrate Data, Artificial Substrates, August 13 and 14, 2012.

SPECIES	T.V.	F.F.G.	Habit	Platte South Upstream			
				B2	B3	B4	Total
Baetidae	4	CG	SP				
Baetis sp.	5	CG	SP				
Labiobaetis longipalpus					161		161
Caenidae						60	60
Americaenis ridens	7	CG	SP		80	60	140
Caenis sp.	7	CG	SP				
Heptageniidae				20		60	80
Heptagenia sp.	4	SC	CN				
Maccaffertium mexicanum	5	SC	CN		80		80
Maccaffertium sp.	3	SC	CN				
Isonychiidae							
Isonychia sp.	2	CG	SW		1		1
Leptophlebiidae	2	CG					
Odonata							
Coenagrionidae	9	PR	CB				
Argia sp.	8	PR	CB	21			21
Enallagma sp.	9	PR	CB				
Libellulidae	9	PR	SP				
Neurocordulia molesta	4	PR	SP				
Plecoptera							
Perlidae							
Acroneuria sp.	1	PR	CN				
Megaloptera							
Corydalidae	4	PR	CB				
Corydalus cornutus	4	PR	CB			1	1
Trichoptera							
Brachycentridae							
Brachycentrus sp.	3	CG	SP				
Hydropsychidae	5	CF	CN	320	1200	1380	2900
Cheumatopsyche sp.	5	CF	CN	20	161	241	422
Hydropsyche cf. bidens	5	CF	CN			61	61
Hydropsyche orris	8	CF	CN	20	561	60	641
Hydropsyche simulians	4	CF	CN	60	81	360	501
Hydropsyche sp.	5	CF	CN				
Potamyia flava	6	CF	CN	367	1201	1620	3188
Hydroptilidae	4	SC	cn	20			20
Hydroptila sp.	6	SC	CN				
Mayatrichia sp.	6	SC	CN	160	560	422	1142
Leptoceridae	4	CG	CN				
Ceraclea sp.	4	CG	CB				
Mystacides sp.							
Oecetis sp.	3	PR	SP				
Polycentropodidae							
Cyrnellus fraternus							
Neureclipsis sp.	6	FC	CN		1	1	2
Coleoptera							

Table 1A. Benthic Macroinvertebrate Data, Artificial Substrates, August 13 and 14, 2012.

SPECIES	T.V.	F.F.G.	Habit	Platte South Upstream			
				B2	B3	B4	Total
Elmidae							
Stenelmis sp.	5	SC	CN				
Diptera							
Ceratopogonidae							
Chironomidae							
Conchapelopia sp.	6	PR	SP	142	80	180	402
Corynoneura sp.	3	CG	SP				
Cryptochironomus sp.	8	PR	SP			60	60
Glyptotendipes sp.	10	CF	BU	20			20
Nanocladius distinctus	2	CG	SP	40	160	60	260
Paratendipes albimanus	6	CG	SP				
Polypedilum flavum (convictum)	4	SH	SP	61	480	240	781
Polypedilum halterale gp.	7	SH	SP				
Rheotanytarsus exiguus gp.	6	FC	CN	6523	12800	8520	27843
Tanytarsus sp.	6	CF	CB	680	2240	1080	4000
Empididae	8	CG	SP	2		60	62
Hemerodromia sp.	6	PR	CN	20	80		100
Simuliidae							
Simulium sp.	6	FC	CN				
TOTAL NO. OF ORGANISMS				**8697**	**22248**	**16088**	**47033**
TOTAL NO. OF TAXA				**21**	**21**	**24**	**33**
EPT TAXA							**15**
HBI							**5.99**