2011

WAPPAPELLO LAKE

WATER QUALITY

REPORT

U.S. ARMY CORPS OF ENGINEERS, ST. LOUIS DISTRICT
ENVIRONMENTAL ENGINEERING SECTION – WATER QUALITY

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Executive Summary

The purpose of this report is to provide an annual analysis of the water quality in the lake for the past year. Wappapello Lake is located on the upper St. Francis River in Wayne County, Missouri. The dam is located at river mile 213.2, 16 miles northeast of Poplar Bluff, Missouri, and regulates the drainage of 1,310 square miles. The area consists mainly of rugged upland terrain. Approximately 45% of the watershed upstream of the lake is included within the boundaries of the Mark Twain Forest and about 20% is privately owned woodland. Approximately 11% is used for the production of crops which consists of hay, small grains, and corn. Eight percent is used as pasture and the remaining 16% is raods, lakes, railroads and urban areas. The lake levels range from 31,100 acre-feet of water which covers 5,200 acres at conservation pool to 613,300 acre-feet which cover 23,200 acres at flood pool. Wappapello Dam and lake was authorized for downstream flood control by the Flood Control Act of 1936.

The water of Wappapello Lake and the downstream river channel is generally good. The lake is a medium depth reservoir nestled in the Ozark Hills. The lake tends to stratify during the summer months.

All sampling sites met the appropriate state standards during 2011 except the phosphorous levels. Phosphorous levels have exceeded the state standard on a routine basis. Generally the tailwater levels are lower than the incoming tributary flows, which indicates that the lake is sinking the phosphorous. This is also occurring with nitrogen. The project area has little pollution potentials at present time, no major form of degradation to the lake or streams is apparent. Constant water quality monitoring will continue to check future degradation of the watershed.

WATER QUALITY MONITORING PROGRAM

1.0 GENERAL OVERVIEW

This report summarizes water quality activities of the St. Louis District for Fiscal Year 2011 in accordance with ER 1110-2-8154 Water Quality & Environmental management for Corps Civil Works Projects and ETL 1110-2-362 Environmental Engineering Initiatives for Water Management.

Water quality monitoring remains one of the Sections major responsibilities in the area of environmental stewardship. The objective is to maintain a reasonable environmental monitoring program for the Mississippi River and the 5 lakes under the St. Louis District's control. The District's reservoirs consist of Mark Twain and Wappapello Lakes in Missouri, and Shelbyville, Carlyle and Rend Lakes in Illinois. Water quality sampling is conducted within the lakes and their tributaries to establish trend analysis and maintain water quality at or above state and federal regulations.

The main objective is to provide technical expertise of an environmental nature to all Corps elements requesting assistance in accordance with ER 1110-2-8154. This would include updating the water quality management priorities for the district's projects to ensure water quality meets the state and federal regulations, for protection of human health and the environment, and for the safety and economic welfare of those at Corps projects. Ongoing goals include ensuring that downstream water quality meets all state and federal regulations, is suitable for aquatic and human life, and continue to evaluate trend analysis in relation to baseline conditions at all projects.

Water quality data is provided to the Missouri Department of Natural Resources (MDNR) to be used as a screening mechanism for the Missouri Water Quality Report which is required every two years by the Clean Water Act Sections 303(d) and 305(b). MDNR does not routinely monitor Wappapello Lake, however the University of Missouri-Columbia has been taking 4 samples per year in the forebay at the lake since 1989.

The National Water Quality Inventory Report to Congress (305(b) report) is the primary vehicle for informing Congress and the public about general water quality conditions in the United States. This document characterizes our water quality, identifies widespread water quality problems of national significance, and describes various programs implemented to restore and protect our waters.

Under Section 303(d) of the 1972 Clean Water Act, states, territories and authorized tribes are required to develop a list of water quality limited segments. These waters on the list do not meet water quality standards, even after point sources of pollution have installed the minimum required levels of pollution control technology. The law requires that these jurisdictions establish priority rankings for water on the lists and develop action plans, called as Total Maximum Daily Loads (TMDL), to improve water quality.

The 2011 water quality report compiled by the Missouri Department of Natural Resources listed the upper St. Francis River near Farmington, as impaired for low Dissolved Oxygen. Wappapello Lake is listed as eutrophic. Continued monitoring of the lake and its tributaries is vital in assisting the future assessment of the lake for these and other possible impairments. The water quality monitoring program represents the single metric that encompasses the overall health of the watershed as it is a direct measure of how well the environmental stewardship programs are working.

1.1 INTRODUCTION

Wappapello Lake is located on the upper St. Francis River in southeastern Missouri and is primarily utilized as a recreational lake. Lake Wappapello is an 8,400 acre reservoir located in Wayne County, with the southern arms reaching into Butler County. Construction of this lake began in September of 1938 and was completed in June 1941. Approximately 71% of Lake Wappapello's large, 1,310 square mile watershed is forested and 21% is covered by grassland. The surrounding lands are residential with little agricultural use due to the steep terrain.

Nestled in the foothills of the Ozark Mountains, Wappapello Lake offers activities for all walks of life. Over 44,000 acres of public lands and water welcome hunting, fishing, swimming, boating, camping and picnicking. Interpretation of the natural resources through trails, Visitor Center exhibits and various programs highlight the natural beauty found in Southeast Missouri.

The operating purposes of Wappapello Lake are fishing, hunting and other wildlife activities as well as recreation uses, such as boating and swimming. The area around the lake has camping sites and nature trails. The water quality management program for the lake includes monitoring baseline parameters and ecological trends as well as investigating problem areas to keep the lake within state and federal standards.

The water quality monitoring program was conducted during 2011 at five lake sites to assure that safe conditions were maintained for human recreation, wildlife and aquatic life. One of the five sites was selected as a quality control duplicate site during each sampling event and was denoted as WAP-15. Four water quality sampling events took place during 2011, between April and October. The locations of the 5 sampling sites are depicted on the lake map in Figure 1.

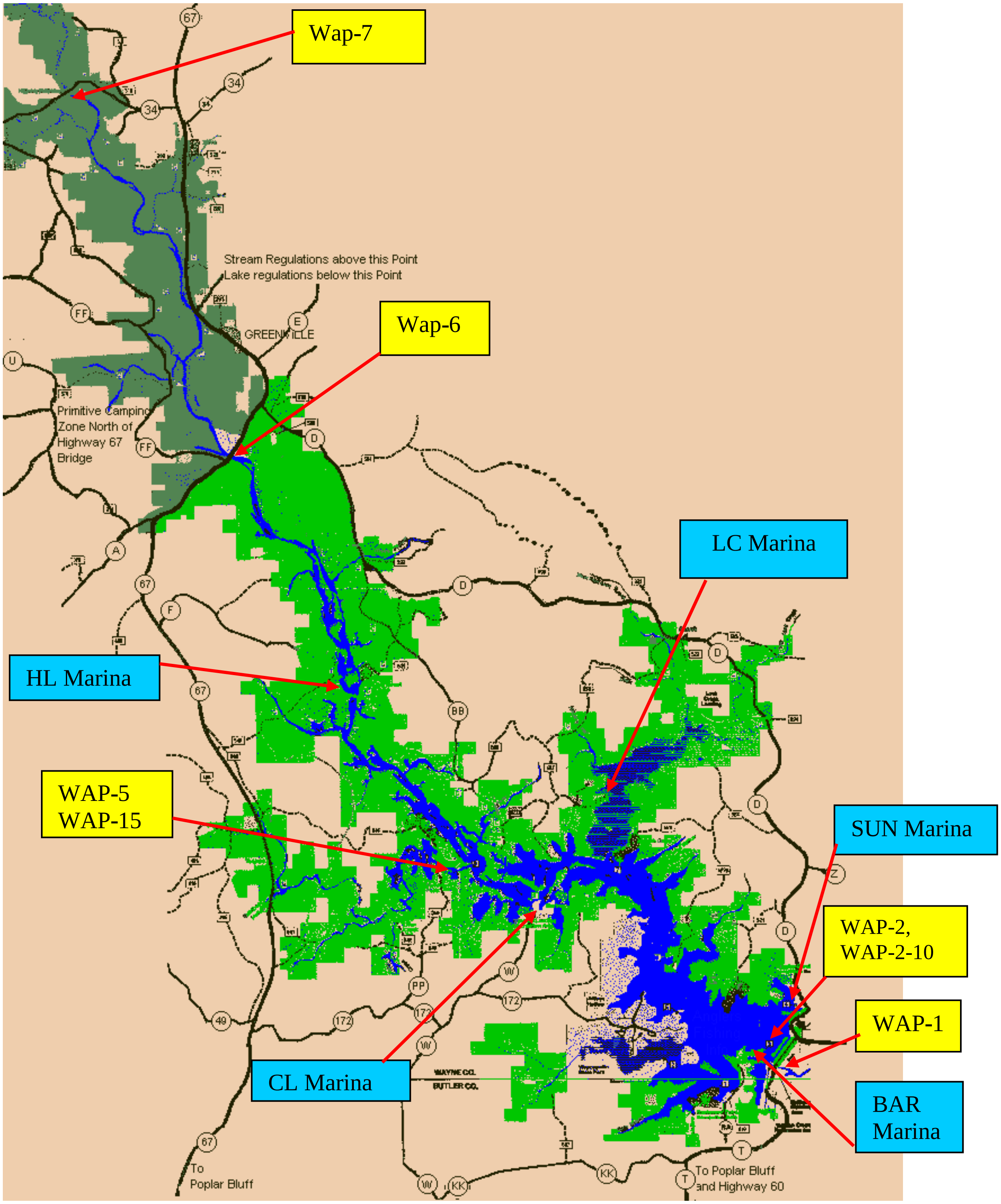


Figure 1
Location of sample sites

2.0 WATER QUALITY ASSESSMENT CRITERIA

2.1 Water Quality

The water quality assessment criteria were based upon the State of Missouri regulatory limits for certain contaminants, which has been generally accepted criteria for sustaining adequate aquatic plant and animal growth. The samplings and analysis which were conducted at the Wappapello Lake sites reflect the minimal set of parameters needed to analyze the current status of water quality for the Wappapello Lake system.

The following parameters were analyzed in the Fiscal Year 2011 samplings at Wappapello Lake: Total Organic Carbon (TOC), iron, manganese, ammonia-nitrogen, nitrate-nitrogen, orthophosphate, total phosphate, Total Suspended Solids (TSS), Total Volatile Suspended Solids (TVSS), fecal coliform, pH, temperature, dissolved oxygen, specific conductance, oxidation-reduction potential (ORP), chlorophyll, and pheophytin-a. In addition sediment samples were taken at the 3 lake sites and analyzed for metals, TKN, phosphates, nitrogen, solids, TOC, and pesticides.

The Missouri Department of Natural Resources, Code of State Regulations, Division 20, Chapter 7 classifies water quality criteria based on designated usage. These standards are used to determine the aquatic water quality of the lake. Table 2.1 provides a listing of the regulatory limits for the parameters analyzed where a limit has been established.

TABLE 2.1
State of Missouri
Water Quality Standards

PARAMETER	LIMIT
Temperature	20.5°C - 33°C (68°F - 90°F)
Ammonia Nitrogen	15 mg/L
Nitrate Nitrogen	10 mg/L
Iron	1.0 mg/L (Aquatic Life)
Manganese	0.05 mg/L (Drinking Water & GW)
Phosphorous as Phosphate	0.05 mg/L
E. Coli	Missouri standard is 235 E. coli per 100ml for single sample or 126 for geometric mean
pH	Range: 6.5 to 9.0
DO	> 5.0 mg/L
Atrazine	0.003 mg/L[1]; 82ug/L[2]; 9ug/L[3]
Alachlor	0.002 mg/L (Drinking Water Standard)
Conductivity	1,700 *u*S/cm≈TDS of 1,000 mg/L
Total Suspended Solids (TSS)	116mg/L(streams); ≥12mg/L Lakes
Cyanazine	370ug/L Acute; 30ug/L Chronic
Metolachlor	1.7mg/L Acute
Simazine	4.0ug/L [1]
Trifluralin	26ug/L Acute; 1.1ug/L Chronic

[1] Drinking Water Standard

[2] Acute
[3] Chronic

Nitrogen is an essential component of proteins, genetic material, chlorophyll, and other key organic molecules. All organisms require nitrogen in order to survive. Nitrogen exists in several forms. These forms include gaseous nitrogen (N_2), nitrites (NO_2), nitrate (NO_3), ammonia nitrogen (NH_3-N), and ammonium (NH_4). Ammonia can be toxic to fish and other aquatic organisms at certain levels. Unlike ammonia, ammonium (NH4) is not toxic to aquatic organisms and is readily available for uptake by plankton and macrophytes. Nitrogen levels have increased as human activities have accelerated the rate of fixed nitrogen being put into circulation. High nitrogen levels can cause eutrophication. Eutrophication increases biomass of phytoplankton, decrease water transparency, and causes oxygen depletion. Ammonia nitrogen is monitored so that the effects on fish spawning, hatching, growth rate and pathologic changes in gills, liver and kidney tissue can be related to the detected levels of ammonia nitrogen. Nitrate-nitrogen degrades to nitrite or produces ammonia which has a detrimental effect on aquatic life and, therefore, has been monitored to assure levels are below the regulatory "safe" limit.

Phosphate has been analyzed as phosphorus and has been monitored due to the potential for uptake by nuisance algae. Levels of phosphate can indicate the potential for rapid growth of algae (algae bloom) which can cause serious oxygen depletion during the algae decay process. Phosphorous is typically the limiting nutrient in a water body. Therefore, addition of phosphorous to the ecosystem stimulates the growth of plants and algae. Phosphorous is delivered to lakes and streams by way of storm water runoff from agricultural fields, residential property, and construction sites. Other sources of phosphorous are anaerobic decomposition of organic matter, leaking sewer systems, waterfowl, and point source pollution. The general standard for phosphorous in lake water is 0.05mg/L. Dissolved phosphorous also called ortho-phosphorous is generally found in much smaller concentrations than total phosphorous and is readily available for uptake. For this reason dissolved phosphorous concentrations are variable and difficult to use as an indicator of nutrient availability.

The metals manganese and iron are nutrients for both plants and animals. Living organisms require trace amounts of metals. However, excessive amounts can be harmful to the organism. Heavy metals exist in surface waters in three forms, colloidal, particulate, and dissolved. Water chemistry determines the rate of adsorption and desorption of metals to and from sediment. Metals are desorbed from the sediment if the water experiences increases in salinity, decreases in redox potential, or decreases in pH. Metals in surface waters can be from natural or human sources. Currently human sources contribute more metals than natural sources. Metals levels in surface water may pose a health risk to humans and the environment.

Photosynthetic activity can be hindered by the levels of total suspended solids. Total suspended solids concentrations, which cause the photosynthetic activity to be reduced by more than 10% from the seasonably established norm, can have a detrimental effect on aquatic life. Soil particles, organic material, and other debris comprise suspended solids in the water column. Secchi disk measurements are inverse to suspended solid measurements. As the total suspended solids (TSS) increase, the secchi disk depth or water transparency decreases. Total suspended solids can be an important indicator of the type and degree of turbidity. TSS measurements represent a combination volatile suspended solids (VSS) which is comprised of organic material and nonvolatile suspended solids (NVSS) which is comprised of inorganic mineral particles in the water. In order to more accurately determine the types and amounts of suspended solids, volatile suspended solids (VSS) are analyzed. VSS concentration represents the organic portion of the total suspended solids. Organic material often includes plankton and additional plant and animal debris that is present in water. Total volatile solids indicate the presence of organics in suspension and, therefore, show additional demand levels of oxygen. Missouri does not currently have a standard for TSS or TVSS. However, literature suggests that NVSS above 15mg/L could highly impair recreational lake use and a NVSS of 3 to 7mg/L might cause slight impairment.

Chlorophyll and pheophytin-a are monitored to provide indicators of algae growth and, therefore, potential oxygen depletion activity. Chlorophyll is measured in lakes to estimate the type and amount of algal productivity in the water column. Chlorophyll a is present in green algae, blue-green algae, and in diatoms. Chlorophyll a is often used to indicate the degree of eutrophication. Chlorophyll b and c are used to estimate the extent of algal diversity and productivity. Chlorophyll b is common in green algae and is used as an auxiliary pigment for photosynthesis. Chlorophyll c is most common in diatom species and serves as an auxiliary pigment. Algal productivity and diversity can be determined by the concentrations of the individual pigments. For example high concentrations of chlorophyll a and b would indicate that green algae is abundant. High concentrations of chlorophyll a would indicate abundance of blue-green algae and concentrations of chlorophyll a and c would indicate diatoms are the dominant species. Chlorophyll production is currently being connected with hypoxia.

Fecal coliform bacteria is monitored for the protection of human health as it relates to full body contact of recreational waters. People can be exposed to disease-causing organisms, such as bacteria, viruses and protozoa in beach and recreational waters mainly through accidental ingestion of contaminated water or through skin contact. These organisms, called pathogens, usually come from the feces of humans and other warm-blooded animals. If taken into the body, pathogens can cause various illnesses and on rare occasions, even death. Waterborne illnesses include diseases resulting from bacteria infection such as cholera, salmonellosis, and gastroenteritis, viral infections such as hepatitis, gastroenteritis, and intestinal diseases, and protozoan infections such as ameobic dysentery and giardiasis. The most commonly monitored recreational water indicator organisms are fecal coliform, Escherichia coli, (E. coli) and enterococci. Fecal coliform are bacteria that live in the intestinal tracts of warm-blooded animals. The standard for fecal coliform is less than a geometric mean of 200 colonies per 100ml of sample water. Fecal coliform was originally recommended in 1968 by the Federal Water Pollution Control Administration (predecessor to EPA) as an effective water quality indicator organism for recreational waters. Recent studies indicate that fecal coliform show less correlation to illness than other indicator organisms such as E. coli and enterococci. The Environmental Protection Agency (EPA) currently recommends E. coli or enterococci as an indicator organism for fresh waters. Since 2009 the St. Louis District has been using E. coli as the standard indicator.

Atrazine and Alachlor herbicides are commonly used agricultural chemicals which can be readily transported by rainfall runoff. Both compounds are suspected of causing cancer and, therefore, were monitored for the protection of human and aquatic health. Organic compounds include many pesticides. A pesticide can be any substance that is intended to prevent, destroy, repel, or mitigate any pest. This includes insecticides, herbicides, fungicides, fumigants, algaecides and other substances. Herbicides which are pesticides used to kill vegetation are the most widely used and sampled. Ten of the most frequently used herbicides and detected in water are Atrazine, Metolachlor, Alachlor, 2,4-D, Trifluralin, Glyphosate, Dicamba, Cyanazine, Simazine, and 2,4,5-T. Two of the most widely used pesticides are Atrazine and Alachlor. Atrazine is a preemergence or postemergence herbicide use to control broadleaf weeds and annual grasses. Atrazine is most commonly detected in ground and surface water due to its wide use, and its ability to persist in soil and move in water. Alachlor is a Restricted Use Pesticide (RUP) due to the potential to contaminate groundwater. The drinking water standard for Atrazine is 0.003mg/L and 0.002 mg/L for Alachlor.

Temperature, dissolved oxygen and pH are monitored for the protection of aquatic life. Temperature is important because it controls several aspects of water quality. Colder water hold more dissolved oxygen which is required by aquatic organisms. Plants grow more rapidly and use more oxygen in warmer water. Decomposition of organic matter which uses oxygen is accelerated in warmer water. Temperature can also determine the availability of toxic compounds such as ammonia. Since aquatic organisms are cold blooded, water temperature regulates their metabolism and ability to survive. The number and kinds of organisms that are found in streams or lakes is directly related to temperature. Certain organisms require a specific temperature range, such as trout, which require water temperatures below 20^{o}C. Most aquatic organisms require a minimum concentration of dissolved oxygen to survive. In spring, surface waters of the lake mix with the water below through wind and thermal action. This mixing diminishes as the upper layer of water becomes warmer and less dense. Solar insulation during the summer months stratifies the lake into three zones. The upper warmer water zone is called the epilimnion and the lower cooler water zone is called the hypolimnion. The epilimnion and the hypolimnion zones are divided by a transition zone known as the metalimnion. The thermocline located within the metalimnion exhibits a rapid change in water temperature. During the summer months the hypolimnion may become anaerobic. In this anaerobic zone, chemical reduction of iron and manganese, or the production of methane and sulfides can occur. Iron rapidly oxidizes in aerobic environments, but manganese oxidizes slowly and can remain in the reduced state for long distances down stream even in aerobic environments. The degree of acidity of water is measured by a logarithmetic scale ranging from 0 to 14 and is known as the pH scale. A reading of 7 indicates neutrality and readings below seven are acidic and above are alkaline. Most Missouri lakes range from 6 to 9 on the pH scale. The buffering capacity of water is the ability to neutralize acid better known as alkalinity. A high alkalinity concentration indicates an increased ability to neutralize pH and resist changes, whereas a low alkalinity concentration indicates that a water body is vulnerable to changes in pH.

Conductivity is a measure of a water's ability to conduct an electrical current. The ability to carry a current is often driven by the dissolved materials present in a water column. These materials can include dissolved ions and other materials in the water and thus are directly proportional to the concentration of total dissolved solids (TDS) present in the water column. Typically TDS concentrations represent 50-60% of the conductivity measurements.

Conductivity is also affected by water temperature. Conductivity is proportional to water temperature. Conductivity in streams and rivers is affected by the geology of the area. Streams running through granite areas tend to have lower conductivity due to granite being composed of inert material, materials that do not ionize or dissolve into ionic compounds in water. On the other hand streams that run through areas of limestone or clay soils tend to have higher conductivity readings because of the presence of materials that ionize. Conductivity is useful as a general measure of water quality. A stream tends to have a relatively constant range of conductivity that once establish can be used as a baseline. Significant changes either high or low might indicate a source of pollution has been introduced into the water. The pollution source could be a treatment plant which raises the conductivity or an oil spill which would lower the conductivity.

Redox or Oxidation-Reduction Potential (ORP) is a measurement to oxidize materials. Oxidation involves an exchange of electrons between 2 atoms. The atom that loses an electron is oxidized and the one that gains an electron is reduced. ORP sensors measure the electrochemical potential between the solution and a reference electrode. Readings are expressed in millivolts with positive readings indicating increased oxidizing potential and negative readings being increased reduction. The ORP probe is essentially a millivolt meter, measuring the voltage across 2 electrodes with the water in between. ORP values are used much like pH values to determine water quality. While pH readings characterize the state of a system relative to the receiving or donating hydrogen ions (base or acid), ORP readings characterize the relative state of losing or gaining electrons. The conversion of ammonia (NH_3) requires an oxidating environment to convert it into nitrites (NO_2) and nitrates (NO_3). Ammonia levels as low as 0.002mg/L can be harmful to fish. Generally ORP readings above 400mV are harmful to aquatic life. However, ORP is a non-specific measurement which is a reflection of a combination of effects of all the dissolved materials in the water. Therefore, the measurement of ORP in relatively clean water has only limited utility unless a predominant redox-active material is known to be present.

Water clarity is intuitively used by the public to judge water quality. Secchi depth has been used for many years as a limnological characterization tool for characterizing water clarity. Secchi depth is a measure of light penetration into a waterbody and is a function of the absorption and scattering of light in the water. There are three characteristics of water which affect the penetration of light. The three factors are the color of water, amount of phytoplankton in the water column, and amount of inorganic material in the water column. Secchi depth integrates the combined impacts of all the factors which influence water clarity. Water transparency was measured using a Secchi disk. Secchi disk readings were taken at all lake sites.

2.2 Sediment

In accordance with EM-1110-2-1201, sediment samples should be taken to monitor and assess potential impacts to aquatic and human health. To assess ecological risk, sample values were compared against toxicity information published in the National Oceanic Atmospheric Administrations (NOAA) Screening Quick Reference Tables (SQRT) or similar references for ecological receptors in freshwater sediment. Without standards or other widely applicable numerical tools, NOAA scientists found it difficult to estimate the possible toxicological significance of chemical concentrations in sediment. Therefore, numerical sediment quality guidelines (SQG's) were developed as informal, interpretive tools. The SQGs were not promulgated as regulatory standards, but rather as informal, non-regulatory guidelines for interpreting chemical data from analyses of sediments. For potential ecological risk from inorganic contaminants, seven metals are typically of "most concern" with regards to fish and wildlife: Arsenic, Copper, Cadmium, Selenium, Mercury, Lead, and Zinc. Avian species are thought to be particularly sensitive to arsenic, but is also considered a carcinogenic, mutagenic, and teratogenic contaminant in a variety of species in elevated doses over time. Avian species are also known to be particularly sensitive to lead in the environment with effects ranging from mortality, reduced growth and reproductive output, behavior changes, blood chemistry alterations, and lesions of major organs. Finally, the embryo stages in fish and avian species are known to be the most sensitive life stage to selenium effecting reproductive success.

It is recommended that the next round of sediment samples focus on organochlorines in freshwater sediment to assess potential chronic aquatic impacts (e.g. aldrin, chlordane, endrin, endosulfan, DDT, methoxychlor).

3.0 SUMMARY OF MONITORING RESULTS

3.1 Water Quality Summary

The monitoring program for Wappapello Lake during Fiscal Year 2011 revealed good water quality when compared to limits established by the Missouri Department of Natural Resources for general use, secondary contact, and indigenous aquatic life. Nutrient runoffs were primary concerns for the lake's water quality. Better land management practices, erosion control and buffering zones are methods used to reduce such contaminants from entering the lake. The St. Louis District personnel are available to work with lake personnel, area communities and other agencies in the implementation of educational programs and implementation planning to bring about the use of better management techniques to improve the lake's water quality.

E. coli are sampled at the marinas to ensure that the marina areas are not being contaminated by boats with restroom facilities. Bacteria levels for all the marinas were well below the Missouri standard of 235. We currently do not take enough samples in a month to calculate a geometric mean, so we mainly look at a high mark of 235/100ml of sample to trigger additional investigations. E. coli beach sample results were received from the project office an incorporated into this report. The project office collects beach samples once a week during the recreation season. No samples were above the Missouri standards set for beaches.

Total iron and total manganese are sampled above the dam near the bottom of the river channel (WAP-2-10), and in the spillway area (WAP-1). As was previously stated living organisms require trace amounts of metals, however excessive amounts can be harmful to the organism. Iron exceeded the Missouri Water Quality Standard at site WAP-2-10 in June and August. Iron cycling is a function of oxidation-reduction processes. This elevated level of iron near the bottom of the lake is not detrimental to the overall lake system at this time. Iron oxidizes relatively rapidly (minutes to hours); therefore any iron released through the spillway will normally be oxidized in a short period of time as can be seen from the significant reduction of iron in the spillway. Missouri's standard for manganese is for drinking water and groundwater. Missouri does not have a manganese standard for aquatic life. According to MDNR elevated levels of manganese are common due to the geologic nature of the area.

Nitrogen and phosphates are sampled at all sites. The 2011 phosphate results at site WAP-2 in June and October exceeded the 0.05 mg/L standard. Because phosphorous in water is not considered directly toxic to humans and animals no drinking water standards have been established for phosphorous. However, phosphorous can cause health threats through the stimulation of toxic algal blooms and the resulting oxygen depletion. However, nitrates can pose a threat to human and animal health. Nitrate in water is toxic at high levels and has been linked to toxic effects of livestock and to blue baby disease (methemoglobinemia) in infants. The Maximum Contaminant Level (MCL) for nitrate-N in drinking water is 10mg/L to protect babies 3 to 6 months of age. The Missouri Water Quality Standard for ammonia nitrogen (NH_3-N) is 15mg/L. The increased levels of phosphate in combination with nitrogen and other lake conditions, such as temperature, pH and stagnant lake conditions, can lead to increased algae growth. Eutrophication is currently the most widespread water quality problem in the U.S. and many other countries. Restoration of eutrophic waters requires the reduction of nonpoint inputs of phosphorous and nitrogen. The resulting detrimental effects of algae toxins and oxygen depletion could result in health problems for fish and other aquatic species as well as land animals utilizing the water supply. There were no signs of any of these effects throughout 2011. The spike in ammonia in August may be a result of chemical processes occurring near the bottom of the lake. Normally Nitrate-Nitrogen, Ammonia-Nitrogen, and Phoshates decreased below the dam. The lake appears to capture and use up nitrogen which reduces nutrient levels released from the lake. This reduction of nutrient levels traveling down stream results in an improvement of water quality.

Chlorophyll *a* was sampled at 3 sites, WAP-2, WAP-5, WAP-6 and WAP15. WAP-15 is a duplicate sample of WAP-5. Chlorophyll a is a green pigment found in plants. Chlorophyll *a* concentrations are an indicator of phytoplankton abundance and biomass. They can be an effective measure of trophic status, and used as a measure of water quality. High levels often indicate poor water quality and low levels suggest good conditions. However, elevated levels are not necessarily bad. It is the long term persistence of elevated levels that is the problem. It is natural for chlorophyll *a* levels to fluctuate over time. Chlorophyll *a* tends to be higher after storm events and during the summer months when water temperatures and light levels are elevated. Chlorophyll can reduce the clarity of the water and the amount of oxygen available to other organisms. Missouri does not currently have a standard for chlorophyll. The data indicates a normal increase in chlorophyll levels during the warmer summer months, which is not a concern.

Due to the limited amount of agriculture in the Wappapello watershed and the government chemical restrictions on the use of Atrazine and Alachlor on leased cropland, these chemicals were not sampled.

Total Suspended Solids (TSS) and Total Volatile Suspended Solids (TVSS) samples are collected at all sites. The high TSS reading at WAP-2-10 in June may be to the disturbance of sediments while taking the sample. Normally near bottom samples do not have high TSS reading unless the sediment has been disturbed. Disturbance may be from the weight on the sample tube being lowered into the bottom sediment. Solids can affect water quality by increasing temperature through the absorption of sunlight by the particles in the water, which also affects the clarity of the water. This can then affect the amount of oxygen in the water. Missouri does not currently have a standard for TSS or TVSS. However, literature suggests that Nonvolatile Suspended Solids (NVSS) which is a subdivision of TSS above 15mg/L could highly impair recreational lake use and a NVSS of 3 to 7mg/L might cause slight impairment. Suspended solids decreased below the dam. The lake allows the sediments to drop out of the water column before they are expelled down stream. This results in improved water quality.

Total Organic Carbon (TOC) is collected at all sites. TOC is an indicator of the organic character of water. The larger the carbon or organic content, the more oxygen is consumed. TOC tends to be higher in the summer months which may be a result of plant material, which had grown all summer and begins to decay. Missouri does not currently have a standard for TOC.

Temperature and dissolved oxygen levels were taken at all sites. Measurements were taken at 1 meter intervals at the lake sites. During the summer months the lake stratifies and a boundary is formed between the upper warmer water and the lower cooler water. This transition area is known as the thermocline, the area where the temperature drops significantly. Oxygen levels can also change drastically as a function of depth. This area where the oxygen level significantly drops is called the oxycline. The depth of the thermocline and oxycline can have an effect on the aquatic organisms. Occasionally the thermocline and oxycline are at or near the same depth.

PH is taken at all sites and at 1 meter intervals at lake sites. All sites were within the 6 to 9 pH range except site 6 in April, which was 9.6. This appears to be an anomaly in that other readings at the same site are within the 6 to 9 range as well as other sites on the same day.

Conductivity and redox are taken at all sites and at 1 meter intervals at lake sites. Missouri recommends 1,700*u*S/cm ≈TDS of 1,000mg/L standard for conductivity. No site exceeded this recommendation. Missouri does not currently have a standard for redox.

Seechi disk readings indicate that as the water travels down the lake it becomes clearer. This is most likely the result of sediments dropping out of the water column as the water moves down stream toward the dam.

The monitoring program for Wappapello Lake during Fiscal Year 2011 revealed good water quality when compared to limits established by the Missouri Department of Natural Resources for general use, secondary contact, and indigenous aquatic life. Nutrient runoffs were primary concerns for the lake’s water quality. Better land management practices, erosion control and buffering zones are methods used to reduce such contaminants from entering the lake. The St. Louis District personnel are available to work with lake personnel, area communities and other agencies in the implementation of educational programs and implementation planning to bring about the use of better management techniques to improve the lake’s water quality.

3.2 Sediment Summary

Sediment sampling was not conducted in 2011. Sediment sampling is normally conducted every 5 years if funding is available. Sediment sampling was last conducted in 2007.

4.0 PLANNED 2012 STUDIES

The Wappapello Lake water quality monitoring program will continue in Fiscal Year 2012 on a limited basis. Because of budgetary constraints there will only be 3 sampling events in 2012. A restored number of sampling events would provide the ability to better evaluate water quality trends, to better defend project operations (lake levels, releases, maintenance projects, construction projects, etc.), to better confirm that we meet state water quality standards, and to better confirm that human health and safety are adequately protected. The sampling event is planned to be conducted between April and August in 2012. Wappapello Lake is a high usage recreational lake. The monitoring of water quality is imperative to assure the water quality is within acceptable limits for the designated usage.

The sampling sites include the following: WAP-1 Spillway, WAP-2 lake side of dam, WAP-5 Otter Creek, WAP-6 Greenville, WAP-7 Hwy 34 bridge and all 4 marinas. This combination of sites effectively represents the incoming contaminants and their effects on the lake.

APPENDIX A

DATA

LAB DATA

Water Samples

Site	Date Collected	Matrix	Result	Qualifier	Unit	Analyte Name
Wap-2	11/17/2011	WT			ug/L	Alachlor
Wap-2-10	11/17/2011	WT			ug/L	Alachlor
Wap-6	11/17/2011	WT			ug/L	Alachlor
Wap-7	11/17/2011	WT			ug/L	Alachlor
Wap-1	4/5/2011	WT	0.050	J	mg/L	Ammonia-N
Wap-1	6/8/2011	WT	ND		mg/L	Ammonia-N
Wap-1	8/16/2011	WT	ND		mg/L	Ammonia-N
Wap-15	4/5/2011	WT	0.180		mg/L	Ammonia-N
Wap-15	6/8/2011	WT	ND		mg/L	Ammonia-N
Wap-15	8/16/2011	WT	ND		mg/L	Ammonia-N
Wap-2	4/5/2011	WT	ND		mg/L	Ammonia-N
Wap-2	6/8/2011	WT	ND		mg/L	Ammonia-N
Wap-2	8/16/2011	WT	ND		mg/L	Ammonia-N
Wap-2	11/17/2011	WT	0.03	<	mg/L	Ammonia-N
Wap-2-10	4/5/2011	WT	0.080		mg/L	Ammonia-N
Wap-2-10	6/8/2011	WT	0.380		mg/L	Ammonia-N
Wap-2-10	8/16/2011	WT	1.130		mg/L	Ammonia-N
Wap-2-10	11/17/2011	WT	0.03	<	mg/L	Ammonia-N
Wap-5	4/5/2011	WT	0.180		mg/L	Ammonia-N
Wap-5	6/8/2011	WT	ND		mg/L	Ammonia-N
Wap-5	8/16/2011	WT	ND		mg/L	Ammonia-N
Wap-6	4/5/2011	WT	0.060	J	mg/L	Ammonia-N
Wap-6	6/8/2011	WT	ND	J	mg/L	Ammonia-N
Wap-6	8/16/2011	WT	ND		mg/L	Ammonia-N
Wap-6	11/17/2011	WT	0.03	<	mg/L	Ammonia-N
Wap-7	4/5/2011	WT	0.060	J	mg/L	Ammonia-N
Wap-7	6/8/2011	WT	ND		mg/L	Ammonia-N
Wap-7	8/16/2011	WT	ND		mg/L	Ammonia-N
Wap-7	11/17/2011	WT	0.03	<	mg/L	Ammonia-N
Wap-2	11/17/2011	WT			ug/L	Atrazine
Wap-2-10	11/17/2011	WT			ug/L	Atrazine

Site	Date Collected	Matrix	Result	Qualifier	Unit	Analyte Name
Wap-6	11/17/2011	WT			ug/L	Atrazine
Wap-7	11/17/2011	WT			ug/L	Atrazine
Wap-15	4/5/2011	WT	14.952		mg/m3	Chlorophyll a
Wap-15	6/8/2011	WT	2.136		mg/m3	Chlorophyll a
Wap-15	8/16/2011	WT	25.632		mg/m3	Chlorophyll a
Wap-2	4/5/2011	WT	19.224		mg/m3	Chlorophyll a
Wap-2	6/8/2011	WT	0.000		mg/m3	Chlorophyll a
Wap-2	8/16/2011	WT	51.264		mg/m3	Chlorophyll a
Wap-2	11/17/2011	WT	19.5		mg/m3	Chlorophyll a
Wap-2-10	11/17/2011	WT	18.2		mg/m3	Chlorophyll a
Wap-5	4/5/2011	WT	19.224		mg/m3	Chlorophyll a
Wap-5	6/8/2011	WT	2.136		mg/m3	Chlorophyll a
Wap-5	8/16/2011	WT	27.768		mg/m3	Chlorophyll a
Wap-6	4/5/2011	WT	0.000		mg/m3	Chlorophyll a
Wap-6	6/8/2011	WT	19.224		mg/m3	Chlorophyll a
Wap-6	8/16/2011	WT	6.408		mg/m3	Chlorophyll a
Wap-2	11/17/2011	WT			ug/L	Chloropyrifos
Wap-2-10	11/17/2011	WT			ug/L	Chloropyrifos
Wap-6	11/17/2011	WT			ug/L	Chloropyrifos
Wap-7	11/17/2011	WT			ug/L	Chloropyrifos
Wap-2	11/17/2011	WT			ug/L	Cyanazine
Wap-2-10	11/17/2011	WT			ug/L	Cyanazine
Wap-6	11/17/2011	WT			ug/L	Cyanazine
Wap-7	11/17/2011	WT			ug/L	Cyanazine
Wap-1	4/5/2011	WT	0.930		mg/L	Iron, Total
Wap-1	6/8/2011	WT	0.310		mg/L	Iron, Total
Wap-1	8/16/2011	WT	0.270		mg/L	Iron, Total
Wap-2-10	4/5/2011	WT	0.880		mg/L	Iron, Total
Wap-2-10	6/8/2011	WT	6.800		mg/L	Iron, Total
Wap-2-10	8/16/2011	WT	1.200		mg/L	Iron, Total
Wap-6	11/17/2011	WT	0.26		mg/L	Iron, Total
Wap-7	11/17/2011	WT	0.078		mg/L	Iron, Total
Wap-1	4/5/2011	WT	0.130		mg/L	Manganese, Total
Wap-1	6/8/2011	WT	0.470		mg/L	Manganese, Total
Wap-1	8/16/2011	WT	1.000		mg/L	Manganese, Total
Wap-2-10	4/5/2011	WT	0.140		mg/L	Manganese, Total
Wap-2-10	6/8/2011	WT	2.500		mg/L	Manganese, Total
Wap-2-10	8/16/2011	WT	7.700		mg/L	Manganese, Total

Site	Date Collected	Matrix	Result	Qualifier	Unit	Analyte Name
Wap-6	11/17/2011	WT	0.062		mg/L	Manganese, Total
Wap-7	11/17/2011	WT	0.022		mg/L	Manganese, Total
Wap-2	11/17/2011	WT			ug/L	Metolachlor
Wap-2-10	11/17/2011	WT			ug/L	Metolachlor
Wap-6	11/17/2011	WT			ug/L	Metolachlor
Wap-7	11/17/2011	WT			ug/L	Metolachlor
Wap-2	11/17/2011	WT			ug/L	Metribuzin
Wap-2-10	11/17/2011	WT			ug/L	Metribuzin
Wap-6	11/17/2011	WT			ug/L	Metribuzin
Wap-7	11/17/2011	WT			ug/L	Metribuzin
Wap-1	4/5/2011	WT	0.220		mg/L	Nitrate-N
Wap-1	6/8/2011	WT	ND		mg/L	Nitrate-N
Wap-1	8/16/2011	WT	ND		mg/L	Nitrate-N
Wap-15	4/5/2011	WT	0.180	J	mg/L	Nitrate-N
Wap-15	6/8/2011	WT	ND		mg/L	Nitrate-N
Wap-15	8/16/2011	WT	ND		mg/L	Nitrate-N
Wap-2	4/5/2011	WT	0.180	J	mg/L	Nitrate-N
Wap-2	6/8/2011	WT	ND		mg/L	Nitrate-N
Wap-2	8/16/2011	WT	ND		mg/L	Nitrate-N
Wap-2	11/17/2011	WT	0.05	<	mg/L	Nitrate-N
Wap-2-10	4/5/2011	WT	0.200		mg/L	Nitrate-N
Wap-2-10	6/8/2011	WT	ND		mg/L	Nitrate-N
Wap-2-10	8/16/2011	WT	ND		mg/L	Nitrate-N
Wap-2-10	11/17/2011	WT	0.05	<	mg/L	Nitrate-N
Wap-5	4/5/2011	WT	0.180	J	mg/L	Nitrate-N
Wap-5	6/8/2011	WT	ND		mg/L	Nitrate-N
Wap-5	8/16/2011	WT	ND		mg/L	Nitrate-N
Wap-6	4/5/2011	WT	0.160	J	mg/L	Nitrate-N
Wap-6	6/8/2011	WT	ND		mg/L	Nitrate-N
Wap-6	8/16/2011	WT	ND		mg/L	Nitrate-N
Wap-6	11/17/2011	WT	0.071		mg/L	Nitrate-N
Wap-7	4/5/2011	WT	0.160	J	mg/L	Nitrate-N
Wap-7	6/8/2011	WT	0.080	J	mg/L	Nitrate-N
Wap-7	8/16/2011	WT	ND		mg/L	Nitrate-N
Wap-7	11/17/2011	WT	0.05	<	mg/L	Nitrate-N
Wap-1	4/5/2011	WT	ND		mg/L	Orthophosphate
Wap-1	6/8/2011	WT	0.003	J	mg/L	Orthophosphate
Wap-1	8/16/2011	WT	0.006	J	mg/L	Orthophosphate

Site	Date Collected	Matrix	Result	Qualifier	Unit	Analyte Name
Wap-15	4/5/2011	WT	0.003	J	mg/L	Orthophosphate
Wap-15	6/8/2011	WT	ND		mg/L	Orthophosphate
Wap-15	8/16/2011	WT	0.006	J	mg/L	Orthophosphate
Wap-2	4/5/2011	WT	0.003	J	mg/L	Orthophosphate
Wap-2	6/8/2011	WT	0.006	J	mg/L	Orthophosphate
Wap-2	8/16/2011	WT	0.005	J	mg/L	Orthophosphate
Wap-2	11/17/2011	WT	0.01	<	mg/L	Orthophosphate
Wap-2-10	4/5/2011	WT	ND		mg/L	Orthophosphate
Wap-2-10	6/8/2011	WT	0.008	J	mg/L	Orthophosphate
Wap-2-10	8/16/2011	WT	0.003	J	mg/L	Orthophosphate
Wap-2-10	11/17/2011	WT	0.01	<	mg/L	Orthophosphate
Wap-5	4/5/2011	WT	ND		mg/L	Orthophosphate
Wap-5	6/8/2011	WT	0.008	J	mg/L	Orthophosphate
Wap-5	8/16/2011	WT	0.006	J	mg/L	Orthophosphate
Wap-6	4/5/2011	WT	0.003	J	mg/L	Orthophosphate
Wap-6	6/8/2011	WT	0.003	J	mg/L	Orthophosphate
Wap-6	8/16/2011	WT	0.008	J	mg/L	Orthophosphate
Wap-6	11/17/2011	WT	0.01	<	mg/L	Orthophosphate
Wap-7	4/5/2011	WT	ND		mg/L	Orthophosphate
Wap-7	6/8/2011	WT	0.005	J	mg/L	Orthophosphate
Wap-7	8/16/2011	WT	0.008	J	mg/L	Orthophosphate
Wap-7	11/17/2011	WT	0.01	<	mg/L	Orthophosphate
Wap-2	11/17/2011	WT			ug/L	Pendimethalin
Wap-2-10	11/17/2011	WT			ug/L	Pendimethalin
Wap-6	11/17/2011	WT			ug/L	Pendimethalin
Wap-7	11/17/2011	WT			ug/L	Pendimethalin
Wap-15	4/5/2011	WT	1.000	<	mg/m3	Pheophytin
Wap-15	6/8/2011	WT	1.000	<	mg/m3	Pheophytin
Wap-15	8/16/2011	WT	1.000	<	mg/m3	Pheophytin
Wap-2	4/5/2011	WT	1.000	<	mg/m3	Pheophytin
Wap-2	6/8/2011	WT	1.000	<	mg/m3	Pheophytin
Wap-2	8/16/2011	WT	1.000	<	mg/m3	Pheophytin
Wap-2	11/17/2011	WT	2	<	mg/m3	Pheophytin
Wap-2-10	11/17/2011	WT	2		mg/m3	Pheophytin
Wap-5	4/5/2011	WT	1.000	<	mg/m3	Pheophytin
Wap-5	6/8/2011	WT	1.000	<	mg/m3	Pheophytin
Wap-5	8/16/2011	WT	1.000		mg/m3	Pheophytin
Wap-6	4/5/2011	WT	1.000	<	mg/m3	Pheophytin

Site	Date Collected	Matrix	Result	Qualifier	Unit	Analyte Name
Wap-6	6/8/2011	WT	1.000	<	mg/m3	Pheophytin
Wap-6	8/16/2011	WT	1.000	<	mg/m3	Pheophytin
Wap-1	4/5/2011	WT	ND		mg/L	Phosphorus, Total
Wap-1	6/8/2011	WT	ND		mg/L	Phosphorus, Total
Wap-1	8/16/2011	WT	ND		mg/L	Phosphorus, Total
Wap-15	4/5/2011	WT	ND		mg/L	Phosphorus, Total
Wap-15	6/8/2011	WT	ND		mg/L	Phosphorus, Total
Wap-15	8/16/2011	WT	ND		mg/L	Phosphorus, Total
Wap-2	4/5/2011	WT	ND		mg/L	Phosphorus, Total
Wap-2	6/8/2011	WT	ND		mg/L	Phosphorus, Total
Wap-2	8/16/2011	WT	ND		mg/L	Phosphorus, Total
Wap-2	11/17/2011	WT	0.052		mg/L	Phosphorus, Total
Wap-2-10	4/5/2011	WT	ND		mg/L	Phosphorus, Total
Wap-2-10	6/8/2011	WT	0.065	J	mg/L	Phosphorus, Total
Wap-2-10	8/16/2011	WT	ND		mg/L	Phosphorus, Total
Wap-2-10	11/17/2011	WT	0.056		mg/L	Phosphorus, Total
Wap-5	4/5/2011	WT	ND		mg/L	Phosphorus, Total
Wap-5	6/8/2011	WT	ND		mg/L	Phosphorus, Total
Wap-5	8/16/2011	WT	ND		mg/L	Phosphorus, Total
Wap-6	4/5/2011	WT	ND		mg/L	Phosphorus, Total
Wap-6	6/8/2011	WT	ND		mg/L	Phosphorus, Total
Wap-6	8/16/2011	WT	ND		mg/L	Phosphorus, Total
Wap-6	11/17/2011	WT	0.026		mg/L	Phosphorus, Total
Wap-7	4/5/2011	WT	ND		mg/L	Phosphorus, Total
Wap-7	6/8/2011	WT	ND		mg/L	Phosphorus, Total
Wap-7	8/16/2011	WT	ND		mg/L	Phosphorus, Total
Wap-7	11/17/2011	WT	0.013		mg/L	Phosphorus, Total
Wap-1	4/5/2011	WT	2.600		mg/L	Total Organic Carbon (TOC)
Wap-1	6/8/2011	WT	4.200		mg/L	Total Organic Carbon (TOC)
Wap-1	8/16/2011	WT	9.600		mg/L	Total Organic Carbon (TOC)
Wap-15	4/5/2011	WT	2.500		mg/L	Total Organic Carbon (TOC)
Wap-15	6/8/2011	WT	4.200		mg/L	Total Organic Carbon (TOC)
Wap-15	8/16/2011	WT	4.500		mg/L	Total Organic Carbon (TOC)
Wap-2	4/5/2011	WT	2.300		mg/L	Total Organic Carbon (TOC)
Wap-2	6/8/2011	WT	3.800		mg/L	Total Organic Carbon (TOC)
Wap-2	8/16/2011	WT	5.300		mg/L	Total Organic Carbon (TOC)
Wap-2	11/17/2011	WT	3.6		mg/L	Total Organic Carbon (TOC)
Wap-2-10	4/5/2011	WT	2.900		mg/L	Total Organic Carbon (TOC)

Site	Date Collected	Matrix	Result	Qualifier	Unit	Analyte Name
Wap-2-10	6/8/2011	WT	5.000		mg/L	Total Organic Carbon (TOC)
Wap-2-10	8/16/2011	WT	3.400		mg/L	Total Organic Carbon (TOC)
Wap-2-10	11/17/2011	WT	3.3		mg/L	Total Organic Carbon (TOC)
Wap-5	4/5/2011	WT	2.400		mg/L	Total Organic Carbon (TOC)
Wap-5	6/8/2011	WT	3.800		mg/L	Total Organic Carbon (TOC)
Wap-5	8/16/2011	WT	4.400		mg/L	Total Organic Carbon (TOC)
Wap-6	4/5/2011	WT	1.900		mg/L	Total Organic Carbon (TOC)
Wap-6	6/8/2011	WT	3.600		mg/L	Total Organic Carbon (TOC)
Wap-6	8/16/2011	WT	2.500		mg/L	Total Organic Carbon (TOC)
Wap-6	11/17/2011	WT	1.7		mg/L	Total Organic Carbon (TOC)
Wap-7	4/5/2011	WT	1.900		mg/L	Total Organic Carbon (TOC)
Wap-7	6/8/2011	WT	2.300		mg/L	Total Organic Carbon (TOC)
Wap-7	8/16/2011	WT	2.200		mg/L	Total Organic Carbon (TOC)
Wap-7	11/17/2011	WT	1.6		mg/L	Total Organic Carbon (TOC)
Wap-1	4/5/2011	WT	35.000		mg/L	Total Suspended Solids
Wap-1	6/8/2011	WT	6.000		mg/L	Total Suspended Solids
Wap-1	8/16/2011	WT	12.000		mg/L	Total Suspended Solids
Wap-15	4/5/2011	WT	57.000		mg/L	Total Suspended Solids
Wap-15	6/8/2011	WT	6.000		mg/L	Total Suspended Solids
Wap-15	8/16/2011	WT	16.000		mg/L	Total Suspended Solids
Wap-2	4/5/2011	WT	23.000		mg/L	Total Suspended Solids
Wap-2	6/8/2011	WT	ND		mg/L	Total Suspended Solids
Wap-2	8/16/2011	WT	17.000		mg/L	Total Suspended Solids
Wap-2	11/17/2011	WT	13.5		mg/L	Total Suspended Solids
Wap-2-10	4/5/2011	WT	38.000		mg/L	Total Suspended Solids
Wap-2-10	6/8/2011	WT	296.000		mg/L	Total Suspended Solids
Wap-2-10	8/16/2011	WT	22.000		mg/L	Total Suspended Solids
Wap-2-10	11/17/2011	WT	12.8		mg/L	Total Suspended Solids
Wap-5	4/5/2011	WT	51.000		mg/L	Total Suspended Solids
Wap-5	6/8/2011	WT	8.000		mg/L	Total Suspended Solids
Wap-5	8/16/2011	WT	23.000		mg/L	Total Suspended Solids
Wap-6	4/5/2011	WT	8.000		mg/L	Total Suspended Solids
Wap-6	6/8/2011	WT	8.000		mg/L	Total Suspended Solids
Wap-6	8/16/2011	WT	9.000		mg/L	Total Suspended Solids
Wap-6	11/17/2011	WT	6.8		mg/L	Total Suspended Solids
Wap-7	4/5/2011	WT	8.000		mg/L	Total Suspended Solids
Wap-7	6/8/2011	WT	10.000		mg/L	Total Suspended Solids
Wap-7	8/16/2011	WT	ND		mg/L	Total Suspended Solids

Site	Date Collected	Matrix	Result	Qualifier	Unit	Analyte Name
Wap-7	11/17/2011	WT	3.7		mg/L	Total Suspended Solids
Wap-2	11/17/2011	WT			ug/L	Trifluralin
Wap-2-10	11/17/2011	WT			ug/L	Trifluralin
Wap-6	11/17/2011	WT			ug/L	Trifluralin
Wap-7	11/17/2011	WT			ug/L	Trifluralin
Wap-1	4/5/2011	WT	8.000		mg/L	Volatile Suspended Solids
Wap-1	6/8/2011	WT	ND		mg/L	Volatile Suspended Solids
Wap-1	8/16/2011	WT	10.000		mg/L	Volatile Suspended Solids
Wap-15	4/5/2011	WT	12.000		mg/L	Volatile Suspended Solids
Wap-15	6/8/2011	WT	ND		mg/L	Volatile Suspended Solids
Wap-15	8/16/2011	WT	ND		mg/L	Volatile Suspended Solids
Wap-2	4/5/2011	WT	5.000		mg/L	Volatile Suspended Solids
Wap-2	6/8/2011	WT	ND		mg/L	Volatile Suspended Solids
Wap-2	8/16/2011	WT	6.000		mg/L	Volatile Suspended Solids
Wap-2	11/17/2011	WT	4.3		mg/L	Volatile Suspended Solids
Wap-2-10	4/5/2011	WT	5.000		mg/L	Volatile Suspended Solids
Wap-2-10	6/8/2011	WT	150.000		mg/L	Volatile Suspended Solids
Wap-2-10	8/16/2011	WT	7.000		mg/L	Volatile Suspended Solids
Wap-2-10	11/17/2011	WT	4.5		mg/L	Volatile Suspended Solids
Wap-5	4/5/2011	WT	7.000		mg/L	Volatile Suspended Solids
Wap-5	6/8/2011	WT	ND		mg/L	Volatile Suspended Solids
Wap-5	8/16/2011	WT	ND		mg/L	Volatile Suspended Solids
Wap-6	4/5/2011	WT	ND		mg/L	Volatile Suspended Solids
Wap-6	6/8/2011	WT	7.000		mg/L	Volatile Suspended Solids
Wap-6	8/16/2011	WT	ND		mg/L	Volatile Suspended Solids
Wap-6	11/17/2011	WT	1.25	<	mg/L	Volatile Suspended Solids
Wap-7	4/5/2011	WT	ND		mg/L	Volatile Suspended Solids
Wap-7	6/8/2011	WT	5.000		mg/L	Volatile Suspended Solids
Wap-7	8/16/2011	WT	6.000		mg/L	Volatile Suspended Solids
Wap-7	11/17/2011	WT	1.11	<	mg/L	Volatile Suspended Solids

J indicates an estimated value between Method Detection Limit (MDL) and the Practical Quantitation Limit (PQL)
U Indicates non detect (ND)

E. coli

Site	Date Collected	Matrix	Result	Qualifier	Unit	Analyte Name
Barretts	6/9/2011	w	10	<	MEP	E. Coli
Barretts	8/16/2011	w	10	<	MEP	E. Coli
Chonia Landing	4/5/2011	w	52		MEP	E. Coli
Chonia Landing	6/9/2011	w	10	<	MEP	E. Coli
Chonia Landing	8/16/2011	w	52		MEP	E. Coli
Lost Creek	4/5/2011	w	10	<	MEP	E. Coli
Lost Creek	6/9/2011	w	10	<	MEP	E. Coli
Lost Creek	8/16/2011	w	10	<	MEP	E. Coli
Sundowner	4/5/2011	w	10	<	MEP	E. Coli
Sundowner	6/9/2011	w	10	<	MEP	E. Coli
Sundowner	8/16/2011	w	10	<	MEP	E. Coli

FIELD DATA

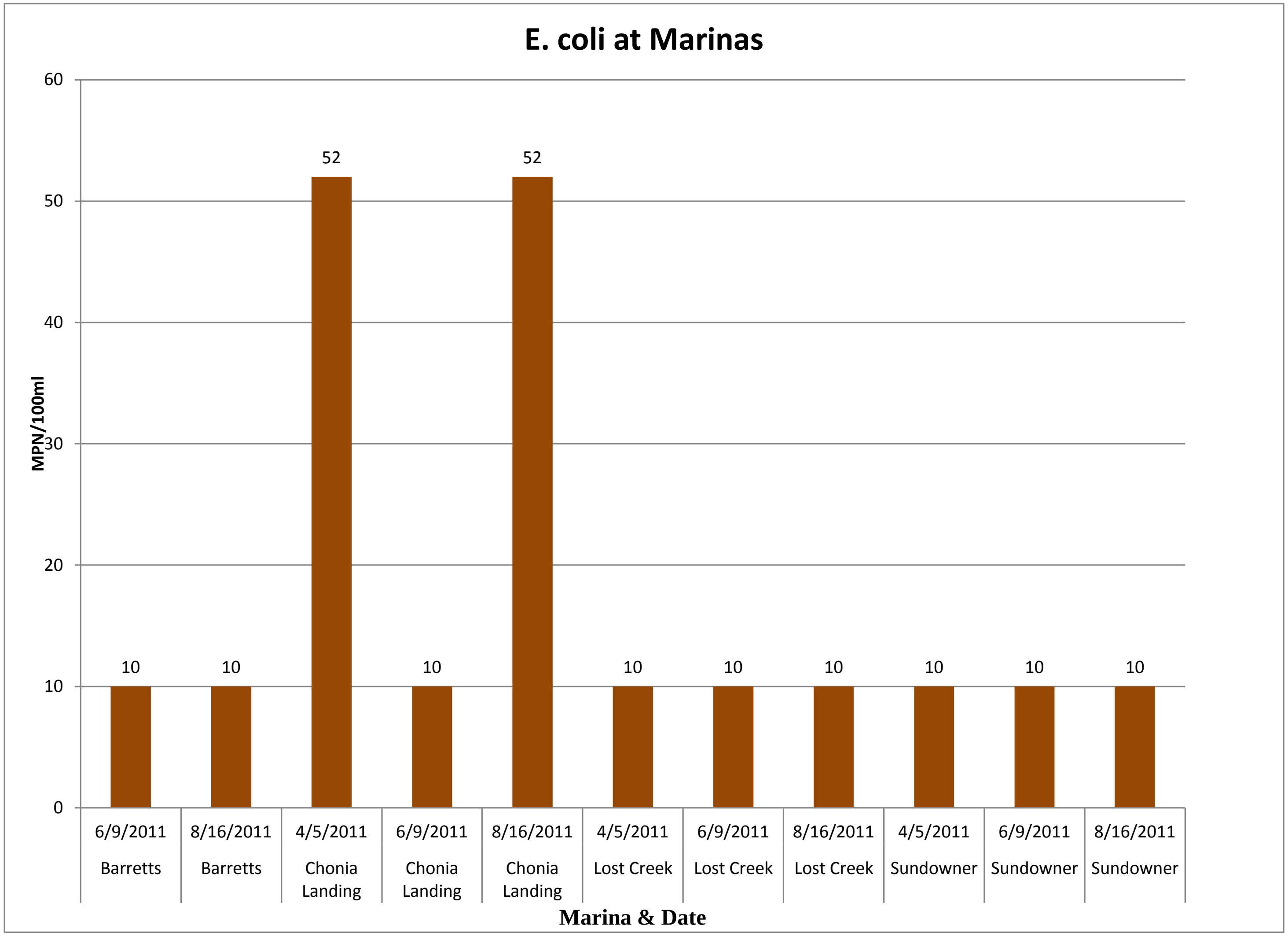
Site	Date	Depth	H2OTemp (oC)	Redox	Cond	D.0.%	D.O.(mg/L)	pH	Time	Seechi (in.)
1	4/5/2011	0.0	13.00	336	179.0	13.5	0.93	8.01	1135	
1	6/8/2011	1.7	22.20	238	123.4	92.7	8.13	7.12	1018	
1	8/16/2011	0.0	27.84	178	218.4	90.6	7.13	7.99	1207	
2	4/5/2011	0.5	14.08	303	175.0	110.0	9.44	8.2	1233	12
2	4/5/2011	1.0	14.27	305	175.0	110.0	9.40	8.2		
2	4/5/2011	2.0	13.80	310	175.0	109.0	9.40	8.2		
2	4/5/2011	3.0	13.75	315	175.0	108.0	9.40	8.7		
2	4/5/2011	4.0	13.70	319	174.0	108.0	9.40	8.5		
2	4/5/2011	5.0	13.70	323	175.0	108.0	9.40	8.4		
2	4/5/2011	6.0	13.50	326	175.0	107.0	9.30	8.3		
2	4/5/2011	7.0	13.30	329	174.0	106.0	9.20	8.2		
2	4/5/2011	8.0	13.20	332	174.0	103.0	9.00	8.2		
2	6/8/2011	0.1	30.18	350	120.8	112.6	8.54	7.6	1105	85
2	6/8/2011	1.0	29.80	351	102.5	112.6	8.59	7.51		
2	6/8/2011	2.0	23.09	366	117.8	96.4	8.48	7.22		
2	6/8/2011	3.0	20.98	383	129.3	22.9	1.44	6.66		
2	6/8/2011	4.0	18.23	164	139.9	3.6	0.32	6.35		
2	6/8/2011	5.0	16.84	122	111.6	2.2	0.21	6.2		
2	6/8/2011	5.8	15.43	57	110.8	2.0	0.20	6.72		
2	8/16/2011	0.0	28.55	238	201.2	116.3	9.08	8.77		
2	8/16/2011	1.0	28.51	238	201.2	117.6	9.10	8.66		
2	8/16/2011	2.0	27.78	252	204.1	84.2	6.62	8.32		
2	8/16/2011	3.0	27.71	260	203.5	77.1	6.08	8.15		
2	8/16/2011	4.0	27.40	268	207.6	63.8	5.05	7.92		
2	8/16/2011	5.0	26.19	147	246.5	4.3	0.31	7.41		
2	8/16/2011	6.0	23.91	27	292.3	2.8	0.23	7.27		
2	8/16/2011	7.0	22.05	-9	307.9	2.0	0.17	7.19		
2	8/16/2011	8.0	21.28	-28	296.8	1.9	0.17	7.15		
2	8/16/2011	9.0	20.64	-46	304.1	1.7	0.16	7.13		
2	8/16/2011	10.0	20.10	-61	324.4	1.6	0.15	7.13		
2	11/17/2011	0.2	13.47	308	219.9	104.2	10.86	7.82		

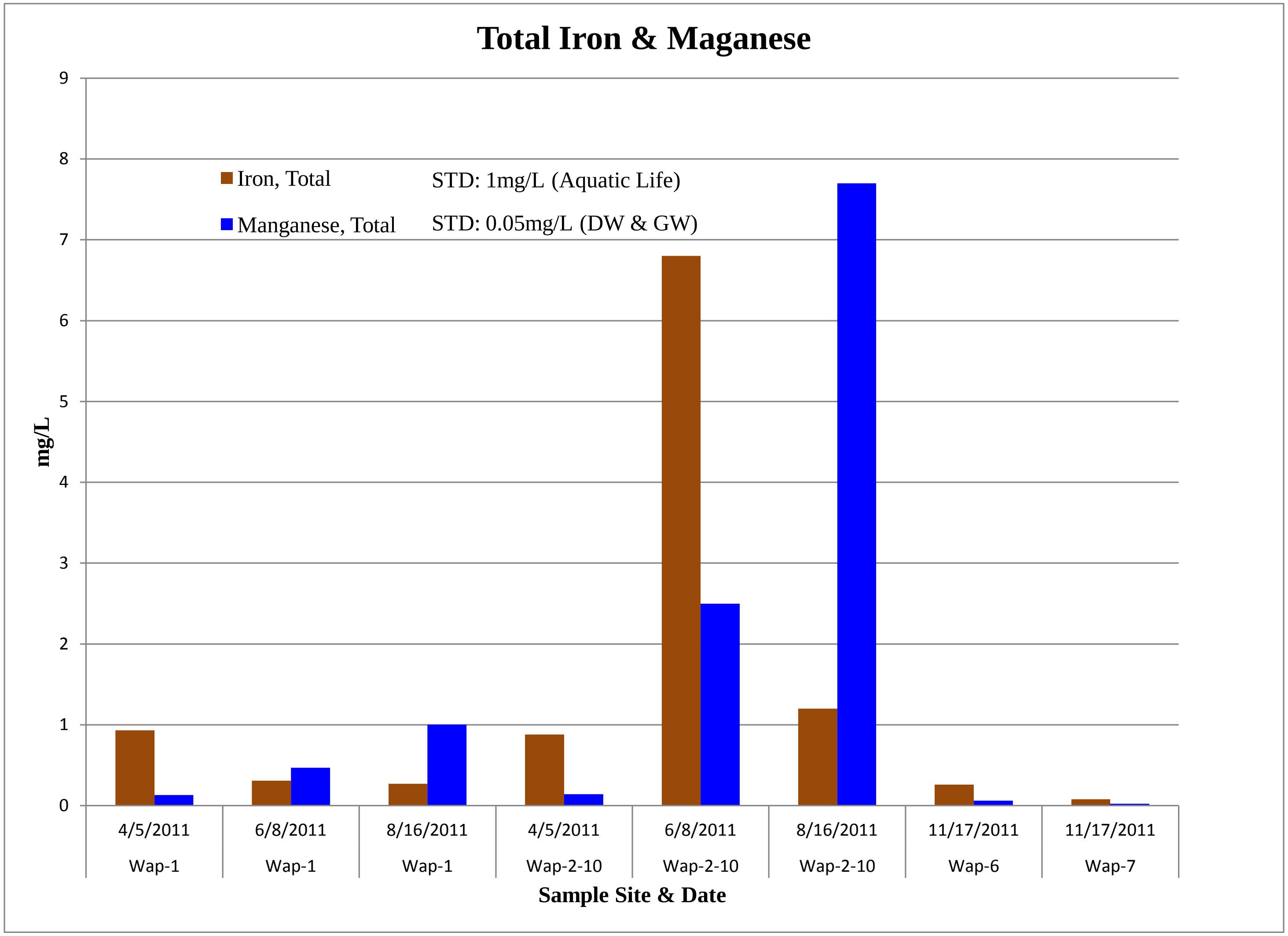
Site	Date	Depth	H2OTemp (oC)	Redox	Cond	D.0.%	D.O.(mg/L)	pH	Time	Seechi (in.)
2	11/17/2011	0.5	13.28	306	221.1	102.0	10.65	8.02		
2	11/17/2011	0.8	13.26	302	222.4	101.0	10.54	8.03		
2	11/17/2011	1.1	13.28	301	222.8	100.3	10.48	7.97		
2	11/17/2011	1.4	13.27	300	223.6	100.0	10.47	7.99		
2	11/17/2011	1.7	13.26	300	224.0	99.9	10.46	7.99		
2	11/17/2011	2.0	13.25	299	223.1	99.5	10.41	7.97		
2	11/17/2011	2.3	13.24	298	223.4	99.8	10.44	7.94		
2	11/17/2011	2.6	13.31	298	223.6	99.9	10.44	7.94		
2	11/17/2011	2.9	13.31	298	223.0	100.1	10.46	7.93		
2	11/17/2011	3.2	13.30	297	222.8	99.7	10.42	8.03		
5	4/5/2011	0.7	14.32	317	153.0	93.9	8.00	8.1	1144	6
5	4/5/2011	1.5	13.85	314	153.0	89.5	7.70	8.2		
5	6/8/2011	0.1	31.18	332	128.4	114.3	8.54	7.59	1210	98
5	6/8/2011	1.0	29.11	332	146.4	122.0	9.56	7.5		
5	6/8/2011	2.0	24.05	329	83.1	131.5	11.15	7.58		
5	6/8/2011	3.0	20.22	361	72.0	46.4	4.13	6.93		
5	6/8/2011	4.0	18.44	221	96.6	10.0	0.91	6.35		
5	6/8/2011	5.0	16.45	125	107.0	4.1	0.39	6.08		
5	6/8/2011	5.6	15.95	50	124.3	2.8	0.28	6.46		
5	8/16/2011	0.0	28.84	243	244.0	95.4	7.37	8.15	1117	16
5	8/16/2011	1.0	27.60	260	229.6	58.2	4.59	7.78		
5	8/16/2011	2.0	26.95	255	225.9	75.4	6.05	7.88		
6	4/5/2011	0.5	14.20	306	197.0	123.0	10.60	9.6	1420	67
6	4/5/2011	1.0	14.00	307	197.0	124.0	10.70	8.8		
6	4/5/2011	2.0	13.80	311	197.0	124.0	10.80	8.7		
6	6/8/2011	0.1	29.37	294	208.8	119.8	9.25	7.61	1234	80
6	6/8/2011	1.0	27.98	298	210.2	118.8	9.34	7.45		
6	6/8/2011	2.0	26.80	319	216.4	50.4	4.02	6.98		
6	6/8/2011	3.0	25.13	223	210.9	6.3	0.50	6.68		
6	6/8/2011	4.0	22.57	131	207.8	3.0	0.25	6.48		
6	6/8/2011	5.0	17.79	118	187.4	2.4	0.23	6.41		
6	6/8/2011	6.0	15.03	169	197.3	28.3	2.99	6.32		
6	6/8/2011	6.7	14.75	200	199.8	40.5	4.16	6.3		
6	8/16/2011	0.0	25.81	298	290.0	91.9	7.49	7.81	1000	28

Site	Date	Depth	H2OTemp (oC)	Redox	Cond	D.0.%	D.O.(mg/L)	pH	Time	Seechi (in.)
6	8/16/2011	1.0	25.67	300	289.8	90.0	7.36	7.79		
6	8/16/2011	2.0	22.58	314	289.3	61.3	5.29	7.43		
6	8/16/2011	3.0	17.33	324	288.1	39.6	3.82	7.22		
6	8/16/2011	4.0	16.81	326	290.2	45.6	4.41	7.17		
7	4/5/2011	0.0	11.97	297	189.6	106.8	9.61	8.63	1030	
7	6/8/2011	0.3	26.57	361	217.8	86.4	6.97	7.48	926	
7	8/16/2011	0.0	26.09	305	268.0	90.7	7.36	7.79	924	

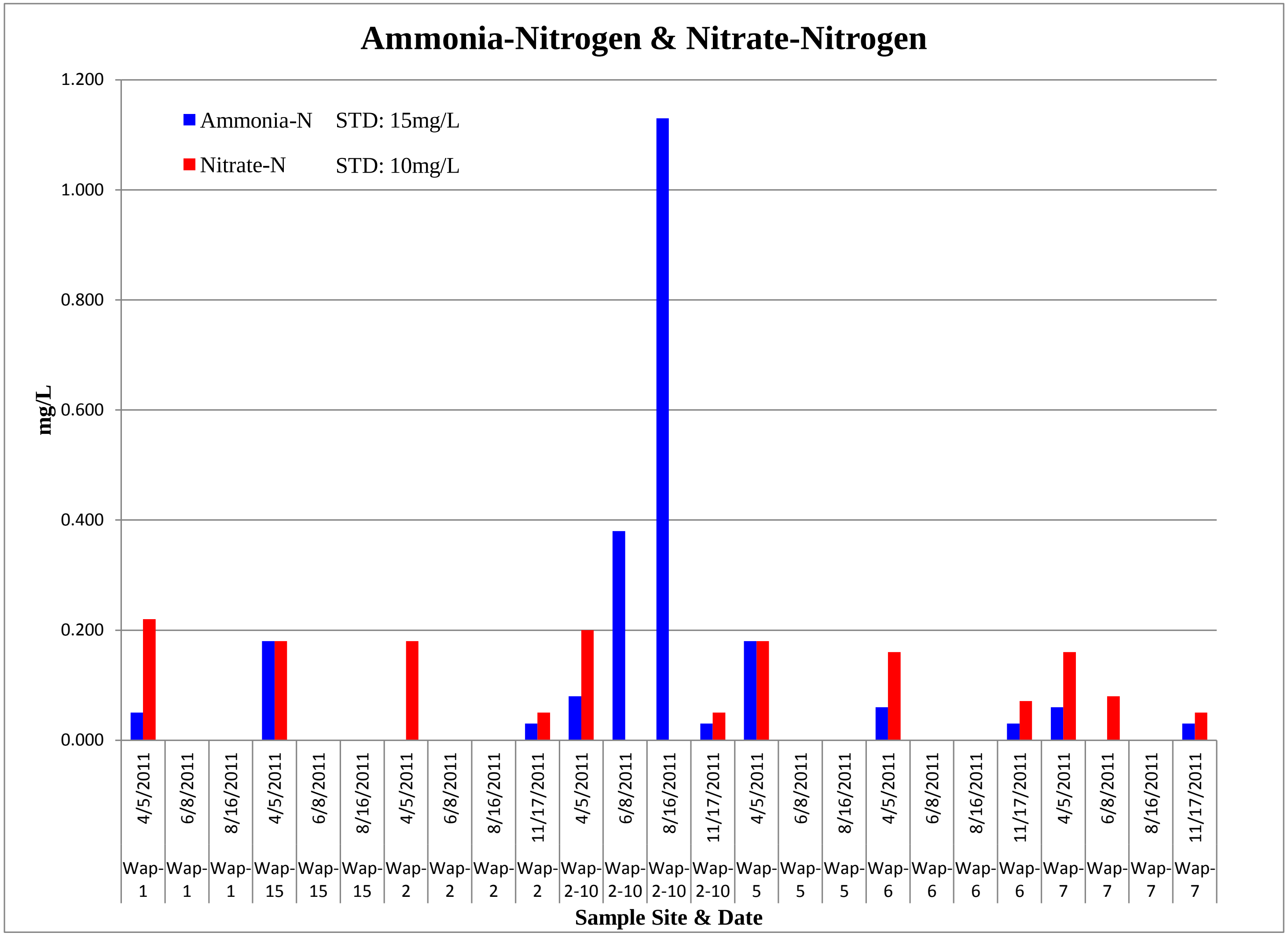
APPENDIX B

LAB DATA
GRAPHS

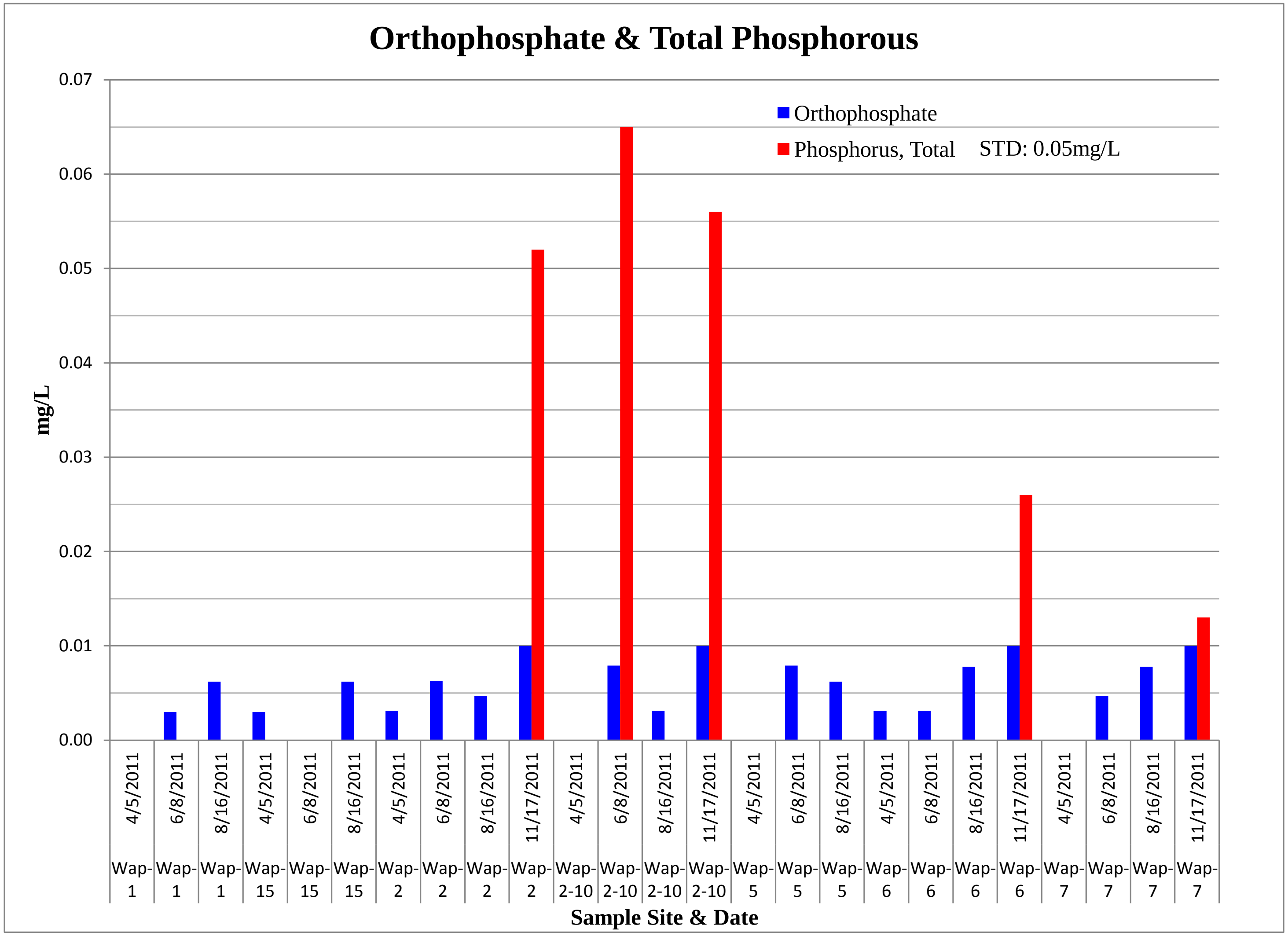

E. coli at Marinas
MPN/100ml
60
50
40
30
20
10
0
52
52
10
10
10
10
10
10
10
10
10
6/9/2011 Barretts
8/16/2011 Barretts
4/5/2011 Chonia Landing
6/9/2011 Chonia Landing
8/16/2011 Chonia Landing
4/5/2011 Lost Creek
6/9/2011 Lost Creek
8/16/2011 Lost Creek
4/5/2011 Sundowner
6/9/2011 Sundowner
8/16/2011 Sundowner
Marina & Date



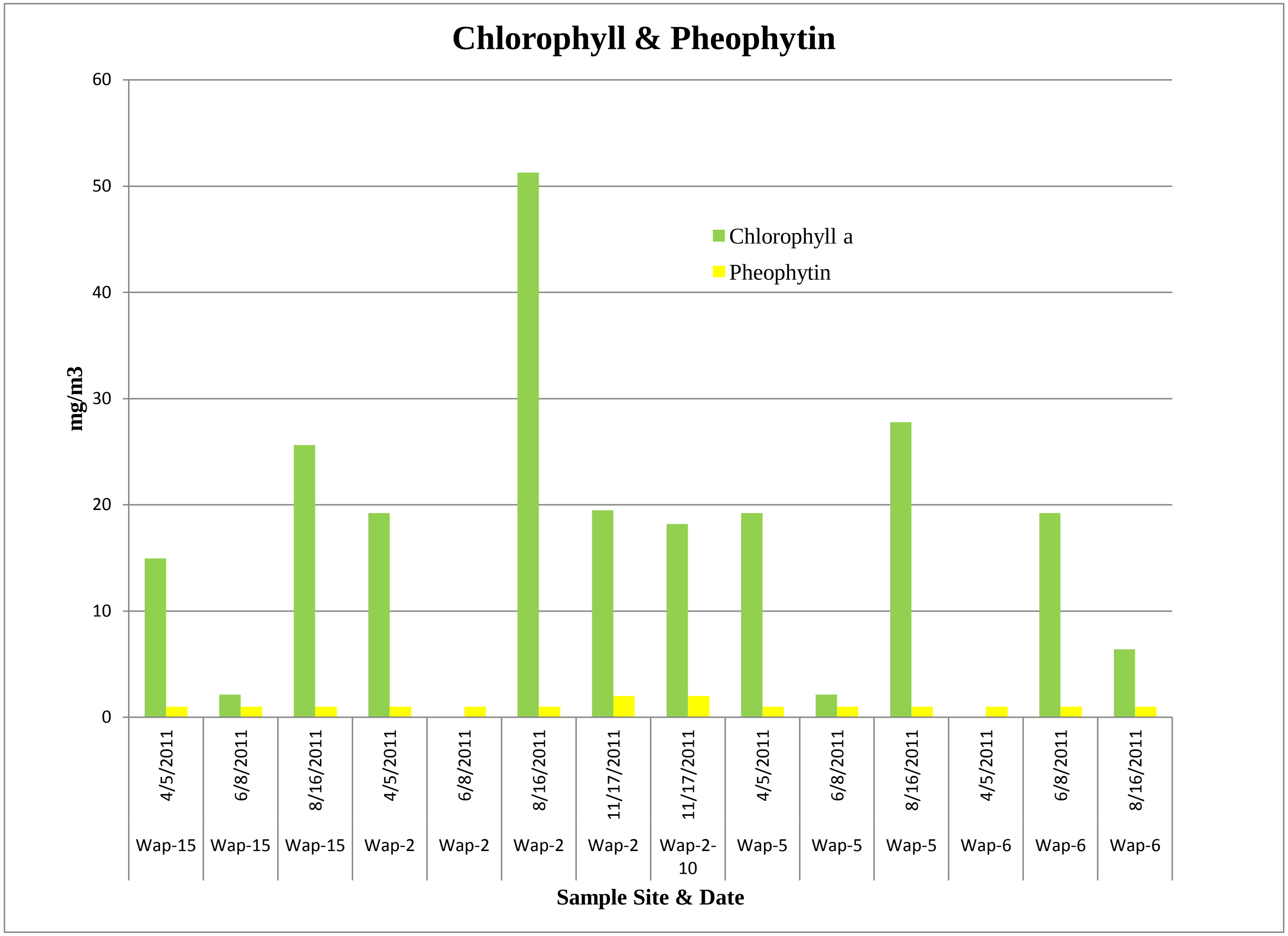
Total Iron & Maganese
mg/L
9
8
7
6
5
4
3
2
1
0
Iron, Total
STD: 1mg/L (Aquatic Life)
Manganese, Total
STD: 0.05mg/L (DW & GW)
4/5/2011
Wap-1
6/8/2011
Wap-1
8/16/2011
Wap-1
4/5/2011
Wap-2-10
6/8/2011
Wap-2-10
8/16/2011
Wap-2-10
11/17/2011
Wap-6
11/17/2011
Wap-7
Sample Site & Date

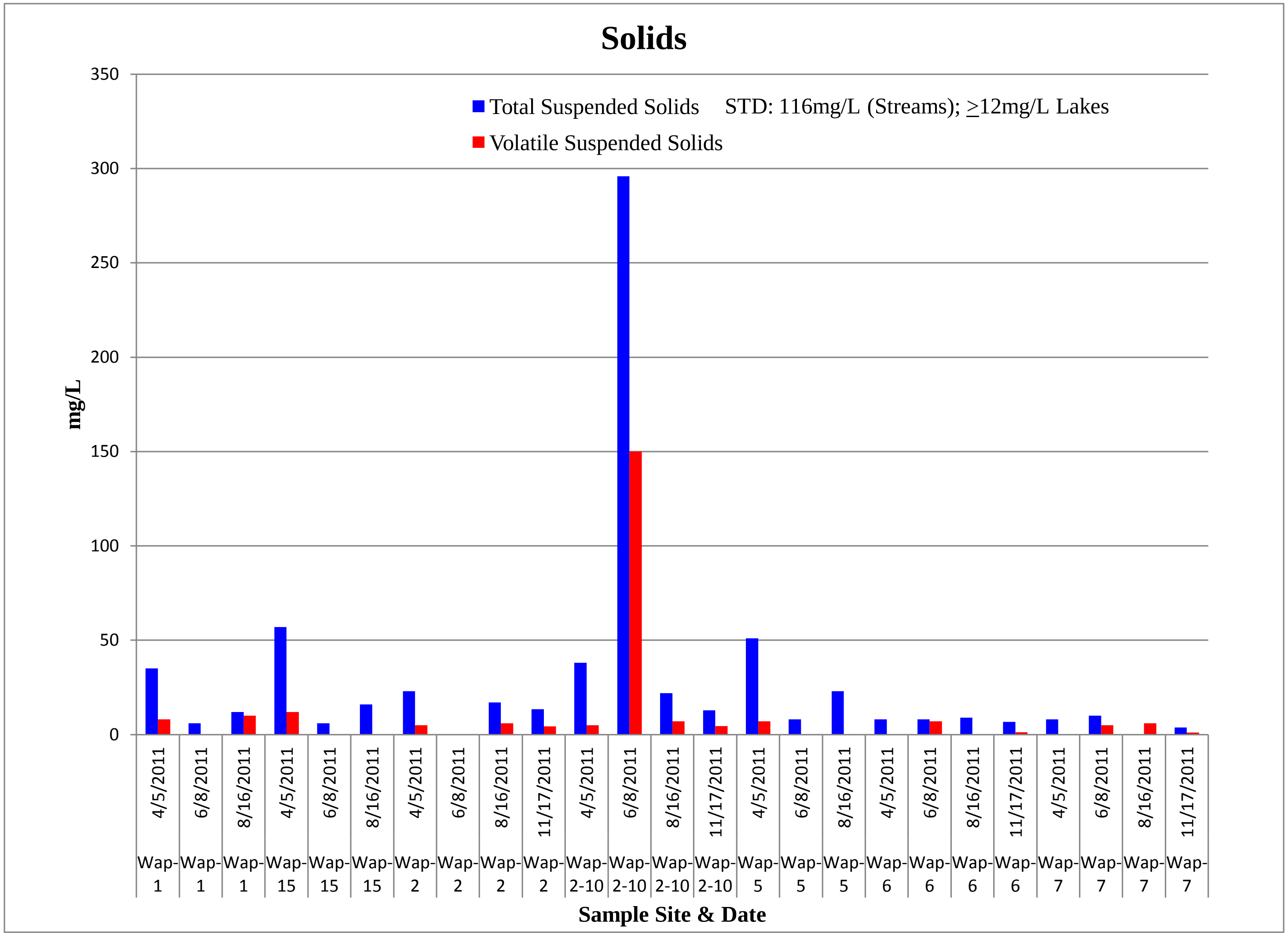


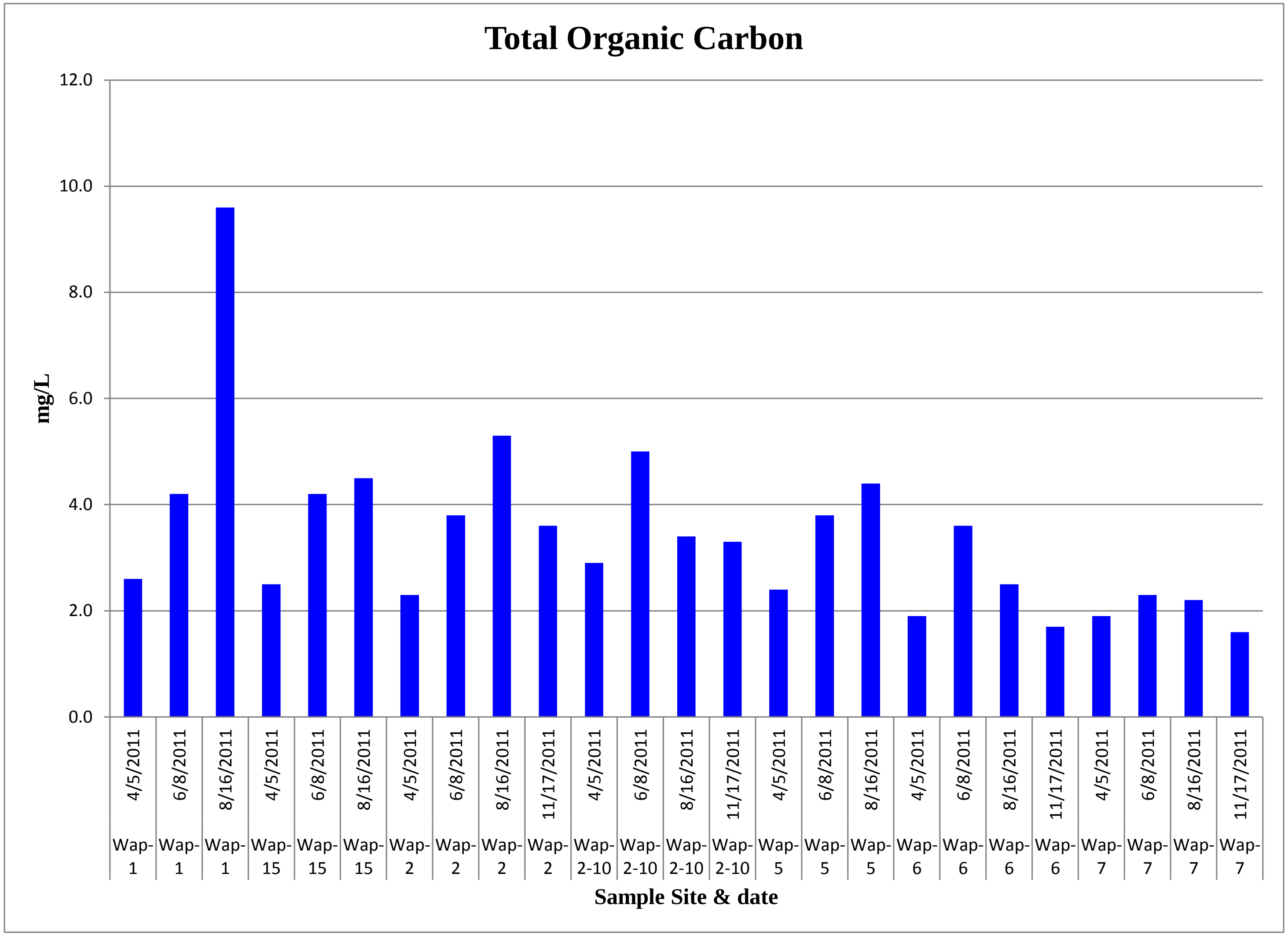
Ammonia-Nitrogen & Nitrate-Nitrogen
1.200
1.000
0.800
0.600
0.400
0.200
0.000
mg/L
Ammonia-N STD: 15mg/L
Nitrate-N STD: 10mg/L
4/5/2011
6/8/2011
8/16/2011
11/17/2011
Wap-1
Wap-15
Wap-2
Wap-2-10
Wap-5
Wap-6
Wap-7
Sample Site & Date



Orthophosphate & Total Phosphorous
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0.00
mg/L
Orthophosphate
Phosphorus, Total
STD: 0.05mg/L
4/5/2011
6/8/2011
8/16/2011
11/17/2011
Wap-1
Wap-15
Wap-2
Wap-2-10
Wap-5
Wap-6
Wap-7
Sample Site & Date

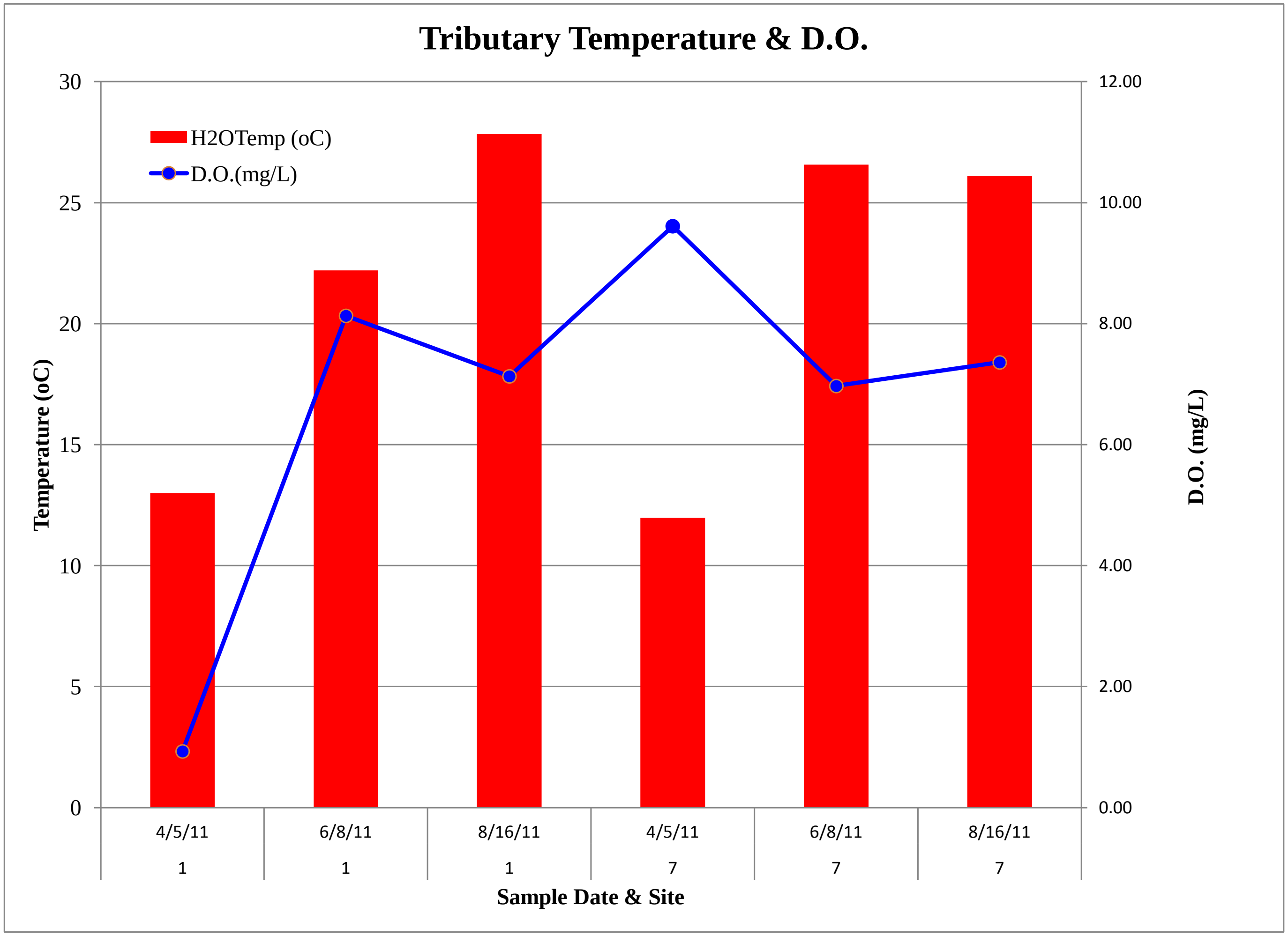

Chlorophyll & Pheophytin
mg/m3
60
50
40
30
20
10
0
Chlorophyll a
Pheophytin
4/5/2011
6/8/2011
8/16/2011
4/5/2011
6/8/2011
8/16/2011
11/17/2011
11/17/2011
4/5/2011
6/8/2011
8/16/2011
4/5/2011
6/8/2011
8/16/2011
Wap-15
Wap-15
Wap-15
Wap-2
Wap-2
Wap-2
Wap-2
Wap-2-10
Wap-5
Wap-5
Wap-5
Wap-6
Wap-6
Wap-6
Sample Site & Date

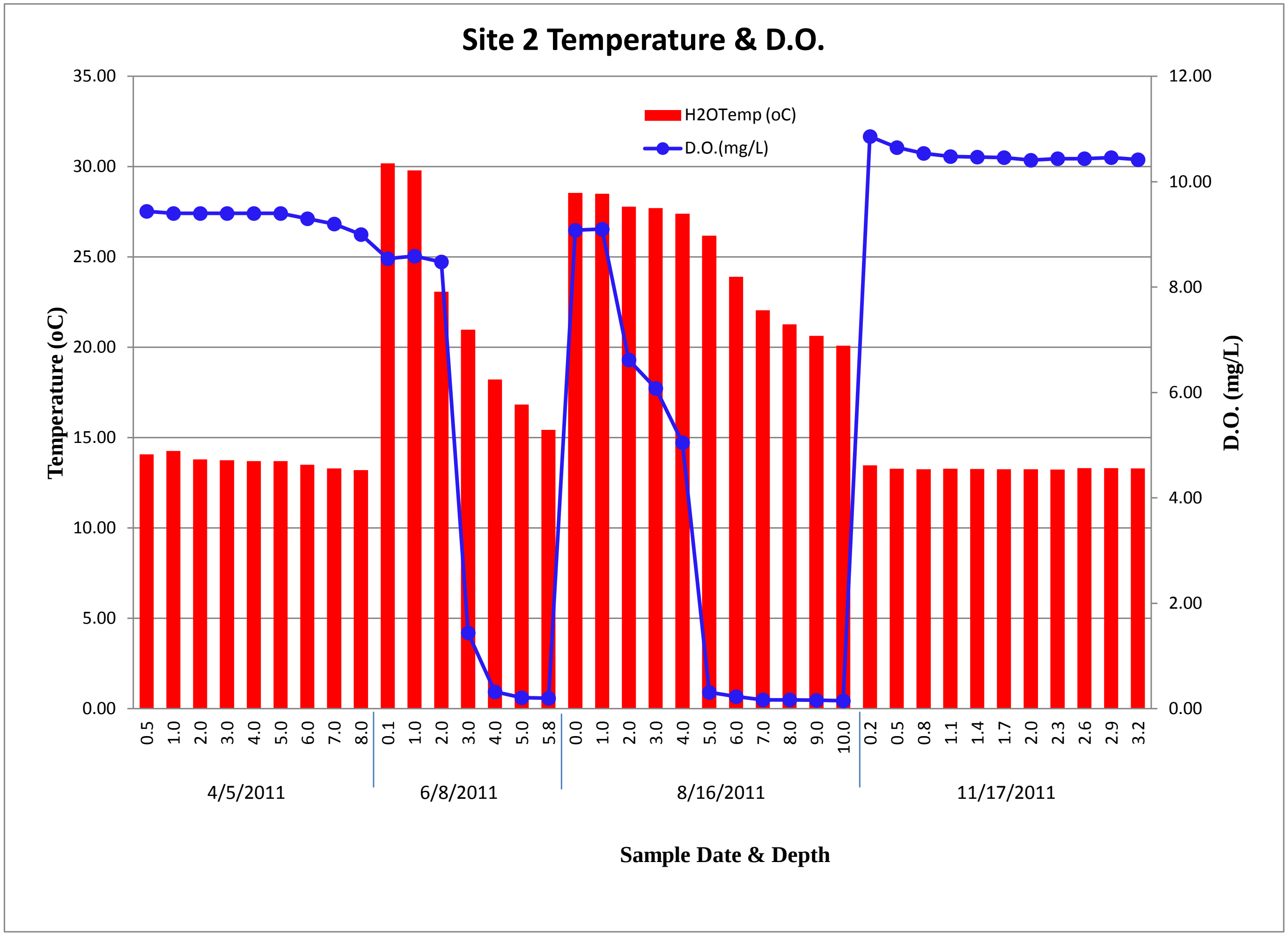

Solids
350
300
250
200
150
100
50
0
mg/L
Total Suspended Solids STD: 116mg/L (Streams); ≥12mg/L Lakes
Volatile Suspended Solids
4/5/2011
6/8/2011
8/16/2011
4/5/2011
6/8/2011
8/16/2011
4/5/2011
6/8/2011
8/16/2011
11/17/2011
4/5/2011
6/8/2011
8/16/2011
11/17/2011
4/5/2011
6/8/2011
8/16/2011
4/5/2011
6/8/2011
8/16/2011
11/17/2011
4/5/2011
6/8/2011
8/16/2011
11/17/2011
Wap-1
Wap-1
Wap-1
Wap-15
Wap-15
Wap-15
Wap-2
Wap-2
Wap-2
Wap-2
Wap-2-10
Wap-2-10
Wap-2-10
Wap-2-10
Wap-5
Wap-5
Wap-5
Wap-6
Wap-6
Wap-6
Wap-6
Wap-7
Wap-7
Wap-7
Wap-7
Sample Site & Date

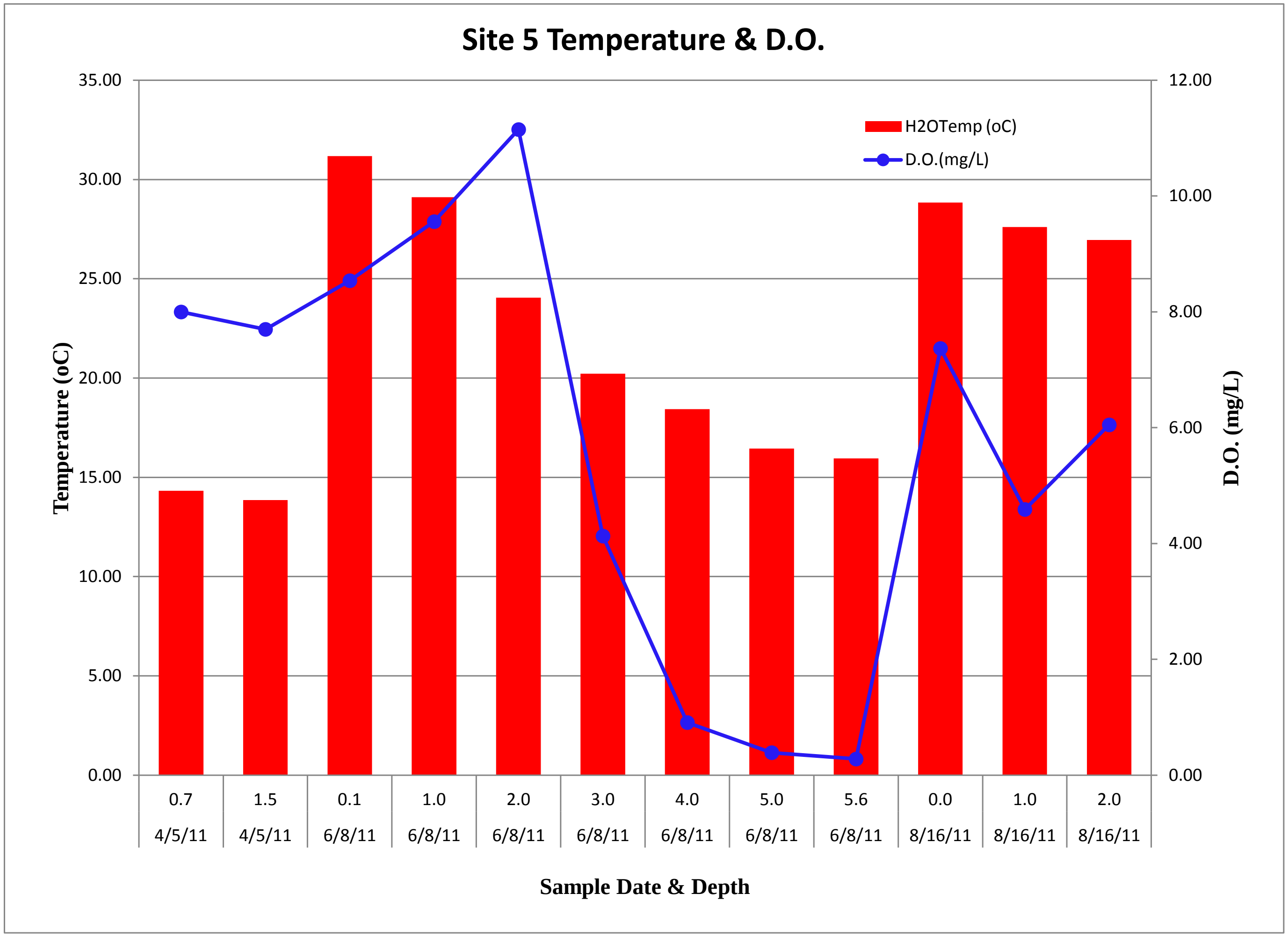

Total Organic Carbon
mg/L
12.0
10.0
8.0
6.0
4.0
2.0
0.0
4/5/2011
6/8/2011
8/16/2011
11/17/2011
Wap-1
Wap-15
Wap-2
Wap-2-10
Wap-5
Wap-6
Wap-7
Sample Site & date

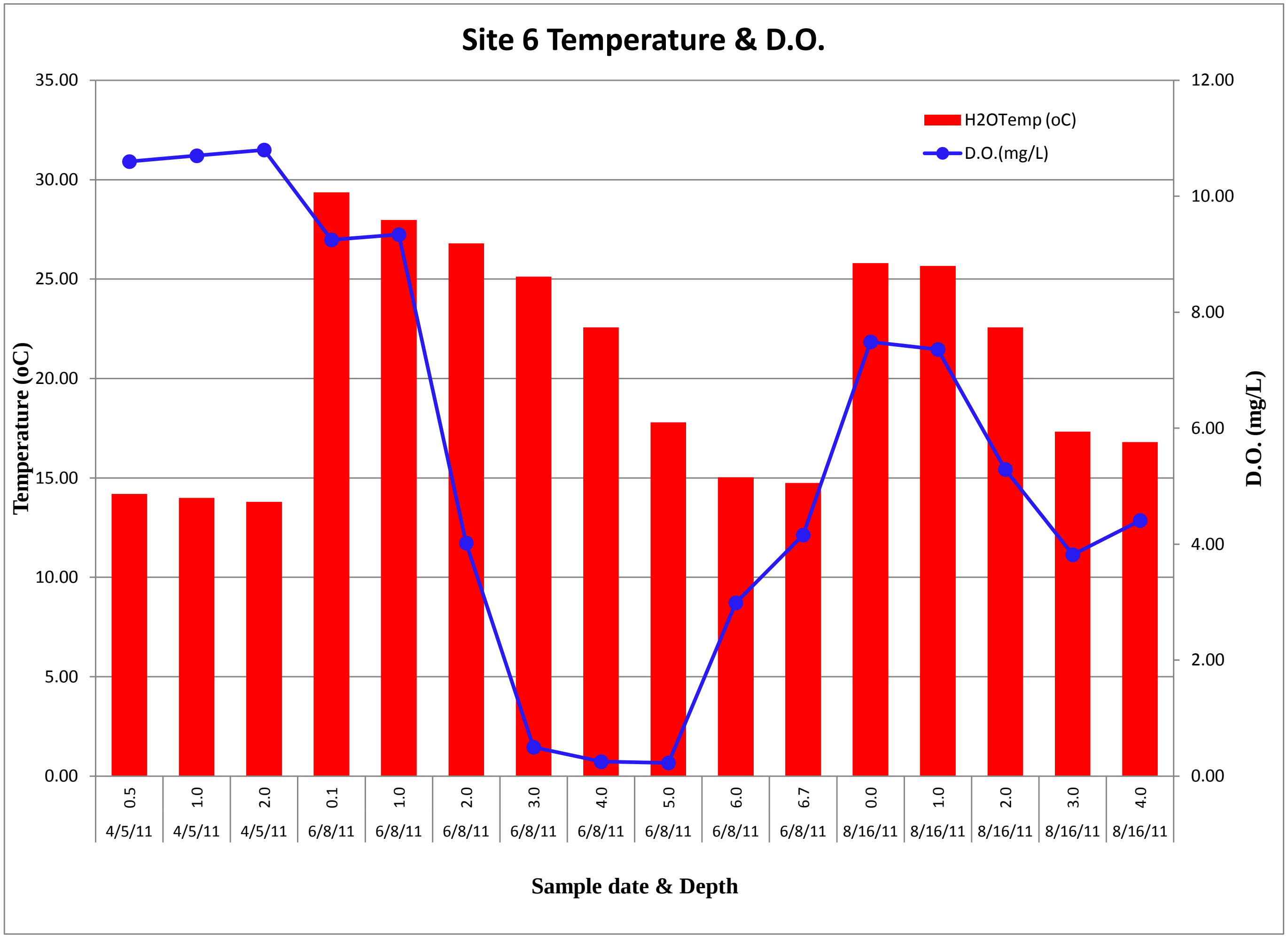
APPENDIX C

FIELD DATA GRAPHS

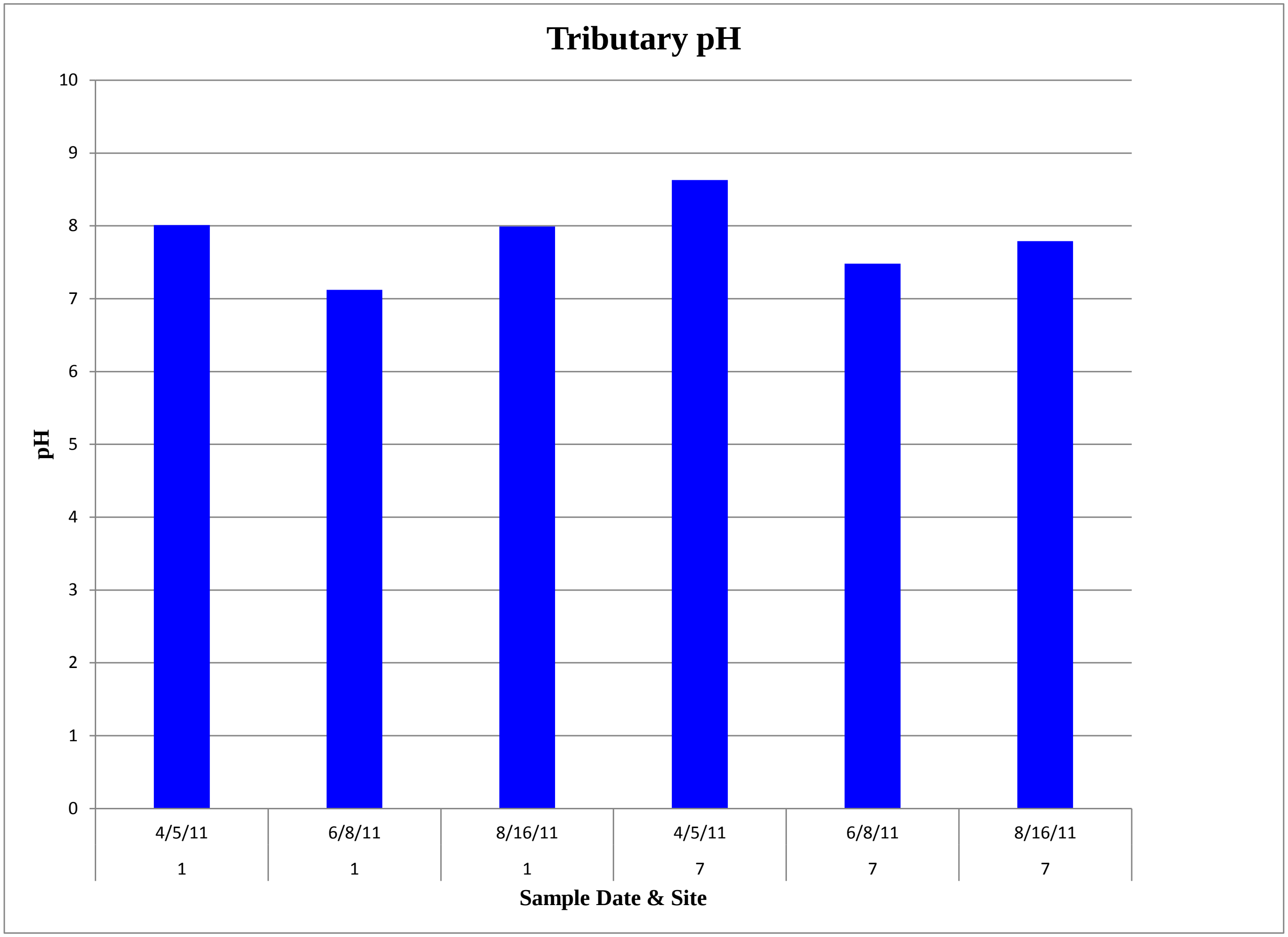

Tributary Temperature & D.O.
H2OTemp (oC)
D.O.(mg/L)
Temperature (oC)
D.O. (mg/L)
30
25
20
15
10
5
0
12.00
10.00
8.00
6.00
4.00
2.00
0.00
4/5/11
1
6/8/11
1
8/16/11
1
4/5/11
7
6/8/11
7
8/16/11
7
Sample Date & Site

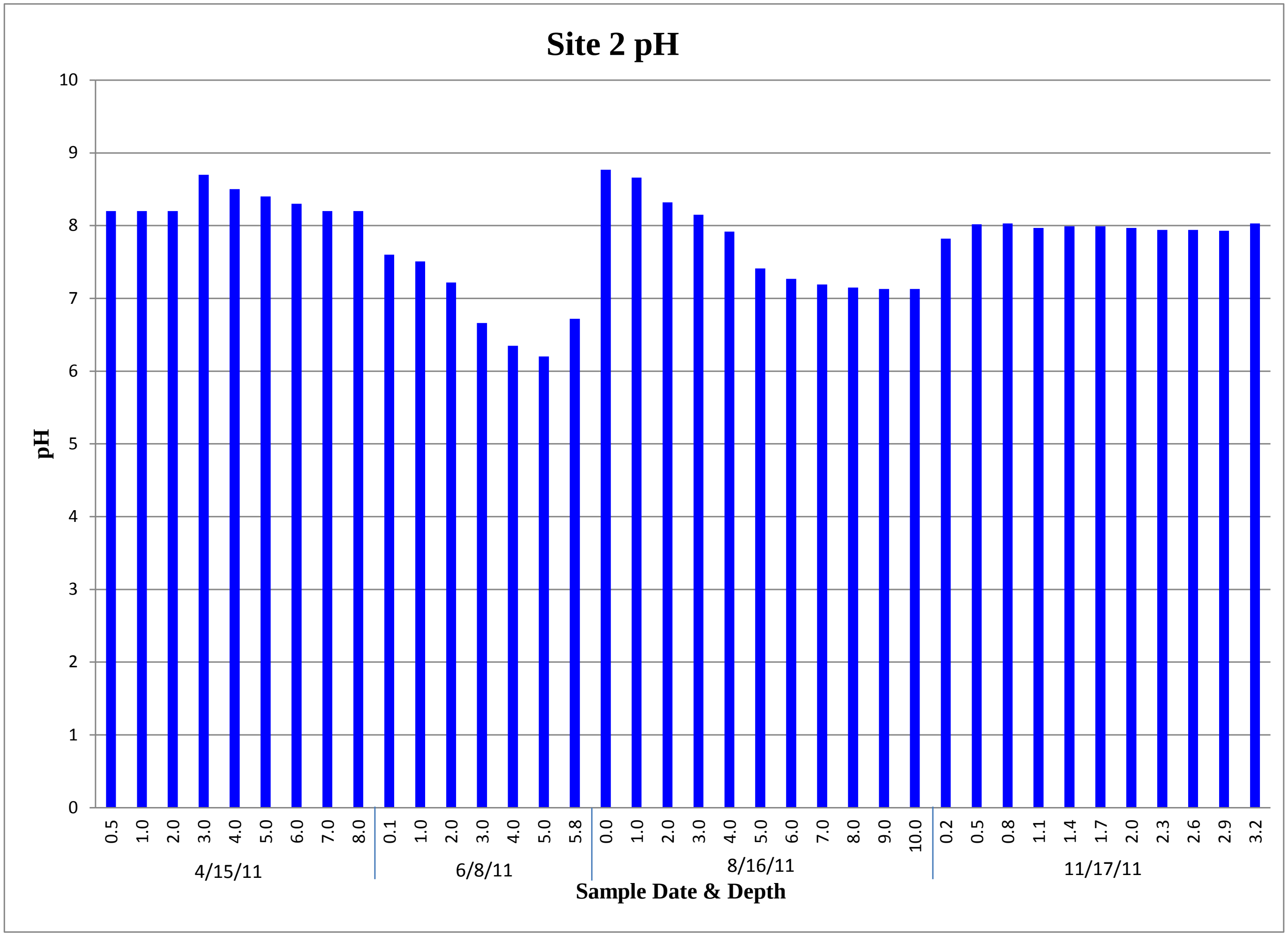

Site 2 Temperature & D.O.
H2OTemp (oC)
D.O.(mg/L)
Temperature (oC)
D.O. (mg/L)
35.00
30.00
25.00
20.00
15.00
10.00
5.00
0.00
12.00
10.00
8.00
6.00
4.00
2.00
0.00
0.5 1.0 2.0 3.0 4.0 5.0 6.0 7.0 8.0
0.1 1.0 2.0 3.0 4.0 5.0 5.8
0.0 1.0 2.0 3.0 4.0 5.0 6.0 7.0 8.0 9.0 10.0
0.2 0.5 0.8 1.1 1.4 1.7 2.0 2.3 2.6 2.9 3.2
4/5/2011
6/8/2011
8/16/2011
11/17/2011
Sample Date & Depth


Site 5 Temperature & D.O.
35.00
30.00
25.00
20.00
15.00
10.00
5.00
0.00
12.00
10.00
8.00
6.00
4.00
2.00
0.00
Temperature (oC)
D.O. (mg/L)
H2OTemp (oC)
D.O.(mg/L)
0.7 4/5/11
1.5 4/5/11
0.1 6/8/11
1.0 6/8/11
2.0 6/8/11
3.0 6/8/11
4.0 6/8/11
5.0 6/8/11
5.6 6/8/11
0.0 8/16/11
1.0 8/16/11
2.0 8/16/11
Sample Date & Depth

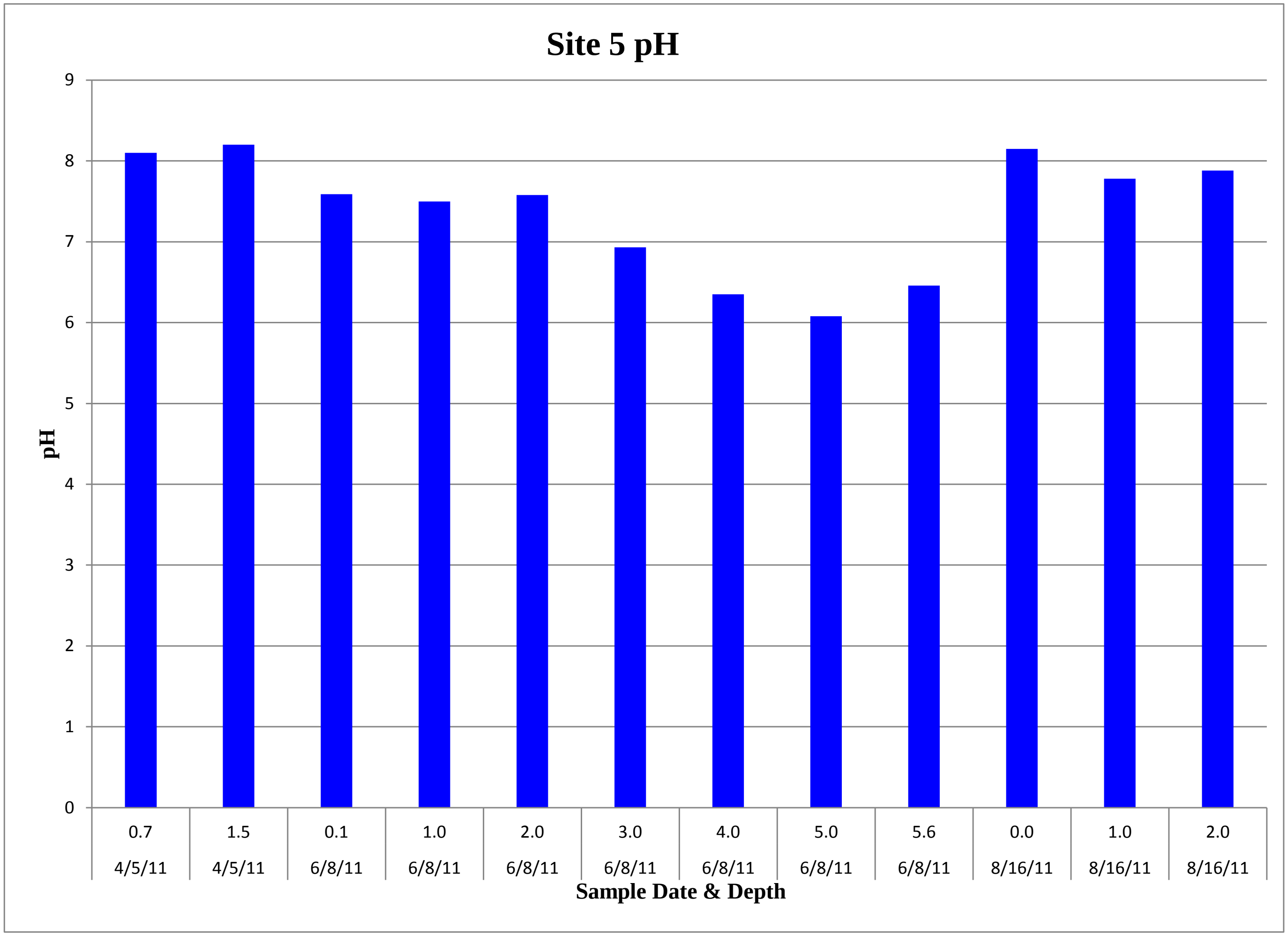


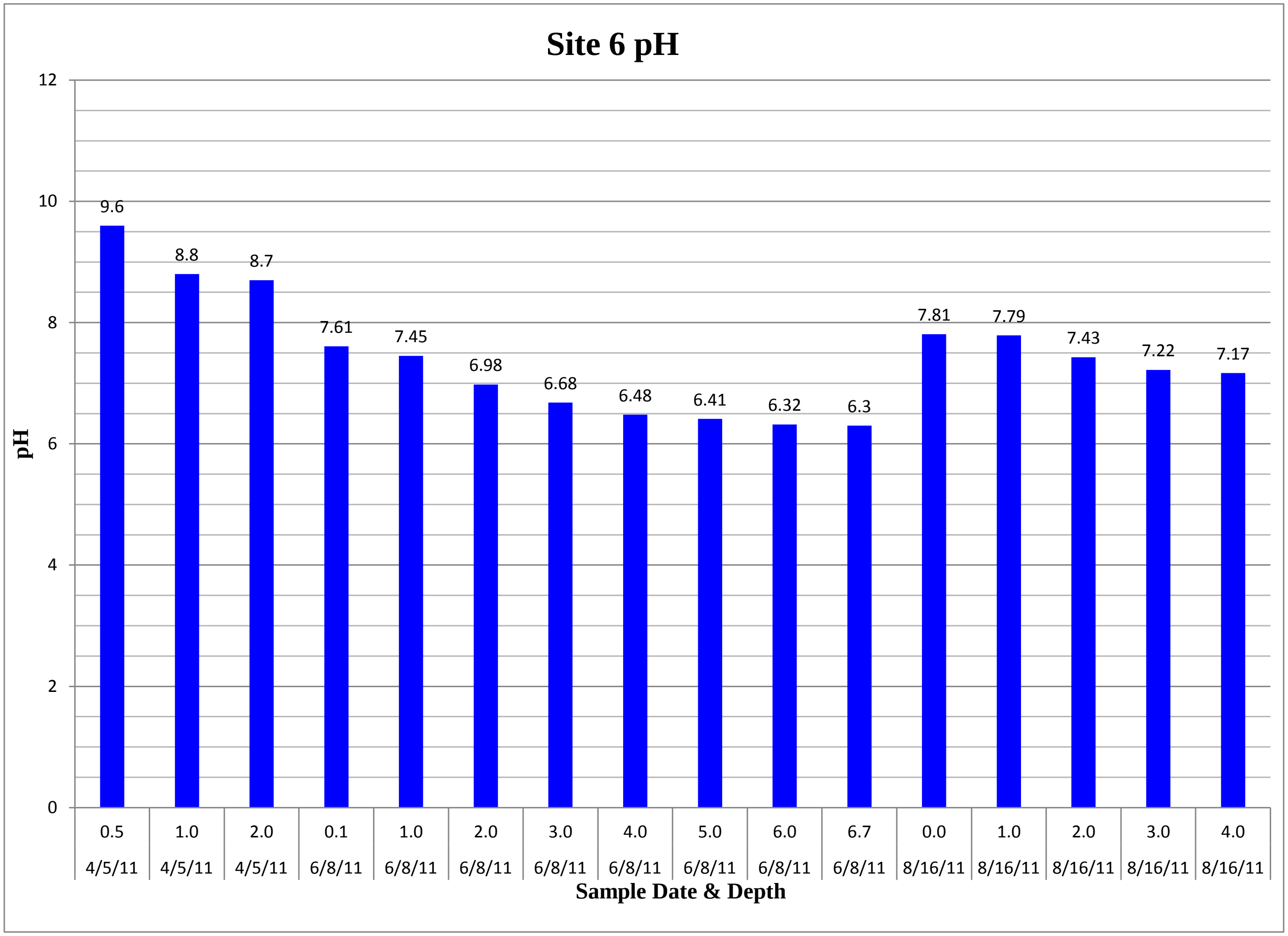
Site 6 Temperature & D.O.
H2OTemp (oC)
D.O.(mg/L)
Temperature (oC)
D.O. (mg/L)
35.00
30.00
25.00
20.00
15.00
10.00
5.00
0.00
12.00
10.00
8.00
6.00
4.00
2.00
0.00
0.5 4/5/11
1.0 4/5/11
2.0 4/5/11
0.1 6/8/11
1.0 6/8/11
2.0 6/8/11
3.0 6/8/11
4.0 6/8/11
5.0 6/8/11
6.0 6/8/11
6.7 6/8/11
0.0 8/16/11
1.0 8/16/11
2.0 8/16/11
3.0 8/16/11
4.0 8/16/11
Sample date & Depth


Tributary pH
10
9
8
7
6
5
4
3
2
1
0
pH
4/5/11
1
6/8/11
1
8/16/11
1
4/5/11
7
6/8/11
7
8/16/11
7
Sample Date & Site

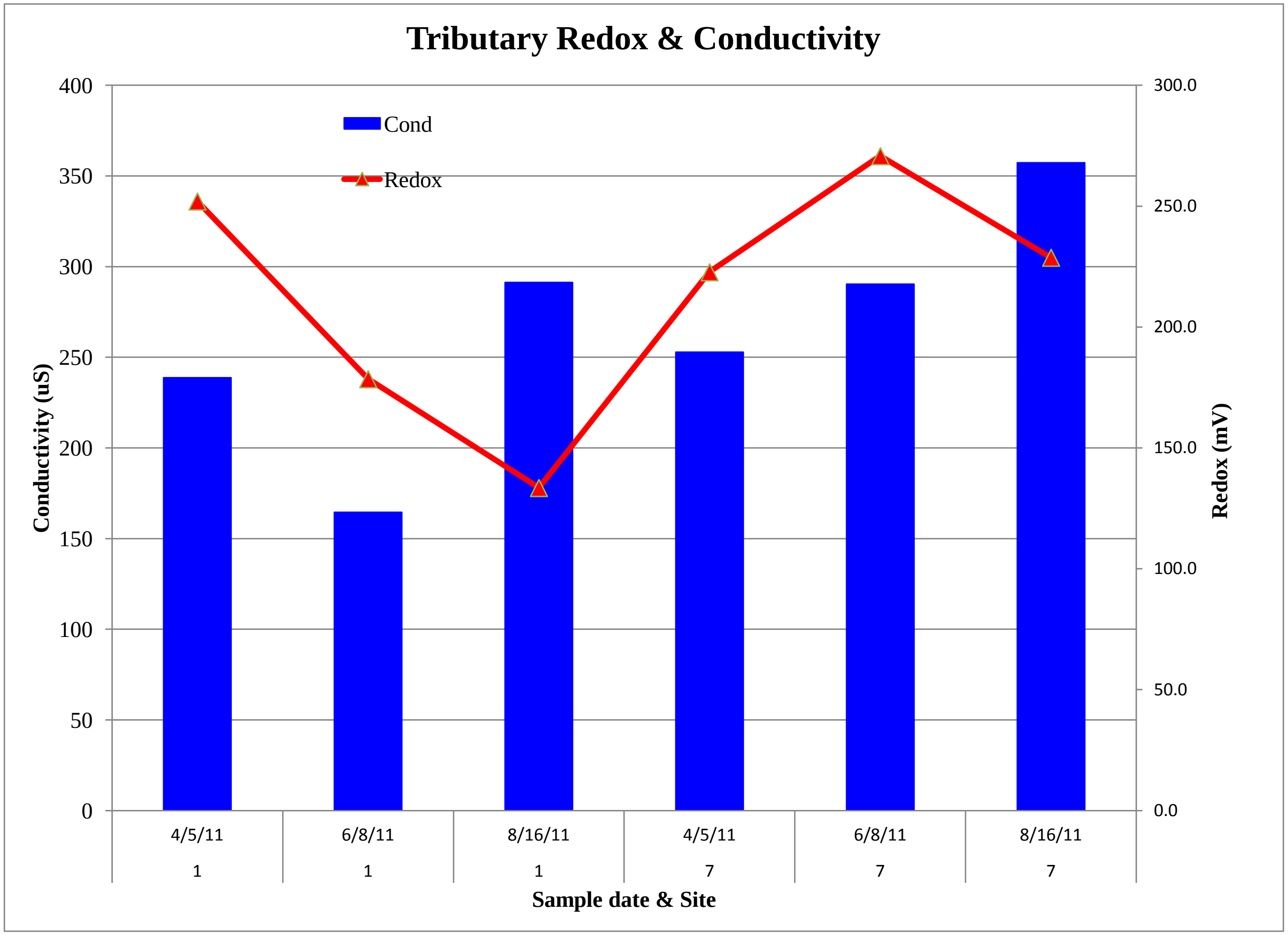


Site 2 pH
10
9
8
7
6
5
4
3
2
1
0
pH
0.5
1.0
2.0
3.0
4.0
5.0
6.0
7.0
8.0
0.1
1.0
2.0
3.0
4.0
5.0
5.8
0.0
1.0
2.0
3.0
4.0
5.0
6.0
7.0
8.0
9.0
10.0
0.2
0.5
0.8
1.1
1.4
1.7
2.0
2.3
2.6
2.9
3.2
4/15/11
6/8/11
8/16/11
11/17/11
Sample Date & Depth

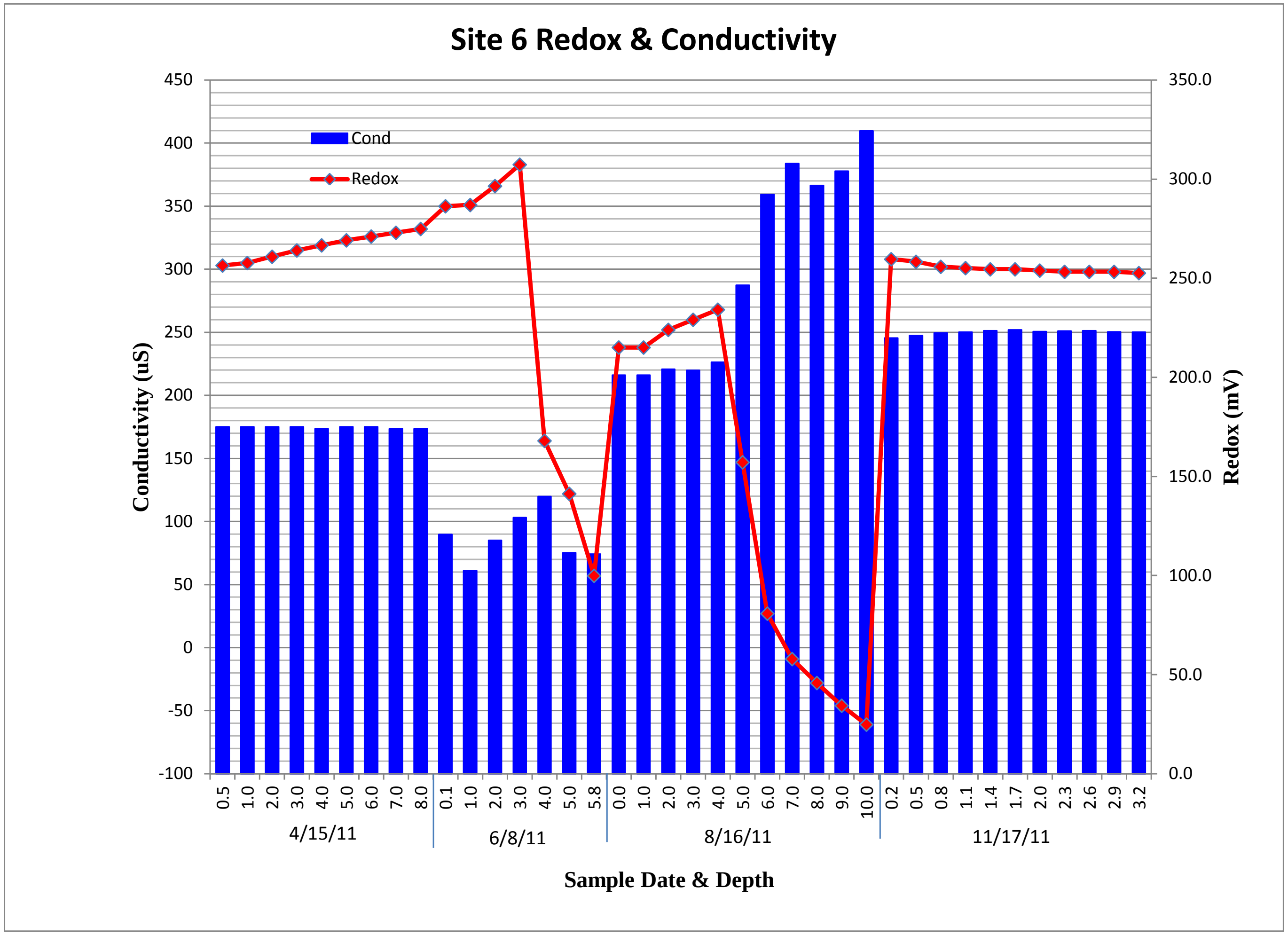

Site 5 pH
pH
9
8
7
6
5
4
3
2
1
0
0.7
4/5/11
1.5
4/5/11
0.1
6/8/11
1.0
6/8/11
2.0
6/8/11
3.0
6/8/11
4.0
6/8/11
5.0
6/8/11
5.6
6/8/11
0.0
8/16/11
1.0
8/16/11
2.0
8/16/11
Sample Date & Depth

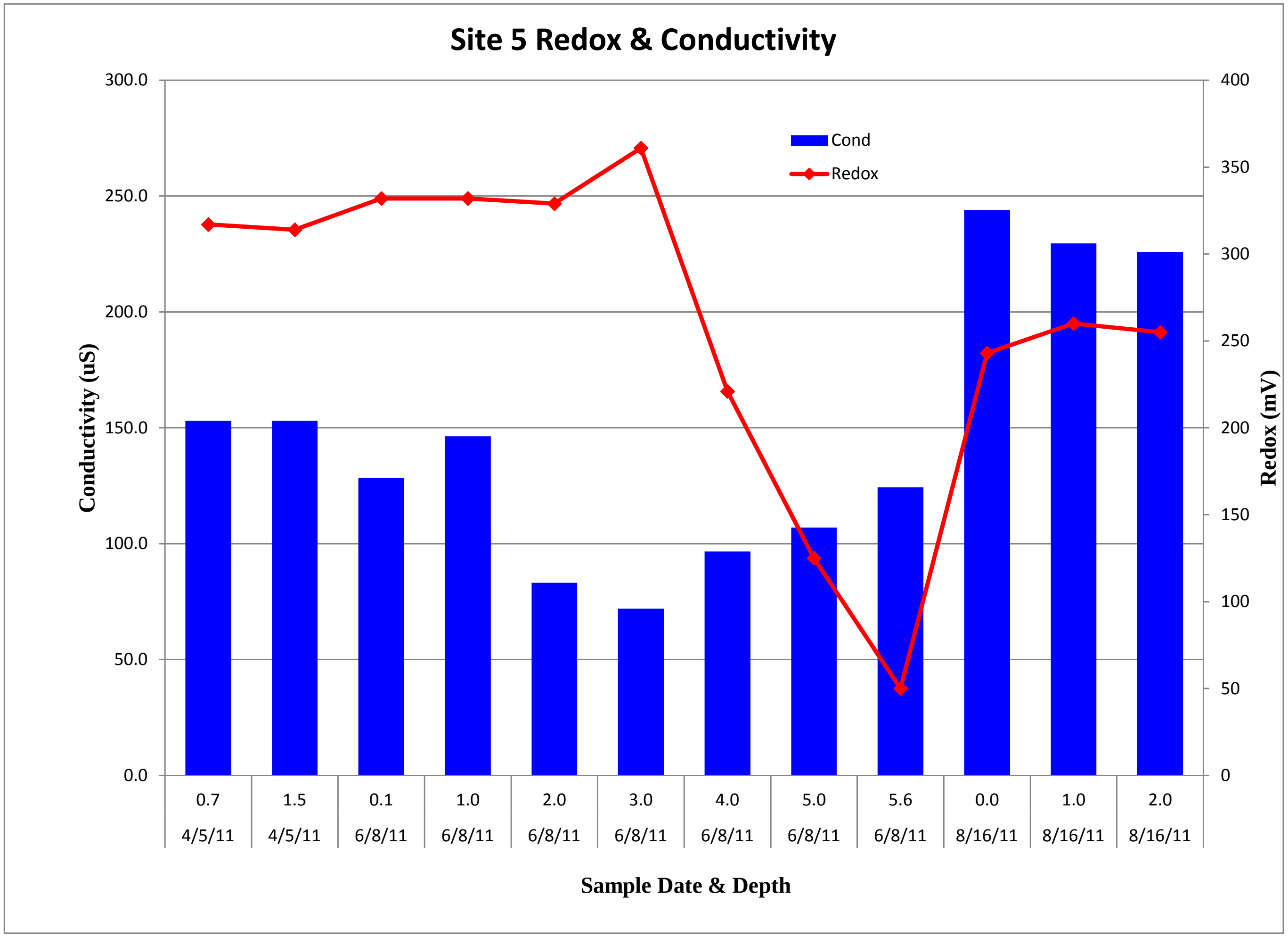


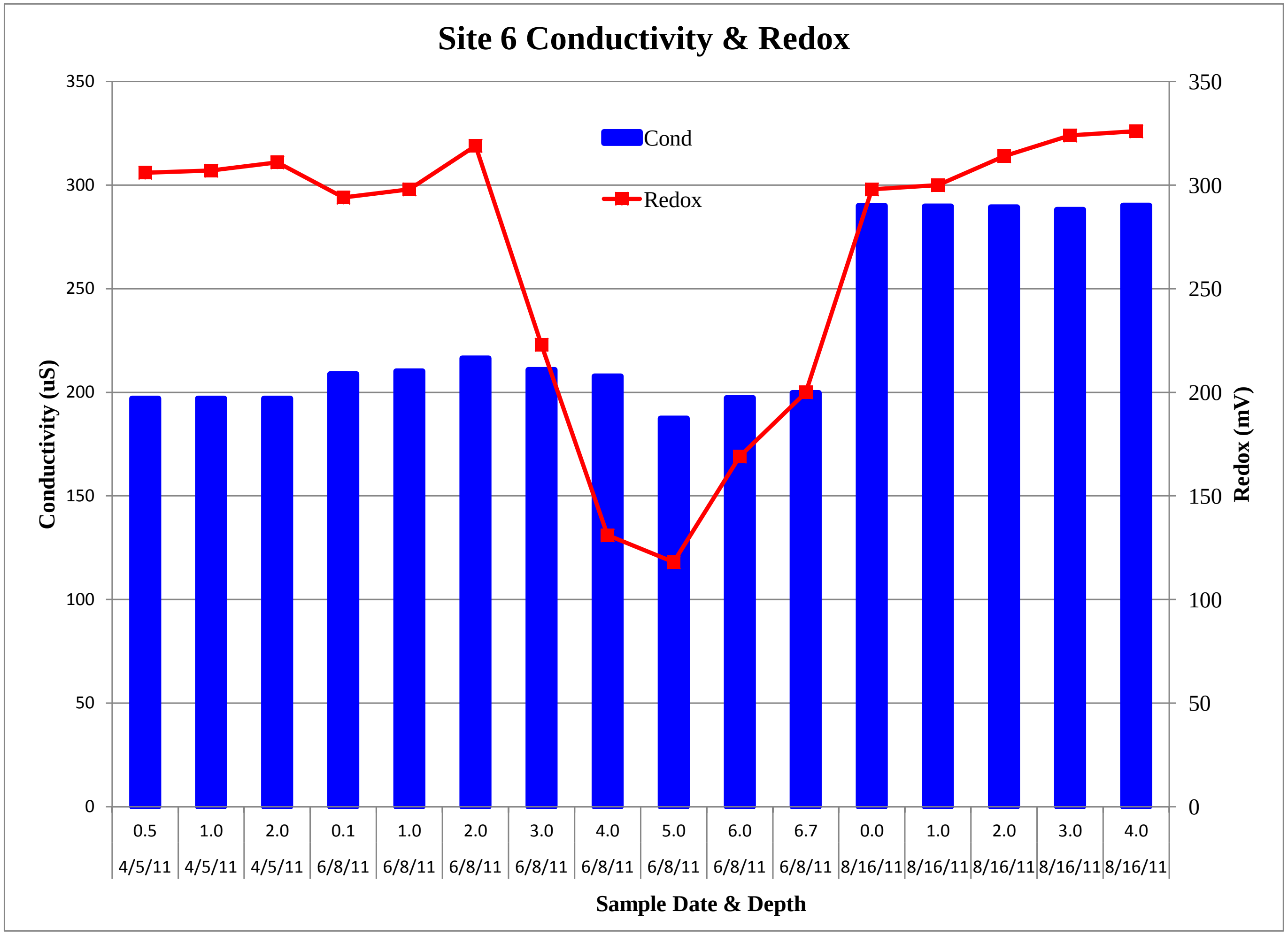
Site 6 pH
pH
Sample Date & Depth
12
10
8
6
4
2
0
9.6
8.8
8.7
7.61
7.45
6.98
6.68
6.48
6.41
6.32
6.3
7.81
7.79
7.43
7.22
7.17
0.5 4/5/11
1.0 4/5/11
2.0 4/5/11
0.1 6/8/11
1.0 6/8/11
2.0 6/8/11
3.0 6/8/11
4.0 6/8/11
5.0 6/8/11
6.0 6/8/11
6.7 6/8/11
0.0 8/16/11
1.0 8/16/11
2.0 8/16/11
3.0 8/16/11
4.0 8/16/11

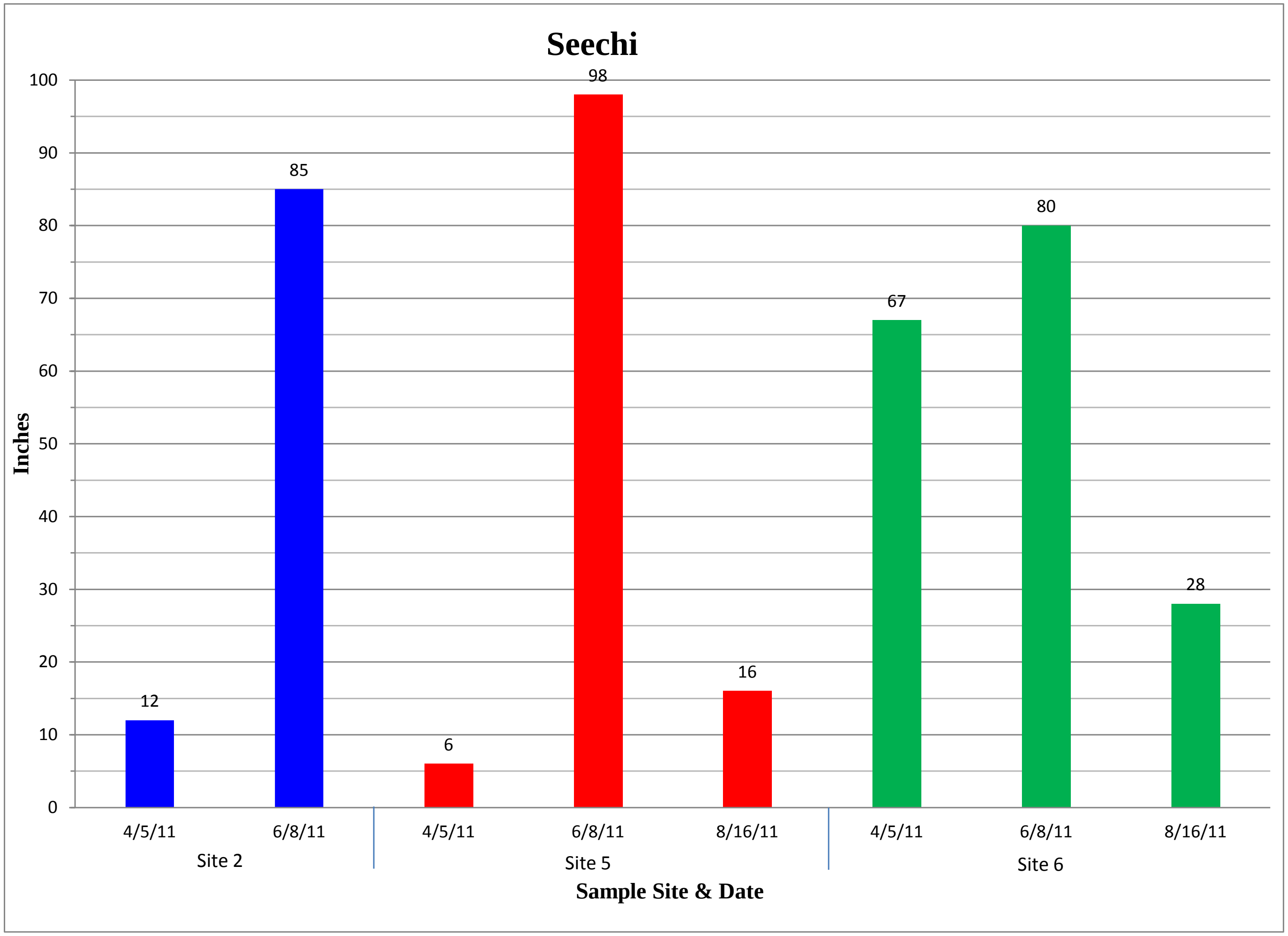


Tributary Redox & Conductivity
Cond
Redox
Conductivity (uS)
400
350
300
250
200
150
100
50
0
Redox (mV)
300.0
250.0
200.0
150.0
100.0
50.0
0.0
4/5/11 1
6/8/11 1
8/16/11 1
4/5/11 7
6/8/11 7
8/16/11 7
Sample date & Site


Site 6 Redox & Conductivity
Cond
Redox
Conductivity (uS)
Redox (mV)
450
400
350
300
250
200
150
100
50
0
-50
-100
350.0
300.0
250.0
200.0
150.0
100.0
50.0
0.0
0.5 1.0 2.0 3.0 4.0 5.0 6.0 7.0 8.0
0.1 1.0 2.0 3.0 4.0 5.0 5.8
0.0 1.0 2.0 3.0 4.0 5.0 6.0 7.0 8.0 9.0 10.0
0.2 0.5 0.8 1.1 1.4 1.7 2.0 2.3 2.6 2.9 3.2
4/15/11
6/8/11
8/16/11
11/17/11
Sample Date & Depth


Site 5 Redox & Conductivity
300.0
250.0
200.0
150.0
100.0
50.0
0.0
Conductivity (uS)
400
350
300
250
200
150
100
50
0
Redox (mV)
Cond
Redox
0.7 4/5/11
1.5 4/5/11
0.1 6/8/11
1.0 6/8/11
2.0 6/8/11
3.0 6/8/11
4.0 6/8/11
5.0 6/8/11
5.6 6/8/11
0.0 8/16/11
1.0 8/16/11
2.0 8/16/11
Sample Date & Depth


Site 6 Conductivity & Redox
Conductivity (uS)
Redox (mV)
Cond
Redox
350
300
250
200
150
100
50
0
0.5 4/5/11
1.0 4/5/11
2.0 4/5/11
0.1 6/8/11
1.0 6/8/11
2.0 6/8/11
3.0 6/8/11
4.0 6/8/11
5.0 6/8/11
6.0 6/8/11
6.7 6/8/11
0.0 8/16/11
1.0 8/16/11
2.0 8/16/11
3.0 8/16/11
4.0 8/16/11
Sample Date & Depth


Seechi
Inches
100
90
80
70
60
50
40
30
20
10
0
12
85
6
98
16
67
80
28
4/5/11
6/8/11
4/5/11
6/8/11
8/16/11
4/5/11
6/8/11
8/16/11
Site 2
Site 5
Site 6
Sample Site & Date

APPENDIX D

Lakes of Missouri Volunteer Monitoring Data

2011 Lakes of Missouri Volunteer Program (LMVP) Data

Lake Name	Site	Date	Temp	Secchi	TP	TN	CHL	ISS	Name+Site
Wappapello	1	6/8/2011	86	66	16	200	5.5	1.2	Wappapello 1
Wappapello	1	7/1/2011	83	48	24	200	7.7	1.8	Wappapello 1
Wappapello	1	7/22/2011	90	36	23	330	13.5	3	Wappapello 1
Wappapello	1	8/9/2011	84	19	49	760	44.4	7.4	Wappapello 1
Wappapello	1	9/1/2011	82	18	61	990	74.3	4.8	Wappapello 1
Wappapello	2	6/8/2011	86	66	25	280	5.9	1.6	Wappapello 2
Wappapello	2	7/1/2011	85	40	28	240	11.2	4.5	Wappapello 2
Wappapello	2	7/22/2011	91	36	47	360	23.2	9.4	Wappapello 2
Wappapello	2	8/9/2011	84	19	64	610	48.3	12.6	Wappapello 2
Wappapello	2	9/1/2011	84	13	77	930	62.9	7.8	Wappapello 2
Wappapello	3	6/8/2011	80	27	24	220	11.4	6.2	Wappapello 3
Wappapello	3	7/1/2011	80		30	130	10.7	3.7	Wappapello 3
Wappapello	3	7/22/2011	85	30	17	180	5.4	5.8	Wappapello 3
Wappapello	3	8/9/2011	80		18	190	6	3	Wappapello 3
Wappapello	3	9/1/2011		24	16	240	5.7	3.8	Wappapello 3
Wappapello	1B	6/8/2011			23	160	10.6	2.4	Wappapello 1B
Wappapello	1B	7/1/2011			35	280	17.4	7.2	Wappapello 1B
Wappapello	1B	7/22/2011			25	280	14	3.6	Wappapello 1B
Wappapello	1B	8/9/2011			46	520	52.1	7.2	Wappapello 1B
Wappapello	1B	9/1/2011			62	880	78.1	9.6	Wappapello 1B
Wappapello	2B	6/8/2011			27	290	13.1	2.4	Wappapello 2B
Wappapello	2B	7/1/2011			49	310	20.7	14	Wappapello 2B
Wappapello	2B	7/22/2011			45	400	24.1	8.8	Wappapello 2B
Wappapello	2B	8/9/2011			62	710	57.1	11.6	Wappapello 2B
Wappapello	2B	9/1/2011			78	920	78.5	10	Wappapello 2B

Site 1 - Near Dam

Site 1b - Near Dam bottom

Site 2 Sanderson Pt. at Lost Creek

Site 2b - Sanderson Pt. at Lost Creek near bottom

Site 3 - Hwy 34 bridge

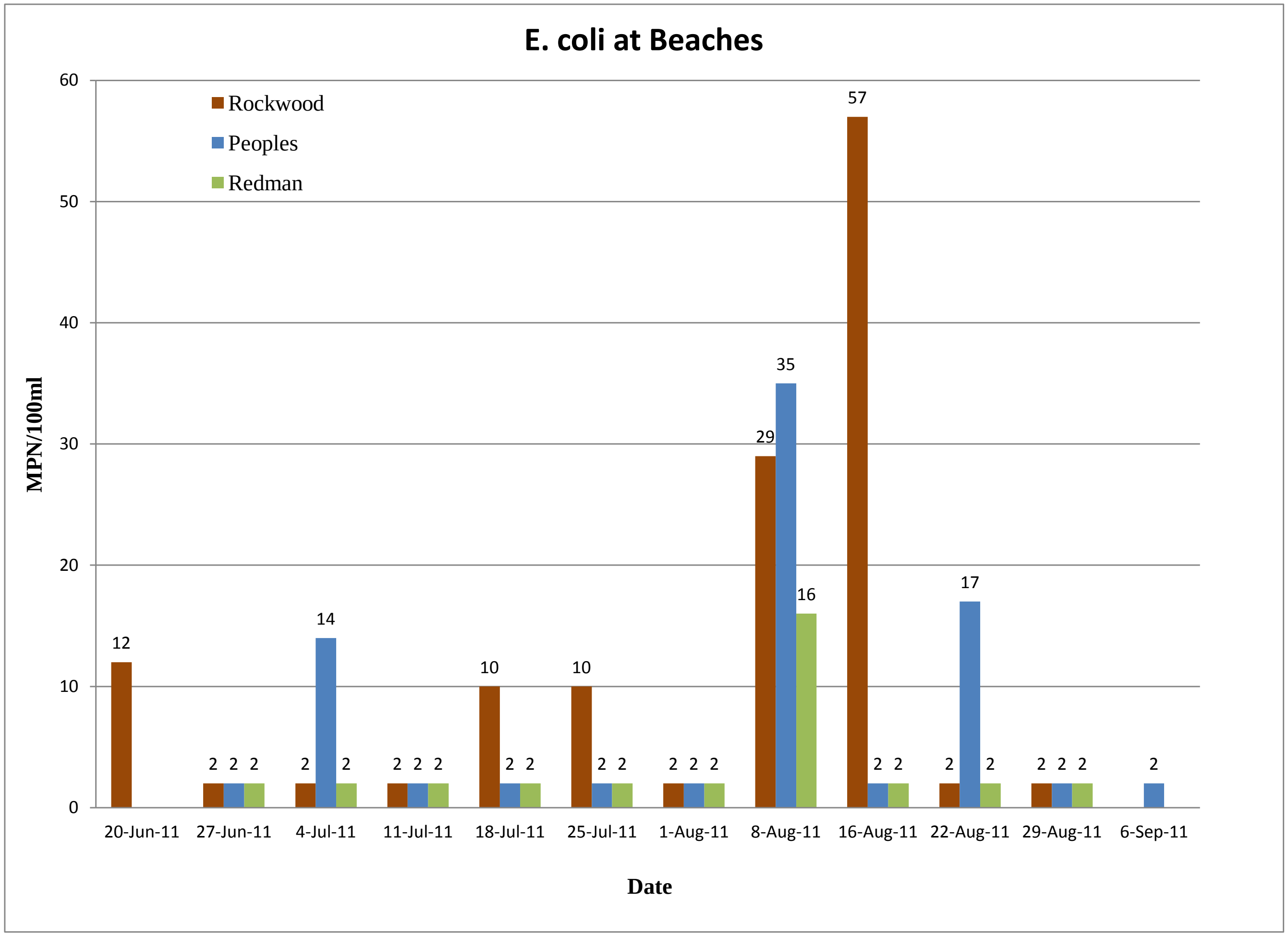
Parameter	Abbreviation	Unit of Measure
Water Clarity (using Secchi disk)	Secchi	Inches (“)
Total Phosphorus	TP	Micrograms per liter (ug/L) or parts per billion (ppb)
Total Nitrogen	TN	Micrograms per liter (ug/L) or parts per billion (ppb)
Chlorophyll	CHL	Micrograms per liter (ug/L) or parts per billion (ppb)
Inorganic Suspended Sediments	ISS	Milligrams per liter (mg/L), or parts per million (ppm) 1mg = 1000 ug
Total Suspended Sediments	TSS	Milligrams per liter (mg/L), or parts per million (ppm) 1mg = 1000 ug

Full report for all lakes in the LMVP can be found at http://www.lmvp.org/lakes.htm.

APPENDIX E

Beach Data & Graphs

	E. coli Beach Samples				
Week	Water Temp	Rockwood	Peoples	Redman	48 Hr Rain
20-Jun-11	81	12			0.18
27-Jun-11	82	2	2	2	0
4-Jul-11	85	2	14	2	0
11-Jul-11	92	2	2	2	0
18-Jul-11	92	10	**2**	2	0
25-Jul-11	92	10	2	2	0.42
1-Aug-11	91	2	2	2	0
8-Aug-11	85	29	35	16	1.75
16-Aug-11	82	57	2	2	0.5
22-Aug-11	86	2	17	2	0.04
29-Aug-11	88	2	2	2	0
6-Sep-11	77		2		0


E. coli at Beaches
Rockwood
Peoples
Redman
MPN/100ml
Date
0
10
20
30
40
50
60
20-Jun-11
27-Jun-11
4-Jul-11
11-Jul-11
18-Jul-11
25-Jul-11
1-Aug-11
8-Aug-11
16-Aug-11
22-Aug-11
29-Aug-11
6-Sep-11
12
2 2 2
2 14 2
2 2 2
10 2 2
10 2 2
2 2 2
29 35 16
57 2 2
2 17 2
2 2 2
2