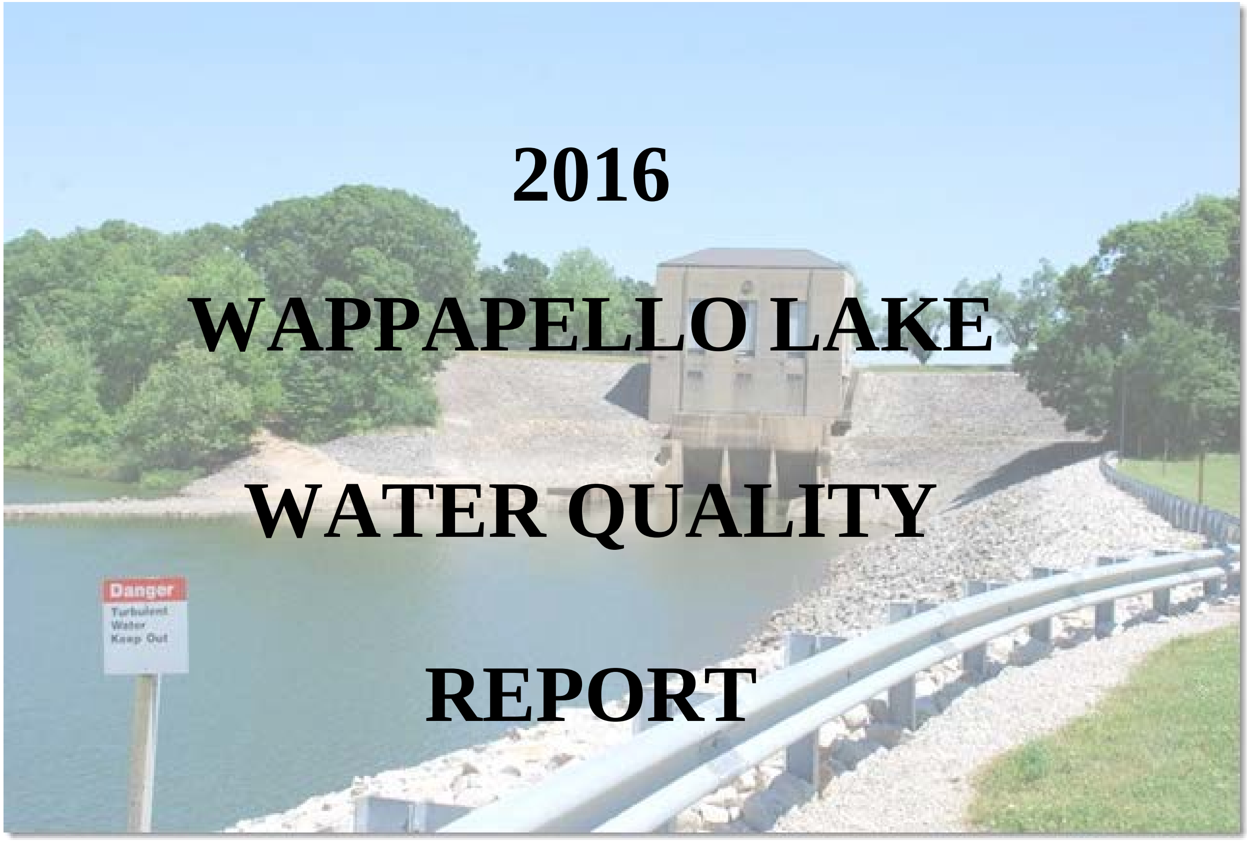
2016

WAPPAPELLO LAKE

WATER QUALITY

REPORT



U.S. ARMY CORPS OF ENGINEERS, ST. LOUIS DISTRICT
ENVIRONMENTAL QUALITY 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 roads, 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 2016 except the phosphorous levels. Phosphorous levels at the lake sites except site 6 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

1.1 GENERAL OVERVIEW

This report summarizes water quality activities of the St. Louis District for Fiscal Year 2016 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 to 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 to 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 Lakes of Missouri Volunteer Program (LMVP) in cooperation with the University of Missouri-Columbia has been taking samples at 3 sites since 1989. The LMVP only analyze for Nutrients and Chlorophyll. In 2016, the LMVP sampled three sites 3 times. See appendix D for data.

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 2016 water quality report compiled by the Missouri Department of Natural Resources list the upper St. Francis River as impaired for temperature. 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.

1.2 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 2016 at five sites to assure that safe conditions were maintained for human recreation, wildlife, and aquatic life. 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 4 marinas. One of the five sites was selected as a quality control duplicate site during each sampling event and was denoted as WAP-15. Three water quality sampling events took place during 2016, between April and September. The locations of the five sampling sites are depicted on the lake map in Figure 1.

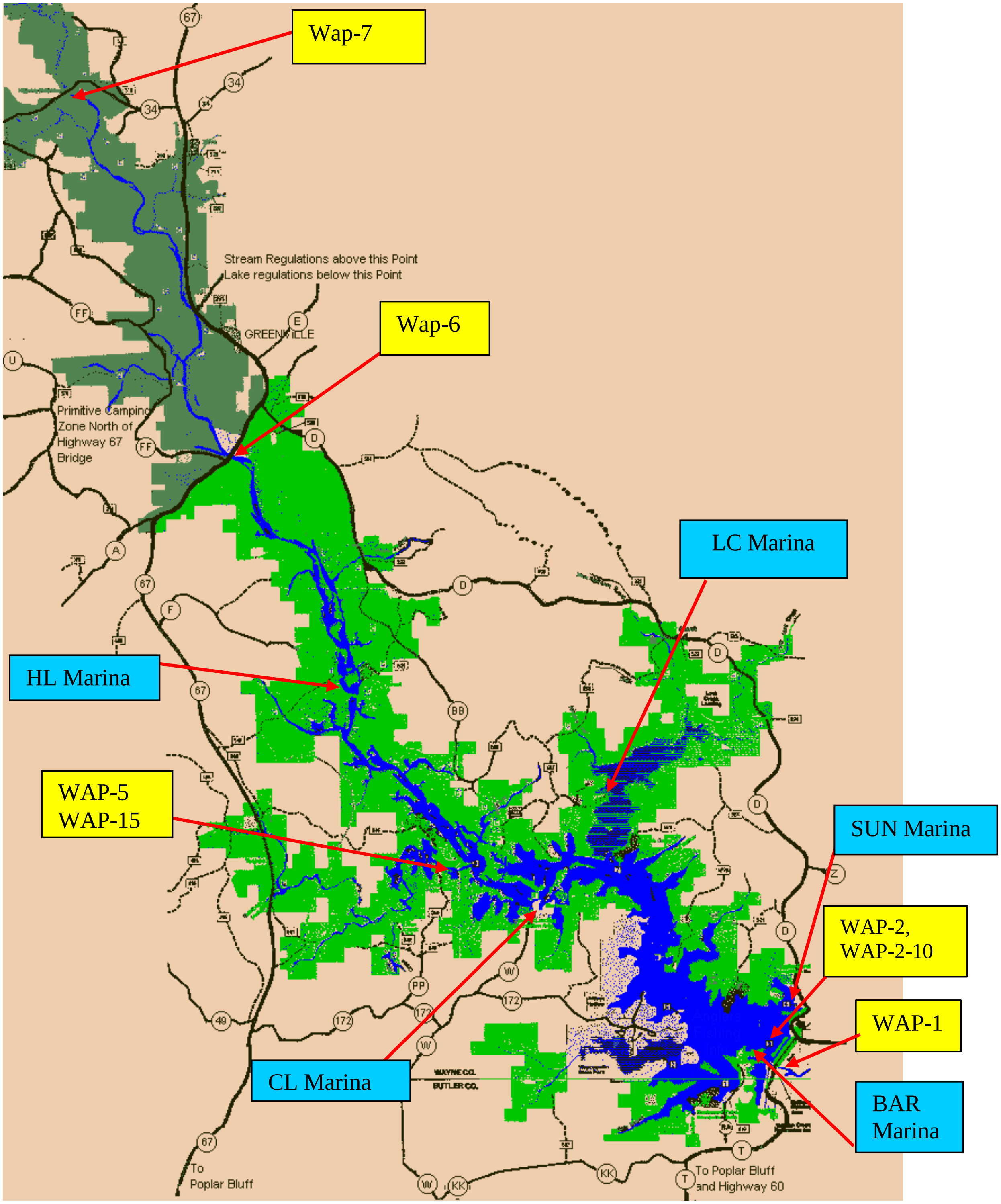


Figure 1
Location of sample sites

2.1 WATER QUALITY ASSESSMENT CRITERIA

2.2 Water Quality

The water quality assessment criteria, which has been generally accepted criteria for sustaining adequate aquatic plant and animal growth were based upon the State of Missouri regulatory limits for certain contaminants. 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 2016 sampling 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), escherichia coliform (E. coli), pH, temperature, dissolved oxygen, specific conductance, oxidation-reduction potential (ORP), chlorophyll, and pheophytin-a.

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 where a limit has been established for the parameters analyzed.

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, decreases 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 total suspended solids (TSS) increases, 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), that consist of organic material and nonvolatile suspended solids (NVSS) which are comprised of inorganic mineral particles in the water. In order to more accurately determine the types and amounts of 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 are 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, IEPA suggests that NVSS above 15mg/L could highly impair recreational lake use. 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 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 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 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. Positive readings indicate increased oxidizing potential and negative readings 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: (1) color of water, (2) amount of phytoplankton in the water column, and (3) amount of inorganic material in the water column. Secchi depth integrates the combined impacts of all three of these factors. Water transparency was measured using a Secchi disk. Secchi disk readings were taken at all lake sites.

2.3 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, and 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 to selenium affecting reproductive success.

3.1 SUMMARY OF MONITORING RESULTS

3.2 Water Quality Summary

The monitoring program for Wappapello Lake during Fiscal Year 2016 revealed good water quality when compared to limits established by the MDNR 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 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. On July 29 Peoples Beach E. coli exceeded the 235 standard. Records indicate a light rain shower occurred on the previous day and sample date which may have attributed to this elevated reading. Follow up samples were taken and the results were within the state standard. All other samples were within the Missouri standards set for beaches. Beach data is located in Appendix E.

Total iron and total manganese are sampled above the dam near the bottom of the original 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 cycling is a function of oxidation-reduction processes. Elevated iron levels were detected on June 23 and September 15 at WAP-2-10. 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. Elevated manganese levels were detected at sites WAP-1 and at WAP-2-10 for all sampling events. 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. All sites in April exceeded the 0.05 mg/L phosphorous standard. Sites WAP-1, and WAP-2 exceeded the 0.05 mg/L phosphorous standard on June 23. 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. 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 2016. Nitrogen levels were relatively stable throughout the sampling period for all sites ranging from 0.05 to 0.10. The highest spikes in ammonia nitrogen occurred in April at WAP-1 and June and September at WAP-2-10. Normally Nitrate-Nitrogen, Ammonia-Nitrogen, and Phosphorus 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. Chlorophyll is monitored to provide indicators of algae growth and therefore, potential oxygen depletion activity. Chlorophyll concentrations and cyanobacteria cell counts serve as proxies for the actual presence of algal toxins. Exposure to cyanobacteria or their toxins may produce allergic reactions such as skin rashes, eye irritations, respiratory symptoms, and in some cases more severe health effects. Microcystin is currently believed to be the most common cyanotoxin in lakes. EPA's current guidance as of December 2016 for recreational Ambient Water Quality Criteria (AWQC) for Cyanotoxins is 4ug/L for microcystins and 8ug/L for Cylindrospermopsin. Wappapello lake was in the moderate risk of exposure category for chlorophyll. 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. 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. Solids were high after a rainfall event in April.

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.

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.

Water coming into the lake is very clear, as can be seen from the secchi disk readings for site 6. Site 5 in Otter Creek normally has the lowest readings due to the composition of the creek banks, but had the highest reading in June. The cause of this high reading may be due to no rain fall events prior to this sampling event. Secchi disk reading were lower in April and September due to rain events prior to these dates. The readings improved at the dam. This is most likely the result of sediments dropping out of the water column as the water moves down the lake toward the dam.

The monitoring program for Wappapello Lake during Fiscal Year 2016 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.

3.3 Sediment Summary

Sediment sampling was not conducted in 2016. Sediment sampling is normally conducted approximately every 5 years if funding is available. Sediment sampling was last conducted in 2007.

4.0 PLANNED 2017 STUDIES

The Wappapello Lake water quality monitoring program will continue in Fiscal Year 2017 on a limited basis. A slight increase in funding will allow 4 sampling events in 2017. 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 events are planned to be conducted between April and August in 2017. 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 4 marinas. This combination of sites effectively represents the incoming contaminants and their effects on the lake.

Sediment sampling will be conducted if funding is available.

APPENDIX A

DATA

LAB DATA

Water Samples

Site	Collection Date	Parameter	Flag	Reported Result	MDL	PQL	Units
WAP-1	4/12/2016	Ammonia Nitrogen		0.43	0.030	0.030	MG/L
WAP-2	4/12/2016	Ammonia Nitrogen		0.097	0.030	0.030	MG/L
WAP-2-10	4/12/2016	Ammonia Nitrogen		0.089	0.030	0.030	MG/L
WAP-5	4/12/2016	Ammonia Nitrogen		0.065	0.030	0.030	MG/L
WAP-6	4/12/2016	Ammonia Nitrogen		0.064	0.030	0.030	MG/L
WAP-7	4/12/2016	Ammonia Nitrogen		0.082	0.030	0.030	MG/L
WAP-15	4/12/2016	Ammonia Nitrogen		0.092	0.030	0.030	MG/L
WAP-1	9/15/2016	Ammonia Nitrogen		0.13	0.030	0.030	MG/L
WAP-2	9/15/2016	Ammonia Nitrogen		0.078	0.030	0.030	MG/L
WAP-2-10	9/15/2016	Ammonia Nitrogen		0.38	0.030	0.030	MG/L
WAP-5	9/15/2016	Ammonia Nitrogen		0.069	0.030	0.030	MG/L
WAP-6	9/15/2016	Ammonia Nitrogen		0.071	0.030	0.030	MG/L
WAP-7	9/15/2016	Ammonia Nitrogen		0.089	0.030	0.030	MG/L
WAP-15	9/15/2016	Ammonia Nitrogen		0.090	0.030	0.030	MG/L
WAP-1	6/23/2016	Ammonia Nitrogen		0.042	0.030	0.030	MG/L
WAP-2	6/23/2016	Ammonia Nitrogen	<	0.030	0.030	0.030	MG/L
WAP-2-10	6/23/2016	Ammonia Nitrogen		0.23	0.030	0.030	MG/L
WAP-5	6/23/2016	Ammonia Nitrogen		0.039	0.030	0.030	MG/L
WAP-6	6/23/2016	Ammonia Nitrogen	<	0.030	0.030	0.030	MG/L
WAP-7	6/23/2016	Ammonia Nitrogen		0.044	0.030	0.030	MG/L
WAP-15	6/23/2016	Ammonia Nitrogen		0.031	0.030	0.030	MG/L
WAP-2	4/12/2016	Chlorophyll a		17.6	2.0	2.0	MG/CU.M.
WAP-5	4/12/2016	Chlorophyll a		11.6	2.0	2.0	MG/CU.M.
WAP-6	4/12/2016	Chlorophyll a		11.4	2.0	2.0	MG/CU.M.
WAP-15	4/12/2016	Chlorophyll a		10.9	2.0	2.0	MG/CU.M.
WAP-2	9/15/2016	Chlorophyll a		9.7	1.0	1.0	MG/CU.M.
WAP-5	9/15/2016	Chlorophyll a		21.4	1.0	1.0	MG/CU.M.
WAP-6	9/15/2016	Chlorophyll a		15.4	1.0	1.0	MG/CU.M.
WAP-15	9/15/2016	Chlorophyll a		21.4	1.0	1.0	MG/CU.M.
WAP-2	6/23/2016	Chlorophyll a		7.3	2.0	2.0	MG/CU.M.
WAP-5	6/23/2016	Chlorophyll a		2.1	2.0	2.0	MG/CU.M.

Site	Collection Date	Parameter	Flag	Reported Result	MDL	PQL	Units
WAP-6	6/23/2016	Chlorophyll a		17.8	2.0	2.0	MG/CU.M.
WAP-15	6/23/2016	Chlorophyll a		9.2	2.0	2.0	MG/CU.M.
SUN MARINA	9/15/2016	E. Coliform		5.0	1.0	1.0	COL/100 ML
BAR-MARINA	9/15/2016	E. Coliform		2.0	1.0	1.0	COL/100 ML
LC-MARINA	9/15/2016	E. Coliform		8.0	1.0	1.0	COL/100 ML
CL-MARINA	9/15/2016	E. Coliform		6.0	1.0	1.0	COL/100 ML
SUN MARINA	6/23/2016	E. Coliform	<	1.0	1.0	1.0	COL/100 ML
BAR-MARINA	6/23/2016	E. Coliform		3.0	1.0	1.0	COL/100 ML
LC-MARINA	6/23/2016	E. Coliform		1.0	1.0	1.0	COL/100 ML
CL-MARINA	6/23/2016	E. Coliform		21.0	1.0	1.0	COL/100 ML
WAP-1	4/12/2016	Iron		0.81	0.050	0.10	MG/L
WAP-2-10	4/12/2016	Iron		0.71	0.050	0.10	MG/L
WAP-1	9/15/2016	Iron		0.50	0.050	0.10	MG/L
WAP-2-10	9/15/2016	Iron		2.8	0.050	0.10	MG/L
WAP-1	6/23/2016	Iron		0.56	0.050	0.10	MG/L
WAP-2-10	6/23/2016	Iron		2.2	0.050	0.10	MG/L
WAP-1	4/12/2016	Manganese		0.13	0.0050	0.010	MG/L
WAP-2-10	4/12/2016	Manganese		0.11	0.0050	0.010	MG/L
WAP-1	9/15/2016	Manganese		0.68	0.0050	0.010	MG/L
WAP-2-10	9/15/2016	Manganese		2.1	0.0050	0.010	MG/L
WAP-1	6/23/2016	Manganese		0.73	0.0050	0.010	MG/L
WAP-2-10	6/23/2016	Manganese		2.9	0.0050	0.010	MG/L
WAP-1	4/12/2016	Nitrate as Nitrogen		0.044	0.040	0.040	MG/L
WAP-2	4/12/2016	Nitrate as Nitrogen		0.054	0.040	0.040	MG/L
WAP-2-10	4/12/2016	Nitrate as Nitrogen		0.080	0.040	0.040	MG/L
WAP-5	4/12/2016	Nitrate as Nitrogen		0.056	0.040	0.040	MG/L
WAP-6	4/12/2016	Nitrate as Nitrogen		0.088	0.040	0.040	MG/L
WAP-7	4/12/2016	Nitrate as Nitrogen		0.072	0.040	0.040	MG/L
WAP-15	4/12/2016	Nitrate as Nitrogen		0.048	0.040	0.040	MG/L

Site	Collection Date	Parameter	Flag	Reported Result	MDL	PQL	Units
WAP-1	9/15/2016	Nitrate as Nitrogen		0.10	0.040	0.040	MG/L
WAP-2	9/15/2016	Nitrate as Nitrogen	<	0.040	0.040	0.040	MG/L
WAP-2-10	9/15/2016	Nitrate as Nitrogen		0.068	0.040	0.040	MG/L
WAP-5	9/15/2016	Nitrate as Nitrogen	<	0.040	0.040	0.040	MG/L
WAP-6	9/15/2016	Nitrate as Nitrogen		0.11	0.040	0.040	MG/L
WAP-7	9/15/2016	Nitrate as Nitrogen		0.092	0.040	0.040	MG/L
WAP-15	9/15/2016	Nitrate as Nitrogen		0.048	0.040	0.040	MG/L
WAP-1	6/23/2016	Nitrate as Nitrogen		0.054	0.040	0.040	MG/L
WAP-2	6/23/2016	Nitrate as Nitrogen		0.052	0.040	0.040	MG/L
WAP-2-10	6/23/2016	Nitrate as Nitrogen		0.062	0.040	0.040	MG/L
WAP-5	6/23/2016	Nitrate as Nitrogen		0.068	0.040	0.040	MG/L
WAP-6	6/23/2016	Nitrate as Nitrogen		0.090	0.040	0.040	MG/L
WAP-7	6/23/2016	Nitrate as Nitrogen		0.13	0.040	0.040	MG/L
WAP-15	6/23/2016	Nitrate as Nitrogen		0.054	0.040	0.040	MG/L
WAP-2	4/12/2016	Pheophytin a		5.4	2.0	2.0	MG/CU.M.
WAP-5	4/12/2016	Pheophytin a	<	2.0	2.0	2.0	MG/CU.M.
WAP-6	4/12/2016	Pheophytin a		4.2	2.0	2.0	MG/CU.M.
WAP-15	4/12/2016	Pheophytin a		2.0	2.0	2.0	MG/CU.M.
WAP-2	9/15/2016	Pheophytin a		1.3	1.0	1.0	MG/CU.M.
WAP-5	9/15/2016	Pheophytin a		2.2	1.0	1.0	MG/CU.M.
WAP-6	9/15/2016	Pheophytin a		2.0	1.0	1.0	MG/CU.M.
WAP-15	9/15/2016	Pheophytin a		2.3	1.0	1.0	MG/CU.M.
WAP-2	6/23/2016	Pheophytin a	<	2.0	2.0	2.0	MG/CU.M.
WAP-5	6/23/2016	Pheophytin a		12.3	2.0	2.0	MG/CU.M.
WAP-6	6/23/2016	Pheophytin a		4.1	2.0	2.0	MG/CU.M.
WAP-15	6/23/2016	Pheophytin a	<	2.0	2.0	2.0	MG/CU.M.
WAP-1	4/12/2016	Phosphorus		0.098	0.010	0.010	MG/L
WAP-2	4/12/2016	Phosphorus		0.066	0.010	0.010	MG/L
WAP-2-10	4/12/2016	Phosphorus		0.070	0.010	0.010	MG/L
WAP-5	4/12/2016	Phosphorus		0.12	0.010	0.010	MG/L
WAP-6	4/12/2016	Phosphorus		0.12	0.010	0.010	MG/L
WAP-7	4/12/2016	Phosphorus		0.075	0.010	0.010	MG/L
WAP-15	4/12/2016	Phosphorus		0.11	0.010	0.010	MG/L
WAP-1	9/15/2016	Phosphorus		0.022	0.010	0.010	MG/L
WAP-2	9/15/2016	Phosphorus	<	0.010	0.010	0.010	MG/L

Site	Collection Date	Parameter	Flag	Reported Result	MDL	PQL	Units
WAP-2-10	9/15/2016	Phosphorus		0.070	0.010	0.010	MG/L
WAP-5	9/15/2016	Phosphorus		0.013	0.010	0.010	MG/L
WAP-6	9/15/2016	Phosphorus		0.026	0.010	0.010	MG/L
WAP-7	9/15/2016	Phosphorus	<	0.010	0.010	0.010	MG/L
WAP-15	9/15/2016	Phosphorus	<	0.010	0.010	0.010	MG/L
WAP-1	6/23/2016	Phosphorus		0.068	0.010	0.010	MG/L
WAP-2	6/23/2016	Phosphorus		0.044	0.010	0.010	MG/L
WAP-2-10	6/23/2016	Phosphorus		0.11	0.010	0.010	MG/L
WAP-5	6/23/2016	Phosphorus		0.040	0.010	0.010	MG/L
WAP-6	6/23/2016	Phosphorus		0.048	0.010	0.010	MG/L
WAP-7	6/23/2016	Phosphorus		0.024	0.010	0.010	MG/L
WAP-15	6/23/2016	Phosphorus		0.036	0.010	0.010	MG/L
WAP-1	4/12/2016	Phosphorus, -ortho		0.020	0.010	0.010	MG/L
WAP-2	4/12/2016	Phosphorus, -ortho	<	0.010	0.010	0.010	MG/L
WAP-2-10	4/12/2016	Phosphorus, -ortho	<	0.010	0.010	0.010	MG/L
WAP-5	4/12/2016	Phosphorus, -ortho	<	0.010	0.010	0.010	MG/L
WAP-6	4/12/2016	Phosphorus, -ortho	<	0.010	0.010	0.010	MG/L
WAP-7	4/12/2016	Phosphorus, -ortho	<	0.010	0.010	0.010	MG/L
WAP-15	4/12/2016	Phosphorus, -ortho	<	0.010	0.010	0.010	MG/L
WAP-1	9/15/2016	Phosphorus, -ortho	<	0.010	0.010	0.010	MG/L
WAP-2	9/15/2016	Phosphorus, -ortho	<	0.010	0.010	0.010	MG/L
WAP-2-10	9/15/2016	Phosphorus, -ortho		0.060	0.010	0.010	MG/L
WAP-5	9/15/2016	Phosphorus, -ortho	<	0.010	0.010	0.010	MG/L
WAP-6	9/15/2016	Phosphorus, -ortho	<	0.010	0.010	0.010	MG/L
WAP-7	9/15/2016	Phosphorus, -ortho	<	0.010	0.010	0.010	MG/L
WAP-15	9/15/2016	Phosphorus, -ortho	<	0.010	0.010	0.010	MG/L
WAP-1	6/23/2016	Phosphorus, -ortho	<	0.010	0.010	0.010	MG/L
WAP-2	6/23/2016	Phosphorus, -ortho		0.011	0.010	0.010	MG/L
WAP-2-10	6/23/2016	Phosphorus, -ortho		0.021	0.010	0.010	MG/L
WAP-5	6/23/2016	Phosphorus, -ortho		0.011	0.010	0.010	MG/L
WAP-6	6/23/2016	Phosphorus, -ortho		0.011	0.010	0.010	MG/L
WAP-7	6/23/2016	Phosphorus, -ortho		0.011	0.010	0.010	MG/L
WAP-15	6/23/2016	Phosphorus, -ortho	<	0.010	0.010	0.010	MG/L
WAP-1	4/12/2016	Solids, Total Suspended		19.1	2.2	2.2	MG/L
WAP-2	4/12/2016	Solids, Total Suspended		17.4	2.0	2.0	MG/L

Site	Collection Date	Parameter	Flag	Reported Result	MDL	PQL	Units
WAP-2-10	4/12/2016	Solids, Total Suspended		17.8	2.0	2.0	MG/L
WAP-5	4/12/2016	Solids, Total Suspended		18.4	2.0	2.0	MG/L
WAP-6	4/12/2016	Solids, Total Suspended		72.0	4.0	4.0	MG/L
WAP-7	4/12/2016	Solids, Total Suspended		40.8	4.0	4.0	MG/L
WAP-15	4/12/2016	Solids, Total Suspended		19.0	2.0	2.0	MG/L
WAP-1	9/15/2016	Solids, Total Suspended		7.7	2.9	2.9	MG/L
WAP-2	9/15/2016	Solids, Total Suspended		2.0	1.3	1.3	MG/L
WAP-2-10	9/15/2016	Solids, Total Suspended		14.0	2.9	2.9	MG/L
WAP-5	9/15/2016	Solids, Total Suspended		4.4	2.0	2.0	MG/L
WAP-6	9/15/2016	Solids, Total Suspended		4.6	2.0	2.0	MG/L
WAP-7	9/15/2016	Solids, Total Suspended		8.0	1.2	1.2	MG/L
WAP-15	9/15/2016	Solids, Total Suspended		4.4	2.2	2.2	MG/L
WAP-1	6/23/2016	Solids, Total Suspended		10.0	4.0	4.0	MG/L
WAP-2	6/23/2016	Solids, Total Suspended	<	3.3	3.3	3.3	MG/L
WAP-2-10	6/23/2016	Solids, Total Suspended		21.5	5.0	5.0	MG/L
WAP-5	6/23/2016	Solids, Total Suspended		4.0	3.3	3.3	MG/L
WAP-6	6/23/2016	Solids, Total Suspended		6.3	2.9	2.9	MG/L
WAP-7	6/23/2016	Solids, Total Suspended		6.7	3.3	3.3	MG/L
WAP-15	6/23/2016	Solids, Total Suspended		3.7	3.3	3.3	MG/L
WAP-1	4/12/2016	Solids, Volatile Suspended		3.5	2.2	2.2	MG/L
WAP-2	4/12/2016	Solids, Volatile Suspended		3.4	2.0	2.0	MG/L
WAP-2-10	4/12/2016	Solids, Volatile Suspended		2.8	2.0	2.0	MG/L
WAP-5	4/12/2016	Solids, Volatile Suspended		2.4	2.0	2.0	MG/L
WAP-6	4/12/2016	Solids, Volatile Suspended		4.4	4.0	4.0	MG/L
WAP-7	4/12/2016	Solids, Volatile Suspended		4.8	4.0	4.0	MG/L
WAP-15	4/12/2016	Solids, Volatile Suspended		2.6	2.0	2.0	MG/L
WAP-1	9/15/2016	Solids, Volatile Suspended	<	2.9	2.9	2.9	MG/L
WAP-2	9/15/2016	Solids, Volatile Suspended		1.5	1.3	1.3	MG/L

Site	Collection Date	Parameter	Flag	Reported Result	MDL	PQL	Units
WAP-2-10	9/15/2016	Solids, Volatile Suspended		3.7	2.9	2.9	MG/L
WAP-5	9/15/2016	Solids, Volatile Suspended		2.4	2.0	2.0	MG/L
WAP-6	9/15/2016	Solids, Volatile Suspended	<	2.0	2.0	2.0	MG/L
WAP-7	9/15/2016	Solids, Volatile Suspended	<	1.2	1.2	1.2	MG/L
WAP-15	9/15/2016	Solids, Volatile Suspended		2.9	2.2	2.2	MG/L
WAP-1	6/23/2016	Solids, Volatile Suspended	<	4.0	4.0	4.0	MG/L
WAP-2	6/23/2016	Solids, Volatile Suspended	<	3.3	3.3	3.3	MG/L
WAP-2-10	6/23/2016	Solids, Volatile Suspended	<	5.0	5.0	5.0	MG/L
WAP-5	6/23/2016	Solids, Volatile Suspended	<	3.3	3.3	3.3	MG/L
WAP-6	6/23/2016	Solids, Volatile Suspended	<	2.9	2.9	2.9	MG/L
WAP-7	6/23/2016	Solids, Volatile Suspended	<	3.3	3.3	3.3	MG/L
WAP-15	6/23/2016	Solids, Volatile Suspended	<	3.3	3.3	3.3	MG/L
WAP-1	4/12/2016	Total Organic Carbon		2.2	1.0	1.0	MG/L
WAP-2	4/12/2016	Total Organic Carbon		2.4	1.0	1.0	MG/L
WAP-2-10	4/12/2016	Total Organic Carbon		2.2	1.0	1.0	MG/L
WAP-5	4/12/2016	Total Organic Carbon		1.5	1.0	1.0	MG/L
WAP-6	4/12/2016	Total Organic Carbon		1.6	1.0	1.0	MG/L
WAP-7	4/12/2016	Total Organic Carbon		2.7	1.0	1.0	MG/L
WAP-15	4/12/2016	Total Organic Carbon		1.4	1.0	1.0	MG/L
WAP-1	9/15/2016	Total Organic Carbon		4.3	2.0	2.0	MG/L
WAP-2	9/15/2016	Total Organic Carbon		4.0	2.0	2.0	MG/L
WAP-2-10	9/15/2016	Total Organic Carbon		3.8	2.0	2.0	MG/L
WAP-5	9/15/2016	Total Organic Carbon		4.6	2.0	2.0	MG/L
WAP-6	9/15/2016	Total Organic Carbon		1.2	1.0	1.0	MG/L
WAP-7	9/15/2016	Total Organic Carbon		1.0	1.0	1.0	MG/L
WAP-15	9/15/2016	Total Organic Carbon		4.4	2.0	2.0	MG/L

Site	Collection Date	Parameter	Flag	Reported Result	MDL	PQL	Units
WAP-1	6/23/2016	Total Organic Carbon		3.3	1.0	1.0	MG/L
WAP-2	6/23/2016	Total Organic Carbon		3.3	1.0	1.0	MG/L
WAP-2-10	6/23/2016	Total Organic Carbon		3.7	1.0	1.0	MG/L
WAP-5	6/23/2016	Total Organic Carbon		3.6	1.0	1.0	MG/L
WAP-6	6/23/2016	Total Organic Carbon		1.4	1.0	1.0	MG/L
WAP-7	6/23/2016	Total Organic Carbon	<	1.0	1.0	1.0	MG/L
WAP-15	6/23/2016	Total Organic Carbon		3.5	1.0	1.0	MG/L

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

Marina E. coli

Site	Date Collected	Result	Qualifier	Unit
BAR-MARINA	6/23/2016	3.0		COL/100 ML
BAR-MARINA	9/15/2016	2.0		COL/100 ML
CL-MARINA	6/23/2016	21.0		COL/100 ML
CL-MARINA	9/15/2016	6.0		COL/100 ML
LC-MARINA	6/23/2016	1.0		COL/100 ML
LC-MARINA	9/15/2016	8.0		COL/100 ML
SUN MARINA	6/23/2016	1.0		COL/100 ML
SUN MARINA	9/15/2016	5.0		COL/100 ML

FIELD DATA

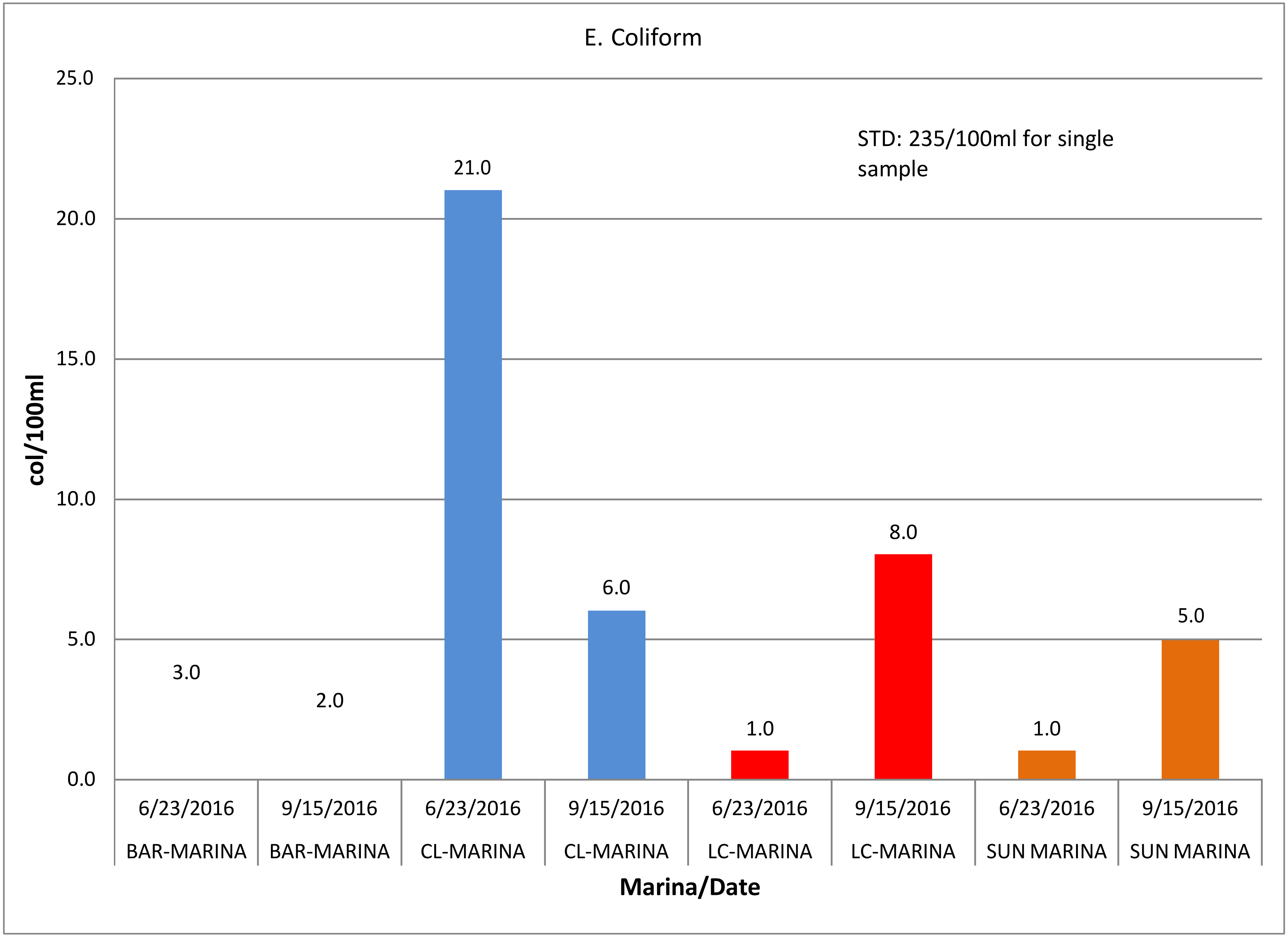
Site	Date	Depth	Water Temp (oC)	Redox (mv)	Cond (uS)	DO %	DO mg/l	pH	Time	Seechi (in)	Total Depth (ft)	Air Temp (oF)
WAP-1	4/12/2016	0.6	15.02	232	142	110.8	11.14	8.06	1225			55
WAP-1	6/23/2016	0.9	27.24	292	193	95.5	7.98	7.52	1055			91
WAP-1	9/15/2016	1.5	25.99	252	123.6	92.3	7.39	7.81	1015			84
WAP-7	4/12/2016	0.5	12.62	205	143	101.5	10.63	7.87	930			50
WAP-7	6/23/2016	0.3	27.49	294	244	81	6.27	7.71	915			91
WAP-7	9/15/2016	0.3	24.5	332	253	83.1	6.88	7.77	912			84
WAP-2	4/12/2016	0.3	15.02	95	112	103.3	10.4	7.9	1130	22	30	52
WAP-2	4/12/2016	1	15.02	105	112	103.6	10.44	7.82	1130			52
WAP-2	4/12/2016	2	14.67	110	112	102	10.35	7.78	1130			52
WAP-2	4/12/2016	3	14.63	112	112	102	10.33	7.78	1130			52
WAP-2	4/12/2016	4	14.63	114	112	102	10.31	7.76	1130			52
WAP-2	4/12/2016	5	14.51	115	112	101.4	10.26	7.76	1130			52
WAP-2	4/12/2016	6	14.49	118	112	100.7	10.21	7.71	1130			52
WAP-2	4/12/2016	7	14.49	119	112	99.8	10.18	7.7	1130			52
WAP-2	6/23/2016	0.4	30.1	232	139	103	7.7	8	1115	39		91
WAP-2	6/23/2016	1	30	236	139	103	7.7	8	1115			
WAP-2	6/23/2016	2	29.9	237	139	103	7.6	8	1115			
WAP-2	6/23/2016	3	29.7	239	138	100	7.49	7.9	1115			
WAP-2	6/23/2016	4	22.9	252	147	0	0	7.3	1115			
WAP-2	6/23/2016	5	20.8	13	152	0	0	7	1115			
WAP-2	6/23/2016	6	19.9	-19	152	0	0	6.9	1115			
WAP-2	6/23/2016	7	19.5	-36	151	0	0	6.9	1115			
WAP-2	6/23/2016	8	19.2	-41	149	0	0	6.9	1115			
WAP-2	6/23/2016	9	18.7	-46	150	0	0	7	1115			
WAP-2	9/15/2016	0.3	27.54	216	126.1	104.5	8.22	7.9	1125	26		84
WAP-2	9/15/2016	1	27.21	227	126.4	104	8.16	7.83	1125			

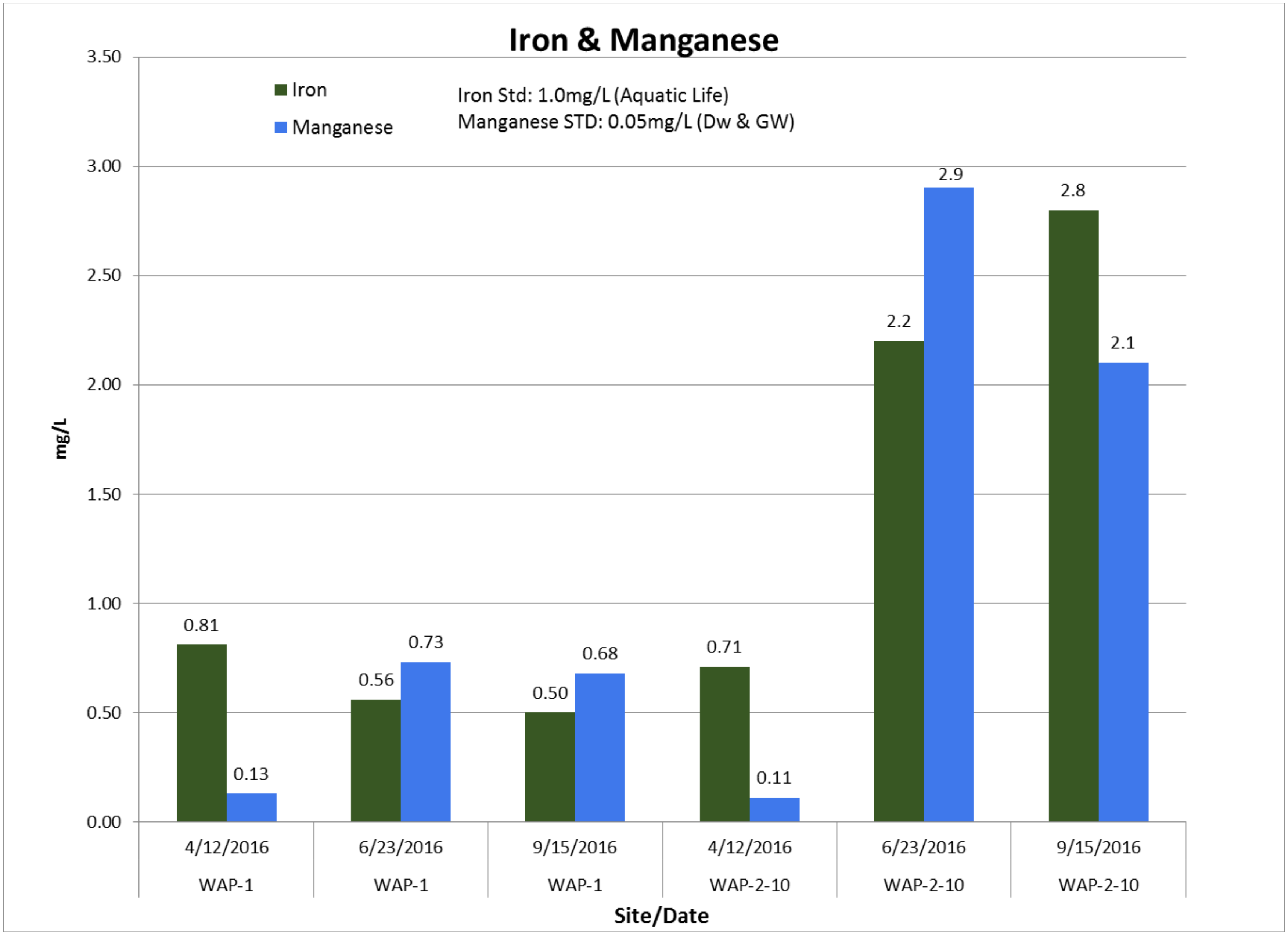
Site	Date	Depth	Water Temp (oC)	Redox (mv)	Cond (uS)	DO %	DO mg/l	pH	Time	Seechi (in)	Total Depth (ft)	Air Temp (oF)
WAP-2	9/15/2016	2	26.34	239	116.1	60.5	4.8	7.46	1125			
WAP-2	9/15/2016	3	25.53	248	121.1	0	0	7.16	1125			
WAP-2	9/15/2016	4	24.26	96	142.1	0	0	6.96	1125			
WAP-2	9/15/2016	5	23.41	34	157	0	0	6.93	1125			
WAP-2	9/15/2016	6	23.08	-49	158.6	0	0	6.93	1125			
WAP-2	9/15/2016	7	22.48	-147	171.5	0	0	6.93	1125			
WAP-2	9/15/2016	8	21.77	-178	149.1	0	0	6.93	1125			
WAP-5	4/12/2016	0.3	15.79	246	146	100.6	10.27	7.87	1040	12	11	50
WAP-5	4/12/2016	1	14.69	228	156	105.6	10.71	7.86	1040			50
WAP-5	4/12/2016	2	14.4	243	158	102.1	10.43	7.78	1040			50
WAP-5	6/23/2016	0.4	30.2	280	136	88	6.5	7.7	1030	48		91
WAP-5	6/23/2016	1	29.9	282	135	89.9	6.6	7.6	1030			
WAP-5	6/23/2016	2	27	293	197	0	0	7.2	1030			
WAP-5	6/23/2016	3	24.1	188	138	0	0	6.9	1030			
WAP-5	6/23/2016	4	21.7	-38	169	1	0	6.7	1030			
WAP-5	9/15/2016	0.4	26.7	270	98.2	94.5	7.49	7.86	1015	15		84
WAP-5	9/15/2016	1	26.52	276	98.2	84.1	6.76	7.56	1015			
WAP-5	9/15/2016	2	25.06	287	1-2.3	1.9	0	7.12	1015			
WAP-5	9/15/2016	3	24.09	141	117.7	0	0	6.87	1015			
WAP-5	9/15/2016	4	23.22	90	127.5	0	0	6.83	1015			
WAP-6	4/12/2016	0.3	12.75	253	158	99.3	10.47	7.8	1005	11	12	50
WAP-6	4/12/2016	1	12.85	237	157	99.6	10.5	7.77	1005			50
WAP-6	4/12/2016	2	12.86	234	157	100.3	10.56	7.78	1005			50
WAP-6	6/23/2016	0.3	28.8	258	251	103	7.8	7.7	1000	31		91
WAP-6	6/23/2016	1	28.2	263	252	83	6.3	7.5	1000			
WAP-6	6/23/2016	2	25.2	267	242	29	2.3	7.3	1000			
WAP-6	6/23/2016	3	16.3	270	209	49.2	4.9	7.3	1000			
WAP-6	6/23/2016	4	14.8	271	203	57	5.8	7.2	1000			
WAP-6	6/23/2016	4.8	14.2	272	205	53	5.3	7.1	1000			
WAP-6	9/15/2016	0.4	25.05	240	264.7	92.7	7.55	7.71	938	17		84

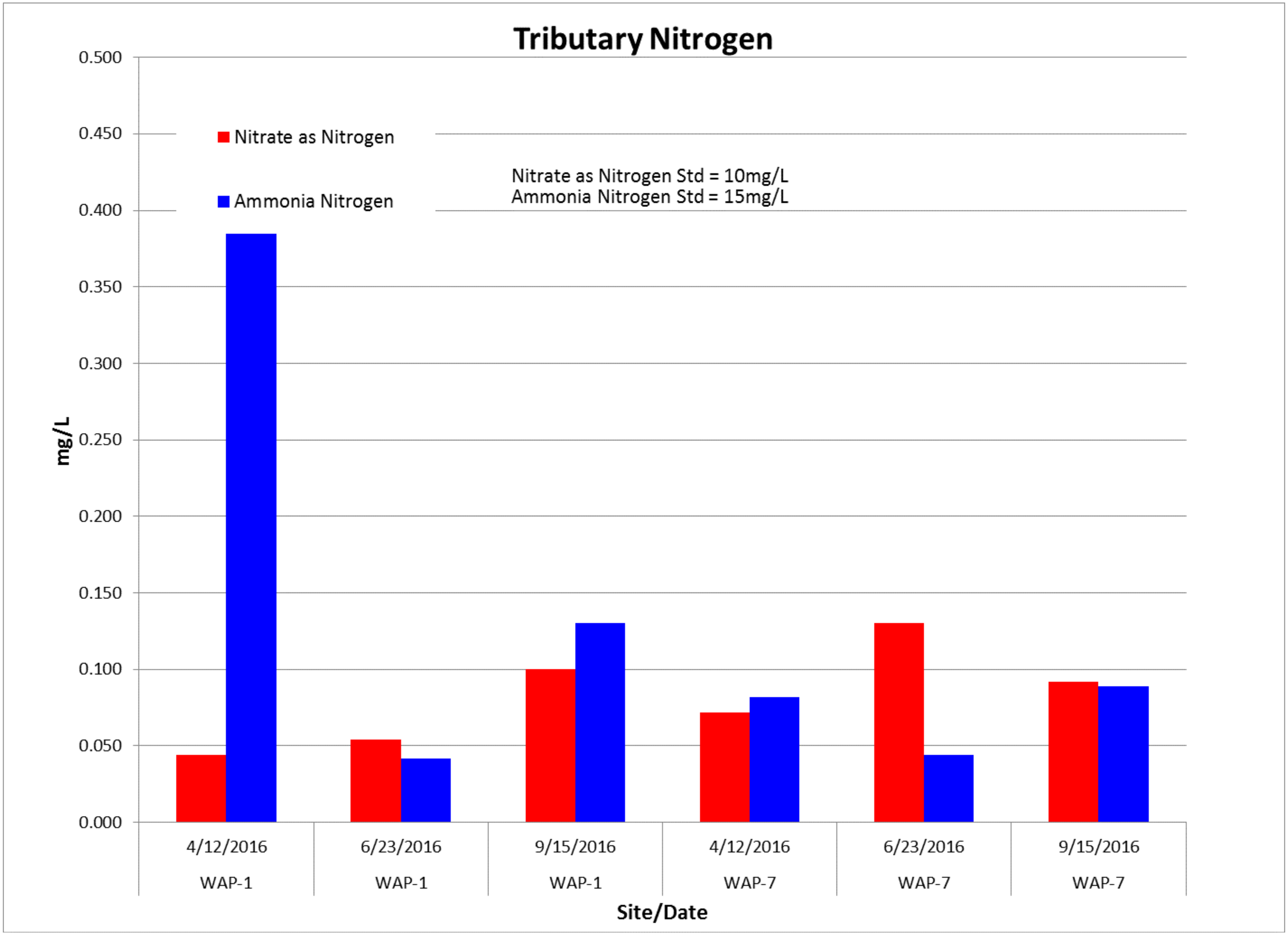
Site	Date	Depth	Water Temp (oC)	Redox (mv)	Cond (uS)	DO %	DO mg/l	pH	Time	Seechi (in)	Total Depth (ft)	Air Temp (oF)
WAP-6	9/15/2016	1	24.97	254	264	89	7.29	7.52	938			
WAP-6	9/15/2016	2	24.37	257	259.9	67.9	5.68	7.41	938			
WAP-6	9/15/2016	3	18.77	262	233.1	41.4	3.81	7.23	938			
WAP-6	9/15/2016	4	16.14	263	220.7	44.5	4.35	7.15	938			
WAP-6	9/15/2016	5	15.83	266	222.4	37.9	3.7	7.1	938			

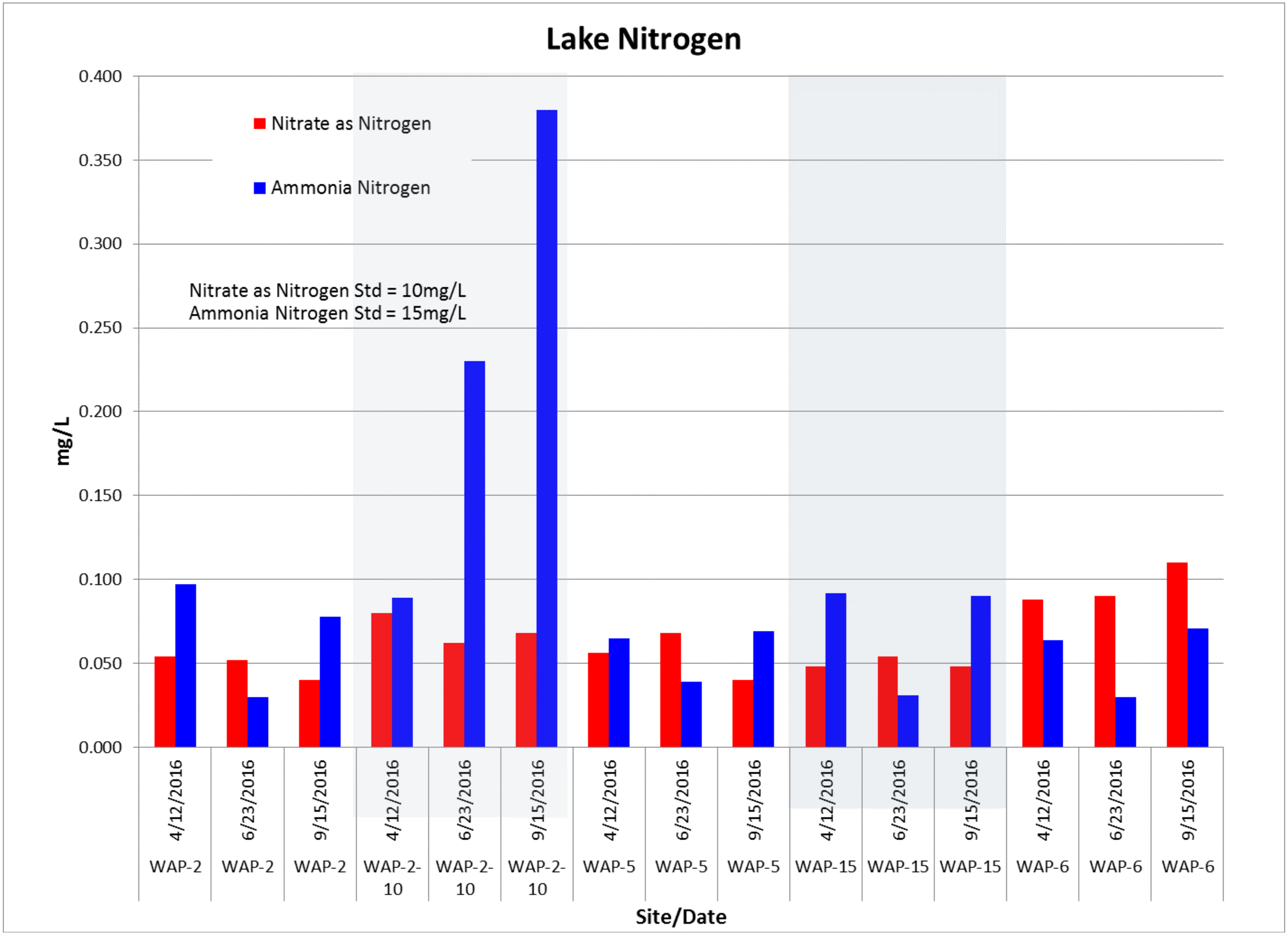
APPENDIX B

LAB
GRAPHS

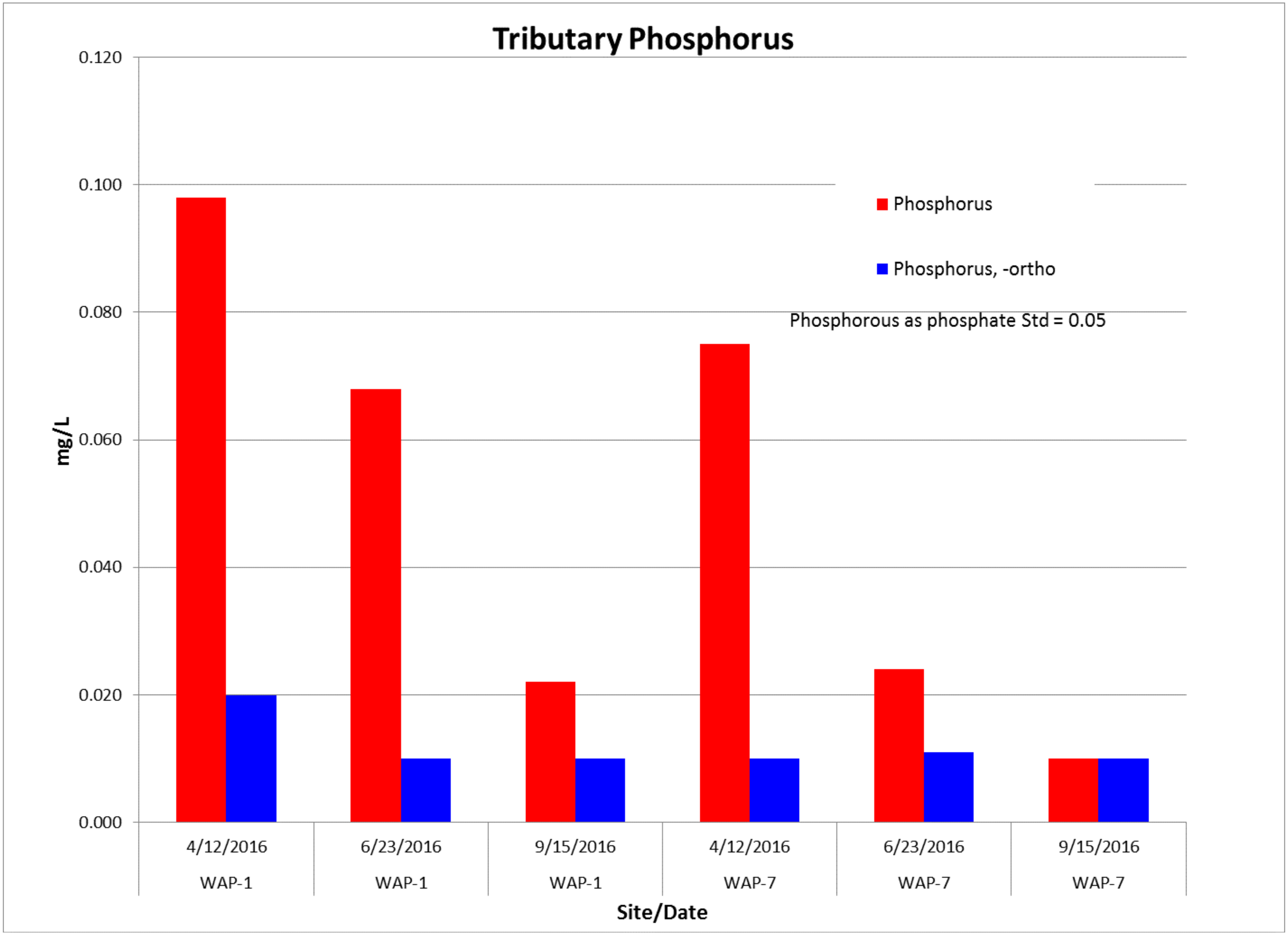

E. Coliform
col/100ml
25.0
20.0
15.0
10.0
5.0
0.0
STD: 235/100ml for single sample
3.0
2.0
21.0
6.0
1.0
8.0
1.0
5.0
6/23/2016
9/15/2016
6/23/2016
9/15/2016
6/23/2016
9/15/2016
6/23/2016
9/15/2016
BAR-MARINA
BAR-MARINA
CL-MARINA
CL-MARINA
LC-MARINA
LC-MARINA
SUN MARINA
SUN MARINA
Marina/Date


Iron & Manganese
Iron
Manganese
Iron Std: 1.0mg/L (Aquatic Life)
Manganese STD: 0.05mg/L (Dw & GW)
mg/L
3.50
3.00
2.50
2.00
1.50
1.00
0.50
0.00
0.81
0.13
0.56
0.73
0.50
0.68
0.71
0.11
2.2
2.9
2.8
2.1
4/12/2016
WAP-1
6/23/2016
WAP-1
9/15/2016
WAP-1
4/12/2016
WAP-2-10
6/23/2016
WAP-2-10
9/15/2016
WAP-2-10
Site/Date

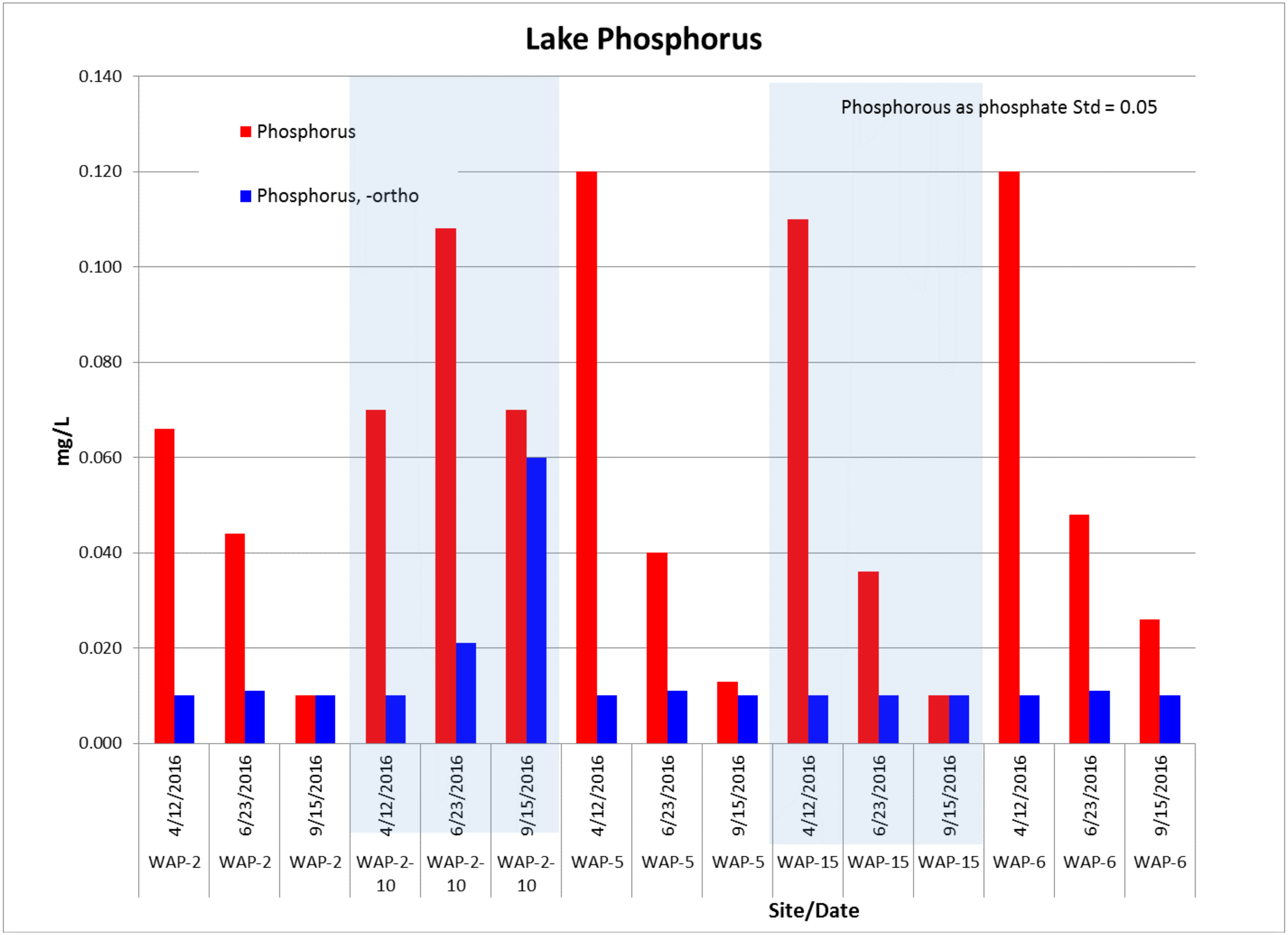

Tributary Nitrogen
Nitrate as Nitrogen
Ammonia Nitrogen
Nitrate as Nitrogen Std = 10mg/L
Ammonia Nitrogen Std = 15mg/L
mg/L
0.500
0.450
0.400
0.350
0.300
0.250
0.200
0.150
0.100
0.050
0.000
4/12/2016
WAP-1
6/23/2016
WAP-1
9/15/2016
WAP-1
4/12/2016
WAP-7
6/23/2016
WAP-7
9/15/2016
WAP-7
Site/Date

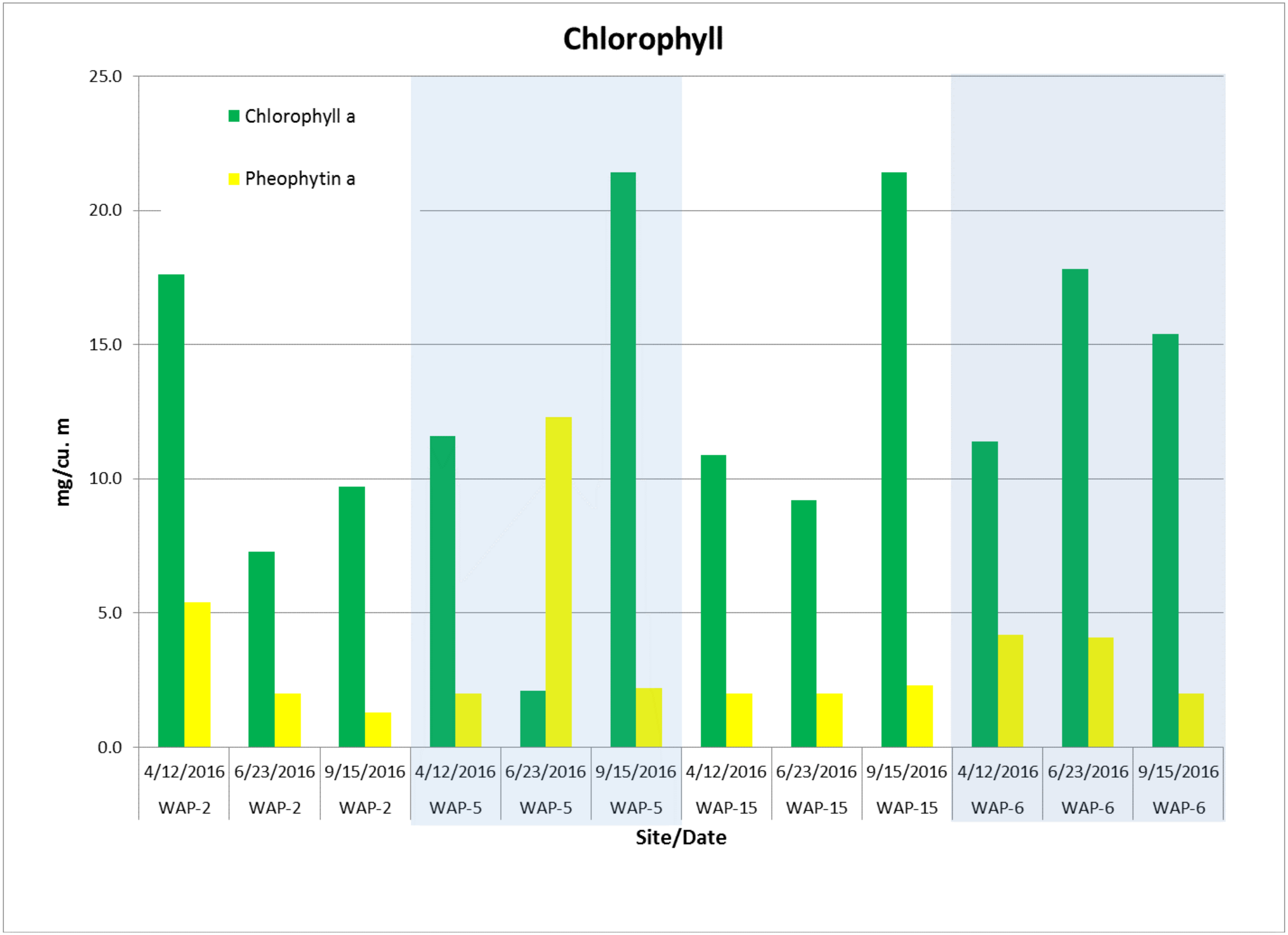


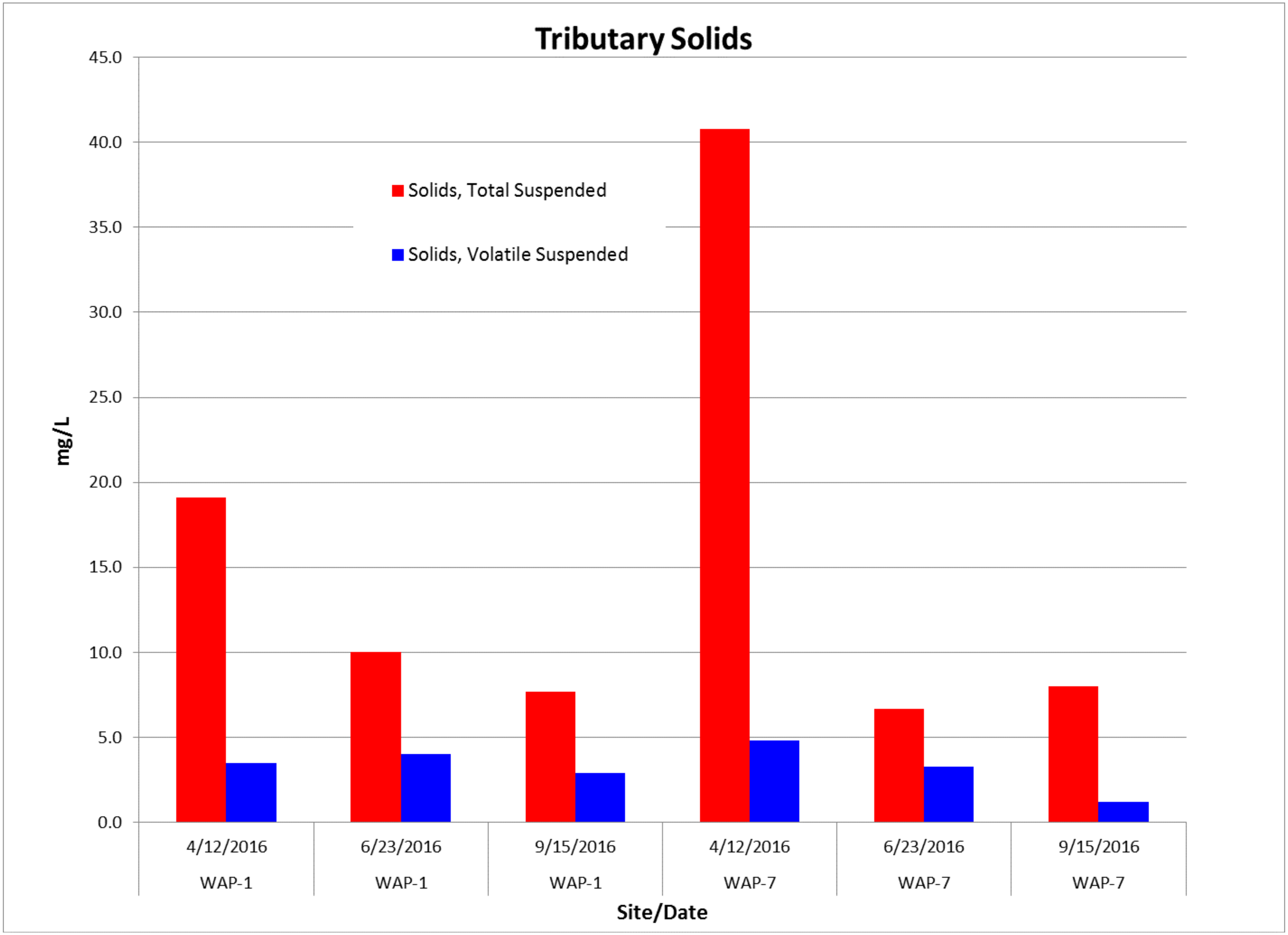
Lake Nitrogen
0.400
0.350
0.300
0.250
0.200
0.150
0.100
0.050
0.000
mg/L
Nitrate as Nitrogen
Ammonia Nitrogen
Nitrate as Nitrogen Std = 10mg/L
Ammonia Nitrogen Std = 15mg/L
4/12/2016
6/23/2016
9/15/2016
WAP-2
WAP-2-10
WAP-5
WAP-15
WAP-6
Site/Date

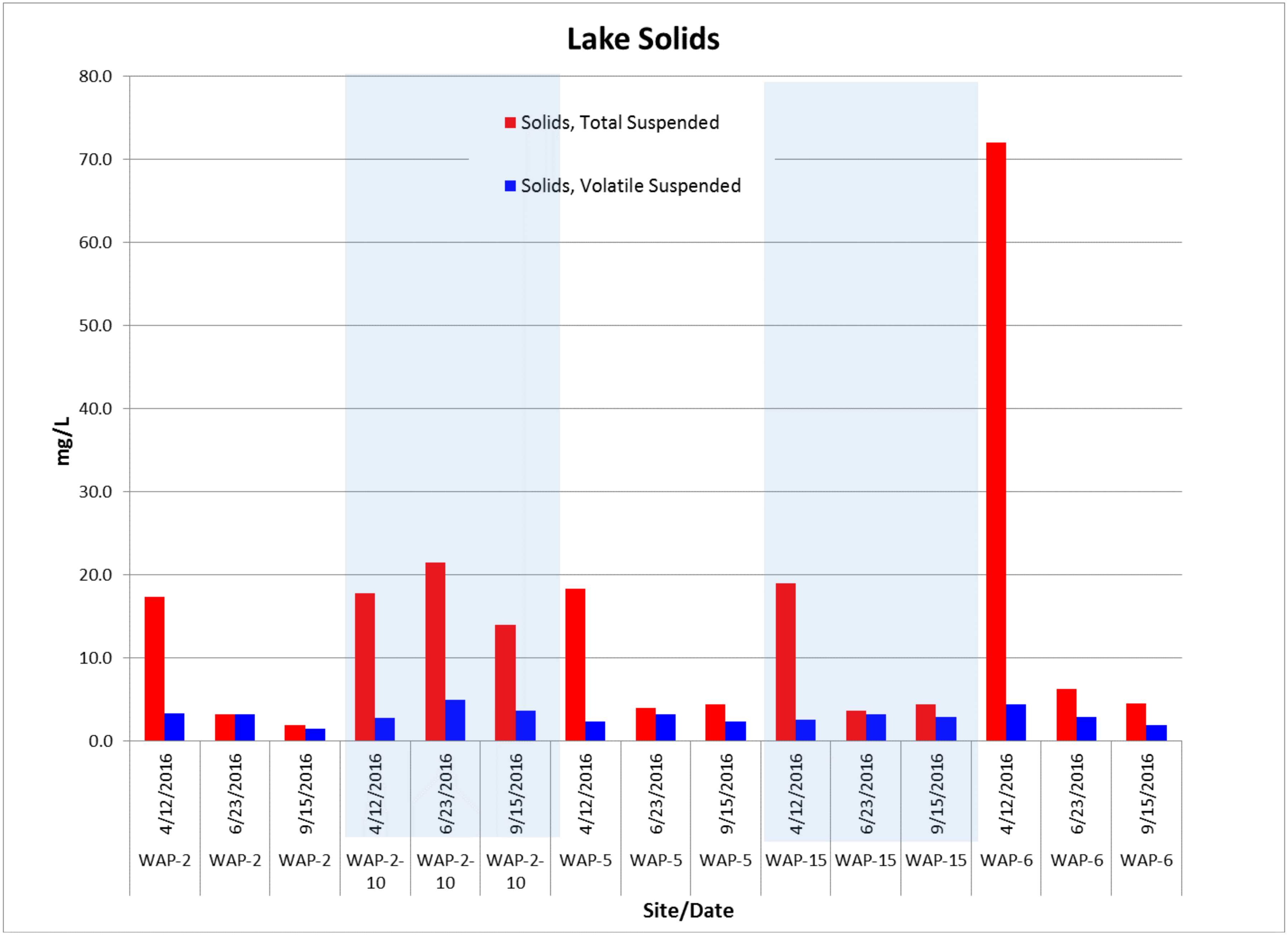


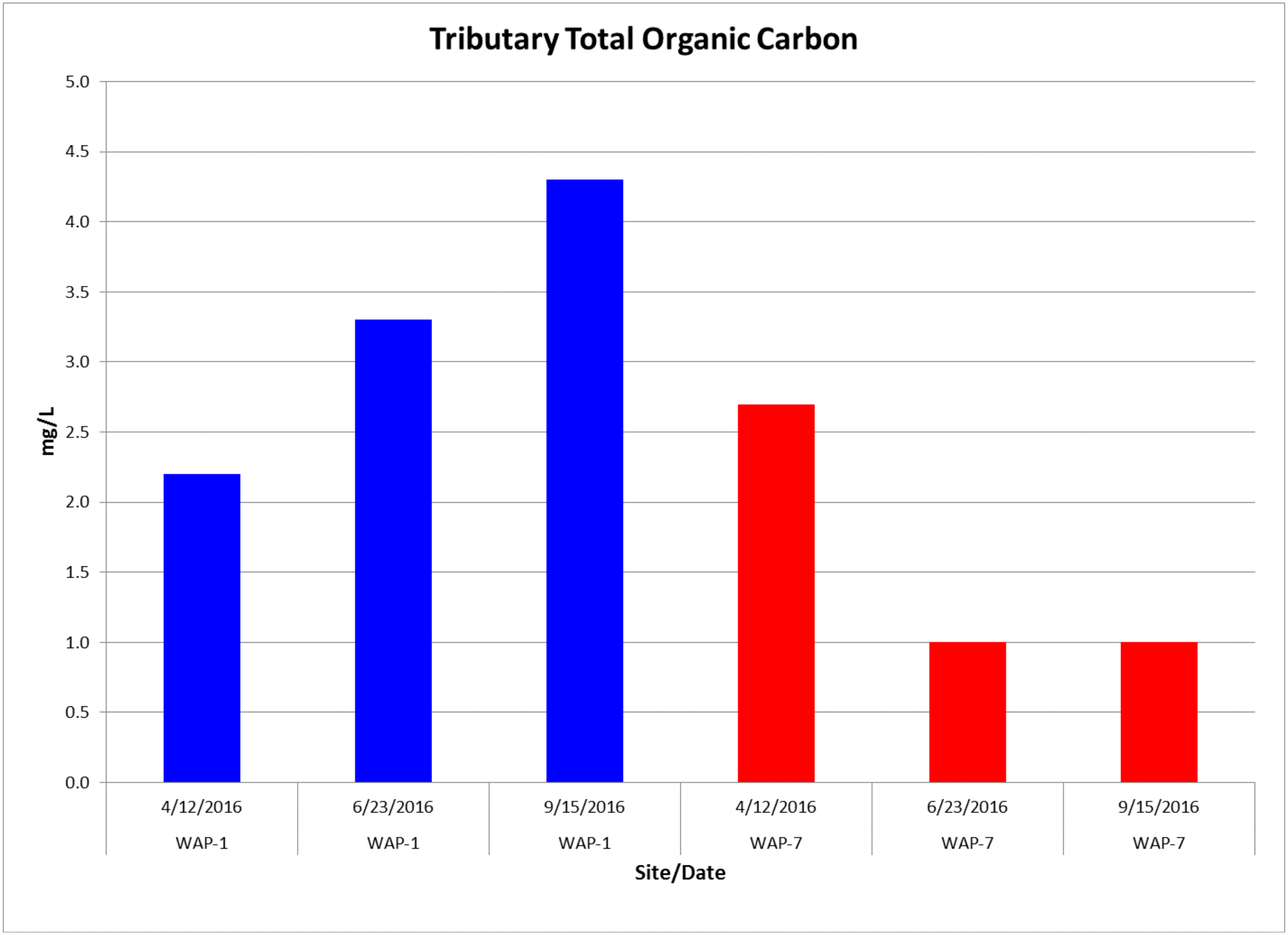
Tributary Phosphorus
0.120
0.100
0.080
0.060
0.040
0.020
0.000
mg/L
Phosphorus
Phosphorus, -ortho
Phosphorous as phosphate Std = 0.05
4/12/2016
WAP-1
6/23/2016
WAP-1
9/15/2016
WAP-1
4/12/2016
WAP-7
6/23/2016
WAP-7
9/15/2016
WAP-7
Site/Date


Lake Phosphorus
0.140
0.120
0.100
0.080
0.060
0.040
0.020
0.000
mg/L
Phosphorus
Phosphorus, -ortho
Phosphorous as phosphate Std = 0.05
4/12/2016
6/23/2016
9/15/2016
WAP-2
WAP-2-10
WAP-5
WAP-15
WAP-6
Site/Date

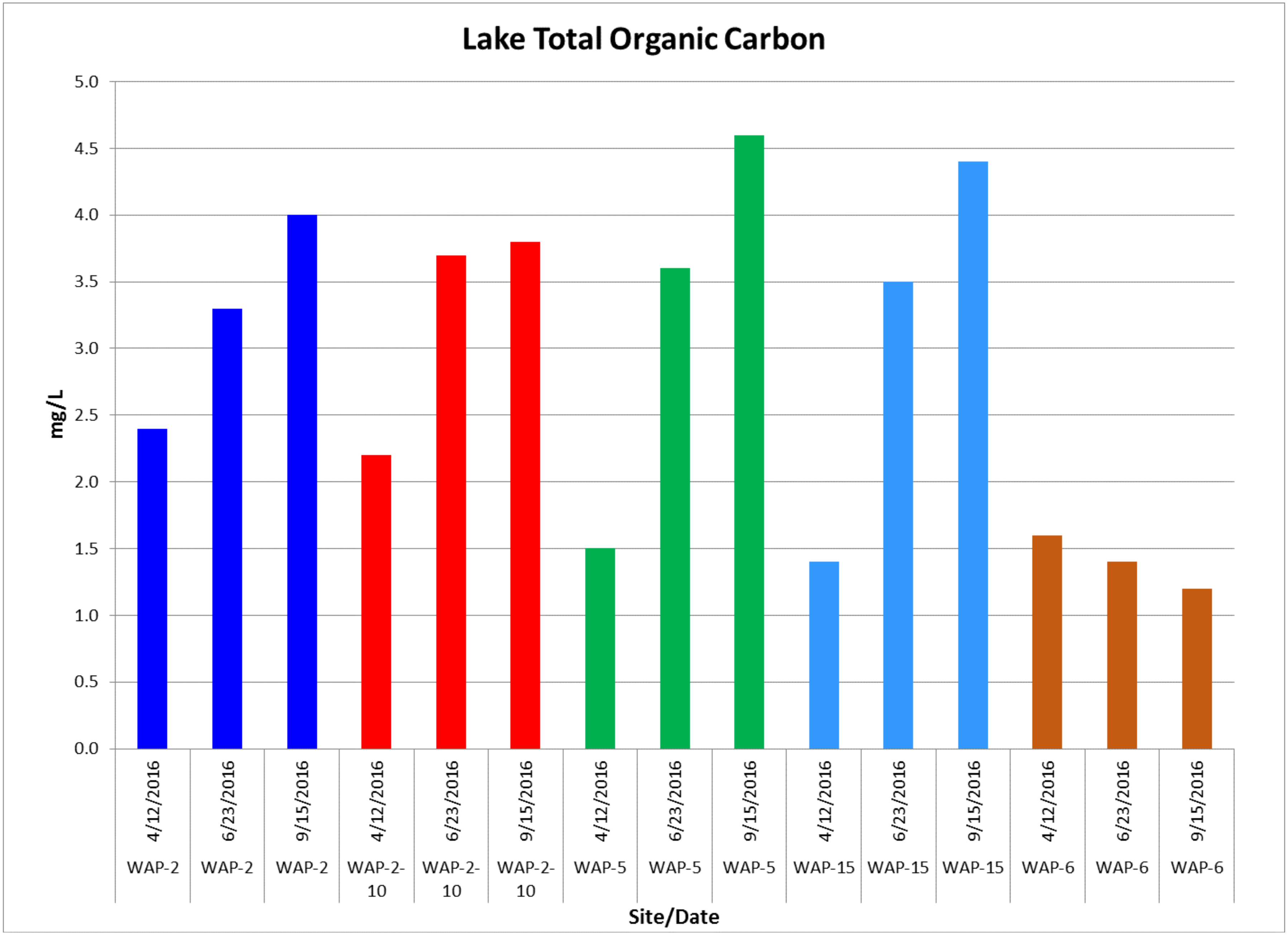

Chlorophyll
25.0
20.0
15.0
10.0
5.0
0.0
mg/cu. m
Chlorophyll a
Pheophytin a
4/12/2016
6/23/2016
9/15/2016
4/12/2016
6/23/2016
9/15/2016
4/12/2016
6/23/2016
9/15/2016
4/12/2016
6/23/2016
9/15/2016
WAP-2
WAP-2
WAP-2
WAP-5
WAP-5
WAP-5
WAP-15
WAP-15
WAP-15
WAP-6
WAP-6
WAP-6
Site/Date


Tributary Solids
45.0
40.0
35.0
30.0
25.0
20.0
15.0
10.0
5.0
0.0
mg/L
Solids, Total Suspended
Solids, Volatile Suspended
4/12/2016
WAP-1
6/23/2016
WAP-1
9/15/2016
WAP-1
4/12/2016
WAP-7
6/23/2016
WAP-7
9/15/2016
WAP-7
Site/Date


Lake Solids
80.0
70.0
60.0
50.0
40.0
30.0
20.0
10.0
0.0
mg/L
Solids, Total Suspended
Solids, Volatile Suspended
4/12/2016
6/23/2016
9/15/2016
WAP-2
WAP-2-10
WAP-5
WAP-15
WAP-6
Site/Date

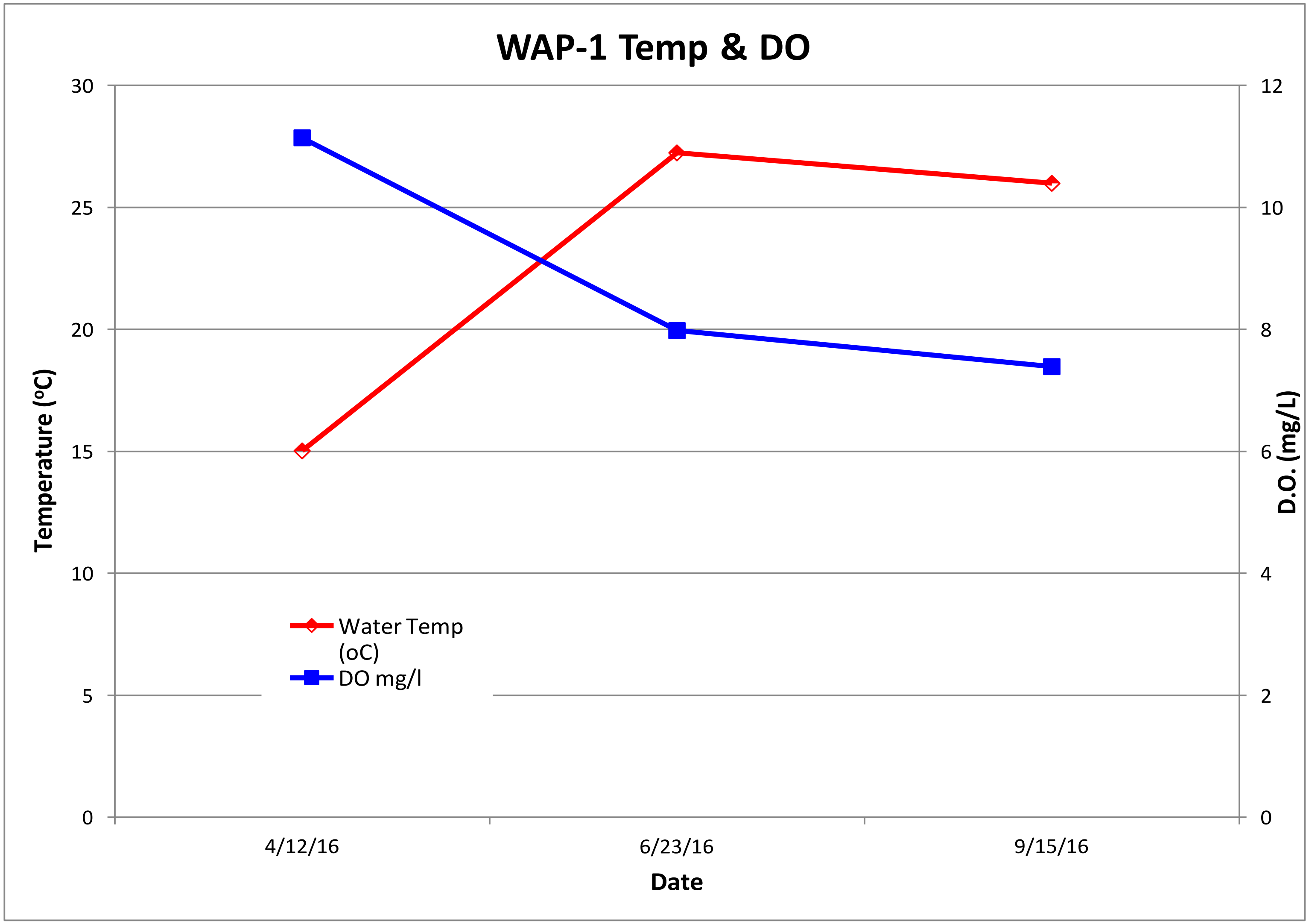


Tributary Total Organic Carbon
mg/L
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
4/12/2016
WAP-1
6/23/2016
WAP-1
9/15/2016
WAP-1
4/12/2016
WAP-7
6/23/2016
WAP-7
9/15/2016
WAP-7
Site/Date

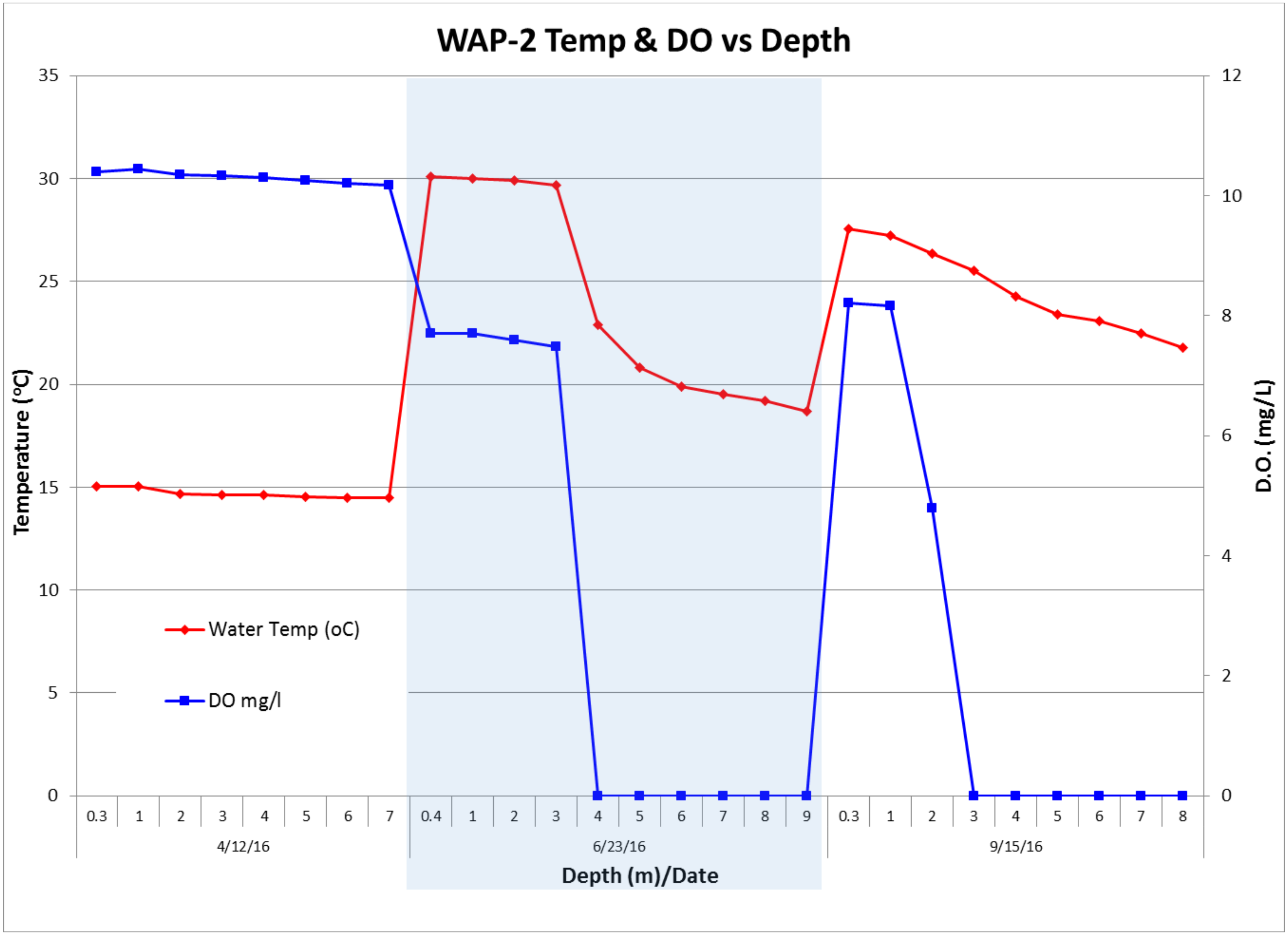

Lake Total Organic Carbon
mg/L
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
4/12/2016
6/23/2016
9/15/2016
WAP-2
WAP-2-10
WAP-5
WAP-15
WAP-6
Site/Date

APPENDIX C

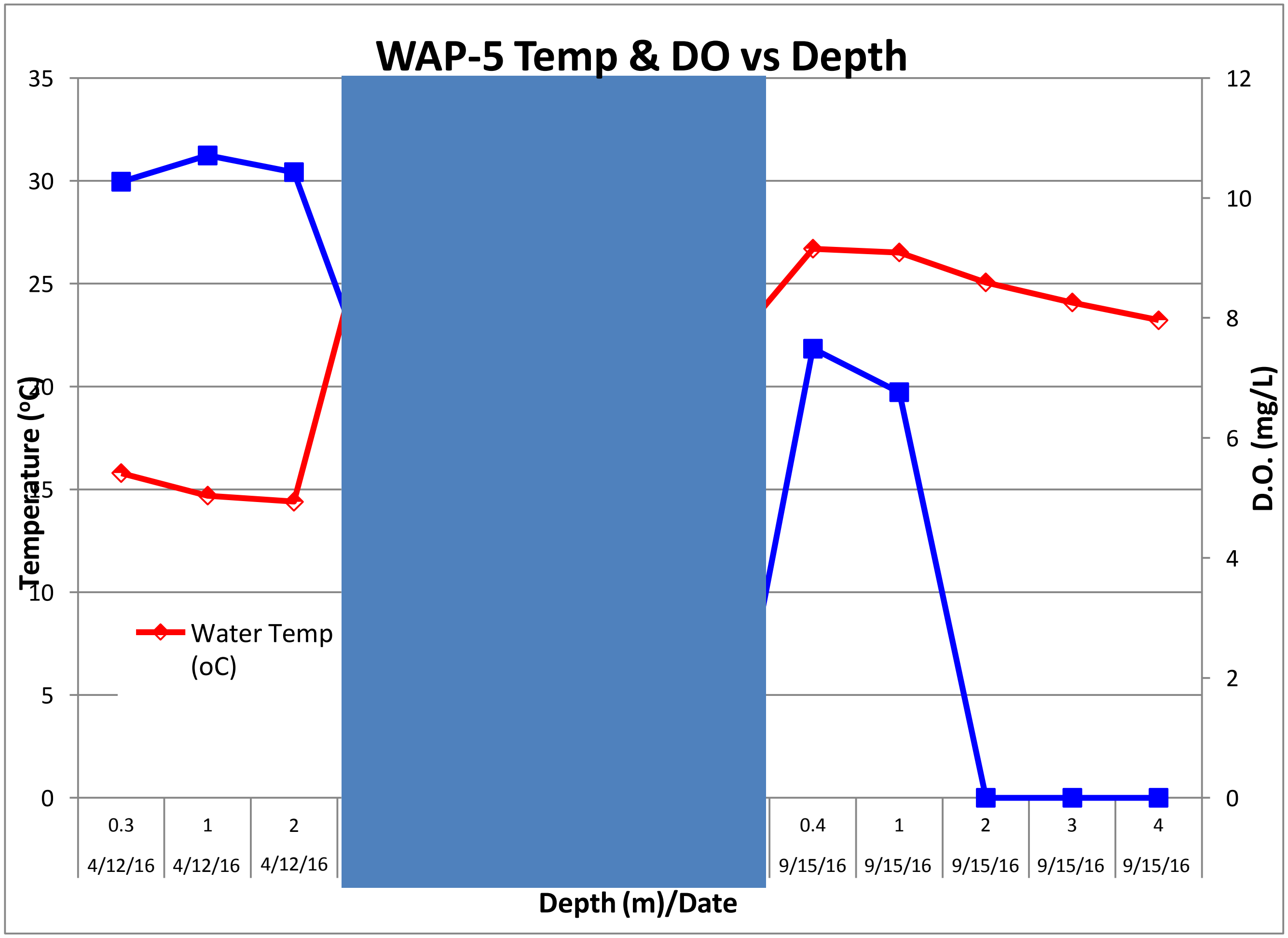
FIELD
GRAPHS



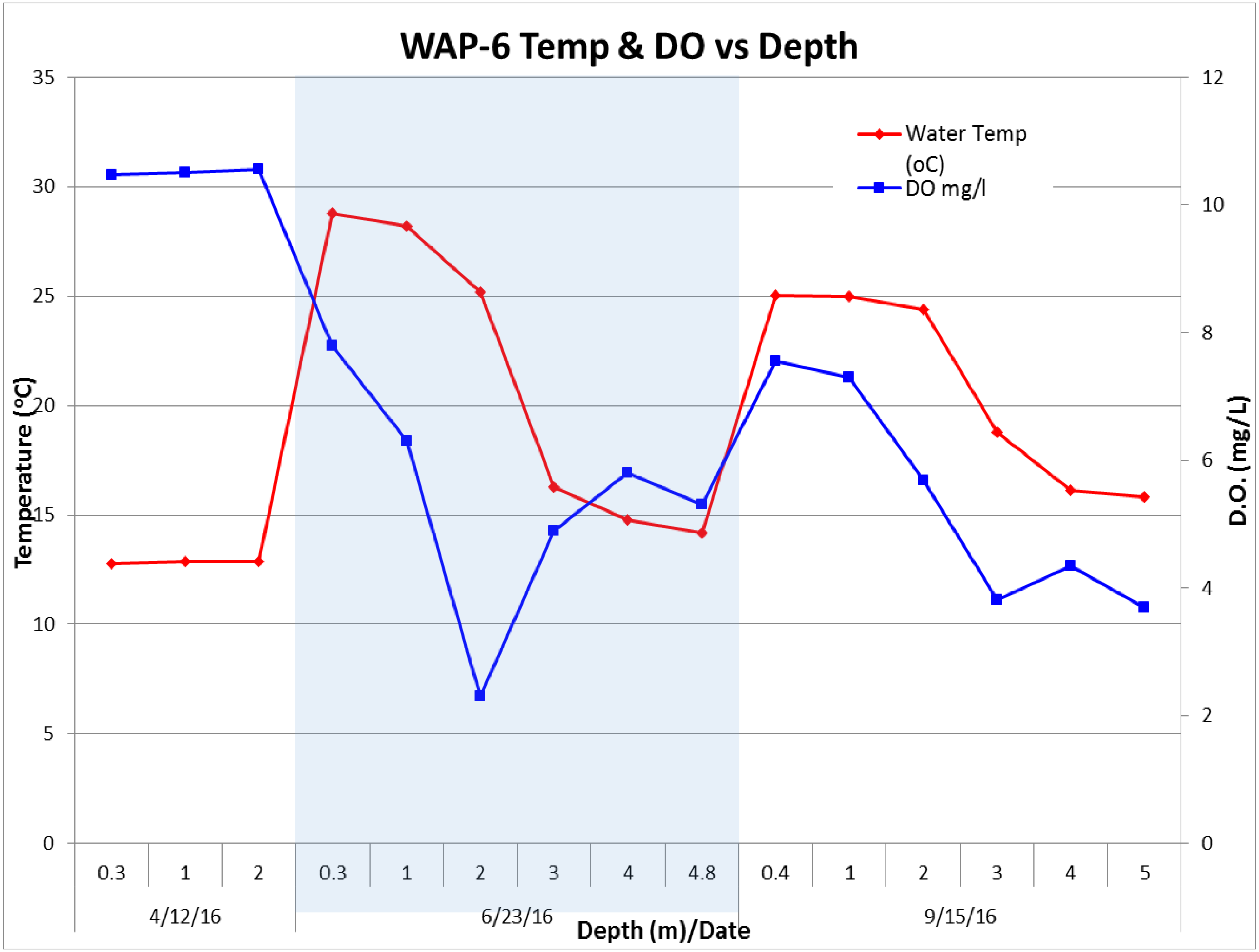
WAP-1 Temp & DO
30
25
20
15
10
5
0
12
10
8
6
4
2
0
Temperature (ºC)
D.O. (mg/L)
Water Temp (oC)
DO mg/l
4/12/16
6/23/16
9/15/16
Date



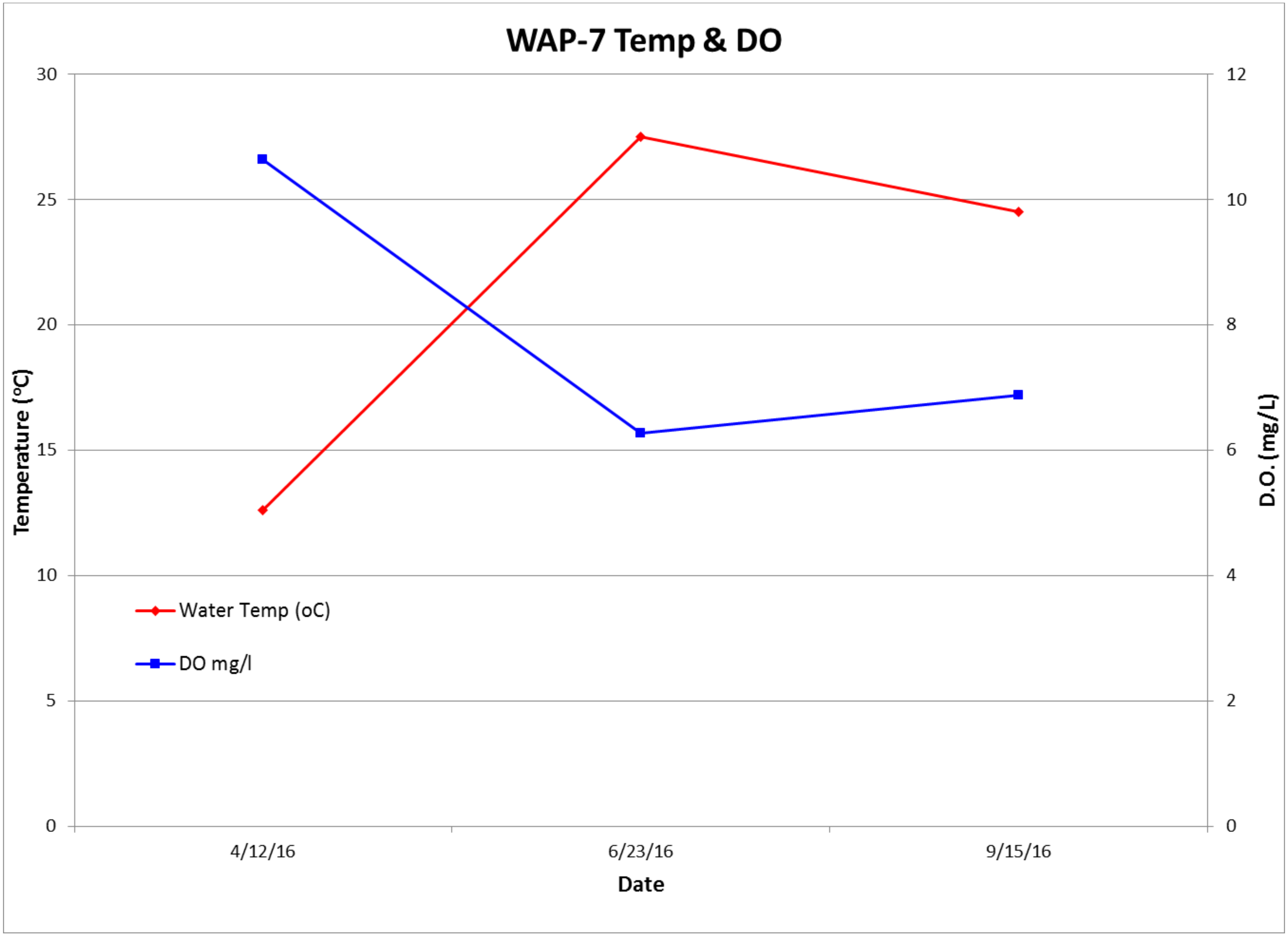
WAP-2 Temp & DO vs Depth
Temperature (°C)
D.O. (mg/L)
Water Temp (oC)
DO mg/l
0.3
1
2
3
4
5
6
7
0.4
8
9
4/12/16
6/23/16
9/15/16
Depth (m)/Date

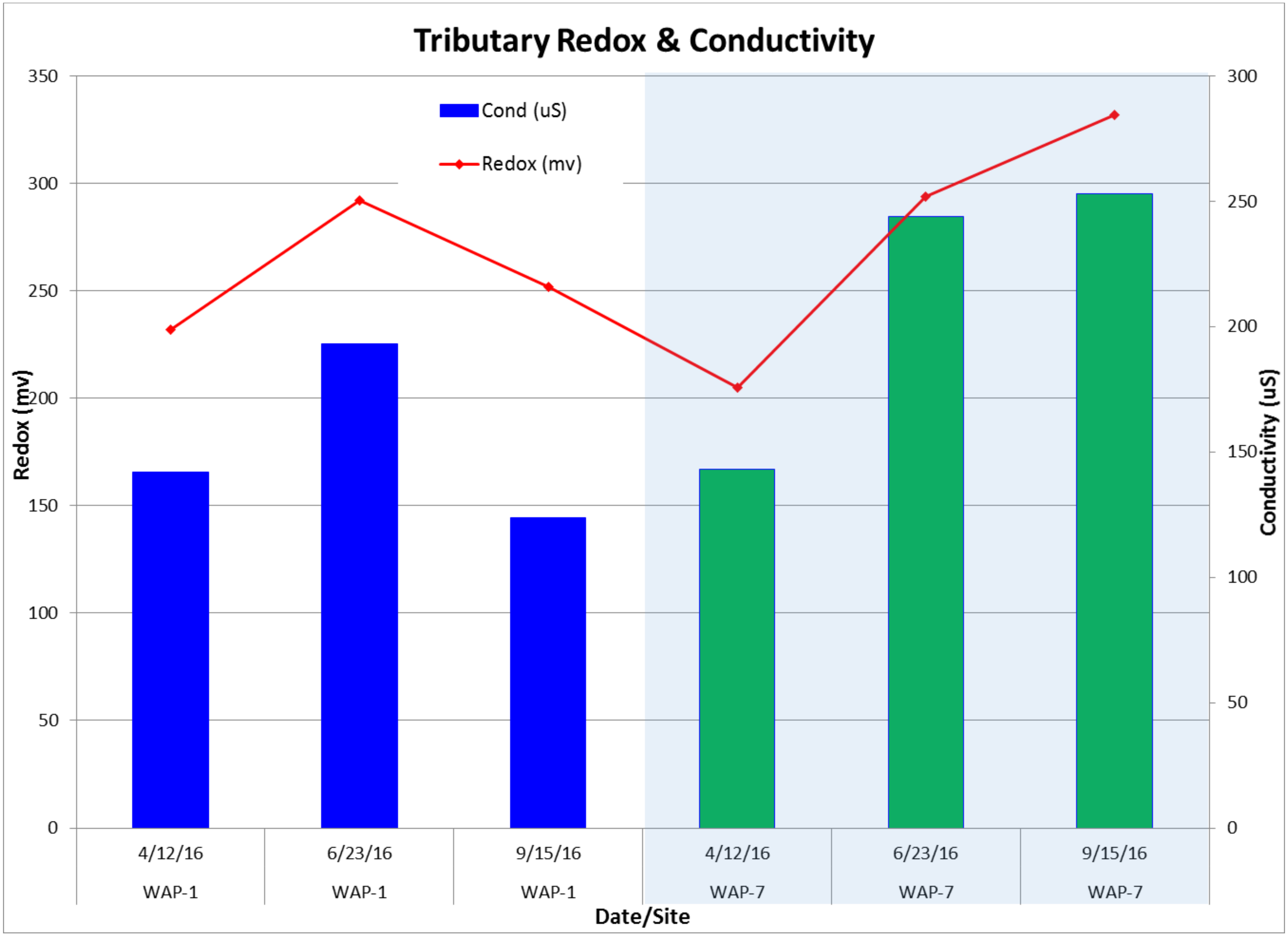


WAP-5 Temp & DO vs Depth
Temperature (°C)
D.O. (mg/L)
Depth (m)/Date
Water Temp (oC)
35
30
25
20
15
10
5
0
12
10
8
6
4
2
0
0.3
4/12/16
1
4/12/16
2
4/12/16
0.4
9/15/16
1
9/15/16
2
9/15/16
3
9/15/16
4
9/15/16

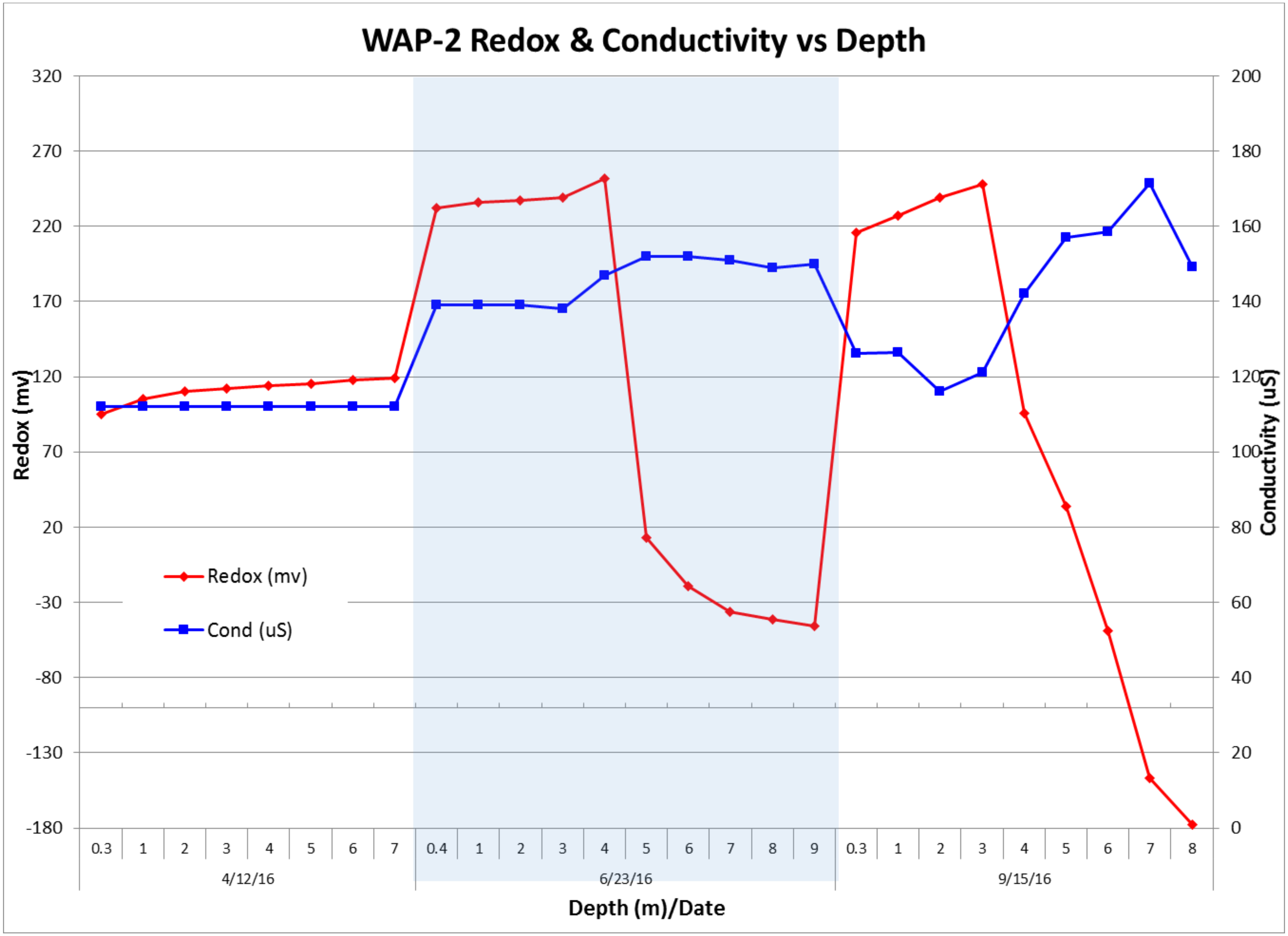


WAP-6 Temp & DO vs Depth
Water Temp (oC)
DO mg/l
Temperature (°C)
D.O. (mg/L)
35
30
25
20
15
10
5
0
12
10
8
6
4
2
0
0.3 1 2 0.3 1 2 3 4 4.8 0.4 1 2 3 4 5
4/12/16
6/23/16
9/15/16
Depth (m)/Date

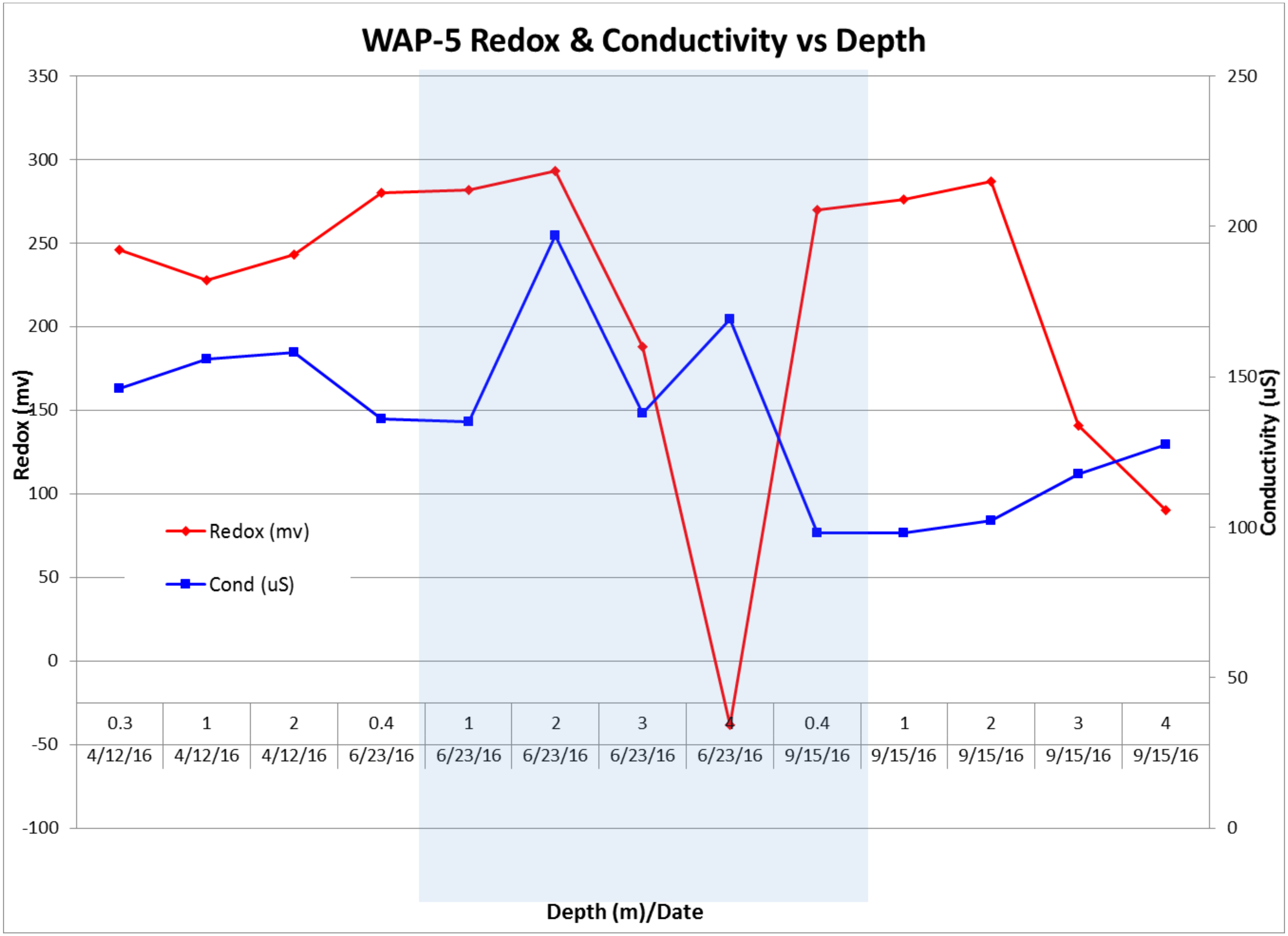

WAP-7 Temp & DO
30
25
20
15
10
5
0
12
10
8
6
4
2
0
Temperature (ºC)
D.O. (mg/L)
Water Temp (oC)
DO mg/l
4/12/16
6/23/16
9/15/16
Date

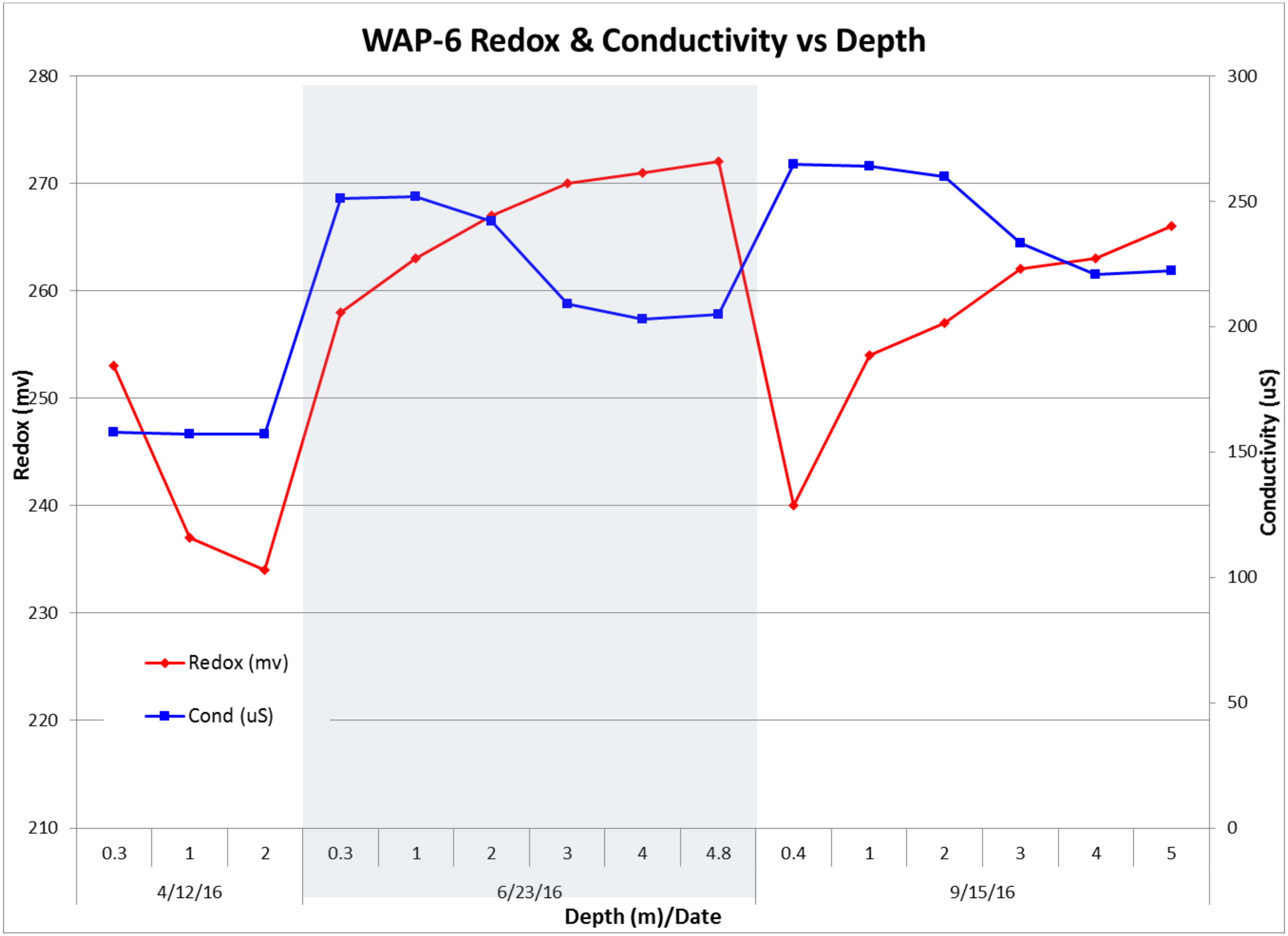


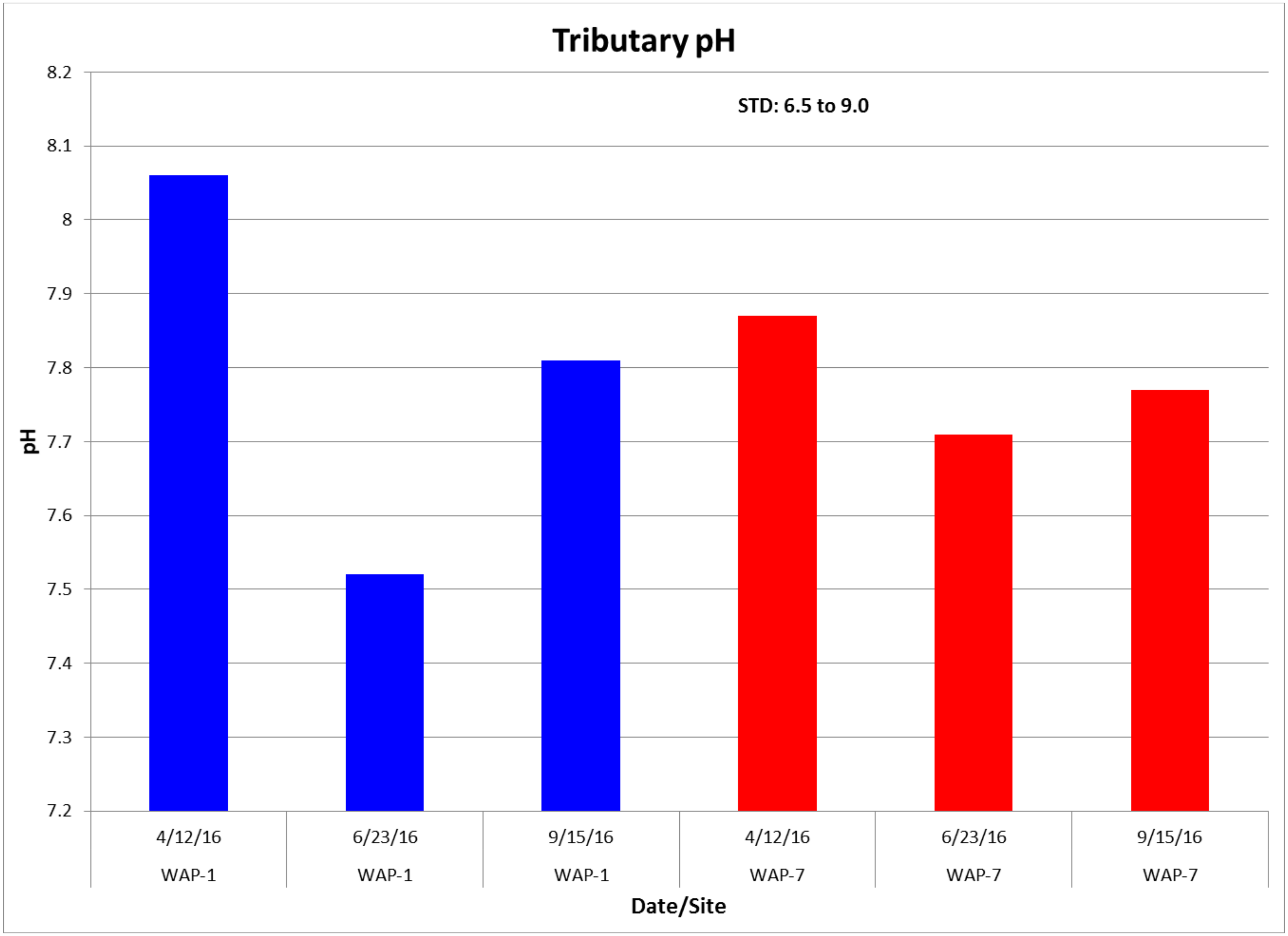
Tributary Redox & Conductivity
Cond (uS)
Redox (mv)
350
300
250
200
150
100
50
0
Redox (mv)
300
250
200
150
100
50
0
Conductivity (uS)
4/12/16
WAP-1
6/23/16
WAP-1
9/15/16
WAP-1
4/12/16
WAP-7
6/23/16
WAP-7
9/15/16
WAP-7
Date/Site



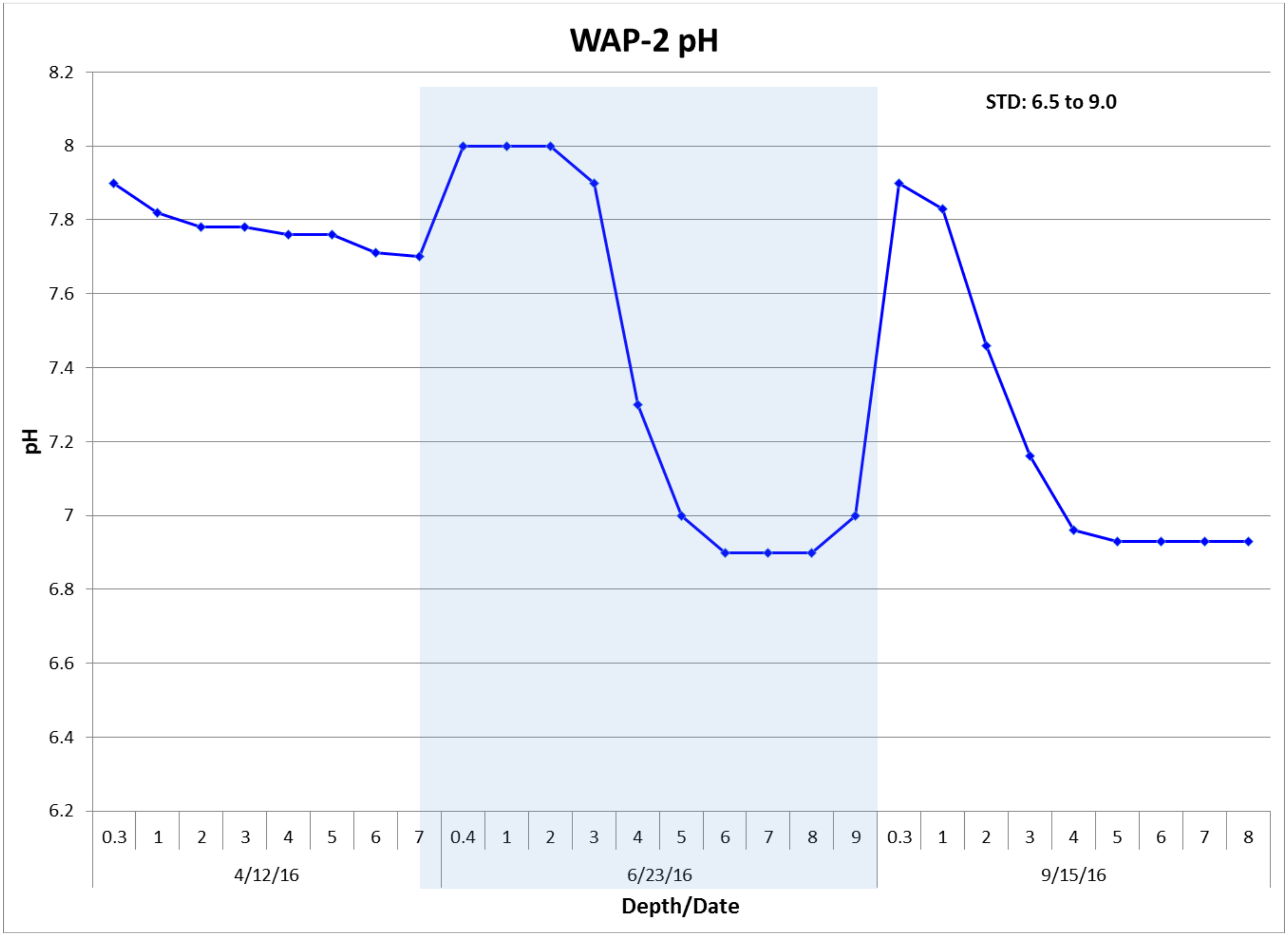
WAP-2 Redox & Conductivity vs Depth
Redox (mv)
Conductivity (uS)
Redox (mv)
Cond (uS)
320
270
220
170
120
70
20
-30
-80
-130
-180
200
180
160
140
120
100
80
60
40
20
0
0.3 1 2 3 4 5 6 7
0.4 1 2 3 4 5 6 7 8 9
0.3 1 2 3 4 5 6 7 8
4/12/16
6/23/16
9/15/16
Depth (m)/Date


WAP-5 Redox & Conductivity vs Depth
Redox (mv)
Conductivity (uS)
350
300
250
200
150
100
50
0
-50
-100
250
200
150
100
50
0
Redox (mv)
Cond (uS)
0.3
1
2
0.4
1
2
3
4
0.4
1
2
3
4
4/12/16
4/12/16
4/12/16
6/23/16
6/23/16
6/23/16
6/23/16
6/23/16
9/15/16
9/15/16
9/15/16
9/15/16
9/15/16
Depth (m)/Date

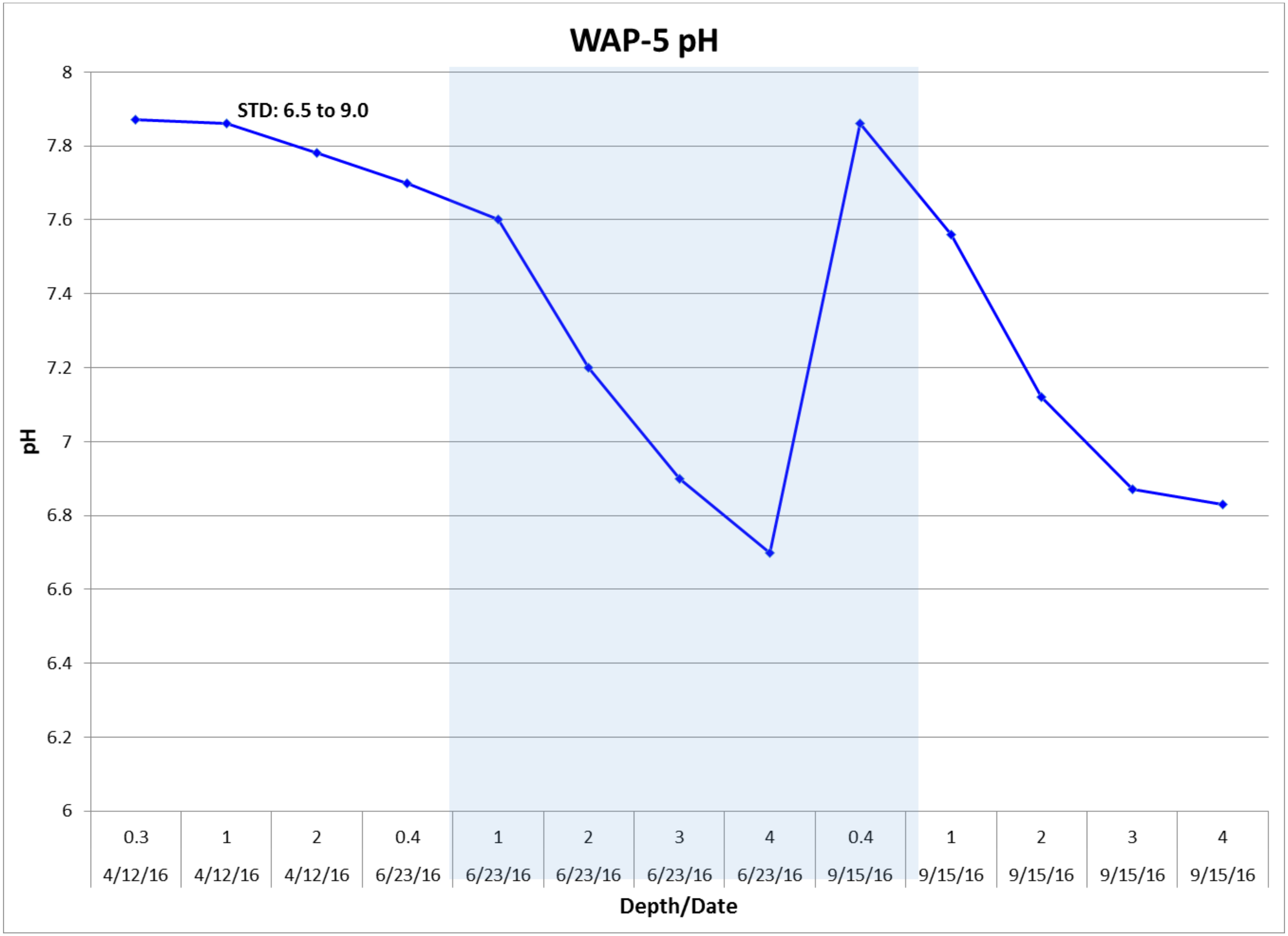

WAP-6 Redox & Conductivity vs Depth
Redox (mv)
Conductivity (uS)
280
270
260
250
240
230
220
210
300
250
200
150
100
50
0
Redox (mv)
Cond (uS)
0.3
1
2
0.3
1
2
3
4
4.8
0.4
1
2
3
4
5
4/12/16
6/23/16
9/15/16
Depth (m)/Date



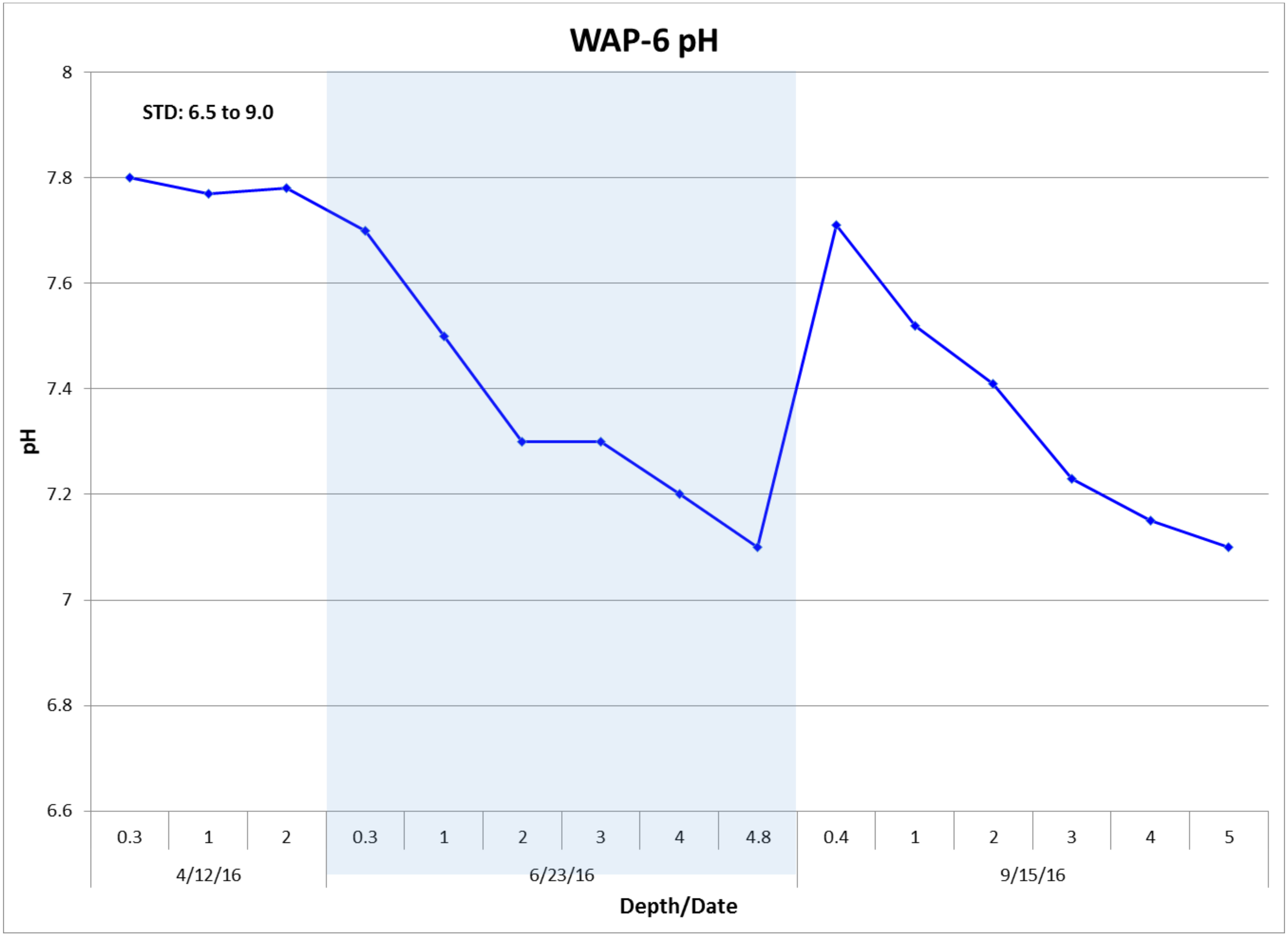
Tributary pH
STD: 6.5 to 9.0
8.2
8.1
8
7.9
7.8
7.7
7.6
7.5
7.4
7.3
7.2
pH
4/12/16
WAP-1
6/23/16
WAP-1
9/15/16
WAP-1
4/12/16
WAP-7
6/23/16
WAP-7
9/15/16
WAP-7
Date/Site

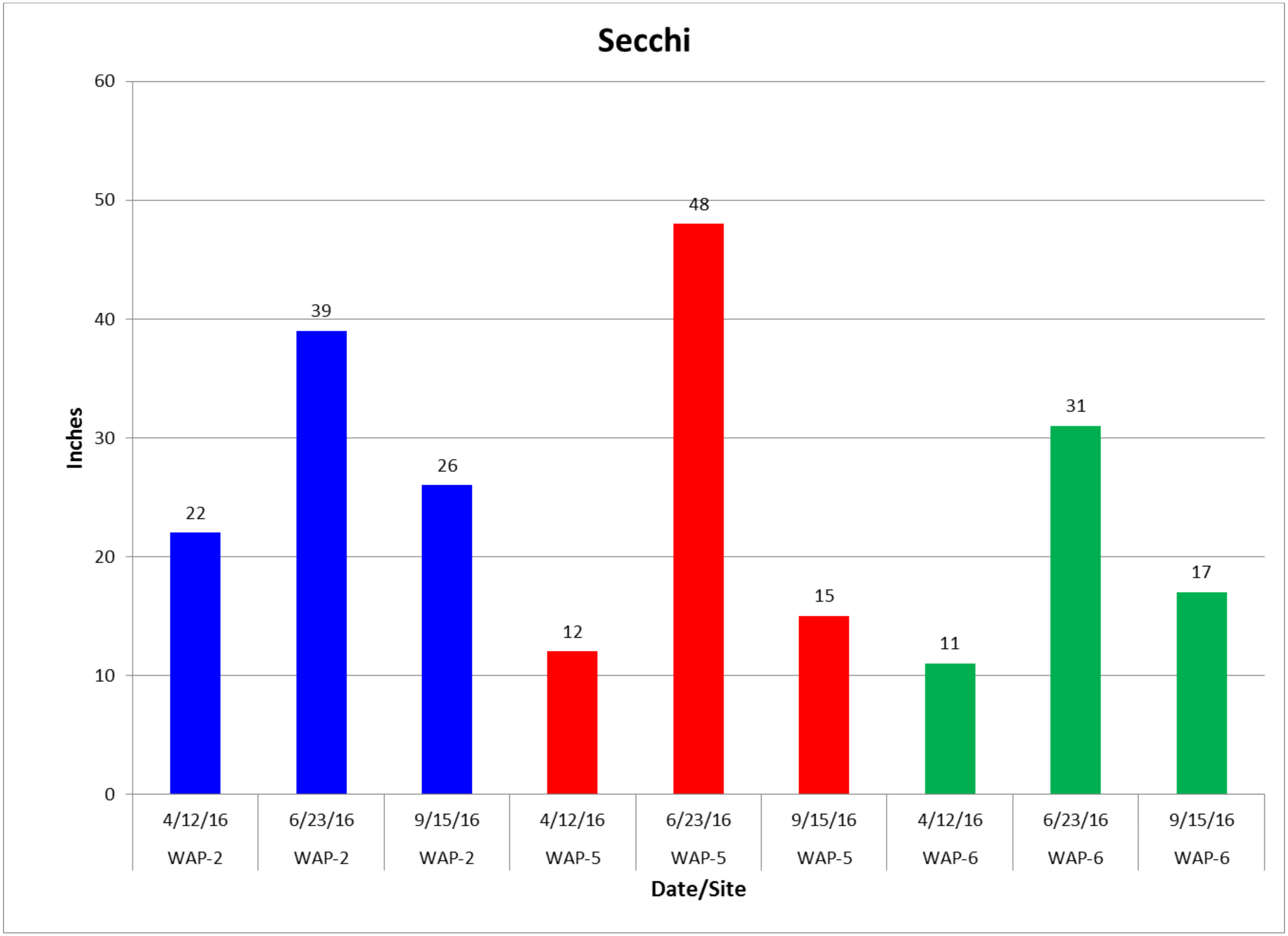


WAP-2 pH
STD: 6.5 to 9.0
pH
8.2
8
7.8
7.6
7.4
7.2
7
6.8
6.6
6.4
6.2
0.3 1 2 3 4 5 6 7
4/12/16
0.4 1 2 3 4 5 6 7 8 9
6/23/16
0.3 1 2 3 4 5 6 7 8
9/15/16
Depth/Date



WAP-5 pH
STD: 6.5 to 9.0
pH
8
7.8
7.6
7.4
7.2
7
6.8
6.6
6.4
6.2
6
0.3 4/12/16
1 4/12/16
2 4/12/16
0.4 6/23/16
1 6/23/16
2 6/23/16
3 6/23/16
4 6/23/16
0.4 9/15/16
1 9/15/16
2 9/15/16
3 9/15/16
4 9/15/16
Depth/Date


WAP-6 pH
STD: 6.5 to 9.0
pH
8
7.8
7.6
7.4
7.2
7
6.8
6.6
0.3
1
2
0.3
1
2
3
4
4.8
0.4
1
2
3
4
5
4/12/16
6/23/16
9/15/16
Depth/Date


Secchi
Inches
60
50
40
30
20
10
0
22
39
26
12
48
15
11
31
17
4/12/16
WAP-2
6/23/16
WAP-2
9/15/16
WAP-2
4/12/16
WAP-5
6/23/16
WAP-5
9/15/16
WAP-5
4/12/16
WAP-6
6/23/16
WAP-6
9/15/16
WAP-6
Date/Site

APPENDIX D

Lakes of Missouri
Volunteer Monitoring Data

2016 Lakes of Missouri Volunteer Program (LMVP) Data

Site	Date	Temp F	Secchi INCHES	TP ug/L	TN ug/L	TCHLa ug/L	CHLa ug/L	PHEO ug/L	ISS mg/L	OSS mg/L	TSS mg/L	Comments	Depth
1	5/16/16	67	33	40	440	20.6	20	1.4	4.9	2.4	7.3		29
1	6/21/16	86	74	21	330	6.3	5.8	1.5	1.4	2.6	4		24
1	7/1/16	83	41			23.7	23.7	0.1	2.5	4.6	7.1		
1DEEP	5/16/16			46	490	0.5	0.5	0.1	17	3.8	20.8	Hand pump broke	
1DEEP	6/21/16			49	410	22.4	22.4	0.1	10.2	2.8	13		
1DEEP	7/1/16			29	400	21.2	20.4	2.3	4.8	4.4	9.2		
2	5/16/16	67	30	45	450	27.9	26.4	3.8	4.3	4	8.3		21
2	6/21/16	85	69	26	340	7.5	6.3	3.1	1.2	2.5	3.7		
2	7/1/16	83	28	88	530	21.8	19.6	5.6	6	4.2	10.2		15
2DEEP	5/16/16			62	570	1	0.6	0.8	44	10.4	54.4		
2DEEP	6/21/16	`		46	400	24.8	20.5	11.1	8.4	3.2	11.6		
2DEEP	7/1/16			42	420	21.4	18.7	7.1	13.6	4.4	18		
3	5/16/16		36	19	390	5.6	4.9	2.2	8.5	2	10.5		
3	6/21/16			17	250	8.6	7.5	3.2	5.6	1.5	7.1		
3	7/1/16			21	230	11.3	9.8	4.3	8.9	1.9	10.8		

Site 1 is in front of dam
Site 2 is in Lost Creek Arm
Site 3 is at Hwy 34 Bridge

Depth is simply the depth of the lake at the sampling location at the time of sample collection
DEEP sample sites represent water collected from near the bottom using a Van Dorn sampling bottle

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 of	Water temp.	Rockwood	E. Coli Peoples	Redman	Rain Previous 2 days	Lake Level	Date	
25-Apr-16	71	4	20	Closed	0	360.77	4/25/2016	Rockwood and Peoples Creek opened 4/29/16
2-May-16	71	12	50	Closed	0.05	361.6	5/2/2016	
9-May-16	71	2	2	Closed	0	360.5	5/9/2016	Peoples closed, Rockwood closed 5/12, Predicted crest 368.0
16-May-16	68	Flooded	Flooded	Flooded	0	369.8	5/19/2016	All beaches closed due to flooding
23-May-16	69	Flooded	Flooded	Flooded	0	368.7	5/26/2016	All beaches closed due to flooding, sample for Rockwood 2
30-May-16	74	Flooded	Flooded	Flooded	0	373.3	6/3/2016	All beaches closed due to flooding
6-Jun-16	76	Flooded	Flooded	Flooded	0	372.1	6/10/2016	All beaches closed due to flooding
13-Jun-16	81	Flooded	Flooded	Flooded	0	368.4	6/17/2016	All beaches closed due to flooding
20-Jun-16	85	8	14	4	0	364.2	6/24/2016	Rockwood opened 6/20, Redman opened 6/24
27-Jun-16	87	8	2	2	0	362.1	6/30/2016	Peoples Creek opened 6/28
4-Jul-16	81	25	28	86	3.95	361.07	7/7/2016	
11-Jul-16	86	6	2	14	0.88	360.76	7/14/2016	
18-Jul-16	89	2	2	2	0.36	360.33	7/21/2016	
25-Jul-16	93	2	590	2	0	360.19	7/29/2016	Contaminated sample, UPS delivery issues. Also geese on beach
29-Jul-16	89		77		0.77	360.19	7/29/2016	Resample of Peoples Creek
1-Aug-16	89	13	88	40	1.1	359.99	8/4/2016	
8-Aug-16	88	6	4	4	0	359.76	8/11/2016	
15-Aug-16	86	Flooded	Flooded	Flooded	7.96	377.22	8/19/2016	All beaches closed due to flooding on 8/14/16
22-Aug-16	81	Flooded	Flooded	Flooded	0.17	375.56	8/26/2016	
29-Aug-16	84	Flooded	Flooded	Flooded	0	372.05	9/2/2016	
5-Sep-16	79	Flooded	Flooded	Flooded	0	368.01	9/9/2016	
12-Sep-16	81	Closed	Flooded	Closed	0	364.25	9/15/2016	Closed for season
		5.874521	14.68163	7.0589				

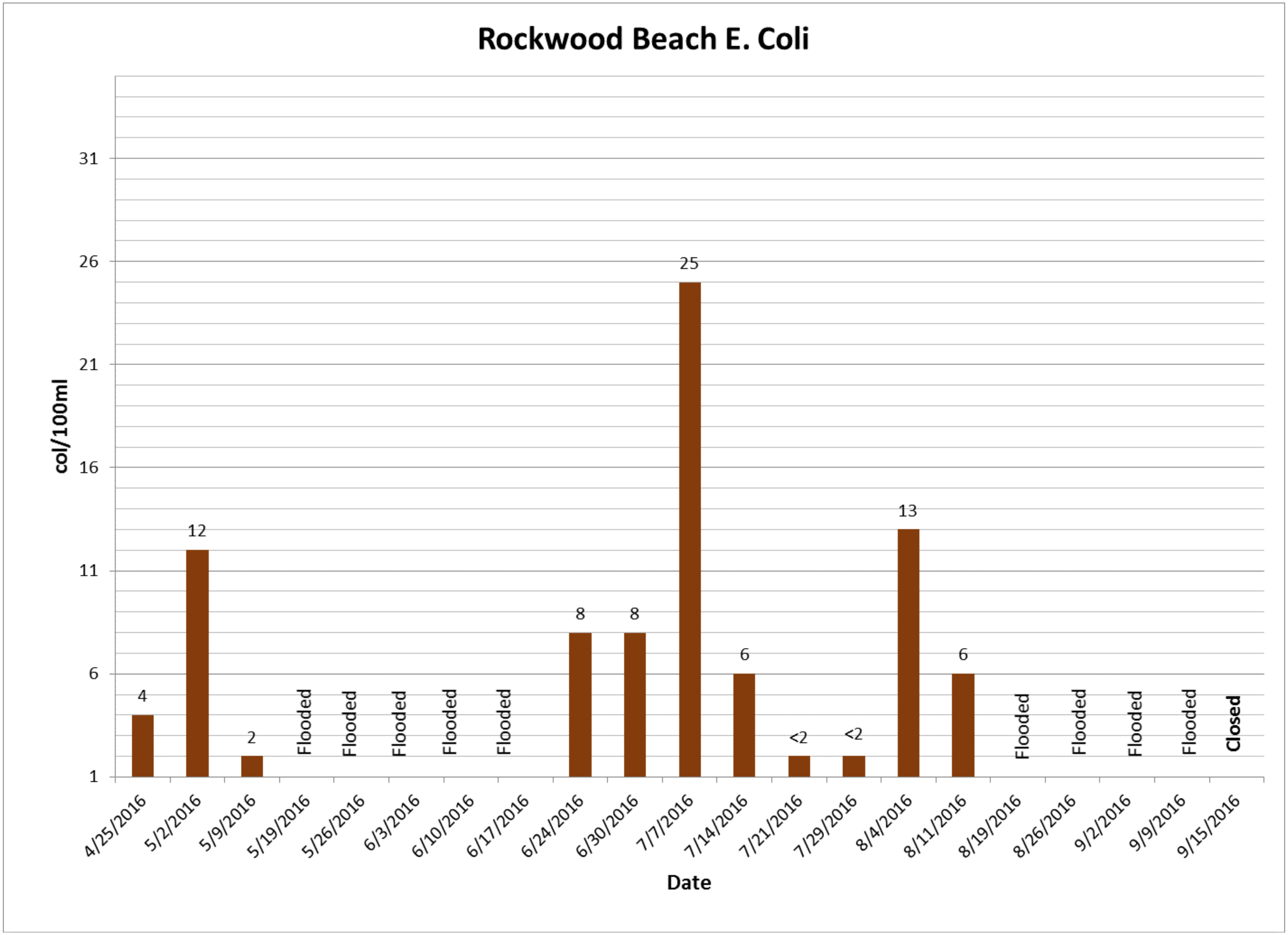
Old Standard, 235 for weekly and a Geometric mean under 126 for last 5 samples.

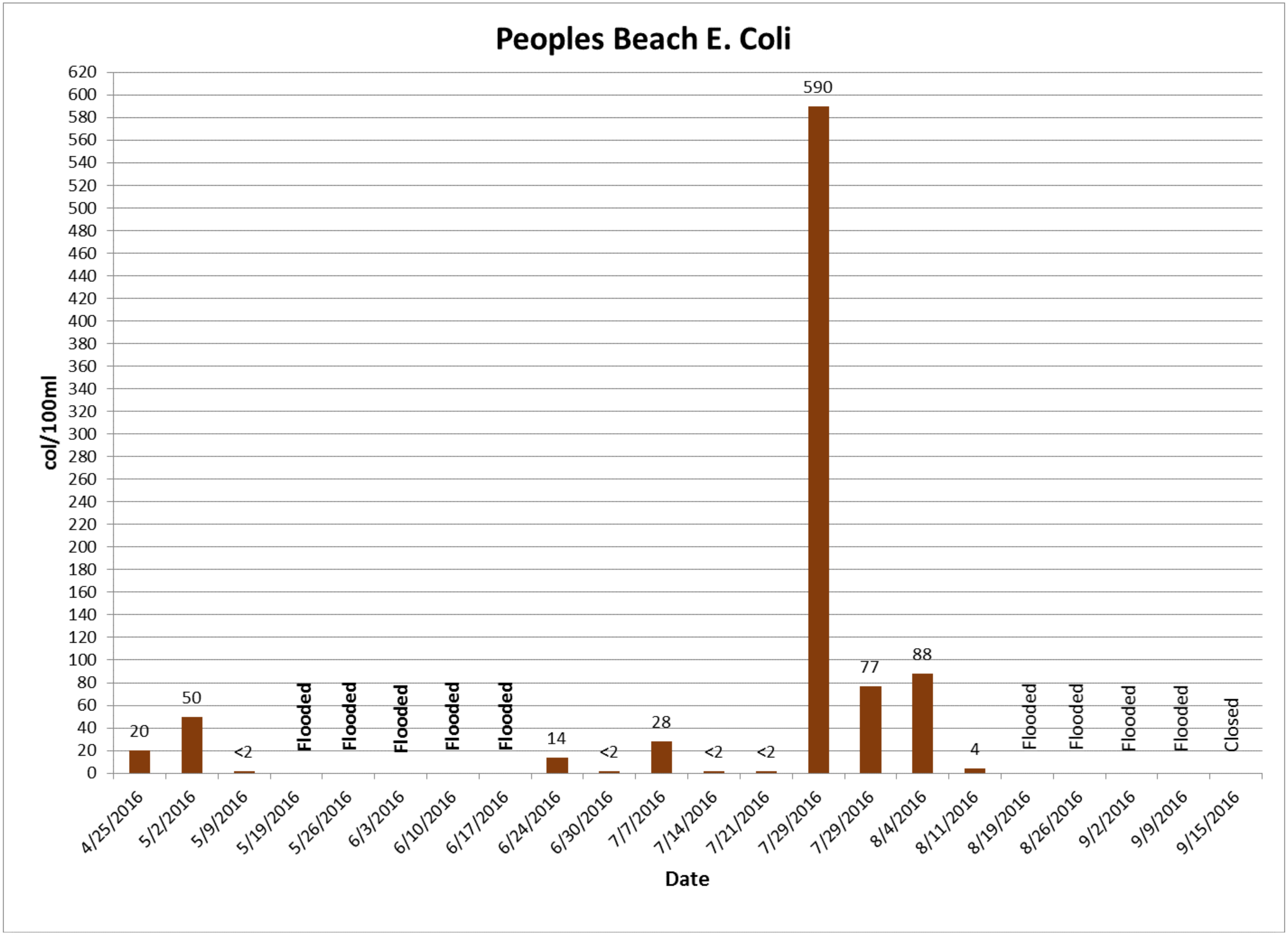
New Standard, Weekly Geometric means 190, DNR and EPA new standards. August 2013

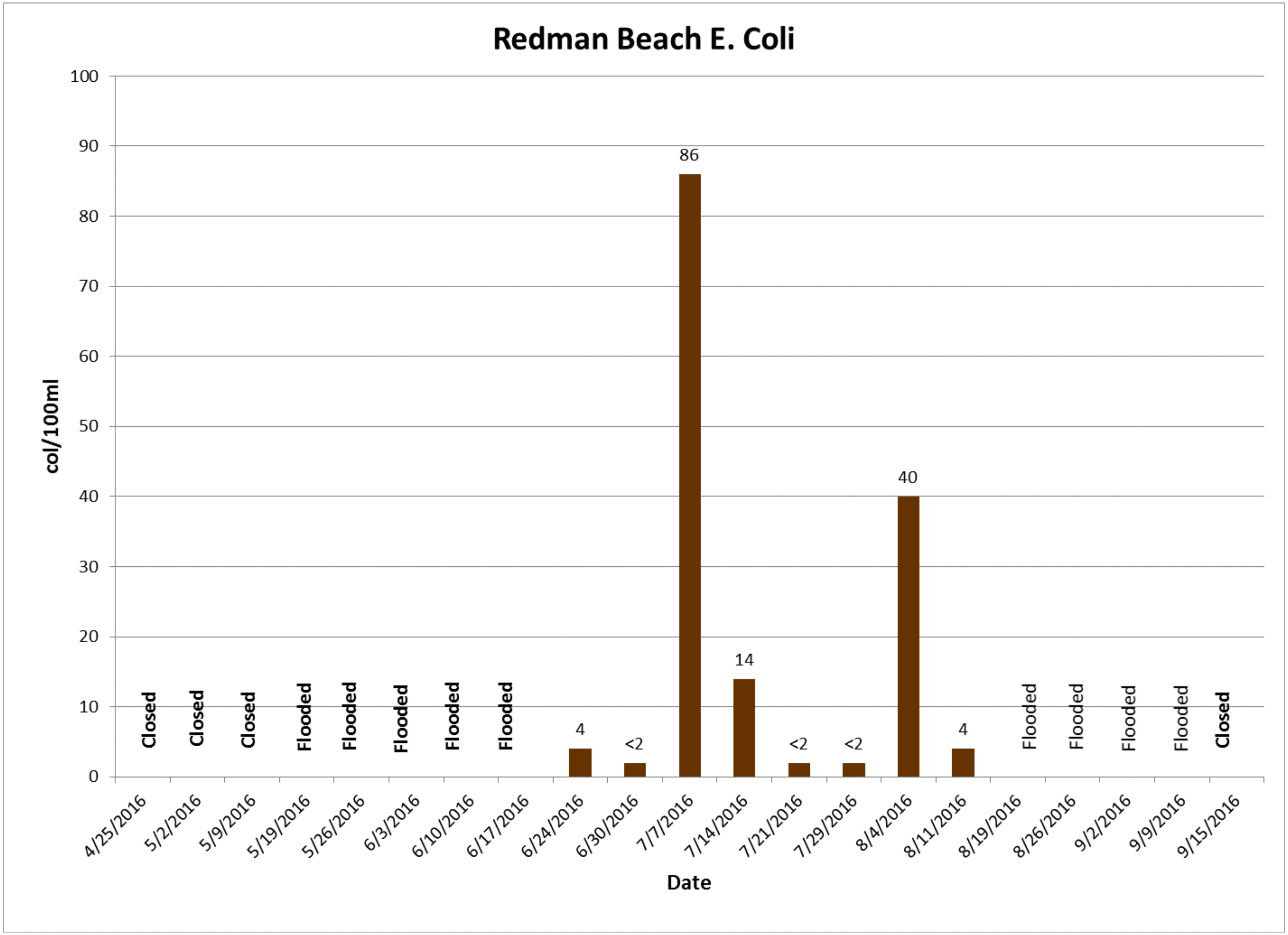
Samples taken on the Monday of each week, except Memorial Day and Labor Day weekend, which will be taken on a Tuesday.

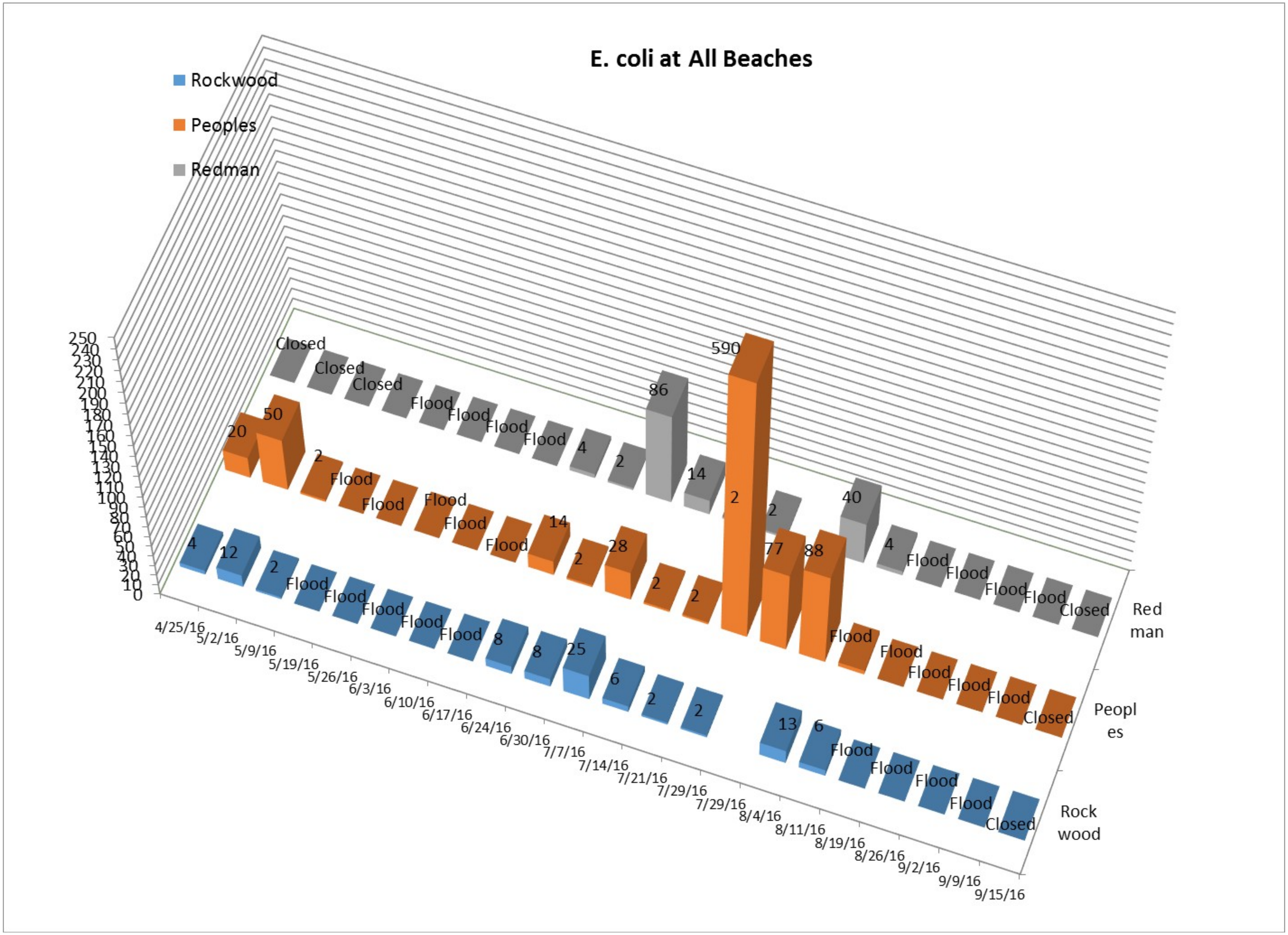
E. Coli is measured in Colony forming units per one hundred millileters, cfu/1000 mls

Peoples Creek closes at 363.0
Redman Creek closes at 365.5
Rockwood closes at 366.8


Rockwood Beach E. Coli
col/100ml
31
26
21
16
11
6
1
4
12
2
Flooded
Flooded
Flooded
Flooded
Flooded
8
8
25
6
<2
<2
13
6
Flooded
Flooded
Flooded
Flooded
Closed
4/25/2016
5/2/2016
5/9/2016
5/19/2016
5/26/2016
6/3/2016
6/10/2016
6/17/2016
6/24/2016
6/30/2016
7/7/2016
7/14/2016
7/21/2016
7/29/2016
8/4/2016
8/11/2016
8/19/2016
8/26/2016
9/2/2016
9/9/2016
9/15/2016
Date


Peoples Beach E. Coli
col/100ml
Date
20
50
<2
Flooded
Flooded
Flooded
Flooded
Flooded
14
<2
28
<2
<2
590
77
88
4
Flooded
Flooded
Flooded
Flooded
Closed
4/25/2016
5/2/2016
5/9/2016
5/19/2016
5/26/2016
6/3/2016
6/10/2016
6/17/2016
6/24/2016
6/30/2016
7/7/2016
7/14/2016
7/21/2016
7/29/2016
7/29/2016
8/4/2016
8/11/2016
8/19/2016
8/26/2016
9/2/2016
9/9/2016
9/15/2016


Redman Beach E. Coli
col/100ml
Date
100
90
80
70
60
50
40
30
20
10
0
86
14
40
4
<2
<2
<2
4
Closed
Closed
Closed
Flooded
Flooded
Flooded
Flooded
Flooded
Flooded
Flooded
Flooded
Flooded
Closed
4/25/2016
5/2/2016
5/9/2016
5/19/2016
5/26/2016
6/3/2016
6/10/2016
6/17/2016
6/24/2016
6/30/2016
7/7/2016
7/14/2016
7/21/2016
7/29/2016
8/4/2016
8/11/2016
8/19/2016
8/26/2016
9/2/2016
9/9/2016
9/15/2016


E. coli at All Beaches
Rockwood
Peoples
Redman
250
240
230
220
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
4/25/16
5/2/16
5/9/16
5/19/16
5/26/16
6/3/16
6/10/16
6/17/16
6/24/16
6/30/16
7/7/16
7/14/16
7/21/16
7/29/16
7/29/16
8/4/16
8/11/16
8/19/16
8/26/16
9/2/16
9/9/16
9/15/16
Red man
Peopl es
Rock wood
Closed
Closed
Closed
Flood
Flood
Flood
Flood
4
2
86
14
2
40
4
Flood
Flood
Flood
Flood
Closed
20
50
2
Flood
Flood
Flood
Flood
Flood
14
2
28
2
2
590
2
77
88
Flood
Flood
Flood
Flood
Flood
Closed
4
12
2
Flood
Flood
Flood
Flood
Flood
8
8
25
6
2
2
13
6
Flood
Flood
Flood
Flood
Closed